SANTA CRUZ RIVER, PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA FINAL FEASIBILITY STUDY

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS), THE DEPARTMENT OF THE ARMY

TRANSMITTING

A STUDY ON THE SANTA CRUZ RIVER, PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA, PURSUANT TO PUB. L. 75–761

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

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JAN 15 2009

HOUSE DOCUMENT NUMBER 111-13

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

Dear Madam Speaker:

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 May 17, 1994 requested a review of reports for the State of Arizona to determine whether modifications of the recommendations contained therein are advisable in the interest of flood damage reduction, environmental protection and restoration, and related purposes. In partial response to this authorization and resolution, a study has been completed for the Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona. The proposal is described in the report of the Chief of Engineers dated March 28, 2006, which includes other pertinent reports and documents. The views of the State of Arizona and other interested agencies are set forth in the enclosed report. The project was authorized by Congress in Section 1001(3) of the Water Resources Development Act (WRDA) of 2007.

The ecosystem restoration and recreation plan would restore ecological functions and values to about a 7.5-mile reach of the Santa Cruz River in Pima County and in the City of Tucson, between Los Reales Road and Congress Street. The plan recommended in the report of the Chief of Engineers includes five water harvesting basins at existing grade control structures and eight water harvesting basins at tributary confluences. The water harvesting basins are shallow, gravel-lined depressions overlain with topsoil and plantings, range in size from 1.3 to 4.2 acres, and are designed to hold surface water runoff and slowly release it to the project area. Approximately 10.6 miles of existing steeply eroded banks along both the left and right sides of the channel would be regraded to about a 5-to-1 side slope, and vegetation would be reestablished. An irrigation system would be constructed to provide reclaimed water to establish and sustain vegetation. Recreational features in the recommended plan include interpretive signage, a comfort station, footpaths, and parking areas. Implementing the recommended plan would restore and improve approximately 718 acres of mesquite, 356 acres of riparian shrub, 18 acres of cottonwood-willow, and 6 acres of emergent marsh.

Based on October 2008 prices, the total first cost of the project is estimated at $108,100,000 with the ecosystem restoration portion estimated at $106,700,000 and the separable recreation features estimated at $1,400,000. 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 $69,350,000 and the non-Federal share would be about $37,350,000. The Federal and non-Federal shares for the separable recreation features, which have a benefit cost ratio of 1.3, would be about $700,000 each. The total first cost of the project would be shared at about $70,050,000 Federal and about $38,050,000 non-Federal. The costs for all operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project, plus supplemental irrigation water costs, are estimated at $2,230,000 annually. The Pima County, Arizona, Flood Control District would be the sponsor for the project and would be responsible for all OMRR&R costs."

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

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

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

Very truly yours,

John Paul Woodley, Jr.

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

Enclosures

6 Enclosures

1. Record of Decision, Jan 21, 2009
2. OMB Letter Jan 13, 2009
3. State of Arizona Letter Feb 23, 2006
4. DOI Letter Jan 17, 2006
5. Report of the Chief of Engineers, Mar 28, 2006
6. Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona Final Feasibility Study and Final Environmental Impact Statement, July 2005

RECORD OF DECISION
SANTA CRUZ RIVER (PASEO DE LAS IGLESIAS) ECOSYSTEM RESTORATION
PIMA COUNTY, ARIZONA

The Final Feasibility Report and Environmental Impact Statement (FR/FEIS) for the Santa Cruz River (Paseo de las Iglesias) Ecosystem Restoration project, Arizona, dated July 2005, addresses ecosystem restoration and flood damage reduction opportunities along the Paseo de las Iglesias reach of the Santa Cruz River in Pima County, Arizona. Based on my review and the views of interested agencies and the concerned public, I find the project authorized by Congress in Section 1001(3) of the Water Resources Development Act of 2007 (Public Law 110-114) to be technically feasible, economically justified, environmentally acceptable, and in the public interest.

The authorized project would restore ecosystem functions and values to about a 7.5-mile reach of the Santa Cruz River in Pima County and in the City of Tucson, between Los Reales Road and Congress Street. No flood damage reduction project could be justified within the study area. The recommended plan consists of the following major features:

- Construction of about 13 water harvesting basins at existing grade control structures and at tributary confluences;
- Flattening of approximately 56,000 linear feet of existing steeply eroded channel banks to about a 5-to-1 slope;
- Restoration of about 718 acres of mesquite, 18 acres of cottonwood-willow forest, 6 acres of emergent marsh, and 356 acres of desert scrub shrub habitat;
- Installation of an irrigation system to help in the establishment and maintenance of vegetation;
- Provision for recreation where compatible with ecosystem features by construction of about 5 miles of trails, pedestrian bridges, parking lots, comfort stations, and interpretive signs; and
- Construction of maintenance roads and ramps for safety and river access.

A total of 14 action alternatives and the no-action alternative were examined in detail to evaluate potential measures to improve aquatic functions of the Santa Cruz River. Alternatives were screened for consistency with natural vegetation patterns, production of sufficient habitat diversity, and maintenance flood water conveyance capacity. Water availability and the importance of including a substantial acreage of cottonwood-willow habitat were also identified as important issues for the alternatives screening process. Through an iterative process, an array of three alternatives was produced, plus the no action plan. These alternatives can generally be considered as low, medium and high water use plans. Additional refinement of these alternatives based on water availability and subsequent analysis of costs and ecosystem restoration benefits relative to their effectiveness, acceptability, completeness, and efficiency led to the selection of Alternative 3E as the recommended plan. This plan will restore a significant ecosystem resource along the Pacific Flyway for neo-tropical birds, reconnect wildlife corridors, restore wildlife habitat for species significant to Pima County, provide potential habitat for threatened and endangered species, and restore threatened plant communities of cottonwood/willow riparian forest, emergent wetland, and mesquite bosque.

The FEIS contains a complete disclosure of environmental impacts, as well as information concerning compliance with applicable environmental laws, statues and executive orders. Mitigation for impacts to National Register of Historic Places properties will be developed in a Memorandum of Agreement between the Corps, Arizona State Historic Preservation Officer, and Native American Tribes in accordance with Section 106 of the National Historic Preservation Act. The authorized project is expected to have no significant adverse affects, and is expected to have significant beneficial impacts to wildlife in the area. A Monitoring and Adaptive Management Plan is part of the project. This cost-shared program will provide a mechanism to evaluate the effectiveness of restoration efforts and, if necessary, to implement minor adaptive changes for up to 5 years. The authorized project is the environmentally preferable alternative as well as the least environmentally damaging practicable alternative. Full compliance with the Clean Water Act will be accomplished prior to execution of a project partnership agreement and initiation of construction.

The authorized project has been extensively coordinated with the public, Native American Tribes and with Federal, state and local resource agencies, and is in compliance with environmental requirements, including the Endangered Species Act, the Fish and Wildlife Coordination Act, the National Historic Preservation Act, the Clean Air Act, the Clean Water Act, and all relevant Executive Orders. Comments on the FEIS were received from the State of Arizona Governor's Office and the U.S. Fish and Wildlife Service and were supportive of the Recommended Plan.

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, and local government plans were considered in the evaluation of alternatives. Based on review of these evaluations, I find that the non-monetary benefits of the proposed ecosystem restoration outweigh the costs and 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 13, 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 Army Corps of Engineers Santa Cruz River, Paseo de las Iglesias report.

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

STATE OF ARIZONA

JANET NAPOLITANO
GOVERNOR

OFFICE OF THE GOVERNOR
1700 WEST WASHINGTON STREET, PHOENIX, AZ 85007

MAIN PHONE: 602-542-4331
FACSIMILE: 602-542-7601

February 23, 2006

Col. Alex C. Dornstauder, USA
Commander, US Army Corps of Engineers (Los Angeles, District)
915 Wilshire Boulevard, Suite 1500
Los Angeles, California 90017

Dear Colonel Dornstauder:

It is my understanding that the Corps of Engineers, Pima County and the City of Tucson wish to launch the environmental restoration of a seven-mile reach of the Santa Cruz River from the San Xavier District (Tohono O'odham reservation) to the Los Reales Road alignment. Pima County Regional Flood Control District representatives inform me that the *Paseo de las Iglesias* project would complement the County's ongoing Sonoran Desert Conservation Plan, which has had my complete support for some time. I believe that projects such as *Paseo de las Iglesias* are extremely important to urban renewal because they foster improvement and expansion of riparian habitats.

With that in mind, I would like to lend my support to Pima County and the City of Tucson in securing Department of Army and Congressional authorization to proceed with design and construction of the project. If there is anything more that I can do to help achieve that objective, please do not hesitate to call upon me.

Yours very truly,

Janet Napolitano
Governor

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, DC 20240

TAKE PRIDE IN AMERICA

JAN 17 2006

ER 05/961

Mr. Thomas W. Waters
Chief, Policy and Policy Compliance Division
Directorate of Civil Works
Headquarters, U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

Dear Mr. Waters:

As requested, the U.S. Department of the Interior has reviewed the Chief of Engineers' Proposed Report on Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona.

The Department does not object to the proposed project and has no comments to offer. The point of contact is Ms. Loretta Sutton, 202-208-7565. We appreciate the opportunity to review the Chief's Proposed Report and supporting documents.

Sincerely,

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

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

REPLY TO ATTENTION OF:

MAR 28 2006

CECW-PC/CEMP-SPD (1105-2-10a)

SUBJECT: Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the study of flood damage reduction and ecosystem restoration opportunities on the Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona. My report is accompanied by the report of the district and division engineers. These reports are in partial response to a resolution adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives on May 17, 1994. The resolution requested a review of reports for the State of Arizona to determine whether modifications of the recommendations contained therein are advisable in the interest of flood damage reduction, environmental protection and restoration, and related purposes. Pre-construction engineering and design activities will continue under the cited study authority.

2. The reporting officers recommend a plan for ecosystem restoration and recreation. The plan would restore ecosystem functions and values to about a 7.5-mile reach of the Santa Cruz River in Pima County and in the City of Tucson, between Los Reales Road and Congress Street. No flood damage reduction project could be justified within the 5,000-acre study area. The recommended plan includes the following features to support ecosystem restoration:

- Five water harvesting basins at existing grade control structures,
- Eight water harvesting basins at tributary confluences,
- Flattening approximately 56,000 linear feet of existing steeply eroded channel banks to about a 5-to-one side slope,
- Reestablishment of vegetation,
- An irrigation system to establish vegetation and provide reclaimed water during drought conditions, and
- Maintenance roads and ramps for safety and river access.

3. The water harvesting basins - shallow, gravel-lined depressions overlain with topsoil and plantings - would range in size from 1.3 to 4.2 acres, and are designed to hold surface water runoff and slowly release it to the project area. Public recreation use of the restored area would be confined to locations where compatible uses would not degrade restored ecosystem features. Public use areas would be defined by about 5 miles of multi-use, non-motorized, decomposed granite trails, pedestrian bridges, parking lots, comfort stations, and interpretive signs.

4. The reporting officers recommend Federal participation in cost-shared monitoring and minor modifications, as may be required to ensure success of the project, as identified and described within the Monitoring and Adaptive Management Plan of the report for up to 5 years. The reporting officers further recommend that the plans, recommended herein, be exempt from regulations of the Clean Water Act, pursuant to Section 404(r) of the Clean Water Act. The 404(r) exemption will cover the construction phase and the operation and maintenance phase of the project, as described in the feasibility report and environmental impact statement.

5. Restoration of this resource in this urban setting is significant because riparian areas in the Southwest represent only 1 percent of the landscape yet the survival of 75 to 90 percent of life in the Southwest is dependant on riparian areas. In Arizona, over 90 percent of riparian areas have been lost due to impacts from historic settlement and urbanization. The US Fish & Wildlife Service refers to the habitat types being restored as "exceedingly rare and high-value habitat types." To insure recommendation of an efficient plan, alternative ecosystem restoration plans were evaluated using functional assessment, cost effectiveness, and incremental analysis techniques. An additional constraint that weighed heavily in the analysis was project sustainability: the local sponsor was able to commit only 2,000 acre-feet of water per year to the project. Currently the 5,000 acre study area includes 840 acres of various natural vegetative cover and the remainder is either developed or highly disturbed. It is projected that within a few years without a restoration project there will be no natural vegetative cover remaining. The cost of the recommended ecosystem restoration features are justified by the production of about 454 average annual functional capacity units and provides for achieving ecosystem function increases in the most cost effective manner. The recommended plan would restore a significant, highly productive habitat for resident mammals, insects, reptiles, and birds, and for neo-tropical birds using the Pacific Flyway all of which make use of the shade and food resources of this oasis-like riparian ecosystem resource. The restored area would help reconnect wildlife corridors, restore wildlife habitat for species significant to Pima County, and restore threatened plant communities of cottonwood/willow riparian forest and mesquite bosque. Although no species or habitats protected by the Endangered Species Act are known to use the study area today, both the endangered Southwestern willow flycatcher and the endangered Gila topminnow are found nearby within the Santa Cruz basin. Potential habitat for these endangered species will evolve incidental to the proposed restoration as willows and other woody riparian plant communities re-establish, mature and partially shade the stream in the restored riparian zone. Given time, the flycatcher and topminnow may repopulate the project area. Restoration of these regionally rare and declining habitats will also benefit at least ten additional species of concern to state and local agencies. The ecosystem function would increase 14 times over the expected future without project condition. The recommended plan is the national ecosystem restoration (NER) plan considering the constraints and limitations on available water supply. The recommended plan would restore and improve approximately 1,098 acres of habitat, including 718 acres of mesquite bosque, 356 acres of riparian shrub, 18 acres of cottonwood/willow, and 6 acres of emergent marsh. Recreation features of the recommended plan would provide average annual benefits of about $135,000, and have a benefit-to-cost ratio of 1.3.

6. Based on October 2004 price levels, the estimated first cost of the recommended plan is $92,100,000. 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 $59,700,000 and the estimated non-Federal share would be approximately $32,400,000. The estimated total first cost of the ecosystem restoration portion of the recommended plan is $90,900,000, which would be cost shared 65 percent Federal and 35 percent non-Federal. The estimated Federal cost is $59,100,000, and an estimated non-Federal cost is $31,800,000. The estimated total first cost of the recommended plan includes approximately $2,500,000 for 5 years of monitoring and adaptive management necessary to ensure success of the project. Additionally, the estimated total first cost of the recommended plan includes recreation features compatible with the ecosystem restoration project. These features have an estimated first cost of $1,200,000, which would be shared 50 percent Federal and 50 percent non-Federal, and have an estimated Federal cost of $600,000 and an estimated non-Federal cost of $600,000. The total estimated equivalent annual operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs for the recommended project are estimated to be $800,000. Additionally, supplemental irrigation water costs are estimated as $1,100,000 annually. OMRR&R and supplemental water costs are the responsibility of the non-Federal sponsor. The Pima County, Arizona, Flood Control District has agreed to be the non-Federal sponsor for the project.

7. I generally concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona, project be constructed in accordance with the reporting officers' recommended plan with such modifications as in the discretion of the Chief of Engineers may be necessary and advisable.

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 total project costs allocated to environmental restoration and 50 percent of the total 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 and the provision of water, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

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

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which 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. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project and otherwise perform its obligations in a manner that will not cause liability to arise under CERCLA.

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

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

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

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

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

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

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 or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the 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, US Army
Chief of Engineers

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

REPLY TO
ATTENTION OF:

MAR 2 8 2006

CECW-PC/CEMP-SPD (1105-2-10a)

SUBJECT: Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the study of flood damage reduction and ecosystem restoration opportunities on the Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona. My report is accompanied by the report of the district and division engineers. These reports are in partial response to a resolution adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives on May 17, 1994. The resolution requested a review of reports for the State of Arizona to determine whether modifications of the recommendations contained therein are advisable in the interest of flood damage reduction, environmental protection and restoration, and related purposes. Pre-construction engineering and design activities will continue under the cited study authority.

2. The reporting officers recommend a plan for ecosystem restoration and recreation. The plan would restore ecosystem functions and values to about a 7.5-mile reach of the Santa Cruz River in Pima County and in the City of Tucson, between Los Reales Road and Congress Street. No flood damage reduction project could be justified within the 5,000-acre study area. The recommended plan includes the following features to support ecosystem restoration:

- Five water harvesting basins at existing grade control structures,
- Eight water harvesting basins at tributary confluences,
- Flattening approximately 56,000 linear feet of existing steeply eroded channel banks to about a 5-to-one side slope,
- Reestablishment of vegetation,
- An irrigation system to establish vegetation and provide reclaimed water during drought conditions, and
- Maintenance roads and ramps for safety and river access.

3. The water harvesting basins - shallow, gravel-lined depressions overlain with topsoil and plantings - would range in size from 1.3 to 4.2 acres, and are designed to hold surface water runoff and slowly release it to the project area. Public recreation use of the restored area would be confined to locations where compatible uses would not degrade restored ecosystem features. Public use areas would be defined by about 5 miles of multi-use, non-motorized, decomposed granite trails, pedestrian bridges, parking lots, comfort stations, and interpretive signs.

4. The reporting officers recommend Federal participation in cost-shared monitoring and minor modifications, as may be required to ensure success of the project, as identified and described within the Monitoring and Adaptive Management Plan of the report for up to 5 years. The reporting officers further recommend that the plans, recommended herein, be exempt from regulations of the Clean Water Act, pursuant to Section 404(r) of the Clean Water Act. The 404(r) exemption will cover the construction phase and the operation and maintenance phase of the project, as described in the feasibility report and environmental impact statement.

5. Restoration of this resource in this urban setting is significant because riparian areas in the Southwest represent only 1 percent of the landscape yet the survival of 75 to 90 percent of life in the Southwest is dependant on riparian areas. In Arizona, over 90 percent of riparian areas have been lost due to impacts from historic settlement and urbanization. The US Fish & Wildlife Service refers to the habitat types being restored as "exceedingly rare and high-value habitat types." To insure recommendation of an efficient plan, alternative ecosystem restoration plans were evaluated using functional assessment, cost effectiveness, and incremental analysis techniques. An additional constraint that weighed heavily in the analysis was project sustainability: the local sponsor was able to commit only 2,000 acre-feet of water per year to the project. Currently the 5,000 acre study area includes 840 acres of various natural vegetative cover and the remainder is either developed or highly disturbed. It is projected that within a few years without a restoration project there will be no natural vegetative cover remaining. The cost of the recommended ecosystem restoration features are justified by the production of about 454 average annual functional capacity units and provides for achieving ecosystem function increases in the most cost effective manner. The recommended plan would restore a significant, highly productive habitat for resident mammals, insects, reptiles, and birds, and for neo-tropical birds using the Pacific Flyway all of which make use of the shade and food resources of this oasis-like riparian ecosystem resource. The restored area would help reconnect wildlife corridors, restore wildlife habitat for species significant to Pima County, and restore threatened plant communities of cottonwood/willow riparian forest and mesquite bosque. Although no species or habitats protected by the Endangered Species Act are known to use the study area today, both the endangered Southwestern willow flycatcher and the endangered Gila topminnow are found nearby within the Santa Cruz basin. Potential habitat for these endangered species will evolve incidental to the proposed restoration as willows and other woody riparian plant communities re-establish, mature and partially shade the stream in the restored riparian zone. Given time, the flycatcher and topminnow may repopulate the project area. Restoration of these regionally rare and declining habitats will also benefit at least ten additional species of concern to state and local agencies. The ecosystem function would increase 14 times over the expected future without project condition. The recommended plan is the national ecosystem restoration (NER) plan considering the constraints and limitations on available water supply. The recommended plan would restore and improve approximately 1,098 acres of habitat, including 718 acres of mesquite bosque, 356 acres of riparian shrub, 18 acres of cottonwood/willow, and 6 acres of emergent marsh. Recreation features of the recommended plan would provide average annual benefits of about $135,000, and have a benefit-to-cost ratio of 1.3.

6. Based on October 2004 price levels, the estimated first cost of the recommended plan is $92,100,000. 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 $59,700,000 and the estimated non-Federal share would be approximately $32,400,000. The estimated total first cost of the ecosystem restoration portion of the recommended plan is $90,900,000, which would be cost shared 65 percent Federal and 35 percent non-Federal. The estimated Federal cost is $59,100,000, and an estimated non-Federal cost is $31,800,000. The estimated total first cost of the recommended plan includes approximately $2,500,000 for 5 years of monitoring and adaptive management necessary to ensure success of the project. Additionally, the estimated total first cost of the recommended plan includes recreation features compatible with the ecosystem restoration project. These features have an estimated first cost of $1,200,000, which would be shared 50 percent Federal and 50 percent non-Federal, and have an estimated Federal cost of $600,000 and an estimated non-Federal cost of $600,000. The total estimated equivalent annual operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs for the recommended project are estimated to be $800,000. Additionally, supplemental irrigation water costs are estimated as $1,100,000 annually. OMRR&R and supplemental water costs are the responsibility of the non-Federal sponsor. The Pima County, Arizona, Flood Control District has agreed to be the non-Federal sponsor for the project.

7. I generally concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona, project be constructed in accordance with the reporting officers' recommended plan with such modifications as in the discretion of the Chief of Engineers may be necessary and advisable.

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 total project costs allocated to environmental restoration and 50 percent of the total 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 and the provision of water, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

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

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which 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. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project and otherwise perform its obligations in a manner that will not cause liability to arise under CERCLA.

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

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

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

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

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

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

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 or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the 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, US Army
Chief of Engineers

NOTICE

SANTA CRUZ RIVER, 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.

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Study

Volume 1 of 3
Final Feasibility Report and Environmental Impact Statement

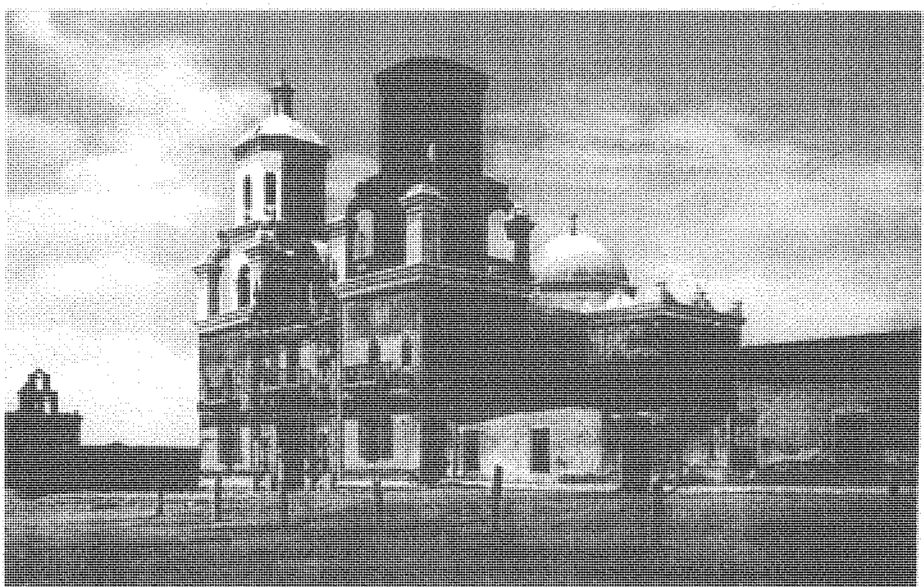
July 2005

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

US Army Corps
of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report



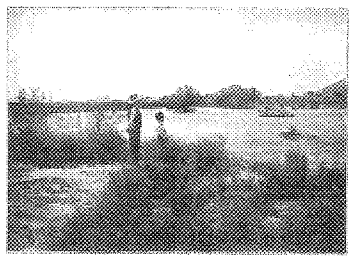
July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

EXECUTIVE SUMMARY

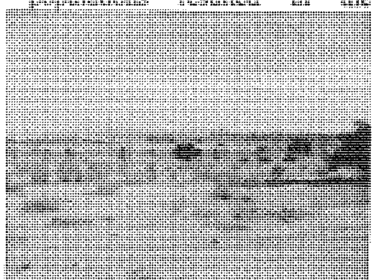
The U.S. Army Corps of Engineers (the "Corps") is conducting a feasibility study in the Paseo de las Iglesias reach of the Santa Cruz River to identify, define and solve environmental degradation, flooding and related water resource problems. These efforts are proceeding in partnership with the Pima County Flood Control District, the non-Federal sponsor.

The Paseo de las Iglesias Study Area consists of a segment of the Santa Cruz River and its tributaries, including the Old and New West Branch, extending downstream from Los Reales Road to Congress Street in the City of Tucson, Pima County, Arizona. The study area boundary encompasses an area approximately seven miles long varying from 0.5 miles to 1.6 miles wide, and contains approximately 5,005 acres.



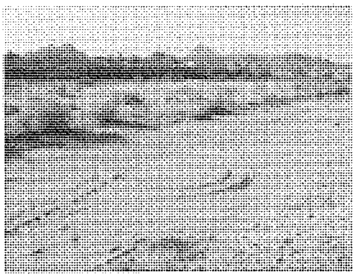
The landscape around this part of the Santa Cruz River has changed dramatically since the early 20th century. Only a century ago, the river flowed year-round through the Paseo de las Iglesias reach. Historical accounts from the 1850s and early 1900's describe a winding river channel lined with continuous stands of tress and grasses along the riverbanks and floodplain. The high water table supported the extensive forests of mesquite, cottonwood, and willow that provided habitat for diverse wildlife species. The abundant water supported early settlements and irrigation projects. Those conditions have not existed in the Paseo de las Iglesias study area in more than half a century.

Increasing appropriation of surface and groundwater to support expansion of agriculture, accelerated head cutting resulting from human interference and growing urban populations resulted in the transformation of the verdant Santa Cruz riparian corridor to a dry ephemeral wash with both hardened and unstable banks. The river now flows only in response to storm runoff. In some parts of the study area, the groundwater is now over 150' below the surface.



As a result, native riparian habitat is nearly absent in the study area, and rare throughout Pima County. Loss of riparian habitat is extremely devastating in the desert ecosystem. Originally comprising a mere 1% of the landscape historically, over 95% of riparian habitat has been lost in Arizona. This type of river-connected riparian and fringe habitat is of an extremely high value due to its rarity.

Arid Southwest riparian ecosystems are designated as a critically endangered habitat type. It has been estimated that 75 to 90 percent of all wildlife in the arid southwest is riparian dependent during some part of its life cycle. As a direct consequence of the extensive degradation and loss of riparian habitat, the area has experienced a major reduction in species diversity and in the population of remaining species. In addition, destruction of native riparian habitat facilitates an increase in invasive plant species that are more tolerant of disturbed conditions.



The majority of lands immediately adjacent to the Paseo de las Iglesias reach of the Santa Cruz River are undeveloped due to required floodway setbacks and a predominance of ownership by public entities. This condition offers an opportunity to accomplish important ecosystem restoration in the study area. Restoration alternatives have the potential to increase the area of riparian habitat, improve riparian habitat quality, increase biotic diversity, control invasive plant species and provide an extremely valuable ecological resource that is absent or waning in the Sonoran Desert eco-region.

The Federal planning objective for ecosystem restoration studies is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. The specific objectives for environmental restoration within the study area have been identified as follows:

- Increase the acreage of functional riparian and floodplain habitat within the study area;
- Increase the wildlife and habitat diversity by providing a mix of riparian habitats with an emphasis on restoration of riparian forests within the river corridor, riparian fringe and historic floodplain;
- Provide passive recreation opportunities;
- Provide incidental benefits of flood damage reduction, reduced bank erosion, reduced sedimentation and improved surface water quality consistent with the ecosystem restoration; and
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

A number of ecosystem restoration measures have been developed based upon those originally identified in Reconnaissance Phase of the study, with additional restoration measures added based upon the results of public input and on other similar studies in the region. Once compiled, these potential restoration measures were evaluated for feasibility, with some being screened out and others simply being refined.

For the purpose of plan formulation, it was initially assumed that an unlimited quantity of water could be made available for ecosystem restoration. Removing water availability as a constraint allowed the Corps and the non-Federal sponsor to examine the NER benefits produced by plans having a wide range of water requirements.

A variety of restoration measures were developed consisting of water harvesting features, irrigation options, riverbank and terrace treatments, and native tree, shrub and wetland plant community combinations. These measures were grouped into three categories based on the amount of water required for implementation, then assigned to one or more of three existing hydrogeomorphic settings (river channel, terrace, and/or historic floodplain). A matrix of grouped restoration measures was created that allowed initial consideration of potential measure combinations (including "no action") and hydrogeomorphic settings to create 47 potential alternatives.

Alternatives that were not consistent with natural vegetation patterns, that failed to produce sufficient habitat diversity, or that reduced conveyance of flood waters were eliminated, leaving 14 alternatives to be considered in more detail. Further analysis resulted in two restoration alternatives that provided the most ecological benefit for the investment, plus the "no action" alternative. Additional analysis of costs and ecosystem restoration benefits relative to their effectiveness, acceptability, completeness, and efficiency led to the selection of the recommended plan. Pima County has endorsed the recommended plan based on community input received during the plan formulation process.

To ensure no flood damage reduction opportunities were missed, the existing flood damages were identified. The average annual damages were not sufficient to support inclusion of flood damage reduction as a project purpose in development of detailed alternative plans.

Once the NER benefits of the best buy alternatives had been determined, the non-Federal sponsor decided that the most cost effective best buy plan, while requiring only 253 acre-feet/year water, would not restore a sufficiently diverse mix of riparian habitat as it would create a habitat dominated by riparian shrub. The low water use plan also did not include restoration of the rare and declining cottonwood-willow habitat, nor the structural diversity that such habitat would bring to the overall restoration effort. The need to include his rare habitat type in the recommended plan has become increasingly apparent during the planning process, largely as a result of comments received and the desires of the non-Federal sponsor.

The two "best buy" plans were compared based on their costs and outputs under the System of Accounts. Those accounts are National Economic Development, Environmental Quality, Regional Economic Development and Other Social Effects. The comparison indicates that Alternative 3E is the most productive plan. Alternative 3E is characterized by irrigated plantings of mesquite and riparian shrub on terraces above the low flow channel and in the historic floodplain with small areas of emergent marsh and cottonwood-willow habitat located at water harvesting features scattered throughout the project.

The construction and planting of subsurface water harvesting basins would occur at the confluences of 8 tributaries and upstream of 5 existing grade control structures. A variety of methods would be used to provide permanent irrigation systems for all planted areas including the basins.

The reaches of steep eroded banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes graded at a 5 foot horizontal to 1 foot vertical slope and planted. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it will reestablish a hydrologic connection to the river, reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout.

Alternative 3E is mesquite dominated with 718 acres of that cover type. It will restore 356 acres of xeroriparian shrub, 18 acres of cottonwood-willow and 6 acres of emergent marsh. Alternative 3E has an estimated first cost of $90,916,632 that, when annualized over a 50-year period, yields an average annual cost of $5,765,687. OMRR&R costs, including water, are estimated at $1,869,961 so the total average annual cost of the alternative is $7,635,648. This alternative produces a net gain of 454 average annual Functional Capacity Units at a cost of $16,819 per unit.

Cost Type	Amount
Construction & Real Estate	$72,828,371
Contingency at 15%	$6,987,940
PED at 10%	$4,658,627
EDC at 1%	$465,863
Construction Mgmt at 6.5%	$3,482,323
Adaptive Management	$1,870,205
Monitoring	$623,304
Total First Costs	$90,916,632
Federal Government Share	$59,095,811
Local Share	$31,820,821
OMRRR	$770,786
Water	$1,099,175

The addition of recreation features was evaluated and justified. The recommended plan includes multipurpose trails, ramadas, benches, parking, and trail links that serve a recreation purpose by providing opportunities to a variety of recreational users. Comfort stations serve the basic safety needs of the recreational user. Warning signs are also added to direct pedestrians off the newly restored area guide pedestrians away from any potential danger. The recreation plan produces an increase in average annual recreation benefits of $135,484 at average annual cost of $105,734. This results in a benefit to cost ratio of 1.29 with net benefits of $29,750. The recreation plan has a first cost of $1,141,914. Cost sharing for recreation features is 50 percent Federal and 50 percent non-Federal. Fifty percent of the first cost of the recreation plan is $570,957, increasing the level of Federal financial participation by approximately 1%. The cost for environmental education, public art, associated costs of water, and all operations and maintenance (O&M) costs for the recommended project would be the responsibility of the non-Federal sponsor. Annual costs for operation and maintenance are estimated at $36,260.

The total first cost of the recommended plan is $92,058,546 and the total operation and maintenance costs including water are $1,906,221. The Federal share of the recommended plan is $59,666,768 and the non-Federal share is $32,391,778. The analysis presented in this report shows that the selected plan is feasible and would provide environmental restoration and recreational benefits that serve the public interest. Plan features are consistent with the desires expressed by public involvement work groups. Implementation of the selected plan is supported by the United States Fish and Wildlife Service, the Arizona Game and Fish Department, the Center for Biological Diversity, the Santa Cruz River Alliance, and the Tucson Herpetological Society.

The EIS includes a 404(b)(1) compliance evaluation as part of the feasibility study. The Corps has determined that this project as proposed is consistent with the Section 404)b)(1) guidelines, is in compliance with the Clean Water Act, and meets the Section 404(r) exemption criteria. The Corps plans to seek an exemption from the requirement to obtain State water quality certification under Section 404(r) of the Clean Water Act. The 404(r) exemption would cover both the construction period and the five year adaptive management plan.

The Arizona Department of Environmental Quality (ADEQ), an agency of the state responsible for water quality, was contacted to coordinate the process in accordance with ER 1105-2-100. A letter in response from ADEQ was received August 18, 2004, which states the proposed restoration project should comply with State surface water quality standards and that it should not have a negative impact upon the physical, chemical or biological integrity of the Santa Cruz River or its tributaries. It further states that the State of Arizona concurs with the 404(r) exemption for State 401 Water Quality Certification (See Appendix 14.3 of the Final EIS).

The analysis presented in this report shows that the selected plan is feasible and would provide environmental restoration and recreation benefits that serve the public interest. Therefore, it is recommended that the selected plan described herein for habitat restoration and recreation 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 financing arrangements satisfactory to the President and Congress.

PASEO DE LAS IGLESIAS, PIMA COUNTY
FEASIBILITY STUDY

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CHAPTER I
STUDY AUTHORITY

A Paseo de las Iglesias, Pima County, Arizona Feasibility Report was specifically authorized by section 212 of the Water Resources and Development Act of 1999, Pub. L. No. 106-53, 33 U.S.C. 2332. Section 2332(a) states:

> The Secretary [of the Army] may undertake a program for the purpose of conducting projects to reduce flood control hazards and restore the natural functions and values of rivers throughout the United States.

Subsection (b)(1), 33 U.S.C. 2332(b)(1), provides authority to conduct specific studies "to identify appropriate flood damage reduction, conservation, and restoration measures." Subsection (c), 33 U.S.C. 2332(c), states the cost-sharing requirement applicable to studies and project conducted pursuant to section 2332. Subsection (e), 33 U.S.C. 2332(e), identifies priority areas. It states in pertinent part:

> In carrying out this section, the Secretary shall examine appropriate locations, including--
>
> (1) Pima County, Arizona, at Paseo de las Iglesias and Rillito River; . . . .

CHAPTER II
STUDY PURPOSE, STUDY SCOPE, AND STUDY AREA

A. Study Purpose

The Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona Feasibility Study and Environmental Impact Analysis is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the Pima County Flood Control District (PCFCD). This feasibility study provides an interim response to the study authority. The specific purpose of this study is to define environmental and related problems in the Paseo de las Iglesias area of Santa Cruz River in the City of Tucson and Pima County, Arizona, and to investigate the feasibility of providing solutions to these problems.

This report presents the planning process for determining existing conditions in the project area, forecasting the expected future without-project conditions, formulating plans to address the inherent problems and opportunities, and determining the plan that best addresses those problems and opportunities within the context of identified study goals and constraints. Conditions at the time of the study are collectively called the existing condition. The future without-project condition is the same as the "no action" alternative, and describes what is anticipated to occur in the absence of Federal or non-Federal action. The future status of the significant natural, economic, and social resources described in the existing conditions, when forecast for the future conditions, provides the basis for comparing the effects of proposed projects with the no action alternative. Effects are compared over a 50-year period beginning with the project base year. The project base year is the first year in which a Federal project would produce benefits. The project base year for this study is 2012, and the future condition extends 50 years later to 2062.

Restoration plans were developed to increase habitat values and the diversity of native wildlife species with potential incidental benefits accruing to recreation, environmental education, flood damage reduction, water quality and supply. This report is intended to document the process of plan formulation and evaluation while providing the basis for completion of the decision document: the completed Feasibility/FEIS that presents the results of the feasibility phase of the General Investigation effort and the anticipated environmental effects of implementing the alternative. This report is intended to accomplish the following:

- Presentation of the study results and findings, including those developed in the reconnaissance phase, so that readers can reach their own conclusions regarding the report recommendations;
- Demonstration of compliance with applicable statutes, executive orders, and policies; and
- Establishment of a sound and documented basis for decisions makers at all levels to judge the recommended solution(s).

B. Study Scope

The scope of this study consists of: 1) the identification of problems and opportunities associated with loss of riparian habitat and related water resource concerns; 2) the formulation of alternative measures for environmental restoration, incidental reduction of future flood damages and maximization of National Environmental Restoration (NER) and National Economic Development (NED) benefits; and 3) the identification of the opportunity and the role for Corps participation in environmental restoration and related water resources planning.

The proposed project offers an opportunity to restore critical riparian habitats that have been lost in the watershed due to changes in consumptive use of water resources in Pima County. The opportunity exists to use knowledge gained from existing ecosystem restoration projects that provide examples of how to utilize other water sources to expand and sustain riparian habitat.

Study efforts are being conducted in coordination with the Corps, the PCFCD, other Federal agencies, state resource agencies, and concerned members of the public.

C. Study and Report Process

The Los Angeles District of the Corps of Engineers completed the first phase of the General Investigations study in November 1999. The results and conclusions of the first phase were presented in the Santa Cruz River Paseo de las Iglesias, Arizona Reconnaissance Report. The reconnaissance report established Federal interest in proceeding to the feasibility phase of the General Investigation Study to investigate the opportunities for providing aquatic ecosystem restoration and, to the extent that it could be integrated with restoration, flood damage reduction in the Paseo de las Iglesias area of Tucson, Arizona. The scope of this feasibility study established during the reconnaissance phase and examination of the Without Project conditions limited flood damage reduction investigation to bank stabilization measures that could be integrated with restoration as well as other measures in specific areas.

This report presents a summary of the process of problem identification, restoration measure evaluation, and tentative selection of a recommended plan. In this report, the Corps six step planning process specified in ER 1105-2-100, Planning Guidance Notebook, April 22, 2000 was used to develop, evaluate, and compare the array of candidate plans that have been considered. Steps in the plan formulation process include the following:

1. Specific problems and opportunities were identified, and the causes of the problems were discussed and documented. Planning goals were set, objectives were established, and constraints were identified.
2. Existing and future without-project conditions were identified, analyzed and forecast. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation were characterized and documented.

3. The study team formulated alternative plans that addressed the planning objectives. An initial set of alternatives was developed and evaluated at a preliminary level of detail.
4. Alternative project plans were evaluated for effectiveness, efficiency, completeness, and acceptability. The impacts of alternative plans were evaluated using the system of accounts framework (National Economic Development, Environmental Quality, Regional Economic Development, Other Social Effects) specified in the Principles and Guidelines and ER 1105-2-100.
5. Alternative plans were compared to the without-project condition. The public involvement program was used to obtain public input to the alternative identification and evaluation process. Cost effectiveness and incremental cost analysis was used to prioritize and rank ecosystem restoration alternatives.
6. A plan was tentatively proposed for selection, and a justification for plan selection was prepared.

Throughout the planning process for this project, public input has been solicited utilizing a variety of avenues including local newspaper articles, public information mailings, and coordination with special-interest groups, public workshops and formal public hearings. The feasibility planning process began with meetings on March 31, 2001 to identify and review the primary issue areas involved in the Paseo de las Iglesias study area. Over 100 people attended one or more of the sessions. Concerns expressed included how the restoration planning process would proceed, a desire for more natural riverbanks, habitat restoration, the potential sources and effects of reintroduced river flow, and how restoration would fit with other municipal development projects. Written comments were submitted by seventy-six attendees. Many goals were expressed by the attendees and considered in development of the study objectives. Public recommendations included:

- Restoring water, vegetation, diverse structure of native vegetation (grasses, shrubs, trees).
- Evaluating water sources such as storm water harvesting, treated effluent and the Central Arizona Project (CAP).
- Evaluating restoration of the West Branch of the river near Mission Gardens and convents.
- Ensuring habitat is sustainable with available water.
- Giving consideration to plans that complement and are consistent with the County's Sonoran Desert Conservation Plan.
- Re-evaluating the use of soil cement in currently unprotected reaches. Using permeable bank protection would aid restoration efforts.
- Looking for opportunities to remove the cement soil banks and return the Santa Cruz to a meandering river.
- Preserving the less developed west side in its historical context.
- Setting aside land to create a wider floodplain.
- Promoting groundwater recharge.

Public comments specific to the Old West Branch suggested:

- Developing plans which serve multiple objectives.
- Incorporating more permaculture techniques in water harvesting, planning, design, and implementation. Permaculture is an approach that strives for the harmonious integration of human dwellings, microclimate, annual and perennial plants, animals, soils, and water into stable, productive communities.
- Incorporating civic amenities such as a self-guided historic walk with benches and written information, shade and benches, trails, picnic areas, and ramadas with BBQs.

None of the participants expressed support for flood damage reduction efforts in the study area. Because of the public interest evidenced during the initial meeting, further meetings were scheduled to establish a process for development of public involvement in planning for restoration of the Santa Cruz River in the study area. The principal participants in this public workshop planning process were representatives from Federal, state, and local agencies, citizens from the local area, and other stakeholders.

Two smaller workshops were held on March 21, 2002 and again on April 9, 2003. In each case, representatives of local agencies, citizens from the local area and other stakeholders were convened to solicit input regarding restoration measures and desired outputs. In addition, a public open house to discuss preliminary findings was conducted by Pima County on January 22, 2004.

D. Study Coordination

Formal and informal coordination occurred with a variety of Federal, state and local agencies in addition to the public involvement efforts described above. Agencies contacted included the United States Fish and Wildlife Service (USFWS), the Arizona Game and Fish Department (AGFD), the City of Tucson Parks, Tucson Water Department, City of Tucson Transportation, Pima County Department of Transportation, Pima County Cultural Resources, Pima Association of Governments, and Pima County Parks and Recreation. Representatives from USFWS and AGFD participated in development and application of the model for habitat evaluation. The USFWS also participated in development and design of alternatives. The USFWS has prepared a Planning Aid Letter and is currently preparing a Coordination Act Report for this study.

E. Study Area

The City of Tucson is located in the northeast portion of Pima County in southeast Arizona, approximately 110 miles southeast of Phoenix. Tucson is bordered by the Coronado National Forest to the north and the Saguaro National Park to the east. A smaller portion of the park lies to the west of Tucson. Tucson is the second largest city in Arizona and is the County seat of Pima County.

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it turns to flow northward and reenters Arizona about six miles east of Nogales. The river continues northward to Tucson then northwest to its confluence with the Gila

River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the study area. Throughout this reach, flow occurs only as a result of secondary treated wastewater effluent discharges or following major storms.

The Paseo de las Iglesias study area was defined in coordination with the PCFCD, based on factors such as jurisdictional boundaries, physical impediments (i.e., highways), and historical floodplain limits. The Paseo de las Iglesias study area is approximately 5005 acres and consists of a 7-mile reach of the Santa Cruz River and the New and Old West Branch tributary washes. Beginning where Congress Street crosses the river in downtown Tucson, the study area extends upstream to the south along the river to the boundary of the San Xavier District of the Tohono O'odham Nation (Figure 2.1). The eastern study boundary is represented by Interstates 10 and 19. The western study area boundary is represented by Mission Road and the San Xavier District of the Tohono O'odham Nation. The study area name, Paseo de las Iglesias, translates to "Walk of the Churches." The study area derives its name from the fact that it provides the physical and cultural connection between the 18th century San Xavier Mission and the Mission San Augustin archeological site. This area is the cradle of modern day Tucson and has a lineage of continued habitation dating thousands of years before settlement of the area by the Spanish missionaries.

The main channel of the Santa Cruz River flows in a relatively straight northerly direction from the southern to the northern borders of the study area. The West Branch of the Santa Cruz River currently extends from the southern border of the study area to the north approximately 3.5 river miles to where it joins the main stem of the Santa Cruz River, just north of Irvington Road. The portion of this channel just north of Irvington Road, the New West Branch, has been re-routed. The former channel (before it was re-routed) is called the Old West Branch and extends from just north of Irvington to just south of 22nd Street where it joins the main stem of the Santa Cruz River. The Old West Branch was once the principal western channel of the Santa Cruz River. However, entrenchment of the eastern river channel isolated the western channel, cutting off its water supply. It became known as the West Branch of the Santa Cruz River and, following construction of the flood control diversion, the Old West Branch.

Currently, the area lacks significant stands of native riparian vegetation. The study area also includes a portion of Tucson designated for redevelopment under the City of Tucson's Rio Nuevo Master Plan. That plan includes historic restoration and landscaping initiatives, which could integrate with environmental restoration measures to increase project outputs. The study area has also been designated for inclusion in Pima County's Sonoran Desert Conservation Plan.

1. Population

The population of Pima County has grown sharply in recent years, going from 531,443 in 1980 to 843,746 in 2000, an increase of 59% in 20 years (U.S. Bureau of the Census, 2000). The population is expected to rise to 1,222,837 year 2020 (City of Tucson Planning Department, 2003).

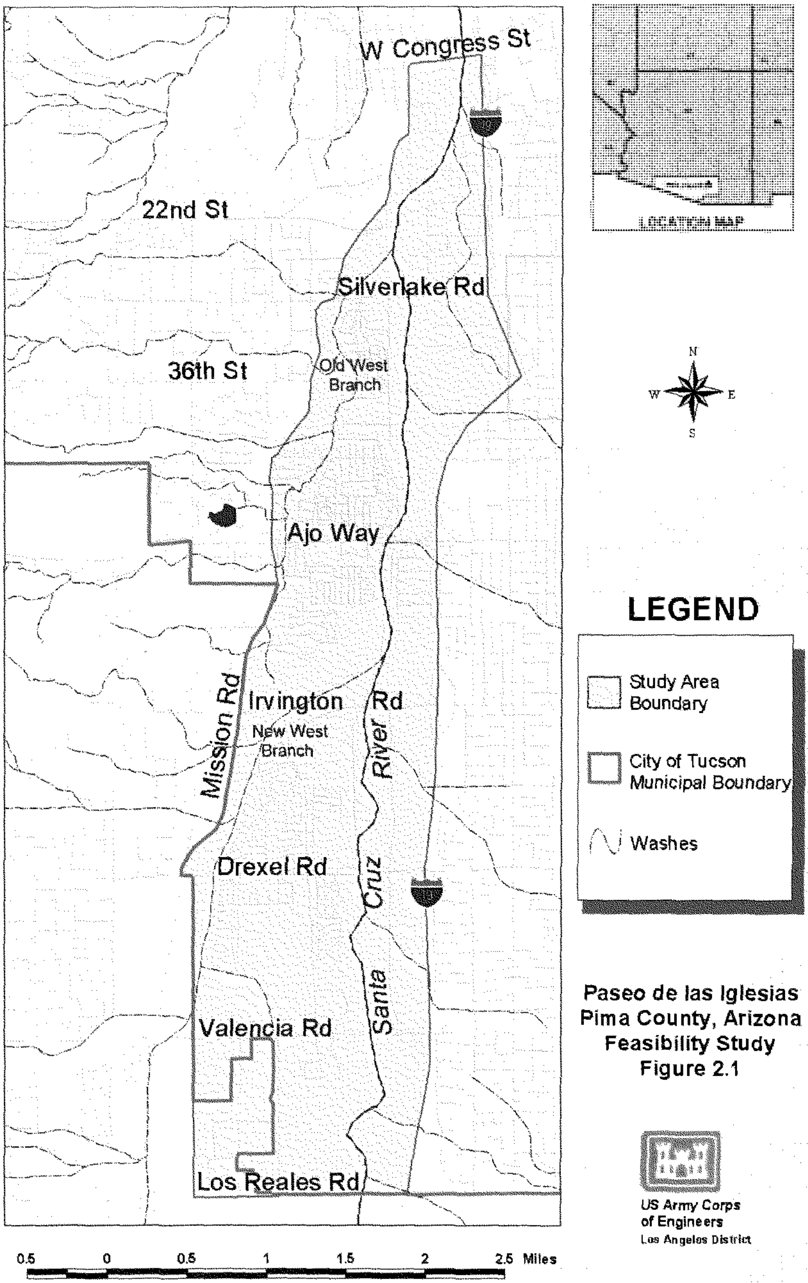


FIGURE 2.1 Location Map

Table 2.1
Population Trends in Tucson and Pima County

Jurisdiction	1980	1990	1997	2000	% Increase (1980-2000)	% Annual Increase (1980-2000)*	% Projected Growth (2000-2020)
Tucson	330,537	405,390	452,836	486,699	47.2%	2.4%	21.2%
Total Pima County	531,443	666,880	789,650	843,746	58.8%	2.9%	43.0%

2. Meteorology and Climate

The climate in the Santa Cruz River Basin is desert in character with short, dry winters and long, hot summers. High diurnal temperature variations are characteristic of the region due to the low humidity and general lack of cloud cover. Temperature extremes below 3,000 feet elevation range from about 1 degree Fahrenheit (F) in the winter to about 120 degrees F in the summer. Temperatures can exceed 80 degrees F in any month of the year.

Precipitation occurs in two distinct seasons of the year: summer and winter, and primarily occurs in the form of rainfall. Summer runs from June into October. Winter runs from December through February. The primary precipitation falls during the summer months from thunderstorms caused by moist air flowing from th

e Gulf of Mexico. These storms occur frequently in the afternoons and evenings of summer days, producing generally localized precipitation. Floods can occur from heavy thunderstorms, but are typically of short duration (lasting up to three hours). The frequently occurring 2-year, 6-hour event in Tucson is about 1.5 inches of rainfall. The extreme 100-year, 6-hour event is about 3.6 inches.

Occasionally, longer-term summer storms occur, associated with tropical storms from the Gulf of Mexico or the Pacific Ocean. These storms may provide heavy precipitation for up to 24 hours, causing longer lasting flood events (24 hours or more). The 2-year, 24-hour event is about 1.8 inches in Tucson. The extreme 100-year, 24-hour event is about 4.6 inches.

Winter storms provide lesser amounts of precipitation and are associated with frontal storm systems from the Pacific Ocean. Precipitation typically occurs as rainfall in the lower elevations, but can occasionally occur as snow. Additional detail regarding meteorology and climate may be found in the Hydrology Appendix.

3. Existing Land Use

Approximately 95% of the Paseo de Las Iglesias study area is located within the municipal limits of the City of Tucson. The remaining five percent is contained within unincorporated Pima County (Pima County Real Property Services, 2001). The reach of the river between San Xavier Mission and downtown Tucson is characterized as an arroyo with most high flows entirely contained within the main channel. Soil cement bank protection is discontinuous and is located on both banks at the Valencia Road bridge, on both banks from Ajo Way to Irvington Road, and from Silverlake Road to Grant Road. The corresponding unprotected areas include the reach between San Xavier Mission and Valencia Road, the reach north of Valencia Road to Irvington Road, and the reach from Ajo Way to Silverlake Road.

The 100-year floodplain of the Santa Cruz River is narrow as it passes through the study area due to the effects of earlier channelization and down cutting by the river. While the Paseo de las Iglesias study area is within the City of Tucson, significant amounts of the land adjoining the river are publicly owned. As a result, a significant percentage of the study area remains undeveloped.

The study area currently contains a variety of land uses. It consists of mainly residential areas, light industrial and commercial uses, as well as open space and public parks. Table 2.1 lists the corresponding acres by land use category in the study area. These were identified using the Pima County GIS Database. Figure 2.2 depicts the distribution of land uses within the study area.

Table 2.2
Land Use in the Paseo de las Iglesias Study Area

Land Use	Acres
Residential – Single Family	1,975
Residential- Multiple Family	87
Residential – Open Space	20
Commercial	483
Industrial	385
Public	1,456
Dedicated Rights-Of-Way	567
Intuitional (Schools, Churches)	32
TOTAL	5,005

Over one-quarter of the study area (1,456 acres) is publicly owned with the majority of public acreage being held by the City of Tucson. The areas adjoining the study area have surrounding land use that is predominantly residential and commercial with some manufacturing or light industrial use. Construction activities associated with a selected alternative would occur mostly within the river floodplain and its tributary floodplains. Within the entire City of Tucson, approximately 30 percent (or 79 square miles) of the land area is vacant.

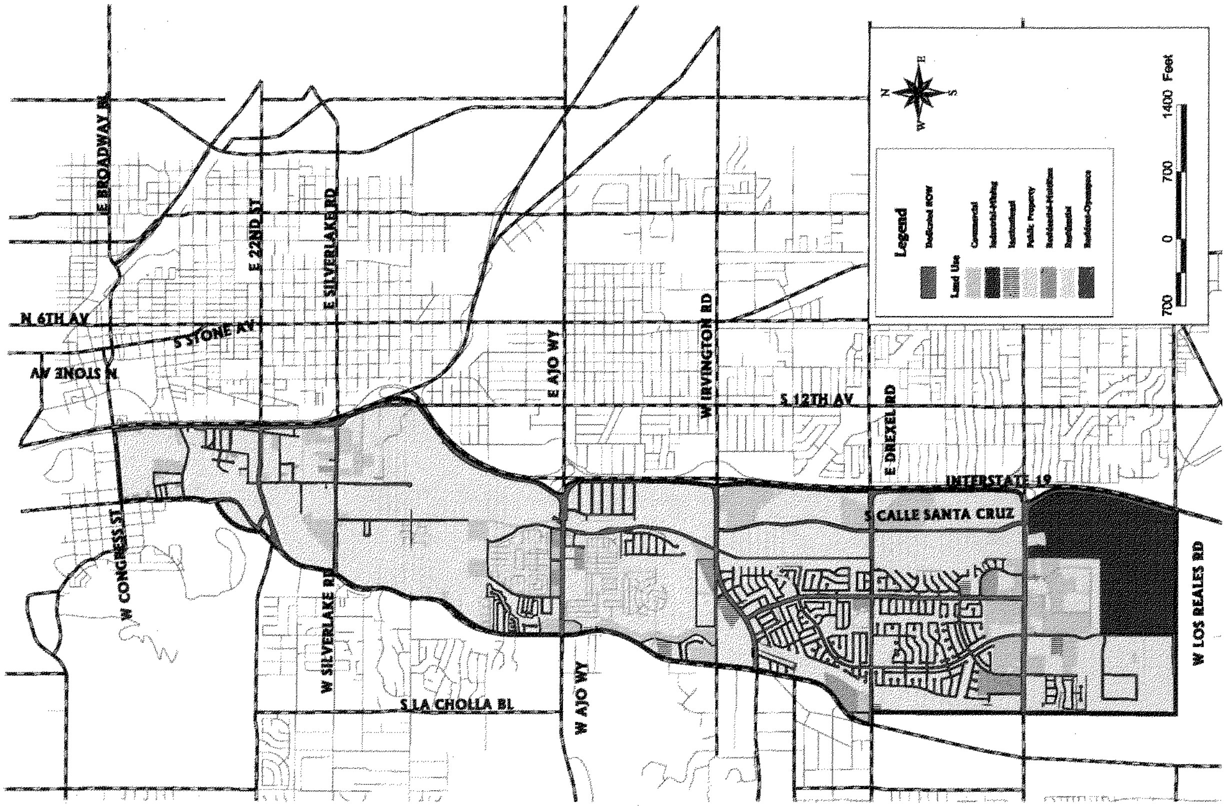


FIGURE 2.2 Land Use

CHAPTER III
PRIOR STUDIES, REPORTS & EXISTING PROJECTS

A. Prior Studies or Reports

Many studies have been conducted pertaining to water and related land resources within the study area. These studies have examined themes including development trends, environmental resources, water supply, groundwater recharge, wastewater management, flooding and erosion, geology, cultural resources, history, and recreation. The following is not intended to be a comprehensive list of previous reports, but to provide a sample of the types of studies that have been completed in the study area.

Arizona Stream Navigability Study for the Santa Cruz River (Gila River Confluence to the Headwaters) Final Report, Prepared by SFC Engineering Company for the Arizona State Land Department

Sonoran Desert Conservation Plan: Relationships Between Land and People –The Cultural Landscapes Approach in Archaeology and History (May, 2000) Pima County

Overview of Traditional Cultural Places in Pima County (May, 2000), Pima County

Preserving Cultural and Historic Resources – A Conservation Objective of the Sonoran Desert Conservation Plan, (May 1999) Pima County

San Xavier to San Augstin, An Overview of Cultural Resources for the Paseo de las Iglesias Feasibility (2002), Prepared by Scott O'Mack and Eric Klucas, Statistical Research Inc., for Pima County

Master Plan for Pima County, Arizona Segment, Juan Bautista de Anza National Historic Trail (2002), McGann & Associates

Sonoran Desert Conservation Plan: Pygmy Owl Update (November, 1999) Pima County

Final Documentation October, 1993 Flood Damage Report, Pima County Department of Transportation and Flood Control District

Pima County Flood Control District Comprehensive Program (December, 1990), Pima County Department of Transportation and Flood Control District, Planning and Development Division

Pima County Flood Control District Comprehensive Program Report FY1990-91-FY1995-96 (January, 1997), Pima County Department of Transportation and Flood Control District, Planning and Development Division

Santa Cruz River Alignment Recharge Study - Final Report (July, 1986), Prepared by Pima Association of Governments for City of Tucson

Existing Conditions Hydrologic Modeling for the Tucson Stormwater Management Study (TSMS), Phase II, Stormwater Master Plan, Task 7, Subtask 7A3. Prepared by Simons, LI & Associates, Inc. for the City of Tucson, November, 1995.

Landfills and Waste Disposal Sites along the Lower Santa Cruz River - Final Report (February, 1995) Prepared by Pima Association of Governments for Pima County Flood Control District

Landfills Along the Santa Cruz River in Tucson and Avra Valley – Final Report, Arizona (May, 1995) Prepared by Pima Association of Governments for City of Tucson Office of Environmental Management

Arizona Stream Navigability Study for the Santa Cruz River (Gila River Confluence to the Headwaters) Final Report, Prepared by SFC Engineering Company for the Arizona State Land Department

Sonoran Desert Conservation Plan: Mountain Parks (August, 1999) Pima County

*Pima County River Parks Master Plan (*December, 1996) Prepared by Planners Ink for Pima County Department of Transportation and Flood Control District

Sonoran Desert Conservation Plan Draft Report (October, 1998), Pima County

Sonoran Desert Conservation Plan Update – Focus on Riparian Areas (July, 1999), Pima County

Paseo de las Iglesias – Restoring Cultural and Natural Resources in the Context of the Sonoran Desert Conservation Plan (April, 1999), Pima County

Paseo de las Iglesias, Pima County, Arizona - Reconnaissance Phase Study, 905B Analysis (1999) Pima County, Arizona

Reconnaissance Phase Study, 905B Analysis (September, 2000) (*Includes Tres Rio del Norte and Agua Caliente),* U.S. Army Corps of Engineers Los Angeles District

Gila River, Santa Cruz River Watershed, Pima County Arizona – Final Feasibility Report (August, 2001), U.S. Army Corps of Engineers Los Angeles District

B. Existing Projects

There are no existing Federal water resource projects within the study area. Existing local improvements include:

- Soil cement bank stabilization on the Santa Cruz River between 29th Street and Congress Street and between Irvington Road and Ajo Way.
- Repair and soil cement protection of the 22nd Street and Valencia bridges.
- Construction of an energy dissipator on the New West Branch confluence with the Santa Cruz River.
- Establishment of the Santa Cruz River Park between 29th Street and Mission Lane and between Irvington Road and Ajo Way.

The Corps of Engineers is in the initial stages of a Feasibility Study to evaluate the potential for environmental restoration immediately downstream of the Paseo de las Iglesias study area in an area identified as El Rio Medio (Congress St. to Prince Rd.). At the northern boundary of the El Rio Medio study area, the Corps of Engineers is engaged in a Feasibility Study to evaluate the potential for environmental restoration along a seventeen mile reach of the Santa Cruz River, identified as Tres Rios del Norte. Another

Corps environmental restoration study has been completed on the Rillito River upstream of it confluence with the Santa Cruz River. There are other Federal projects and studies on tributaries to the Santa Cruz in or near the study area. They include the Tucson Diversion Channel and Tanque Verde Wash flood control projects. Should some or all of these projects come to fruition, these projects would add environmental restoration or recreation measures. The addition of adjacent and possibly contiguous restored areas would likely increase the benefits of a restoration project in the Paseo de las Iglesias study area due the creation of larger continuous or nearby areas of native habitat. The connection of recreational trails in adjacent projects would likely increase the recreation benefits. These potential projects are unlikely to produce cumulative effects on most other resources beyond their immediate effects.

C. Master Planning

1. Pima County Comprehensive Plan

The most current information regarding the Pima County Comprehensive Plan can be found at the following web site:

http://www.pimaxpress.com/Planning/ComprehensivePlan/

The purpose of the comprehensive plan is to conserve the natural resources of the county, to ensure efficient expenditure of public funds, and to promote health, safety, convenience, and general welfare of the public. The comprehensive plan includes the following guidelines related to aesthetic resources:

- Restore and preserve natural areas. This may include floodplain acquisition, purchase of development and water rights, and limitations on rezoning.
- Construct wetlands and riparian areas. This may include the use of reclaimed water or CAP water, and recharge projects.
- Preserve open space characteristics of development sensitive lands and promote development that blends with the natural landscape and protects wildlife habitat. Extend visually the public land boundaries.
- Provide natural open space.

2. Sonoran Desert Conservation Plan (SDCP)

The most current information regarding the Sonoran Desert Conservation Plan can be found at the following web site: http://www.co.pima.az.us/cmo/sdcp/index.html

The Sonoran Desert Conservation Plan is a comprehensive, local planning initiative to conserve the County's most valued natural and cultural resources, while accommodating the inevitable population growth and economic expansion of the community.

In the most recent phase of this planning effort a Science Technical Advisory Team and staff of the County developed the concept for a differentiated biological reserve where Pima County biological resources are ranked in level of importance. That concept was applied to establish a framework for designing a Conservation Lands System for eastern Pima County. The Conservation Lands System is a first draft attempt to place value on conserving natural biological resources of the County. The intent of the master planning effort is to ultimately extend the system to the establishment of similar priorities for cultural and historic resources, ranching, riparian and mountain parks.

3. Rio Nuevo Master Plan

The Rio Nuevo Master Plan is a City of Tucson initiative that addresses redevelopment of urban Tucson, primarily along the Santa Cruz River immediately north and south of West Congress Street. The aim of the master plan is the creation of a network of unique experience areas, linked by shaded plazas that connect new cultural, civic, entertainment and business uses interwoven in a historically accurate and aesthetically pleasing manner throughout the Rio Nuevo District.

Following the completion of the Rio Nuevo master plan in early 2001, the City of Tucson began to evaluate the ability of a myriad of public, private and non-profit agencies to participate in new development, management and marketing activities. In an October memorandum to the City Council, city staff evidenced concern with "duplication of effort and lack of accountability" among the agencies involved. To advance downtown development, a strategic approach was recommended to clarify organizational responsibilities and develop stronger public/private collaboration. Subsequently, the City of Tucson Rio Nuevo Multipurpose Facilities District (RNMFD) contracted with an urban planning consultant to conduct a downtown Tucson stakeholder summit. That summit was held on January 16th and 17th, 2002, and resulted in a series of recommendations to City government to advance the Rio Nuevo master plan. The plan includes a number of landscape concepts that could complement restoration efforts.

CHAPTER IV
PROBLEMS AND OPPORTUNITIES

A. Historical Conditions and Problem Development

1. History

In order to have a complete understanding of historic conditions and the lost value of the study area ecosystem, it is necessary to consider the study area in the broader ecological context of the arid southwest. In the recent past, there were hundreds of locations across the southwest where waters flowed perennially or seasonally. These watercourses were often just the exposed tips of vast aquifers that rose upward to the earth's surface. The surface and subterranean waters created springs and riparian areas along rivers and streams scattered across the arid southwestern landscape. Some of these areas were relatively small, only a few acres or less in size, but others were thousands of acres of lush, nurturing habitat and travel corridors for local and migratory wildlife. Wildlife thrived in broad marshes and dense mesquite thickets, in galleries of cottonwoods and willows shading the watercourses, in expansive meadows of native grasses and shrubs, and in the water itself, which teemed with fish, frogs, turtles, insects, and aquatic plants.

When the first people arrived in the southwest a few thousand years ago, they used these riparian areas first as migratory corridors and then to establish permanent settlements. When the first Europeans arrived in the late 1600's, they found the same riparian ecosystem embedded in an arid landscape. They used the riparian areas as others had before as highways and places to settle. One of the first places they settled was in the Santa Cruz River Valley. In the mid 19^{th} century, wagon trains carrying American migrants to the gold fields of California passed through the region. As they had in the past, the riparian areas provided an essential place to rest, hunt, graze livestock, and fill water barrels in preparation for long, dry stretches westward. Without these sanctuaries of freely flowing water and the habitat it supported, it is doubtful that any sizable groups could have traversed the region. In the late 19th century, substantial riparian areas remained in many parts of the Tucson area (Betancourt & Turner, 1985).

For many years, there were reliable year-round springs at San Xavier and at Sentinel Peak ("A" Mountain), though the river sometimes grew marshy in between. Cottonwood trees lined the river, and mesquite bosques hugged its banks. The shallow bed was nearly the same elevation as the surrounding floodplain. In some places water flowed on the surface for only a few months each year, while in others it flowed constantly except in the driest years. Early accounts describe dense mesquite growth in the usually dry reaches above and below that perennial stretch that surfaced at the base of Sentinel Peak. From the peak, upstream and downstream for miles, cottonwoods and willows marked the course of the river and irrigation ditches. A grassy marsh, or "cienega," covered 1.5 square miles on each side of the Spring Branch of the river upstream from the church named San Xavier. An impressive mesquite forest, interspersed with small meadows, lay in the western floodplain of the river near the San Xavier Mission. Historical accounts of that mesquite forest describe tree specimens with trunks over four feet in diameter and heights exceeding 60 feet. The river continued northward to another Spanish church named San Agustín, that served a community in what is now downtown Tucson. The river was the passage (Paseo) between churches (Iglesias) and was the life stream of the communities.

In 1855, Julius Froebel, a visitor to the Tucson area, made the following observations (Froebel, 1859):

"...the banks of the river, and the valley itself, are covered with poplars and willows, ash-trees and plantains, oaks and walnut trees ... Some portions of the valley are of such grand, rich and simple beauty, as for instance Tumacacori and San Xavier del Bac, that they would be remarkable in any part of the world."

Another journal entry (U.S. Fish and Wildlife Service, 1999) made while camped on the Santa Cruz River near Tucson describes a:

"...rapid brook, clear as crystal, and full of aquatic plants, fish, and tortoises of various kinds, flowed through a small meadow covered with shrubs."

As the 19th century ended, more and more people settled in the well-watered areas of the southwest. Easterners responded to the promise of fertile valleys, abundant water and nearly endless sunshine by moving west in large numbers to places like Tucson.

The uses of water increased as entrepreneurs built dams to create lakes for boating and fishing as well as to power flourmills. Increasing numbers of wells were sunk to support burgeoning industry and farms. As more and more water was consumed, the natural springs and cienegas slowly diminished. Mesquite forests shrank under saw and ax while the flows nurturing cottonwood and willow reduced and trees began to wither. Slowly, the aquifers that sustained the riparian islands during the dry times began to recede.

Discontinuous arroyos existed 6 to 12 miles upstream of Tucson as early as 1849 but photos of the Santa Cruz River near Sentinel Peak from the early and late 20th Century provide an illustration of how historic habitat conditions have changed (Figure 4.1). As the end of the 19th century approached, a series of occurrences in Tucson dramatically accelerated the transition of the Santa Cruz River valley, particularly in the study area, into an arid landscape. In 1887, entrepreneur Sam Hughes excavated a ditch to tap near-surface flows in the vicinity of the St. Mary's Road crossing of the Santa Cruz River to provide water for irrigation of cultivated lands north of St. Mary's Road. Severe flooding occurred along the Santa Cruz River in July and August of 1890, following a period of severe drought. The flood breached the dams and eroded lakes. During one of the August floods, Sam Hughes' new ditch served as the starting point for an upstream erosion (head cut) that retreated for a time at the rate of about 100 feet per hour toward Congress Street. Subsequent events extended the erosion. By 1910, the resulting arroyo had coalesced with a gully at Valencia Road that continued to Martinez Hill. During the 1914-1915 floods, the arroyo eroded to a point several kilometers south of Martinez Hill on the Indian Reservation (Betancourt and Turner, 1985).

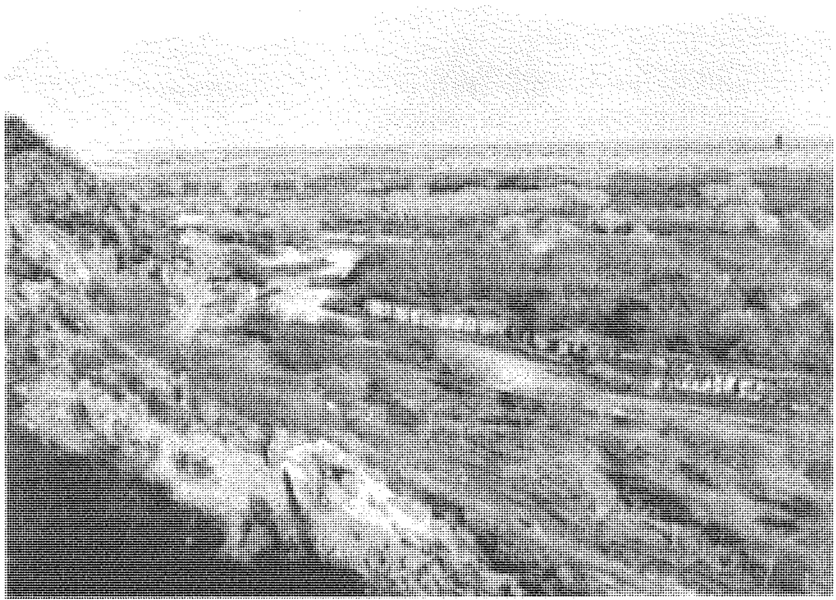
Groundwater pumping for agricultural and municipal uses caused the groundwater table to drop. At the time of statehood (1912), the Santa Cruz River was still perennial in some of the reaches that had shown historic surface flows, but flows were becoming increasingly intermittent in most areas. U.S. Geological Survey stream gage summaries (1907, 1912) indicate that all surface water flows were diverted at the Tucson gaging station by irrigation ditches. Agricultural uses in Tucson and San Xavier accounted for most of the area's surface water with supplemental irrigation water coming from groundwater pumps. Diversions, and groundwater pumping, also diminished flows on major tributaries, especially the Rillito River. In 1935, the Works Progress Administration (renamed the Works Projects Administration in 1939) straightened the channel from San Xavier downstream to Congress Street. The current was deflected into the channel by revetments made of discarded automobile frames. Much of the remaining riparian vegetation was destroyed during the process of placing the revetments.

Throughout the 20^{th} century, groundwater pumping increased at a rate far greater than natural recharge. By the 1950s, the perennial water was gone. A spectacular mesquite forest, four or five miles wide, survived into the 1940s on the now barren Tohono O'odham land in the San Xavier District. Ornithologist Herbert Brandt measured the trees in the 1930s, recording girths up to 13 feet and heights up to 72 feet. These centuries old forests were home to legions of birds, among them the now-endangered cactus ferruginous pygmy owl. "A woodland of giant mesquite trees...drew to itself such a fine list of unusual birds that I feel it merits designation as a separate type of desert area," Brandt (1951) reported. The forest died off by the early 1950s.

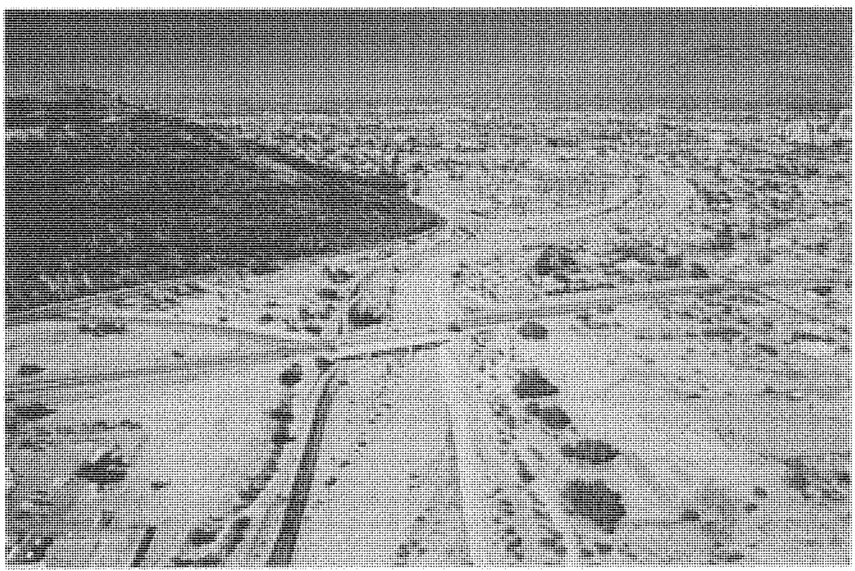
In the 1950s and 1960, tons of garbage were dumped in landfills established in the channel or on the adjacent floodplain, resulting in a narrowing of the channel. Overburden from highway construction was also deposited on the east bank of the river to allow construction inside the meander. Riparian and floodplain fringe vegetation was progressively destroyed during the construction of Interstates 10 and 19.

Wildlife biologists, ecologists and naturalists have long recognized the importance of arid landscape riparian ecosystems. Over 100 state and Federally listed species in New Mexico and Arizona are riparian dependent (Johnson, 1989). Riparian ecosystems are the richest bird habitat in North America, particularly in the arid West where an astounding array of species depend upon these thin ribbons of lush vegetation (Van Hylckama, 1980). The highest population densities of non-colonial nesting birds in North America, in fact, are in the cottonwood forests of central Arizona (Johnson, 1971; Carothers, et al., 1974). Riparian corridors and their tributaries are important breeding areas, migratory pathways for a multitude of wildlife species and winter residents for migratory land birds, including species that over-winter in the Neotropics. A large proportion, 75-80% of vertebrate wildlife species depend on riparian areas for food, water, cover and migration routes (Gillis, 1991).

The loss of western riparian ecosystems can scarcely be overstated. The degradation of riparian ecosystems in the Southwest is extreme; losses in California and Arizona have been estimated to be in excess of 95% (Warner, 1979). The Arizona Nature Conservancy (1987) rates the cottonwood-willow community as North America's most rare forest type. The National Center for Environmental Research and the Society for Ecological Restoration recognize the importance of restoring the hydrological and geomorphologic functions of riparian ecosystems (National Center for Environmental Research – Progress Report 2001, Society for Ecological Restoration, 2002).

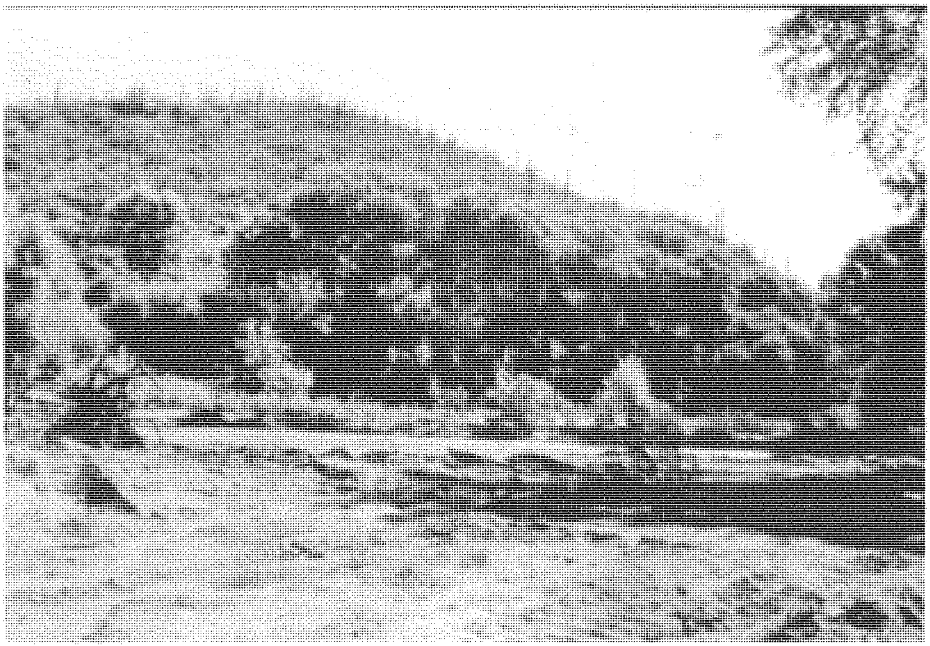


Confluence of the West Branch and the Santa Cruz River from Sentinel Peak, 1904
(Arizona Historical Society, Tucson)



The same area as it appears in a contemporary photograph

FIGURE 4.1 Comparison of Historic and Present Conditions



Cottonwoods persisted at the base of Martinez Hill near San Xavier in the 1940s
(Arizona Historical Society, Tucson)

FIGURE 4.2 Historic Conditions

2. Historic Riparian Conditions and Development of a Restoration Concept

The presence of water near the surface is the primary factor that controls the presence and persistence of plants and animals in an ecosystem. The position, frequency, duration and relative kinetic energy of water dictate what types of plants and animals occur and where in the landscape they tend to occur. Water forms the landscape as it carves resistant earth and re-deposits earth particles, the created form of which then controls the frequency and duration of subsequent exposure to water, which again re-shapes the surface over which it flows. This constant change is the essential, dynamic characteristic of the riparian ecosystem. The plants and animals using this ecosystem are fully attuned to the changes, taking advantage of the seasonal or multi-year cyclic alterations by the ways in which they use and populate the habitats.

Habitat complexity is a characteristic created by hydrogeomorphic processes. The land surface is shaped into a mixture of steep grades, gradual slopes, channel meanders and depressions which offer variable exposure to sun and shade, and provide variability water loss or retention in soils. Such high variability of earth forms supports species diversity and their relative distribution as recognizable groupings and distributions across the riparian landscape. The diversity of life forms and the interspersion of communities are the often-noted characteristics cited by many observers of riparian ecosystems.

A simplified, typical cross-section aids in describing characteristics of the riparian ecosystem and the relationships between geomorphic processes, water (hydrologic) presence and the occurrence of plant communities. Figure 4.3, entitled "Natural Sonoran Riparian System", was created based on systematic discussions in the Sonoran Desert Conservation Plan (SDCP, July 1999) and observations of relatively undisturbed riparian sites, located both within the Santa Cruz system and in the region.

The linear flow of water across a landscape carves the recognizable flattened trapezoid-shaped, valley cross-section depicted in Figure 4.3. Rarely occurring, high energy, violent water flow creates a different cross-sectional form than more frequent normal flows. Since both types of flow occur due to variability in precipitation, the effects of both types of flow are properly represented in the typical cross-section. The higher energy flows associated with greater volumes of water create the floodplain, relatively abrupt slopes and the vertically separated, topographic steps identified as *terraces* or *benches*. Portions of the landscape generally above even the higher flows are here identified as the *overbank* area. Ordinary flow or frequent moderately higher flows create and maintain the active channel, relic channels and linear, low ridges of sediment identified as *point bars*.

The presence of groundwater near the active channel and the depth at which it discharges from the surrounding landscape relative to the elevation of the channel determines whether a given reach of stream flows continuously (perennial stream) or intermittently. An actively flowing, perennial channel may simultaneously represent the lowest point of the surface hydrologic system and the highest point of the groundwater hydrologic system as there is no distinction between the two. They are a continuum of water movement through the riparian ecosystem that provides it its essential nature. The condition of groundwater presence perennially near the topographic elevation of the active channel bottom is the characteristic that creates perennial channel flow and a higher frequency of wetter plant community types (*cienegas*) in relic channels and behind point bars, characterized in many accounts of the pre-development Santa Cruz River ecosystem within the study area reach.

The hydrogeomorphic regime of a particular riparian landform is created by its position in the channel cross section, including its elevation above the active channel, local groundwater influences, and storm event flow volumes. Each regime can be described by the frequency, duration, and depth of water present at a location. Water presence for all riparian hydrogeomorphic regimes is greater than for desert (which receives water only as direct precipitation), since water may be directed and concentrated by way of surface runoff during rainfall events, flooding, shallow groundwater migration and groundwater discharge. Three broadly interpretive terms are used to describe riparian hydrogeomorphic regimes: *hydroriparian*, *mesoriparian* and *xeroriparian*. Certain plant species, growth forms and species groupings (habitats) are typically found in each of these regimes. While these vegetation types are depicted on Figure 4.3 to establish linkages with landforms and hydrogeomorphic regimes, detailed discussions of vegetation and habitats are found later in this document.

Hydroriparian regime. This is the portion of a channel that is exposed to water at, above or near the surface for all, or nearly all of the time. Spatially, this includes some or all of the active channel and the topographically lower portions of relic channels and braids. Sources of water include direct rainfall, local runoff from uplands, channel flow from an extended drainage basin, capillary migration (movement of water between soil particles) and groundwater discharge. Plants typically associated with this regime include submerged, floating and emergent species with succulent tissues and often grass-like growth forms. Trees and shrubs, particularly willow, may occur. Vegetation density is typically high. Diversity is moderate to high and inversely proportional to the duration of inundation. Soil evaporation is low due to shading from taller plants growing in this and the next zone, however evapotranspiration is high due to the combination of high desert temperatures and lavish water supplies.

Mesoriparian regime. This portion of the channel cross-section occurs on first benches and terraces located above ordinary channel flow levels, to as much as 1-4 feet above, depending on soil grain size and local drainage patterns. Water is provided by direct precipitation, local runoff and relatively frequent flooding. These areas are not exposed to normal channel flow waters but may be inundated or saturated several times each year to as much as every two years by flood events. Groundwater contributes to water presence in this zone by way of soil capillarity and deep roots. Dominant plants occurring include cottonwood-willow mixtures, mesquite, perennial bunchgrasses, such as sacaton, and medium shrubs adapted to floodway disruption, such as burrobrush. Overall, vegetation density is moderate to high. Species diversity is typically high due to the relatively steep gradient in available moisture across this zone. Soil evaporation is typically low due to relatively dense shading.

Xeroriparian regime. This zone is found on secondary terraces, generally above the elevation of the two-year recurrence interval storm, extending upward to the periphery of the ten-year storm floodway (and higher). Available moisture in this zone always exceeds surrounding desert and includes sources of direct precipitation, lateral overland flow from uplands and occasional flood inundation. Groundwater may be important to only the more deep-rooted trees and shrubs. Vegetation density may range from high to low depending on position relative to actual water concentration potential, but is lowest on average for all the riparian zones. Species diversity is moderate to high. Typical vegetation is the mesquite bosque habitat, although various brush or cactus-dominated communities may temporarily prevail due to flood or fire disruptions.

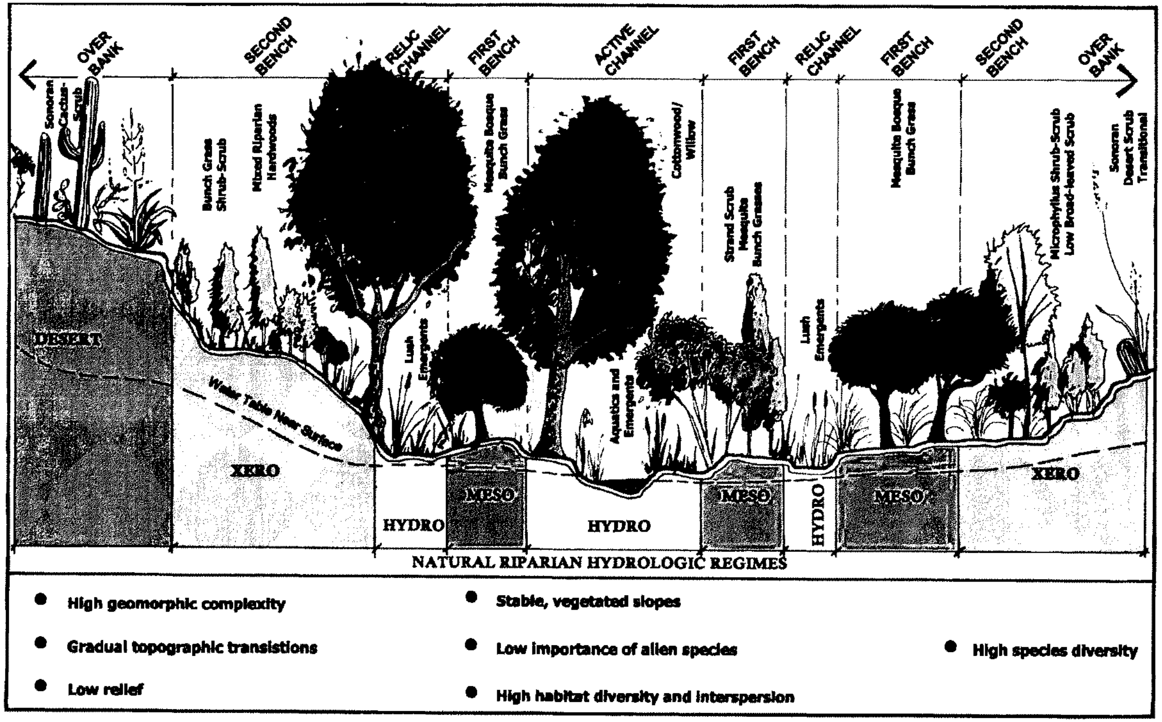


FIGURE 4.3 Natural Sonoran Riparian System

Natural riparian systems will display a high geomorphic complexity, relatively low absolute topographic relief (each rising zone being broader and flatter than the previous), and high soil stability due to higher maintained vegetation densities. In a relatively undisturbed landscape, riparian change occurs gradually, almost imperceptibly in human temporal references, and at a scale amenable to biological processes. A point bar will change its orientation, a bank will slough or a back channel will fill with sediment. These newly altered areas, exposed to a continual rain of propagules (seeds) from surrounding vigorous populations, will be quickly re-colonized by species adapted for the conditions. The catastrophic changes that have occurred in the riparian zone and particularly in the landscape surrounding the Paseo de las Iglesias reach of the Santa Cruz River have resulted in a very different riparian condition than that occurring under the natural circumstances.

3. Present Conditions

The Santa Cruz channel is now a 10 to 40 foot deep, usually desiccated erosional scar, with frequently steep, near vertical and unstable banks through much of the Paseo de las Iglesias reach. Figure 4.4 entitled, "Degraded Santa Cruz River Riparian System", is designed to both depict present typical conditions and contrast with Figure 4.3. Natural geomorphic complexity has been replaced by a simplified set of parallel flat terraces separated by steep banks. The highest flat, formerly the xeroriparian mesquite bosque that was topographically disconnected from the Santa Cruz flooding regime by progressive head-cutting events, is a highly disrupted, nearly barren plain with a desert hydrogeomorphic regime. First and second terraces, formed since the occurrence of the major channel erosion events, may support a xeroriparian regime in many places, with occasional stands of the alien buffelgrass, invasive salt-cedars and native burro-brush. The channel bottom may support a mesoriparian regime; however, occasional flood flows tend to sweep out all vegetation, leaving only a dry sand bed that is highly suitable for off-road vehicle traffic. Biological resources within the study area are severely degraded. Continuous groundwater mining has dramatically lowered the area's groundwater table; the water table is over 100 feet below the riverbed. Surface water is rare, and occurs only following rainfall events or because of release of water by people.

Currently, the study area consists primarily of urban and disturbed land on both sides of a frequently disturbed, deeply entrenched ephemeral riverbed (Figure 4.5 & 4.6). It is almost entirely isolated from natural vegetative communities by urban development and barren lands. Continuing disruptions in the former floodplain include chronic channel and overbank erosion, ongoing development, relict agricultural operations and landfills, off-road vehicle use, construction of soil cement lined banks, illegal dumping, and transient camps. The aquatic and riparian communities have vanished, and the mesquite bosques are represented only in diminished, isolated pockets of stunted trees sprouting from cut or burned stumps. Exotic plant species, including salt cedar (*Tamarix ramosissima*) and Athel tamarisk (*Tamarix aphylla*), have replaced most of the native cottonwood and willow.

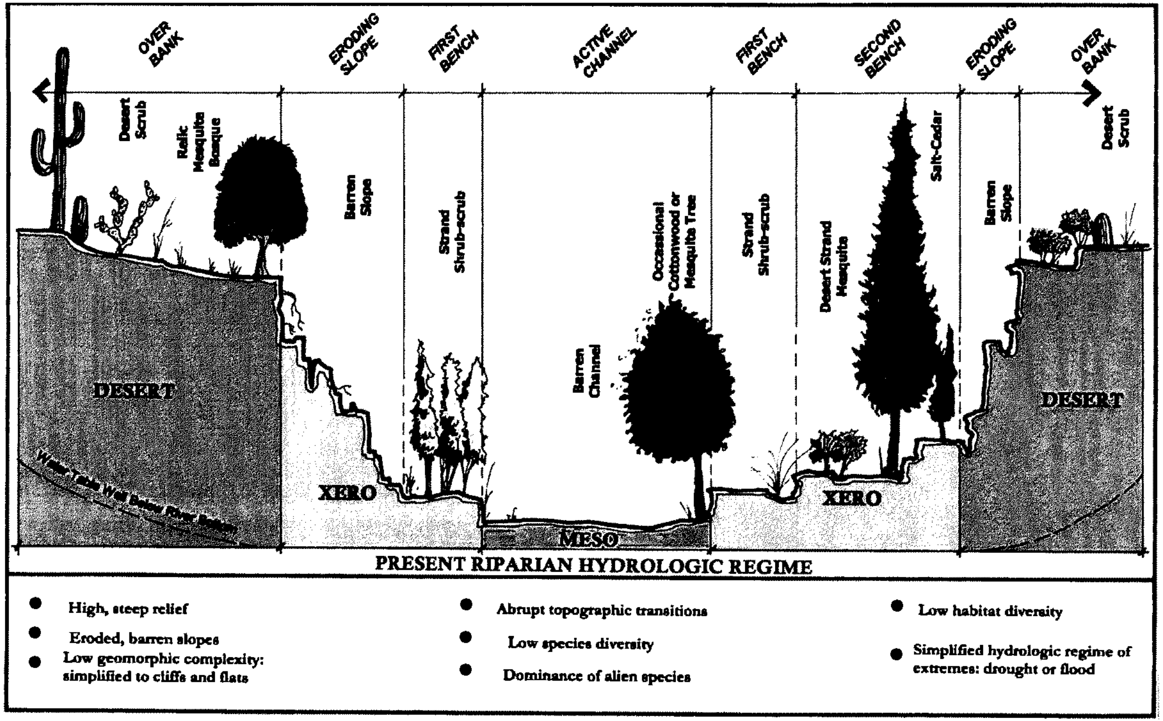


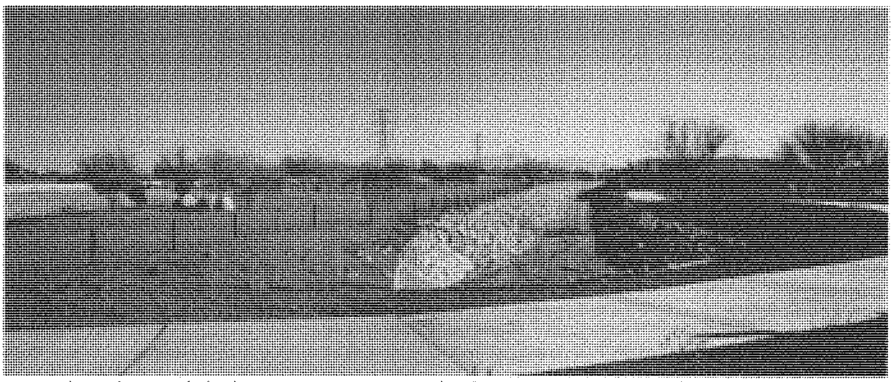
FIGURE 4.4 Degraded Santa Cruz Riparian System

Note the nearly vertical banks in this unprotected reach south of Drexel

Debris left in channel north of Irvington

FIGURE 4.5 Existing Conditions

Bank and River Park trail south of Ajo Way



New housing and drainage structures on the Santa Cruz west bank south of Ajo Way

Condition of tributary wash upstream of its confluence with the Santa Cruz River

FIGURE 4.6 Existing Conditions

4. Flooding History

The most severe flooding events in recent history occurred in 1977, 1983, 1990 and 1993 (USACE, 2001). However, little information exists regarding specific damages within the study area. The 1977 flood caused an estimated $8,607,000 in damages, of which approximately $6.8 million was in agricultural damages. Most urban flood damage was recorded to the south of the City of Tucson near Green Valley. Considerable damage, estimated at $230,000, was done to the Silverbell Golf Course, located north of the study area near Roger Road. Considerable damage was caused to both public and private property. The 1983 flood caused extensive damage throughout the region. Unfortunately, little information is available regarding specific dollar values associated with damages. Information on damage amounts from the 1990 flood is also limited but the Operations Division of the Pima County Department of Transportation and Flood Control District estimated damages at approximately $1.7 million. Damages from the 1993 flood caused occurred primarily in the north and northeast portions of the Tucson metropolitan area. In these and other past flood events, damages did occur to the roadway bridge crossings. However, all bridges and abutments are now protected by soil cement or the bridges were reconstructed.

Other potential flood risks during severe infrequent flood events exist along the remaining unprotected reaches of the Paseo de las Iglesias study area. Erosion protection has not been constructed south of Irvington Road, except for the Valencia Street Bridge or between Ajo Way and Silverlake Road. These areas are at risk of experiencing significant lateral channel migration during major infrequent flood events. Based on the historic rates of channel migration, the damage potential arising from such erosion is limited. However, impacts to downstream, upstream, and overbank areas resulting from aggradation of the channel invert from deposition of sediment could reduce the river's ability to convey flood flows.

B. Base Year Conditions

1. Definition of Base Year Conditions

Base Year conditions are defined as those conditions which are expected to exist within the study area in the earliest year that a project could begin to produce NER and/or NED benefits. A thorough assessment and evaluation was conducted for existing conditions in the study area and was brought forward in time based on expected future change in the study area. The year 2012 was chosen as the Base Year based on the assumption that this feasibility study would be completed on 2004. The Planning, Engineering and Design Phase (PED) was estimated to commence in 2006, with actual construction commencing in 2009. Construction is estimated to last approximately three years, ending in 2012. However, it is conceivable that NER benefits could begin accrue incrementally earlier in the construction phasing.

2. Environmental Resources

Cultural Resources

A literature search and cultural resources overview of the proposed project area of potential effects (APE) has been performed through the Arizona State Museum (ASM). This search indicates that less than 50 percent of the APE has been surveyed by archeologists. These surveys have recorded 47 archeological sites within the project APE. Site AZ BB:13:15 (Valencia Site) was nominated and listed in the National Register of Historic Places (NRHP) in 1984 (along with AZ BB:13:74) by William Doelle with the Institute of American Research. At least four sites are eligible for the NRHP including AZ AA:16:3 (West Branch Site), AZ AA:16:49 (Dakota Wash Site), AZ BB: 13:6 (Clearwater Site, Mission San Agustín del Tucson, Tucson Pressed Brick Company), and AZ BB 13:17 (Julian Wash Site). The Corps determined the Julian Wash Site eligible for the NRHP in 1995 as part of the Tucson Diversion Channel Project. The remainder of recorded sites within the study area are undetermined as to NRHP eligibility, unless destroyed. Sites described as destroyed are subject to confirmation via a field check. Many of the sites in the study area can be considered potentially eligible (O'Mack and Klucas, 2002).

In accordance with 36 CFR 800, regulations implementing Section 106 of the National Historic Preservation Act, identification and evaluation studies will be coordinated with the Arizona State Historic Preservation Office (SHPO), Pima County, and interested Native American Indian tribes. Given the study area's association with the Santa Cruz River floodplain, the overall archeological sensitivity and potential are very high. The floodplain may contain buried resources. Therefore, complete avoidance of all cultural resources by project alternatives may not be possible.

Water Resources

Groundwater: The most important groundwater resources in the Tucson basin occur in the sedimentary rocks and alluvium that form a single aquifer. The aquifer consists of the Pantano Formation, the Tinaja Beds, and the Fort Lowell Formation (from bottom to top). The Pantano Formation yields small to moderate amounts of water while the Tinaja beds yield small to large amounts of water, frequently in excess of 1000 gal/min. The elevation of this primary aquifer is within 350 ft. of the ground surface throughout most of the basin. Due to localized and/or perched water tables, the depth to groundwater ranges from less than 20 ft. to about 170 ft. below the ground surface along the Santa Cruz and Rillito Rivers. Current well information included in this report indicates that depths to groundwater in the wells generally ranges from about 100 to 200 feet below ground surface in the study area close to the Santa Cruz channel.

Large-scale pumping of groundwater in the Tucson basin began in about 1900 and increased dramatically in the 1940s. Most of the groundwater pumped in 1940 was used for irrigation. The centers of greatest water-level decline are along the Santa Cruz River near Sahuarita and in the City of Tucson. Declines exceeding 100 ft. have occurred in Tucson and in portions of the study area, while to the south along the river, the maximum decline has been about 150 ft. Detailed information on depth to groundwater, including mapping may be found in the Geotechnical Appendix (Appendix F).

Infiltration of storm runoff in the stream channels during the rainy seasons is the major source of recharge to the groundwater basin (Davidson, 1973). Seepage of runoff along the mountain fronts constitutes the second largest source of recharge. This natural system recharges about 100,000 acre-ft/yr, but there is a demand for 300,000 to 400,000 acre-ft annually. The resulting deficit is causing the water table to decline at an approximate average annual rate of 2.7 ft (PCDOT, 1986). For additional information regarding groundwater, see the Geotechnical Appendix.

Surface Water: No local permanent water resources exist along the Santa Cruz River in the study area. Surface water is rare and occurs only following rainfall events or after water is released by people. There are small areas of flooded inactive gravel pits in the southern portion of the study area. Conditions at these are rapidly changing as mining activity ceased in 2003.

Biological Resources

Watersheds and associated riparian habitats within Pima County have been profoundly altered in the past one hundred years. Historically, many of the rivers flowed perennially supporting lush riparian vegetation and marsh habitat in the study area. Before 1890, dense stands of cottonwood, willow, ash and walnut trees lined the Santa Cruz and many of its tributaries. Mesquite bosques covered the floodplain terraces and beaver dams were common. It is estimated that eighty-five to ninety-five percent of high-quality riparian habitat in Pima County has been lost over the past century. Virtually all riparian habitat has been lost in the study area.

Riparian systems provide critical habitat for many plants and animals. Riparian habitat is especially important in the semi-arid Southwest. Migratory birds, for instance, depend upon riparian areas for foraging, refuge during migration, and breeding areas. These strings of habitat, while encompassing less than one percent of the Southwest landscape, support a disproportionate number of wildlife species. It is estimated that seventy-five to ninety percent of all wildlife in the arid southwest is riparian dependent during some part of its life cycle. Degradation or loss of riparian habitat within Pima County has had great impacts on most resident species.

Vegetation:

Riparian Forests

Vegetation communities of the Paseo de las Iglesias study area include very small remnants of Sonoran Desert Scrub, Sonoran Deciduous Forest and Woodlands, Sonoran Deciduous Riparian Scrub and Sonoran interior strand habitat. Vegetation community naming is based on the Brown, Lowe and Pase (Brown, 1980, 1994) vegetation classification system. The use of the term communities to describe the degraded, scattered fragments of formerly definable natural systems is an overstatement of the characteristics of the mostly barren, weed-dominated Santa Cruz vicinity. Most areas consist of developed and disturbed areas. Soil cement banks and paved trails occur on the east and west side of the river and traverse a variety of habitat types.

The largest percentage of the study area (60.8%) is Urban, a subset of Cultivated and Cultured Uplands, with the next largest (17.6%) being Sonoran Vacant or Fallow Lands, another subset from the same vegetative community (SWCA, 2003). Less than 20 percent of the study area is occupied by uncultivated/uncultured habitat. The majority of these uncultivated habitat areas have been drastically disturbed by erosion, filling, mining and prior development.

Areas with ephemeral stream channels support struggling remnants of xeroriparian vegetation such as mesquite and acacia. Shallow groundwater and areas of intermittent surface flow support occasional mesoriparian plants such as a few larger stands of mesquite. Outside of inactive mining process ponds and a few storm water outlets, wetlands and perennial watercourses supporting hydroriparian vegetation such as cottonwood-willow forests do not exist in the Paseo de las Iglesias reach of the Santa Cruz River.

These riparian communities had been extremely rich in species diversity, supporting several hundred species of plants and sustaining a rich food base for wildlife. While southwest riparian areas represent less than 1% of the regions area (Knopf, F. L., 1989), still 80-90% of vertebrate wildlife species depend on them for food, water, cover and migration (Gillis, 1991). In fact, over 100 state and federally listed species in New Mexico and Arizona are riparian dependent (Johnson 1989).

Riparian dependent plant communities are considered at risk vegetation communities in the Southwest, particularly in Pima County. The Arizona State Park Commission (1988) estimated riparian losses in Arizona and New Mexico to be on the order of 90% while the Arizona Nature Conservancy (1987) rates the cottonwood-willow community as North America's rarest forest type. In addition to outright destruction of riparian habitat in the western United States, the small size of existing fragments and the great distances between them decrease their ability to support healthy distributions, abundances and diversities of bird species (MacArthur and Wilson 1967, Burgess and Sharpe 1981).

Sensitive plant species that could potentially occur onsite and are known to occur in the vicinity are listed in the Final Environmental Impact Statement (FEIS). No Federal or State listed species were observed in the study area during field observations conducted for this study. Riparian communities in the study area have been lost due to diversion of and reduction in stream flow, depletion of groundwater tables, competition by exotic plant species, the effects of grazing and fire, loss of floodplain function by undercutting caused by flood control activities, and encroaching urban and agricultural uses.

One species of concern with potential to occur in the area is the Tumamoc globeberry, an Arizona Department of Agriculture Salvage Restricted Species and a Sonoran Desert Conservation Plan (SDCP) Priority Vulnerable Species (PVS). The range of this plant covers some 31,000 square miles of Sonoran Desert from Sonora, Mexico to Tucson, Arizona, west to Organ Pipe Cactus National Monument and north to Pinal County, Arizona. In Tucson, it is found on hot, dry, south-facing slopes of basalt and along desert washes. The largest population is found in creosote bush desert scrub on gravelly loams primarily derived from weathered granites; however, there are no known populations in the study area. Additional information concerning plants in the study area may be found in Appendix 14.2 of the FEIS, Biological Assessment.

Wildlife:

No Federally listed threatened or endangered species were detected in the study area. The following seven species of primarily local interest were determined to occur or have a potential to occur within the Paseo de las Iglesias corridor: giant spotted whiptail, western yellow-billed cuckoo, burrowing owl, Abert's towhee, Bell's vireo, western red bat, and western yellow bat. Other wildlife species observed during the field investigations were also recorded.

The giant spotted whiptail is designated as a USFWS Species of Concern, a United States Forest Service (USFS) Region 3 Forester Priority Sensitive Species (PSS), and a SDCP PVS. Currently, known populations of the giant spotted whiptail have been recorded from the Santa Catalina, Santa Rita, and Baboquivari Mountains. Once common along the Santa Cruz River, the known population has been reduced to a remnant along the West Branch (Rosen, 2001). Giant spotted whiptails are found in lower Sonoran (chiefly riparian areas) and upper Sonoran life zones, in mountain canyons, arroyos, and mesas in arid and semi-arid regions, entering lowland desert along stream courses. The species is found in dense shrubby vegetation, often among rocks near permanent and intermittent streams, and in grassy areas within riparian habitats.

The western yellow-billed cuckoo is a candidate for listing as endangered by the USFWS, is a USFS Sensitive Species, is an AGFD Wildlife of Special Concern and a SDCP PVS. This subspecies of the yellow-billed cuckoo is believed to have been once widespread and locally common in California and Arizona. Its present distribution in Pima County is at Cienega Creek, Arivaca Creek, San Pedro River, Tanque Verde Wash, Rincon Creek, and the Green Valley pecan orchards. The western yellow-billed cuckoo inhabits mature Sonoran riparian deciduous forest, Cottonwood-Willow Series, and Sonoran riparian scrub in well-developed mesquite bosques.

The western burrowing owl is a SDCP PVS. Burrowing owls are uncommon residents of grasslands, open areas in desert scrub, pastures, and the edges of agricultural lands, and areas of bare dirt subject to erosion. Burrowing owls are known to occur in the project area.

Abert's towhee is a PVS under the SDCP. Abert's towhee inhabits low-elevation riparian sites throughout Pima County. This species tends to occur most often in Sonoran riparian deciduous woodlands and riparian scrublands with dense understories. Most of these communities are now fragmented throughout much of Arizona. Abert's towhees were regularly observed in a variety of habitats during field reconnaissance including mesquite series, urban drainage, Sonoran interior strand, salt cedar disclimax, and maintained park.

Bell's vireo is an SDCP PVS. In Pima County, this species is a common summer resident in dense shrubs and trees of lower canyons, generally below the oak zone, and along desert streams and washes in dense riparian vegetation.

The western red bat is an AGFD Wildlife Species of Special Concern, a USFS Sensitive Species and is a SDCP PVS.

The western yellow bat is an AGFD Wildlife Species of Special Concern and a SDCP PVS.

A complete discussion of wildlife in the study area may be found in Appendix 14.2 of the DEIS, Biological Assessment.

3. Evaluation Methodology

Habitat Evaluation

In the 1970's and early 1980's, the U.S. Fish and Wildlife Service (USFWS), in cooperation with other agencies, developed a non-monetary evaluation procedure for environmental project planning. That process has been used and modified since then for both impact assessment and planning habitat restoration and management projects. Ecological Services Manuals describe the procedure and process in detail (USFWS 1980a-c). The Habitat Evaluation Procedure (HEP) is an objective, reliable and well-documented process used nationwide to generate environmental outputs for all levels of proposed projects and monitoring operations in the natural resources arena. HEP guidebooks focus on individual species. No guidebooks exist for evaluation of species habitat within the Paseo de las Iglesias study area.

To evaluate habitats for planning purposes without existing guidebooks, the Los Angeles District of the Corps of Engineers evaluated wildlife benefits using a technique referred to as modified Habitat Evaluation Procedure (mHEP).

The basic premise of this modified procedure focused on a field reconnaissance approach where biologists surveyed a study site to familiarize themselves with the current conditions of the study area. The conditions were characterized by experts in the field and assigned a Habitat Suitability Index (HSI) score between 0-1 based on expert opinion of healthy, pristine, natural conditions. Graphical illustrations of conditions ranging from the 0-1 HSI scale were provided to the experts, and they were asked to select the "best-fit" representation for each community per site. The HSI for each location of each community was assigned, and an average was calculated for at least five locations (where more than five were available). By multiplying the average value by the total measured area of each community type, a single number was to express Habitat Units (HU). The solution was often efficient; however, the results were subjective and were often not repeatable.

Another restoration assessment approach is the Hydrogeomorphic Method (HGM). HGM is a habitat evaluation tool that employs a functional assessment approach to predicting with and without project values for an array of features and structures associated with ostensible habitat performance. An HGM based functional assessment approach was used as a parallel comparative method for habitat evaluation of the study area because of its broader approach to analysis of processes and conditions necessary for support of riparian habitat and its prior use for other ecosystem restoration studies conducted in the southwest. The HGM method examines habitat based on physical and biological parameters. HGM emphasizes the functions associated with the range of physical and chemical attributes comprising habitat of wetland ecosystems. It also incorporates a structural index based on a set of species identified for the specific model application. Models used in a HEP methodology might be more appropriate in some riparian settings but their overall evaluation of potential changes to the ecosystem dynamic are limited when capturing wetland functionality as a whole. The HGM based approach has one important advantage over the HEP methodology (HSI models in particular) in that it is more inclusive of all ecosystem functions relevant to ecosystem services. Hydrologic and geomorphic conditions are the primary factors governing riverine ecosystem structure and function. HEP models are generally limited to the habitat function in support of species richness, and might overlook key hydrologic and geomorphic influences on the ecosystem. Use of a functional assessment tool includes assessment of both abiotic and biotic functions, if proper functions are selected for assessment.

HGM Results:

Arizona Riverine Model Development

Since there is not a regional guidebook completed specifically for the arid riverine environment in Arizona, existing models were modified to develop a functional assessment tool for planning purposes. The riverine over bank subclass for low gradient streams is the most applicable to the environment. Draft Guidebooks for the Santa Margarita Watershed and San Luis Rey Watershed were also reviewed for information.

A workshop was held to bring together regional experts and seek their input on modifying the model to be applicable to Arizona riverine environments. Workshop participants included the Environmental Lab (EL) of the U.S. Army Corps Engineers Engineering Research and Development Center (ERDC), the Los Angeles District Corps staff, non-Federal sponsor representatives from the City of Phoenix, City of Tucson, Town of Marana, Pima County Flood Control District, and Salt River Pima Maricopa Community, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, professional consultants, and representatives from the scientific and academic community. The methodology used in applying functional assessment valuation of the study area is explained in more detail in the Habitat Analysis Appendix D provided under separate cover.

Reference Sites

Reference sites are riverine or riparian areas selected from a reference domain (a defined geographic area), selected to "represent" sites that exhibit a range of variation within a particular wetland type, including sites that have been degraded/disturbed as well as those sites with minimal disturbance. The use of reference sites to scale the capacity of riparian area or wetlands to perform a function is one of the unique features of the functional assessment approach. The reference sites provide the standard for comparison in the functional assessment approach. They function as the physical representation of riparian areas from the region that can be observed and measured repeatedly. A basic assumption of a functional assessment approach is that the highest, sustainable functional capacity is achieved in riparian ecosystems and landscapes that have not been subject to long-term anthropogenic disturbance.

It is further assumed that under these conditions the structural components and physical, chemical, and biological processes within the wetland and surrounding landscape reach a dynamic equilibrium necessary to achieve the highest, sustainable functional capacity.

Reference sites for model calibration included The Nature Conservancy's Hassayampa River Preserve, the Verde River at the confluence with the Salt River, Santa Cruz River at Tumacocori, the San Pedro River at the San Pedro National Riparian Conservation Area, and Tanque Verde Wash upstream of the Rillito River confluence. These sites were recommended by the Model Development Workshop attendees based on the following criteria: 1) they were reasonable sites considering current conditions, 2) they were in a similar regional riverine subclass with the Santa Cruz River having similar elevation, topography, gradient, and stream order, 3) they represented important aspects of pre-historical conditions, and 4) they were uniform across political boundaries. Model attendees agreed that no truly ideal reference site exists and restoration to the ideal was not achievable due to inability to remove all stressors. The goal in choosing these sites was that the hydrologic, biogeochemical and habitat characteristics be as undisturbed as possible.

Wetland Functions

Wetland functions represent the currency or units of the wetland system for assessment purposes, but the integrity of the system is not disconnected from each function, rather it represents the collective interaction of all wetland functions. Functional capacity is simply the ability of a wetland to perform a given function (e.g. the capability of a wetland to temporarily store (retain) surface water) compared at the level that it is performed in reference standard wetlands. It was decided to use the same type of currency for this functional model as is used in HGM. The HGM methodology assesses wetland function based on a series of predictive Functional Capacity Indices (FCIs). An FCI is an index of the capacity of wetland to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are scaled from 0.0 to 1.0. 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. 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. In summary, FCI models rate the functional capacity of a wetland on a scale of 0.0 (not functional) to 1.0 (optimum functionality). HGM combines both the wetland functionality (FCIs measured with variables) and wetland quantity to generate a measure of change referred to as Functional Capacity Units (FCUs).

Subcategories of wetlands are identified to further increase the resolution of the model. Those subcategories or cover types are referred to as Partial Wetlands Assessment Areas or PWAA. Functions developed for the Arizona riverine HGM model are displayed in Table 4.1. 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).

Under the HGM methodology, each FCU is equivalent to one optimally functioning wetland acre. Like HEP, 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, or years of interest during the project life. In such analyses, 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). Based on the AAFCU outcomes, alternative designs can be formulated, and trade-off analyses can be conducted, to promote environmental optimization.

Cover Types

Habitats evaluated within the study area were classified as one of four Partial Wetland Assessment Areas (PWAAs) or cover types for Arizona riverine systems. Cover types are primarily based on vegetation cover. These are Cottonwood-Willow, Mesquite, Scrubshrub (Sonoran Desert Wash Community), and Riverbottom (potential emergent wetlands or cienega). These are homogenous zones of similar vegetative species, geographic similarities, and physical conditions that make the PWAA unique. In general, cover types are defined based on species recognition and dependence, soils types and topography. Other areas such as a buffer zone, urban areas, and desert areas will be tracked but not evaluated.

Cover types for this study were mapped within the study boundaries. Note that the mapping of these cover types adjacent to the channel was completed for planning purposes and in order to consider the effects of adjacent land use on the study area, not with the intent that actual project features will be planned to that extent. Figure 4.7 depicts cover types and land use found within the project area. Scattered remnants of natural vegetation remain. Those cover types include Mesquite, Scrubshrub and Riverbottom. Cotton-wood willow forests, natural cienegas and seasonal emergent wetlands have disappeared from the study area. Table 4.2 lists the acreage in each cover type.

Cottonwood-Willow Forests

Cottonwood-willow forest is a high-quality hydroriparian habitat in Arizona. Riparian habitats are defined as habitats or ecosystems that are associated with rivers or streams or are dependent on the existence of perennial or intermittent surface or subsurface water. They are further characterized by having diverse assemblages of plant and animal species in comparison with adjacent upland areas. These plant species are also found in habitats that are narrow, linear strands of vegetation parallel to the main direction of water flow that may occur in riverine flood channels and along the banks of streams. In the Sonoran Desert, riparian areas nourish cottonwood-willow forests, one of the rarest and most threatened forest types in North America. An estimated 90% of these critical wet landscapes have been lost, damaged or degraded in the last century. This loss threatens at least 80% of Arizona wildlife, which depends upon riparian habitats for survival. The growth of Tucson and surrounding areas, past land uses such as farming, grazing, gravel mining, and pumping of groundwater have altered the Santa Cruz River. Where it was once perennial, it is now an ephemeral stream. This has contributed to the decline of cottonwood and willow habitat within the study area. Two small stands of Cottonwood-Willow, supported by water from gravel washing operations, remained at the start of this investigation however; the cessation of gravel mining eliminated the water supply and the trees have since died. While an occasional tree survives at scattered locations, the Cottonwood-Willow cover type cannot be found within the study area.

Mesquite Bosques

Mesquite woodlands or bosques historically thrived over large areas within the river floodplain and on higher terraces of the river and were common into the 1940s. These communities have been nearly eliminated from the river ecosystem by a combination of anthropogenic activities (e.g. cutting for firewood) and an ever lowering aquifer combined with an altered flood regime. Significant contiguous stands currently exist along the Old West Branch of the Santa Cruz River. Several smaller patches are scattered throughout the historic floodplain of the Santa Cruz. These small bosques generally consist of struggling trees that have been isolated from the river by soil cement banks and are threatened by urbanization. Together, these areas of mesquite-dominated woodlands total 160 acres.

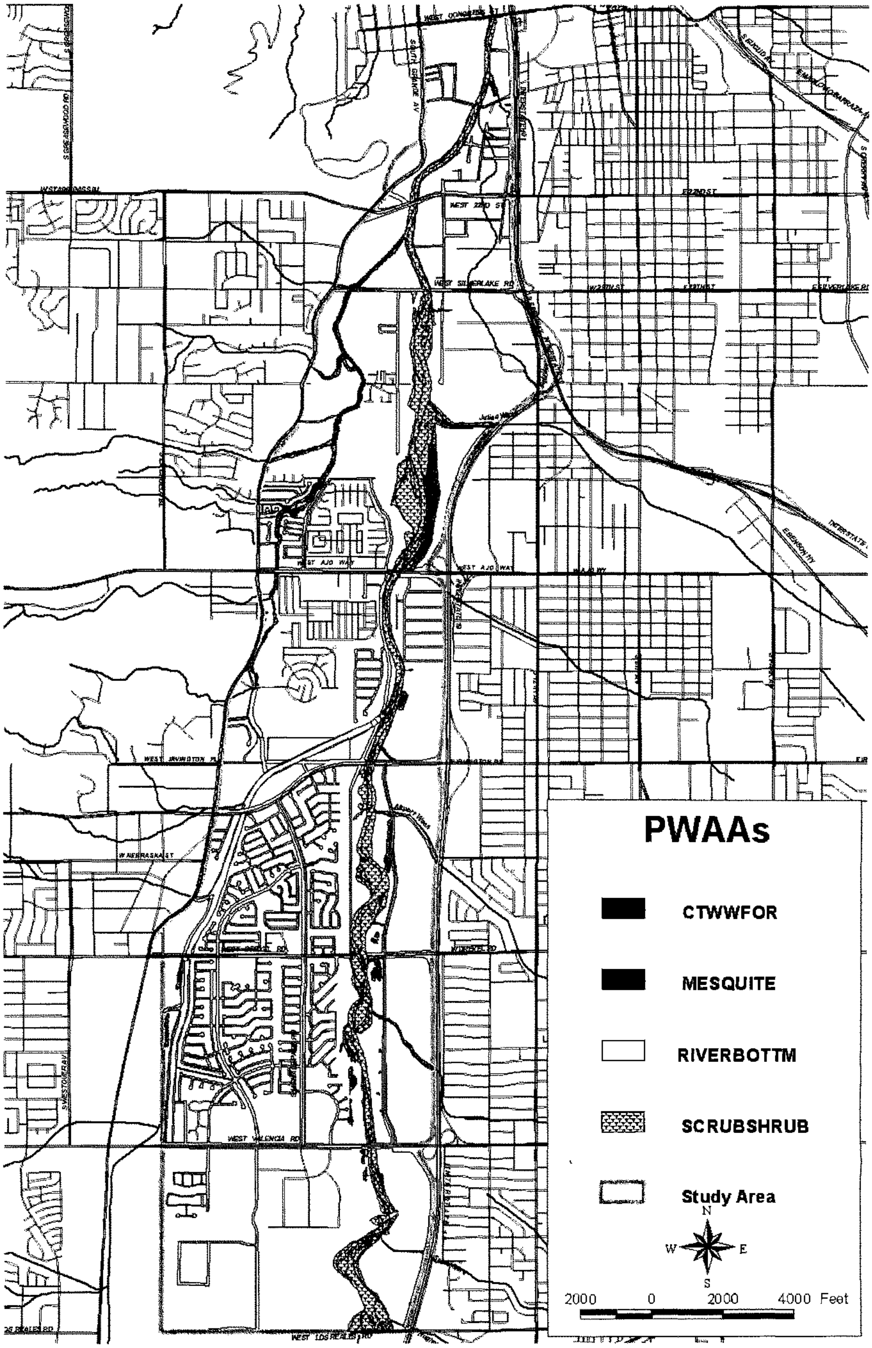


FIGURE 4.7 Distribution of Cover Types

Table 4.1 Riverine Overbank Subclass Functions

Functions Related to the Hydrologic Processes	Description
1. Maintenance of Characteristic Dynamics	The 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).
2. Dynamic Surface Water Storage and Energy Dissipation	The dynamic water storage and dissipation of energy at bank full 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.
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.
4. Dynamic Subsurface Water Storage	The availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic draw down of water table.

Functions Related to Biogeochemical Processes	Description
5. Nutrient Cycling	The abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
6. Detention of Imported Elements and Compounds	The detention of imported nutrients, contaminants, and other elements or compounds.
7. Detention of Particles	The deposition and detention of inorganic and organic particulates (>0.45 um) from the Water column, primarily through physical processes.

Functions Related to Habitat	Description
8. Maintain Characteristic Plant Communities	The 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.
9. Maintain Spatial Structure of Habitat	The capacity of a wetland to support animal populations and guilds by providing heterogeneous habitats.
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.

Sonoran Desert Wash Communities (Scrubshrub)

Scrubshrub is the name given to the desert wash plant community in the functional assessment model. This cover includes shrub-dominated communities common along the low flow channel of the river as well as those common to the floodplain fringe. A healthy Scrubshrub community supports a diverse plant and wildlife community. The existing Scrubshrub community occupies more acreage (256) than any other cover type in the study area. The majority of that acreage is on the low terraces elevated only slightly above the dry low flow channel of the Santa Cruz River. Compared to reference sites and the of model biodiversity for Scrubshrub, within the study area this cover type is severely lacking in diversity. Many of these areas have been highly disturbed in the past from the construction of bank protection, off road vehicle traffic, illegal dumping, and gravel mining activities.

Riverbottom (Cienega)

The Riverbottom includes the low flow channel, tributary channels, and the gravel and sand bars within the braided river channel totaling 173 acres. The Riverbottom should include emergent vegetation and the unique Southwestern cienega types of vegetation. The term cienega is applied in North American areas with Hispanic history to a broad spectrum of marshy and swampy areas. In the Southwest, and particularly in a seasonal cienega, low sedges and grasses dominate the plant community. This community type was once common, but no longer exists. Low flow channels and depressions within the river bottoms of the Santa Cruz River have been almost entirely eliminated. These features are barren when present so the acres listed reflect areas where the cover type would be expected to occur. Due to the composition and lack of diversity within the project area dry river bottom, low flow channel, and emergent wetlands are all combined into this one cover type. This combination is mostly non-vegetated and not sufficiently wet to support hydroriparian communities. The use of the combined acreage for Riverbottom in the HGM analysis thus results in an overestimation of the baseline ecological condition and a subsequent reduction in FCUs obtained from any alternative restoration plan.

The distribution of these Cover Types is illustrated in Figure 4.7 with acreages listed in Tables 4.2 and 4.3. The total study area includes 5,005 acres.

Table 4.2
Riparian Cover Type Acreages

COVER TYPE	ACRES
Cottonwood/Willow Forest	0
Mesquite Bosque	160
Riverbottom (includes low flow and grasses)	173
Scrubshrub (Sonoran Desert Wash Communities)	256
Total	589

Non-riparian cover designations within the study area are tabulated in Table 4.3 below:

Table 4.3
Other Cover Types in the Study Area

COVER TYPE	ACRES
AGCROP	416
DESERT	237
DITCHES	99
PARK	86
SOIL CEMENT	21
URBAN	3557
Total	4416

Baseline Functional Capacity Indices (Ecosystem Quality)

As noted above, functional capacity indices are scaled from 0.0 to 1.0. An index of 1.0 indicates that a PWAA performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under optimum conditions. 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. Baseline (existing) conditions measured within the Paseo de las Iglesias study area are shown in Table 4.4. Definitions of each function were provided in Table 4.1. FCIs were applied to study area cover types to calculate FCUs. Each of the existing Cover Types is in a degraded condition with severely limited acreages of riparian cover types and limited diversity. These results show that riparian and wetland habitats within the study area have low functional values and are therefore highly degraded.

Table 4.4
Hydrogeomorphic Functional Assessment Summary

Function Name	Weighted Functional Capacity Index (FCI)	Applicable Acres	Baseline Functional Capacity Units (TY0 FCUs)
Fxn 01: Maintenance of Characteristic Dynamics	0.200	589	118
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.692	589	408
Fxn 03: Long Term Surface Water Storage	0.188	589	111
Fxn 04: Dynamic Subsurface Water Storage	0.000	589	0
Fxn 05: Nutrient Cycling	0.339	589	200
Fxn 06: Detention of Imported Elements and Compounds	0.297	589	175
Fxn 07: Detention of Particles	0.329	589	194
Fxn 08: Maintain Characteristic Plant Communities	0.168	589	99
Fxn 09: Maintain Spatial Structure of Habitat	0.204	589	120
Fxn 10: Maintain Interspersion and Connectivity	0.197	589	116

Functions 1 to 4 are hydro-geomorphic functions. The hydro-geomorphic characteristics of a riverine ecosystem are the primary ecosystem drivers; these include flow regime, geophysical setting, intermediate-scale geomorphic processes, and anthropogenic impacts that interact and vary in importance across spatial scales in controlling stream environments and shaping biotic communities. As shown below, all but one of the FCIs for these functions are extremely low for the study area:

- *Function 1, Maintenance of Characteristic Dynamics,* is 0.20 because of the effects of channelization, modification of the channel with soil cement, past farming practices and artificially accelerated input of sediment from upstream development.
- *Function 2, Dynamic Surface Water Storage/Energy Dissipation*, has a high value that is most likely a result of the relatively wide channel in the unprotected reaches.
- *Function 3, Long Term Surface Water Storage* scored low as a result of modification of the flood prone area, construction of soil cement, disappearance of perennial flow and lack of a restrictive soil layer to slow infiltration and lack of subsurface flow.
- *Function 4, Dynamic Subsurface Water Storage*, had the lowest score possible because of the depth to groundwater levels due to pumping of groundwater in the Tucson Basin.

Functions 5 to 7 reflect the biogeochemical processes or the availability of nutrients in the ecosystem.

- *Function 5, Nutrient Cycling*, was very low with the study area due because of the lack of sources of organic material.
- *Function 6, Detention of Imported Elements and Compounds*, was extremely low due to lack of perennial flow, lack of a restrictive soil layer, lack of organic sources and a disconnected floodplain due to soil cement banks.
- *Function 7, Detention of Particles*, was very low due to modification of the flood prone area throughout the study area, culturally accelerated sediment sources upstream, and lack of organic input sources within the study area.

Functions 8 to 10 are related to the habitat within the ecosystem.

- *Function 8, Maintain Characteristic Plant Communities*, scored low because of the percent of invasives measured, the low number of plant species, the lack of obligate wetland species present and the low percentages of tree, shrub and herb canopy.
- *Function 9, Maintain Spatial Structure of Habitat*, scored low because of its low number of vegetation layers, and lack of organic debris and litter.
- *Function 10, Maintain Interspersion and Connectivity* also scored low due to lack of perennial flow, low percentages of contiguous vegetation cover between the riverbed and uplands, and modifications to tributary connections to the Santa Cruz.

Figure 4.8 illustrates the functional level of the Paseo de las Iglesias study area and Figure 4.9 displays the resultant Functional Capacity Units. All indices show that the site is poorly functioning. The average FCI is 0.26 for Paseo de las Iglesias. The lowest rated reference site, the Salt River, was rated at 0.57.

To compare Functional Capacity Units between the reference site(s) and the study area, the FCI for each reference site was multiplied times the same acreage per PWAA that exists in the Paseo de las Iglesias study area. When the Paseo de las Iglesias site is compared to the Arizona reference sites, the area has a much lower functional capacity index for desirable cover types. This illustrates the inability of the habitat within this reach to sustain itself. The average across the ten functions for the existing conditions in the study area is 154 AAFCUs, compared to the results for the Salt River reference site (the least productive of the five reference sites), which was 333 AAFCUs.

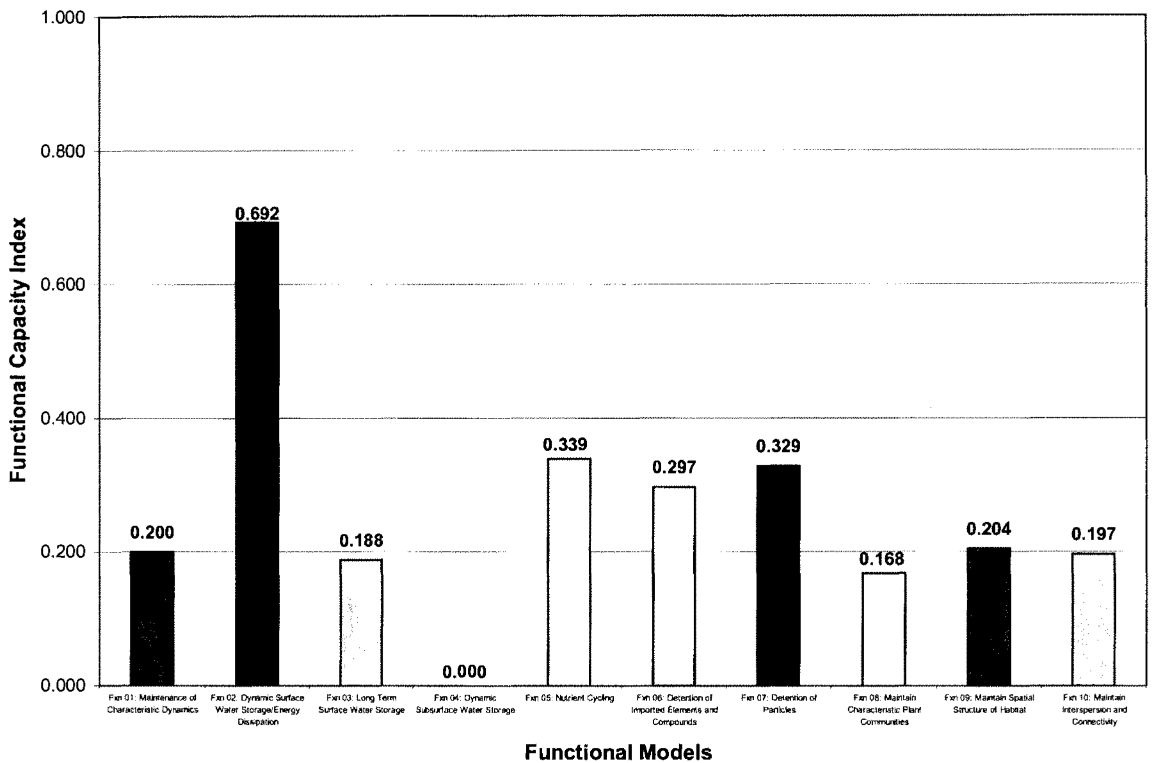


FIGURE 4.8 Baseline Functional Capacity Index Results

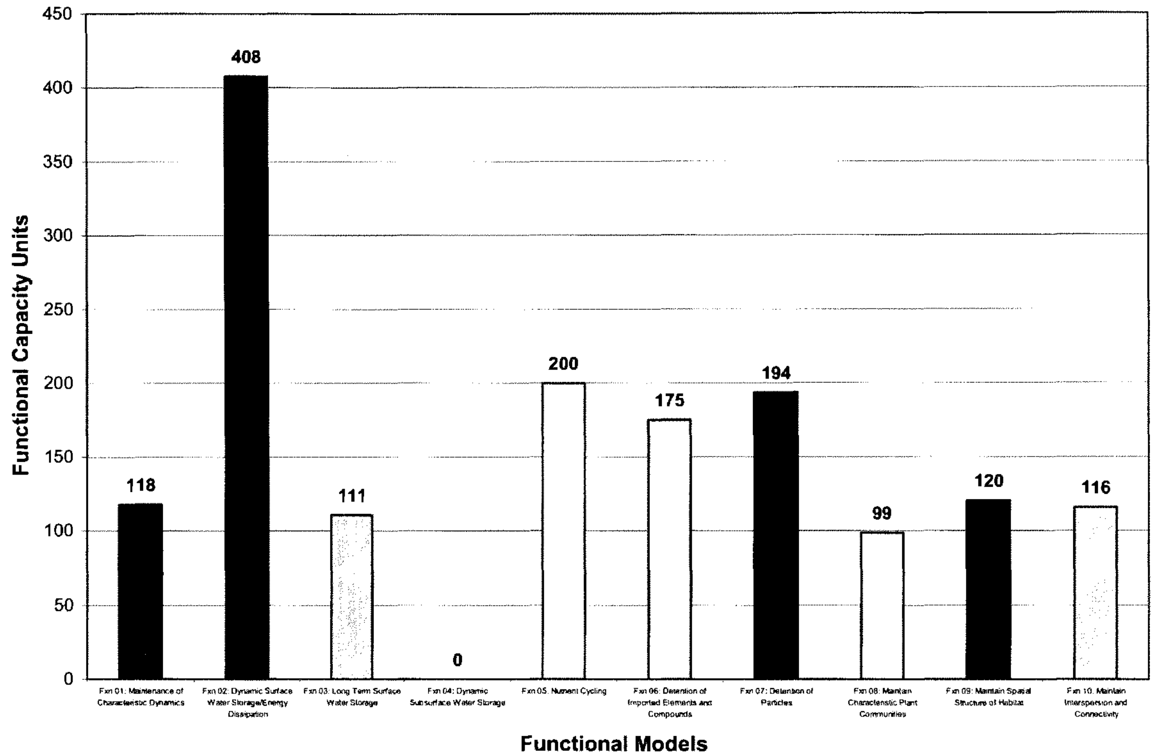


FIGURE 4.9 Baseline Functional Capacity Unit Results

4. NEPA Compliance/Issues & Concerns

Documentation of the Base Year conditions has been coordinated with the USFWS, the Arizona Department of Game and Fish and local interest groups. There are no known occurrences of threatened or endangered species in the proposed project or study area. One USFWS Candidate Species for listing, the Yellow-billed Cuckoo (*Coccyzus americanus*) may possibly occur in the study area during migration and one USFWS Species of Concern, the Giant Spotted Whiptail (*Cnemidophorus burti stictogrammus*) is known to occur in the area.

Endangered Species Act of 1973, as amended

As required by Section 7 of this Act, the Corps requested a list of threatened, endangered, proposed, and candidate species know to occur within the proposed project areas. All pertinent species information is addressed and incorporated in the Final Environmental Impact Statement.

Sensitive Areas

One particularly sensitive area is the Old West Branch of the Santa Cruz River. The Santa Cruz River once flowed through multiple channels. The Old West Branch was once the principal western channel. However, entrenchment of the eastern river channel and a water control and irrigation project in 1915 isolated the western channel, cutting off its water supply. It became known as the West Branch of the Santa Cruz River and, following construction of a flood control diversion upstream in 1980, the Old West Branch. Ironically it has been able to maintain a distinctive biological community in part because it was subjected to less scouring and entrenchment than the east branch.

5. Recreation

A survey of local parks shows substantial existing recreation in the area. Two of those parks, the Santa Cruz and the Rillito River Parks represent models for planned future park expansions of the Santa Cruz River along Paseo de las Iglesias and future development of a river park along the New West Branch of the Santa Cruz River. The Santa Cruz River Park is constructed within and adjacent to the 100-year floodplain. The park contains existing and planned segments of the Juan Bautista de Anza National Historic Trail. Along with the potential future development of River Parks within the Study Area, the City of Tucson master plan for the Rio Nuevo District includes creation of recreation areas and parks along the Santa Cruz River in the northern portion of the study area.

In addition to the planned park expansions noted above, future river parks are planned in other parts of the Tucson metropolitan area for Tanque Verde Creek and Pantano Wash. Together the Santa Cruz, Rillito, Tanque Verde Creek, and Pantano Wash river parks will function as one large unified regional trail system. In the 1997 Bond Election funding was approved for the Santa Cruz River Community Park (a sports field complex) along the east bank of the Santa Cruz River, north of Ajo Way.

The future needs for these parks, trails and recreational areas can be supported through a discussion of recreational demand and the unit day value method. Details of the recreational analysis are incorporated in the Economic Appendix.

6. Geotechnical

Topography

The study area is located near the central portion of the Tucson basin, a broad 1,000 sq. mi. valley in the Santa Cruz River drainage basin. The topography of this basin is typical of the Basin and Range Physiographic Province. Northwestward trending, steep, rugged fault block mountains border the broad, gently northwestward sloping alluvium-filled valley. The basin is about 50 miles long and is approximately 20 miles wide in the southern and central parts, narrowing to 4 miles wide at the northwest outlet. The basin is bounded on the north and east by the Tortolita, Santa Catalina, Tanque Verde, Rincon, Empire and Santa Rita Mountains, and on the west by the Tucson, Black and Sierrita Mountains. The mountains on the west side of the basin range from 3,000 to 6,000 ft. elevation, and those on the north and east side have elevations generally ranging from 6,000 to 8,000 ft., with peaks rising to elevations of 9,400 ft. The metropolitan City of Tucson resides at the approximate center of this basin at an elevation of about 2,400 ft.

Geology

The complex geological history of Arizona has resulted in the formation of three geologic physiographical provinces. The three provinces consist of the Colorado Plateau (in the northern area of the state), the Basin and Range Province (encompassing southern and western Arizona), and the Central Highlands or Transitional Zone (encompassing the central part of the state). The Santa Cruz River Watershed lies within the Sonoran Desert of the Basin and Range Physiographic Province. The north to northwest trending alluvial basin is characterized by a semi-arid to arid broad valley.

The present relief of the Santa Cruz River Basin is a direct result of a period of regional uplifting that took place during the late Tertiary (63 million to 2 million years ago) and early Quaternary (2 million years ago to present). The Basin and Range province in southwestern Arizona has been considered tectonically inactive since that period. Concurrent with the uplifting of the regional mountains, large amounts of alluvium from the surrounding mountains have been deposited within the basin (at the center of the Santa Cruz River basin, bedrock is buried by more than 11,000 feet of alluvial sediments).

Soils

The alluvial sediments deposited within the basin have been divided into four geologic units that are, in descending order of depth: surficial or recent alluvial deposits, the Fort Lowell Formation, the Tinaja Beds, and the Pantano Formation. The surficial deposits occupy the streambed channels and are generally less than 100 feet thick. The coarse surficial deposits allow the infiltration of surface water to recharge the underlying units (LMT, 2002).

Large-scale pumping of groundwater in the Tucson basin began in about 1900 and increased dramatically in the 1940s. Most of the groundwater pumped in 1940 was used for irrigation. Later, groundwater pumping volume was approximately equally divided among irrigation, municipal, and industrial uses. The centers of greatest water-level decline are along the Santa Cruz River near Sahuarita and in the City of Tucson. Declines exceeding 100 ft have occurred in Tucson and portions of the study area, while to the south along the river, the maximum decline has been about 150 ft. This difference has resulted in the formation of two distinct cones of depression in the groundwater table.

The alluvial deposits in the study area consist mainly of recent stream channel and floodplain deposits. These alluvial basin sediments are generally gravel and gravelly sand. Locally, the sediments in the study area are sand to sandy silt of fluvial origin. Lithified sediments do not crop out along the Santa Cruz River and generally, they should not be present within excavation depths of the channel for structure installation, though such formations do approach the riverbed elevation in the vicinity of 22nd Street.

The material generally encountered within the banks was typically fine sandy silt. This material is not layered and has little plasticity but is cemented. There are very few cobble-sized rocks within this sandy silt material. The stability of the existing native embankments is marginal due to the existence of two conditions. One, the natural cementation of the soils allows the banks to stand at a near vertical inclination at many locations along the reaches of the study area. The vertical banks, when impacted by stream flow, are susceptible to being undercut at the bottom and collapsing into the streambed. The undercutting occurs mainly by water breaking down the weak cementation present in the silty material. The second form of stream bank erosion is piping. The particle size of the slope embankment material is such that it is very susceptible to piping. Either surface or subsurface water flowing over or beneath the banks form large cavities or cave-like structures as the materials are removed by piping thru the embankment and out its face.

Any plan to construct features associated with ecosystem restoration or stabilize the slopes would have to be implemented during the dry season when the Santa Cruz River is not flowing. Wet seasonal times and, consequently, stream flow can be expected to occur during the monsoons of late July and August, the early fall time of late September and October, and during the December and January winter rains. During these times, the channel can fill up with flow extending from bank to bank. As the predominant material comprising the channel bed is a fine gravelly sand, bed infiltration during flows and quick drainage of the bed material occurs once the stream flow subsides. Deep borings for the bridges have shown the presence of clay layers on which perched water could and, in some cases, does reside. In addition, there are cemented soils and/or rock at relatively shallow depths near 22nd and 29th (Silverlake) Streets. The depth of such formations is typically more than 20 ft. below the streambed elevation and, thus, would not affect construction.

Subsidence

Groundwater depletion in the Tucson basin has caused the aquifer system to compact (LMT, 2002). This compaction, in turn, has resulted in large areas of land subsidence, a problem that exists in other parts of the Basin and Range province of southern Arizona.

The area of greatest potential land subsidence in the Tucson basin is from the Davis-Monthan Air Force Base area to south of Sahuarita, where water-level declines have been large. The U.S. Geological Survey (USGS) is currently using seven vertical extensometer installations (VEIs) to measure and monitor aquifer compaction and water-level changes in the Tucson Basin. The closest VEI to the study area is located about 2-1/4 miles south of the Rillito River at First Avenue and about 2-1/2 miles northeast of the north end of this study area. A total of about 0.04 ft of aquifer compaction was measured at this installation. This amount would correspond to a minimum subsidence rate of less than 0.01 ft/yr.

Land subsidence was also identified and measured by National Geodetic Survey re-leveling in the Tucson basin in 1980. Results indicated that from 1951-54 to 1979-80, land subsidence ranged from less than 0.1 ft to almost 0.5 ft. The largest amount occurred southeast of Tucson in an area south of Davis-Monthan Air Force Base, approximately 7 to 10 miles east of the Santa Cruz River channel. Subsidence generally was small in relation to water-level decline in the basin during this period. Long-term data indicate a ratio of subsidence to water-level decline of generally less than 0.003 foot per foot. More detailed information regarding land subsidence can be found in the Geotechnical Appendix.

Existing Landfills

Five landfills have been documented within the study area boundaries. Specific information on each landfill can be found in Appendix G, Phase I Site Assessment. These landfills have the potential to affect local groundwater, surface water and soils quality, depending on landfill contents and the potential mobility of contaminants. Contents of these landfills include but are not limited to municipal solid waste, construction debris, inorganic and organic debris, and tires. Wildcat dumping in and near the river channel has also occurred over the years, however it does not appear that the river channel has been subject to prolonged commercial or industrial waste disposal activities.

Due to potential voids, decomposition of materials and lack of compaction during filling, these existing landfills can pose engineering and/or structural risks to restoration efforts on or near the landfills. Chemical hazards could be created during excavation of landfill materials for possible grading or installation of water distribution lines. Construction or excavation on or near the landfills should be prohibited, unless potential hazards are fully characterized and mitigated.

For any restoration efforts in the river channel or historic floodplain, trash and debris should be removed to preclude this deleterious material from contributing to surface or groundwater contamination or detracting from the environmental benefits of restoring riparian habitat.

Phase I Environmental Site Assessment

Seventy-two aerial photographs, taken in 1930, 1959, and 1963 through 2001, were reviewed. The aerial photograph review did not reveal evidence of Reportable Environmental Conditions (RECs). The most recent (1954, photo-revised 1992, text revised, 1995) USGS topographic map of the site did not reveal evidence of any REC's.

As part of the Phase I Environmental Site Assessment, applicable Federal and state environmental regulatory databases were reviewed. Twenty-three sites were identified in the database search that may cause contamination due to migration of contaminants if the sites are not monitored and maintained properly. During a site reconnaissance, debris was observed throughout the entire length of the subject area. Based on the wide distribution of the disposal sites and the contents of the debris piles (papers, boxes, food and beverage containers, scrap wood and metal, household trash, furniture, appliances), it does not appear that the river bottom has been the site of prolonged commercial or industrial waste disposal activities.

Davis-Monthan Air Force Base is located approximately 7 miles from the study area to the east and southeast. No evidence was found suggesting the presence of groundwater contamination from the base that would pose a problem in the study area.

The site reconnaissance did not reveal evidence of any REC's. The study area could be affected by migration of contaminants from facilities observed nearby and/or identified in the environmental regulatory databases. In most instances, only catastrophic releases would result in impacts to the subject site from off-site facilities. On-site landfills have the potential to affect groundwater, surface water and soil quality, depending on landfill contents and potential mobility of contaminants. Further investigation should be made into the wealth of documents and research that are available.

Due to voids, decomposition of materials, and lack of compaction during filling, the landfills can pose engineering and structural risks with respect to structures built on or near the landfills. Chemical exposure hazards could be created during excavation of landfill materials for possible building or utility construction. Construction or excavation on or near landfills should be prohibited until potential hazards are fully characterized and mitigated. Additional details may be found in Appendix G Phase I Site Assessment.

7. Hydrology

Climate

The climate in the Santa Cruz River Basin is typically desert in character with short, mild winters and long, hot summers. High diurnal temperature variations are characteristic of the region. Temperature extremes range from about 12° Fahrenheit in the winter to 122° Fahrenheit in the summer. The prevailing winds are from the east and are usually light, although severe windstorms occur at rare intervals. Mean annual precipitation ranges from 11 inches in the valleys to over 37 inches at elevations greater than 8000 feet NGVD. Studies conducted in the Tucson vicinity show an extremely low percentage (about 1%) of the rainfall appears as runoff, generally evaporating or returning to groundwater. Precipitation occurs in two distinct seasons of the year; summer -late June, July, August, September, and into October); and winter –(December, January, February, and March).

Monsoon Season

Summer rains in the form of thunderstorms originating in moist air that flows into Arizona from the Gulf of Mexico generally occur in middle to late afternoon and are usually of local extent. Approximately 80% of the thunderstorms over the basin occur in the summer months. Floods associated with summer thunderstorms can be extremely flashy (up to 3 hours), and are of short duration.

Cyclonic Season

Some general summer storms do occur during the period July through September. They are associated with an influx of tropical maritime air originating over the Gulf of Mexico or the South Pacific Ocean and entering the area from a southeast or a southwest direction. Usually the influx of tropical air is caused by the circulation about a high-pressure area centered in the southeastern United States, but occasionally is caused by remnants of a tropical hurricane. There is often relatively heavy precipitation for periods of up to 24 hours and showers may continue intermittently for as long as 3 days. Flooding commonly covers a wide area with durations of about 24 hours.

Frontal Season

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 areal extent, with slow and steady intensity. Winter floods from these storms are of longer duration with lower flood crests.

Floods can occur from heavy thunderstorms, but are typically of short duration (lasting up to three hours). The frequently occurring 2-year, 6-hour event in Tucson is about 1.5 inches of rainfall. The extreme 100-year, 6-hour event is about 3.6 inches in Tucson. Occasionally, longer-term summer storms occur, associated with tropical storms from the Gulf of Mexico or the Pacific Ocean. These storms may provide heavy precipitation for up to 24 hours, causing longer lasting flood events (24 hours or more). The 2-year, 24-hour event is about 1.8 inches in Tucson. The extreme 100-year, 24-hour event is about 4.6 inches in Tucson. The mountainous areas may receive up to 5.5 inches during a 100-year event. Winter storms provide lesser amounts of precipitation and are associated with frontal storm systems from the Pacific Ocean.

Stormwater Runoff

While all surface flows in the study area are ephemeral in nature, storm flows can be of a high magnitude. The Santa Cruz River flood of 1983 was estimated at approximately 53,000 cfs at Tucson. This discharge is 1.8 times the previously estimated 100-year (regulatory) discharge of 30,000 cfs at Tucson. As a result of that flood, the validity of the 30,000 cfs estimate had been called into question by local regulatory agencies. Several new estimates had been prepared, ranging from 30,000 cfs to 100,000 cfs. Historically, the flood frequency estimates by the U.S. Army Corps of Engineers (USACE), the U.S. Geological Survey (USGS), the Federal Emergency Management Agency (FEMA) and some local jurisdictions were at odds with one another. This has the effect of resulting in a loss of opportunity for the various entities to work together on floodplain management and flood control projects toward common goals.

Investigations aimed at resolving these differences were conducted as part of the Corps' Gila River, Santa Cruz River Watershed Study (August, 2001). Throughout that analysis the Corps met regularly with the a Hydrologic Task Force whose members included representatives of the Arizona Department of Water Resources, the Arizona Department of Transportation, Pinal County, Natural Resources Conservation Service, Santa Cruz County, United States Geological Survey, the Flood Control District of Maricopa County the Pima County Department of Transportation and Flood Control District. The analysis conducted for that study separated annual peak flow data into three sub-populations: summer thunderstorms (generally occurring from June through August), dissipating tropical cyclones (generally occurring in September and October) and winter storms (generally occurring from November through March). That analysis incorporated comments from the task force and resulted in discharge frequency estimates which more closely approximated local estimates and were accepted by the task force. The estimated frequency discharges relationships for Tucson resulting from that analysis are presented in Table 4.5 below.

Table 4.5
Santa Cruz River: Mixed Population Frequency Analysis
Combined Results (cubic feet per second)

Location	Drainage Area sq. mi.	500-yr	200-yr	100-yr	50-yr	20-yr	10-yr	5-yr	2-yr
Tucson	2,222	120,000	75,000	55,000	35,000	17,000	14,000	9,500	4,900

The City of Tucson Report "Existing Conditions Hydrologic Modeling for the Tucson Storm water Management Study (TSMS), Phase II, Storm water Master Plan, Task 7, Subtask 7A3" provided the hydrologic analysis for existing (baseline) storm water quantity conditions for tributaries along the Santa Cruz River within the City limits.

The results of that analysis are presented in Table 4.6.

Table 4.6
Santa Cruz River Tributary Washes Frequency Analysis
Data at the Confluence of Washes with the Santa Cruz River (cubic feet per second)

Tributary Names South to North	WS Acres	100-yr	50-yr	25-yr	10-yr	5-yr	2-yr
Hughes Wash	5336	2376	1875	1258	738	334	93
Santa Clara Wash	250	389	314	221	143	86	47
El Vado Wash	1468	1558	1327	1003	716	474	287
Valencia Wash	1047	1510	1292	1026	721	441	230
Airport Wash	14546	5164	3981	2691	1549	7740	346
Wyoming Wash	449	877	719	519	335	184	82
Irvington Wash	161	427	343	237	145	75	40
Rodeo Wash	5371	3453	2839	2448	1340	744	321
Julian Wash	27859	5962	4767	3202	1901	945	389
Mission View Wash	1039	1802	1538	1201	885	599	355
18th Street Wash	2345	3085	2503	1921	1363	886	523
Cushing Street Wash	323	1165	993	770	562	375	221
Ajo Wash	1224	3465	2817	2007	1286	689	242
Enchanted Hills Wash	1989	3968	3270	2386	1540	801	256
San Juan Wash	731	1757	1470	1104	757	423	152
Cholla Wash	833	2273	1882	1379	920	529	224
Old West Branch at Confluence with SCR	9543	6621	5417	3818	2447	1352	397
New West Branch at Confluence with SCR		9908	7925	5250	3665	2020	595

Water Budget

At Tucson station located in Congress Street bridge, average daily stream flow rates are 17 cfs to 90 cfs in summer (July-October) and 11 cfs to 42 cfs in winter (December-February) and the annual average daily stream flow rate is 24.4 cfs. Maximum monthly stream flow rates are 312 cfs to 682 cfs in summer (July-October) and 202 cfs to 895 cfs in winter (December-February) and the annual maximum stream flow is 112 cfs. An average daily flow of 1 cfs was exceeded during 17% to 43% of the record during the summer season (July-August-September). Average daily flows of 10 cfs, have been exceeded from 12% to 30% of the record. In the winter months (December through March), average daily flows of 1 cfs were exceeded in 7% to 14% of record. Average daily flows of 10 cfs were exceeded in 5% to 8% of the record. During the remaining months (October-November, April-June), there are zero flows in upwards of 92% of the record.

Data concerning flows at tributary confluences is important since the flows at the end of flood events represent a portion of the potential quantities of storm water that might be harvested to support restoration efforts. There are nineteen notable tributaries joining the

SCR in the study reach. Twelve tributaries – Hughes Wash, Santa Clara Wash, El Vado Wash, Valencia Wash, Airport Wash, Wyoming Wash, Irvington Wash, Rodeo Wash, Julian Wash, Mission View Wash, 18th Street Wash, Cushing Street– join the East bank, while seven tributaries – Ajo Wash, Enchanted Hills Wash, San Juan Wash, Cholla Wash, Old West Branch at Confluence with SCR, New West Branch at Confluence with SCR, Los Reales Road – join the West bank of the Santa Cruz River. Stream flow data are generally not available for tributaries.

Additional analysis for Groundwater and Water Budget Analysis was performed in support of this study. As shown in Table 4.7, eleven of the tributaries are urban tributaries and eight tributaries are rural or natural tributaries. Most of east bank tributaries are relatively urban while west bank tributaries are relatively rural or natural. Average annual tributary runoff is 9,020 AF, 3,535 AF from urban watersheds, and 5,485 AF from natural watersheds. To estimate average monthly runoff volume (Table 4.7), the percentage of annual runoff volumes from the available records of the gauged watersheds was used. Based on the results, the runoff from urban watersheds is more available in July, August, and September, while the runoff from rural or natural watersheds is more available in December, January, February, and March.

Minor ephemeral flows from several tributaries, in addition to ephemeral flows within the Santa Cruz River, provide a source of water that is sufficient to support only minor (less than 5% of the river corridor) patches of riparian habitat. There can be considerable variation in the timing of these flows from the various tributaries and the main river. The 100 feet or more to existing groundwater, in combination with insufficient flows to support habitat, result in an existing conditions water budget that is incapable of supporting larger amounts of habitat. More efficient capturing and retention of the existing flood flows within the study area may result in an incremental increase in the amount of habitat that is supportable.

In addition to runoff, both reclaimed water and treated effluent are potentially available to support restoration. Reclaimed water lines cross the northern portion of the study area just south of Congress Street and parallel the study area to the east as far south as Ajo Way. A spur line crosses the Santa Cruz River and the Old West Branch just south of their confluence. Extensions of existing lines are planned for the next five years. These new lines will extend the line paralleling the study area south from Ajo Way to Drexel with a spur running west along Ajo Way, south along the Santa Cruz River to Irvington and then west across the rest of the study area. While delivery systems are not in place, wastewater treatment plants within several miles of the study area represent potential sources of treated effluent that could be used to support restoration.

Table 4.7
Average Annual Runoff for Tributaries

Tributary Names	Drainage Area (mi^2)	Drainage Area (Acres)	Impervious Area (Acres)[1]	Impervious Area (%)	Basin Rainfall (inch)	Urban[2]	Natural or Rural[3]	Ave. Annual Runoff (AAR_u) for Urban (Acre-ft)	Ave. Annual Runoff (AAR_n) for Natural (Acre-ft)
Hughes Wash	8.3	5,337.5	320.3	6.0%	11.55		X		486.3
Santa Clara Wash	0.4	249.6	74.1	29.7%		X		77.6	
El Vado Wash	2.3	1,465.6	524.7	35.8%		X		150.7	
Valencia Wash	1.6	1,049.6	436.6	41.6%		X		135.1	
Airport Wash	22.7	14,547.0	1,265.6	8.7%	11.55		X		1,228.2
Wyoming Wash	0.7	448.0	109.3	24.4%		X		82.7	
Irvington Wash	0.3	160.0	38.9	24.3%		X		72.7	
Rodeo Wash	8.4	5,369.5	1,127.6	21.0%		X		275.2	
Julian Wash	43.5	27,858.9	5,627.5	20.2%		X		2,174.8	
Mission View Wash	1.6	1,036.8	500.8	48.3%		X		146.4	
18th Street Wash	3.7	2,342.4	958.0	40.9%		X		237.1	
Cushing Street Wash	0.5	320.0	183.4	57.3%		X		93.8	
Ajo Wash	1.9	1,222.4	55.0	4.5%	11.55		X		124.6
Enchanted Hills Wash	3.1	1,990.4	13.9	0.7%	11.55		X		195.5
San Juan Wash	1.1	729.6	16.1	2.2%	11.55		X		77.3
Cholla Wash	1.3	832.0	151.4	18.2%		X		89.0	
Old West Branch at Confluence with SCR	10.2	6,540.7	529.8	8.1%	11.55		X		586.8
New West Branch at Confluence with SCR	33.2	21,247.8	2,124.8*	10.0%	11.55		X		1,743.0
Los Reales Road	19.1	12,198.3	731.9*	6.0%	11.55		X		1,043.8
Total	164.0	104,946.1	11,933.0					3,535.0	5,485.6

*-Assume based on Aerial Photo.

Impervious Area (Acres)1- Source is HEC-1 Brief Summary provided by PIMA County.

Urban2-Assume the urban if impervious area (%) is greater than 10%.

Natural or Rural3-Assume the natural or rural if impervious area (%) is equal or less than 10%.

8. Base Year (2012) Floodplain

The results of the hydraulic analysis of the Santa Cruz River, Old West Branch, New West Branch and Los Reales Improvement District are presented below:

Santa Cruz River

The 2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-year frequency flood events were simulated for the Santa Cruz River. This study reach of the Santa Cruz River was determined to contain between a 50- and 100-year capacity. The bridges within the study reach would not be overtopped during the 100-year flood event. The 200-, and 500-year flood events would overtop the channel banks and bridges.

The floodplains may be found in the Hydraulics Appendix. In the narrower reaches, the channel is generally inundated bank to bank by the 2-year flow. In the wider reaches, it requires a 10 to 20-year flow to inundate the channel bank to bank. No structures would be inundated by the 100-yr flood event. However, the 200- and 500-year flood events would inundate 132 and 1,972 structures, respectively.

Old West Branch

Only the 100-year flood event was simulated for the Old West Branch. The capacity of the channel is approximately 1000 cfs before the banks are overtopped. The 100-year flood event would overtop the channel banks. The 100-yr floodplain may be found in the Hydraulics Appendix. Breakouts were found to between Stations 4.0 and 17.0. Silverlake Road Bridge at Station 4.1 would likely be overtopped. The backwater caused by the bridge would cause the breakout between Station 5.0. Low channel banks would cause the rest of the breakouts.

New West Branch

The 2 through 500-year frequency flood events were simulated for the New West Branch. The New West Branch channel was determined to have a flood conveyance capacity of between the 50 and 100-year flood events. The 100 through 500-year flood events will overtop the channel banks, primarily the left overbank, looking downstream. The breakout over the weir (left levee) extends approximately 760 feet where flood depths of approximately one (1) foot are experienced. The 100-, 200-, and 500-year floodplains may be found in the Hydraulics Appendix.

Los Reales Improvement District

The 2 through 500-year frequency flood events were modeled. The more frequent (2, 5, 10-year) flood events were contained within the existing channel. The 25, 50, 100, 200, and 500-year flood events resulted in shallow sheet flow flooding and may be found in the Hydraulics Appendix.

9. Economics

Four floodplains for analysis are described in detail below.

1. *The Paseo de las Iglesias Segment of the Santa Cruz River*-- Certain areas of Paseo de las Iglesias have been channelized and embanked with soil cement up and downstream of the Valencia Road Bridge, between Irvington Road to Ajo Way, and from Silverlake Road to Grant Road. The remaining stretches that lack channel stabilization are located between Los Reales Road and Irvington Road, and between Ajo Way and Silverlake Road. The Santa Cruz River channel contains the 100-year flood throughout most of the study area. However, some localized areas are still susceptible to lower frequency flood events. The first area is located on the west bank of the river from Congress Street but switches to the east bank toward 22nd Street. A second area is located on both banks of the river south of 22nd Street, but most of the flooding is on the west bank of the river near the Old West Branch of the Santa Cruz River. The third area is located on both banks of the river just south of Ajo Way. The fourth area is susceptible to 500-year flooding located on the west side of the river south of Drexel Road.
2. *The Old West Branch of the Santa Cruz River*—The Old West Branch, located west of the Santa Cruz River between Irvington Road and 22nd Street. This arroyo does not have any channel embankment and 100-year flows flood the area between the Old West Branch and the Santa Cruz River. The area where most of the 100-year flooding occurs is between Silverlake Road and Ajo Way. (Since discharge frequency values other than the 100-year were unobtainable, the US Army Corps of Engineers and the non-Federal sponsor have agreed to limit the analysis to 100-year flow data.)
3. *The New West Branch of the Santa Cruz River*--The New West Branch, located west of the Santa Cruz between Valencia Road and Irvington Road, has been channelized and embanked. At Irvington Road, the New West Branch channel joins the Santa Cruz River. Some damages result from overtopping by the 100 through 500-year flood events.
4. *The Los Reales Area*--A small area on the New West Branch between Valencia Road and Los Reales Road experiences shallow flooding.

Tables 4.8 & 4.9 provide a summary of reach delineations (each starts at the downstream end of each stream and moves upstream), including stream name, and beginning and ending cross-sections for each reach.

Table 4.8
Reach Delineation for the Santa Cruz River

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
1 SC	Congress St. 22nd Street	Santa Cruz River	32.61	33.38
2 SC	22nd Street Ajo Way	Santa Cruz River	33.38	35.77
3 SC	Ajo Way Irvington Rd.	Santa Cruz River	35.77	36.630
4 SC[1]	Irvington Rd. Drexel Rd.	Santa Cruz River	36.630	37.87
5 SC	Drexel Rd. Valencia Rd.	Santa Cruz River	37.87	38.96

[1] 4 SC will not be listed on tables following this one because this reach produced no damages

Table 4.9
Reach Delineation for the New West Branch and Los Reales Areas

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
OWB	22nd Street Ajo Way	Old West Branch	0.50	29.00
1 NWB	Irvington Rd. Drexel Rd	New West Branch	1.00	17.00
2 NWB	Drexel Rd Valencia Rd	New West Branch	17.00	26.00
LR	Valencia Rd. Los Reales Rd.	Los Reales	51.00	78.1

Without-project structure and content damages were computed utilizing the HEC-FDA Flood Damage Reduction Model. The model computes equivalent annual damages based upon the input parameters of structure data, category of structure (single family residence, multi-family residence, public, commercial, industrial, mobile home), stream location, ground elevation, first floor elevation, structure value and content value. These parameters are compared with hydrologic and hydraulic data including frequency-discharge and stage-discharge relationships. Data was input including the appropriate risk and uncertainty variables, for the base year (2012) and the future condition (2062).

Tax assessor data aided in further description of the floodplain by verifying structure inventory data obtained through field survey and providing square footage estimates. Because property delineations in the tax assessor's data are by parcel and not by the number of structures, the individual parcel for residential and non-residential categories may include more than one structure. For example, a residential parcel may include more than one apartment building. Likewise, a non-residential parcel may include more than one office building. In these cases, aerial maps and information gathered during the visit to the study area were relied upon to obtain the number of structures by reach and structure type. Replacement values were computed using the method from Marshall and Swift with depreciation computed using standard techniques. The number of structures shown by frequency is shown in Table 4.10.

Table 4.10
Number of Structures by Frequency for Each Floodplain

Floodplain	50 yr	100 yr	200 yr	500 yr
Santa Cruz	0	0	132	1972
Old West Branch	NA[1]	583	NA	NA
New West Branch	0	222	503	1126
Los Reales	24	47	62	119

[1]NA means overflows were not available for the frequencies listed; therefore structures could not be counted and included in Table 4.11.

The results of the base year computations are presented in Tables 4.11 and Table 4.12 below, which display the expected annual damages for the base year condition using current (2004) price levels.

Table 4.11
Without Project Conditions Santa Cruz River Expected Annual Damages

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
1 SC	$38,030	$29,390	$310	$2,140	$0	$69,870
2 SC	$24,770	$39,730	$24,970	$19,770	$1,710	$110,950
3 SC	$27,690	$97,960	$106,150	$15,600	$11,100	$258,480
5 SC	$77,810	$4,140	$0	$0	$0	$81,940
Total	$168,300	$171,210	$131.42	$37,510	$12,810	$521,250

Table 4.12
Without Project Conditions New West Branch River and Los Reales Area Expected Annual Damages

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
OWB	$48,075	$0	$357,820	$317	$0	$406,212
1 NWB	$0	$0	$141,330	$0	$0	$141,330
2 NWB	$51,000	$0	$0	$0	$13,260	$64,260
LR	$99,320	$3,190	$3,100	$980	$1,150	$107,740
Total	$198,395	$3,190	$622,910	$1,297	$14,410	$719,542

10. Socioeconomics

Three primary areas of employment in Pima County are education, government, and the military. Sources of employment in the education sector include the University of Arizona, Pima County Community College, and the Tucson Unified School District. Government offices offer employment in the state, county and city level. Two military establishments provide further employment opportunities. They are Davis-Monthan Air Force Base and Raytheon Missile Systems Company. All three areas of employment generally require a higher percentage of professional and technical skills as well as some college education. This helps to explain why 24.70 percent of persons employed in Pima County fall within the professional and technical occupations.

This demand for higher paying jobs, combined with steady population growth, may explain why Pima County has enjoyed a low unemployment rate as much as 1.2 and 1.8 percentage points lower than Arizona and the United States. In 2002, local unemployment was 4.9 percent compared with 5.7 percent for Arizona and 6.0 percent for the United States (2003 Pima Association of Governments data).

Construction of housing units has been increasing over the last decade. To accommodate the population expansion in the area, 50,301 housing units were built over the previous nine years. A total of about 348,508 housing units were constructed in Pima County before 1999. This figure is up from 298,207 housing units built before 1990. In fact, the 1999 American Community Survey Profile for Pima County, Arizona, indicated that about 21 percent of the housing stock has been constructed in the past ten years. Most of the newer homes in master planned communities are reasonably priced compared to other metropolitan areas. The average cost of a new single family home is about $109,000, a primary factor making the overall cost of living in Pima County among the lowest of major U.S. metropolitan areas.

C. Future Without-Project Conditions

1. Definition of Future Without-Project Conditions

The future without-project conditions for the 50-year planning horizon describe the most likely future conditions that are expected without a Federal project. It consists of the base year 2012 conditions projected to a future year 2062 utilizing reasonable assumptions of how the base year conditions may change in the absence of any Federal project. The base and future year without-project condition are used to compare and evaluate any proposed actions that are developed.

2. Basic Assumptions

It is assumed that no new ecosystem restoration or flood control projects will be in place before construction of a Federal project. In the event that a new feature is constructed by local interests before such authorization, the feature may be considered as an integral and compatible part of the Federal plan if prior approval is obtained.

South of Valencia Road, along both sides of the River, there are approximately 400 acres of land recently used for sand and gravel extraction. Industrial development continues adjacent to this area. Both public and private interests have prepared numerous development concepts for this area, primarily because of its marketable location along the Interstate 19 (I-19) corridor. The sand and gravel operation is expected to close as a commercial operation before 2012.

Along the east side of the River, between Valencia and Irvington Roads, the Desert Vista Campus of the Pima Community College (PCC) just south of Drexel Road, and east of the Santa Cruz River is projecting an increase in student enrollment in response to the area's growing population and a subsequent expansion of facilities to meet this demand. Other emerging development in this area includes business park uses (Honeywell facility immediately north of the PCC campus), and "Big Box" home improvement and discount stores just south of Irvington. Although the City of Tucson and Pima County own land immediately adjacent to the east bank of the River in this area, land that is privately held in this area will come under increased pressure for commercial development and industrial park development, due to its proximity to I-19.

Given this location and the history of past development in the metropolitan area, the future without-project conditions suggest the following scenario. If river restoration does not occur, it is anticipated that private development will alter the existing ecosystem in this area. As privately held land develops for commercial and park industrial uses (highest and best use based on market demand), adjacent publicly owned areas, available for restoration of upland habitat, preservation of cultural resources, and associated recreational amenities, will come under increased development pressure. Real estate values will rise in response to market demand. In order to maximize development acreage in areas adjacent to the River, a conventional, engineered solution for bank protection and erosion control (i.e., soil cement) would likely be implemented, and there would be minimum development setbacks from the River (according to local land use codes, setbacks can be reduced following construction of structural bank protection measures, City of Tucson Planning Department, 1998).

Although the above development scenario would include trail and recreation amenities (e.g., River Park) as mitigation for bank protection, the River's east corridor would have lost any remaining natural resource value.

The River segment that lies between Irvington Road and Congress Street has experienced minimal development in the past five years, as compared to areas in the southern portion of the study area. However, this may change since the City of Tucson is embarking on a major urban revitalization project (Rio Nuevo) for a large parcel immediately west of the River, between Congress and 22nd Streets. In addition, the larger Rio Nuevo district concept will promote residential, commercial, and public development in areas that are vacant and in close proximity to downtown and the River's eastern bank.

As a result of development pressures and the availability of residentially-zoned land, population is likely to increase along this 7-mile reach of the Santa Cruz River, regardless of project status. Without-project, the unprotected river banks will most likely be soil cemented, thus greatly decreasing native vegetation growth and the floodplain area. In addition, the use of soil cement would increase the amount of developable land in the study area and result in increased residential and non-residential development adjacent to the River. This development would greatly reduce, if not preclude, the opportunity for ecological restoration and that would accrue from an integrated program of water resources and riparian restoration.

Increased development will reduce or eliminate restoration opportunities. Over the past century, a reduction in vegetation adjacent to the River has resulted in an exponential loss of wildlife habitat. Without-project, this trend is expected to continue at an accelerated rate, due to the pressures of urbanization and competing demands on water and other resources within the region. Although the characteristics of this environmental decline will vary within the study area, the overall effect will be the reduction of existing habitat value. This loss of value is reflected in the decrease of the HGM-generated average Functional Capacity Index for the study area from 0.26 in the base year to 0.18 in year 51 and the accompanying reduction in Function Capacity Units from 154 to 32.

3. Recreation Demand

Many factors contribute to make the proposed riparian habitat areas in the study area attractive in terms of their potential to meet unmet demand for passive recreation. Those factors include:

1. *Recreation Experience*--Proposed general recreation activities for the study area include trails for hiking, biking, and jogging. Among the activities identified, most have unmet demand.
2. *Availability of Opportunity*--The proposed facilities along the Paseo de las Iglesias and New West Branch will provide opportunity for many urban individuals to recreate close to their homes, work, and downtown
3. *Carrying Capacity*--As previously discussed, Pima County has experienced rapid population growth. Pima County's MSA population is 843,746 at year 2000 and is expected to reach 1,518,000 by year 2025—a difference of 674,254 over 25 years. With this increase in population comes an increased demand for recreational facilities.
4. *Accessibility*--According to 43% of the Arizona Trails 2000 survey respondents, loss of access to trails is one of the top three most important issues facing trail users today.
5. *Environmental*--As demonstrated earlier, there are several recreation areas located in the study area. Of these parks, there are no thriving riparian areas.

Recreation demand in the study area is expected to grow steadily in the future due to regional population growth and increased tourism.

4. Geotechnical

The following determinations have been made regarding the future without project geotechnical conditions:

- Subsurface conditions would not prevent the construction of engineered bank stabilization measures, if justified.
- Seismicity is not a constraint on the implementation of a project in the Paseo de las Iglesias study area.
- Existing landfills are likely to be remediated and developed upon. Specific information regarding landfill contents, remediation plans, and expected condition of landfill areas following remediation can be found in the Phase I Site Assessment, Appendix G.
- Addition of soil cement bank protection will likely encounter known and unknown landfill material during excavations just as previous soil cement projects encountered.

5. Hydrology

Consideration of increases or decreases in watershed runoff was made in order to predict study area discharge changes for the year future Without-Project condition. The magnitude of the peak discharges (see Table 4.5) on the Santa Cruz River through the study area are not expected to increase significantly. This is attributed to the large size of the contributing watershed (2,222 sq. mi) and the negligible impacts of future urbanization on the remaining developable lands within this watershed on infrequent storm events.

For the Santa Cruz River tributaries, the magnitude of anticipated future growth in Tucson area was also investigated based on the City's development plans, storm water management regulations for new development, amount of available developable land, and existing or planned storm water infrastructure. Local storm water and floodplain management regulations, which place retention & detention requirements on new developments, require developers to maintain pre-development peak discharges (2- 5- 10- 25- 50- and 100- year) to avoid creating and/or compounding downstream flooding. It is likely that in the future without-project condition peak discharges on some of the tributary watercourses may increase, but the increases are anticipated to be insignificant compared to peak discharges and hydrograph timing on the Santa Cruz River mainstem.

6. Hydraulics

The future without project condition includes continued bank erosion in unprotected reaches with degradation to the existing closed landfills. The channel degradation trend will likely continue in spite of being stable since the 1980's. Depth to groundwater will likely continue to increase; however, the goal of the Tucson Active Management Area is to balance the groundwater withdrawal and recharge rates and has a statutory goal of achieving a safe-yield basin-wide balance by 2025. Based on without project conditions hydrology, the 2 – 500-year floodplain limits will not change.

7. Economics

Economic damages include damages to structures, content damages, emergency and clean-up costs, transportation damages, and future flood proofing expenditures. Structure and content damages are based on flood depths. Transportation damages are based on time and reroute distances. Physical damages to utilities (power lines, sewer systems and water supply systems) are included.

Damages to Structures and Contents

Without-project structure and content damages as well as risk and uncertainty analyses were computed for the year 2062 using current price levels. Results were presented above in Tables 4.11 and 4.12. Expected annual damages for the years between 2012 and 2062, inclusive, were converted to equivalent values using standard discounting procedures.

Emergency and Clean Up Costs

Due to the limited amount of information on emergency response costs along the Santa Cruz and West Branch Rivers, emergency response cost estimates were based on estimates derived in the January 1993 Flood Damage Summary Report written by the Pima County Department of Transportation and Flood Control District. In the report, Pima County provided information on the emergency response cost to residents as they evacuates, relocate and, reoccupy their residence during a flood event. Based on the experience of residents who were flooded in the 1993 flood, the temporary relocation cost was approximately $1,400 per resident. This number was applied to the number of residences in the 500-year floodplain and was used along with a non-damaging frequency of a 100-year event (Paseo de las Iglesias) and 25-year event (New West Branch including Los Reales) to perform equivalent annual damages. The equivalent annual damages (EAD) to residents due to flooding along the Paseo de las Iglesias portion of the Santa Cruz River is $11,043, along the Old West Branch of the Santa Cruz River is $77,539, and along the New West Branch including the Los Reales area of the Santa Cruz River is $33,117.

Transportation Costs

Typically, expected annual traffic damages are estimated based upon delineations of floodplain areas with inundation levels exceeding one foot and durations of flooding. However, Hydrology and Hydraulics used the steady state or peak flow method in computing overflows. This method does not allow for a means to estimate durations of flooding by flooding event; therefore, traditional methods of computing traffic damages will not be used. Instead, traffic damages are estimated as a single event assuming traffic flow will be disrupted for a day no matter what the duration. Even if the duration is of a 500-year flood lasts less than a day, traffic is expected to be affected and roads blocked for approximately one day.

According to this analysis, the Santa Cruz River could cause temporary closures of Drexel Road, Ajo Way, Silverlake Road, 22nd Street, and Congress Street. Calculations were based on a 500-year flood. At a detour speed limit of 55 miles per hour, the time involved is 265 hours along Drexel Road, 2,327 hours along Ajo Way, 1,527 hours along

Silverlake Road, 3,116 hours along 22nd Street, and 3,127 hours along Congress Road. Total vehicle delay and operation damages equal $140,564 while average annual vehicle delay and operation damages equal $8,276.

Summary of Damages in the Future Without-Project Condition

Table 4.13 summarizes the expected annual damages discussed above using the current (October 2004) price levels, and is further detailed in the Economic Appendix.

Table 4.13
Without-Project Conditions, Expected Annual Damage Summary

Damage Category	Santa Cruz River	Old & New West Brach Rivers and Los Reales Floodplains	Total
Structure & Content	$521,250	$719,542	$1,240,792
Emergency	$11043	$110,656	$121,699
Transportation	$8,276	0	$8,276
Total	$540,569	$830,198	$1,370,767

D. Problems and Opportunities Summary

1. Problems

Problems within the study area, although interrelated, are principally related to ecosystem degradation, water supply and infrequent flood damage.

As noted earlier, fresh water marshes, riparian forests and adjacent floodplain fringe forests existed in the study area well into the late 19th century. The diversion of surface flows and increased pumping of groundwater combined with early flood control efforts and pressure from development led to loss of nearly all native riparian habitats in this area. The loss of those habitats also affects the populations of many native species.

Flooding problems exist at several locations in the study area. Threat of flood damage exists in the Los Reales Improvement District, along the Old West Branch of the Santa Cruz River and on the New West Branch.

2. Without-Project Summary (No Action Alternative)

Under the Without-Project Condition, there will not be sufficient water to support expansion of existing areas of riparian and associated floodplain fringe habitats. As development continues throughout the Santa Cruz watershed, loss of riparian and floodplain fringe habitat is likely to continue. Many native species will be increasingly confined to continually shrinking and increasingly isolated pockets of suitable environments. The lack of native riparian and associated floodplain fringe habitat will mean the absence of many species of native wildlife from the area. In addition, risks resulting from unstable river geomorphology will remain in unprotected reaches of the study area.

3. Opportunities

Environmental Restoration

Opportunities for large-scale ecosystem restoration exist within the study area. Restoration of riparian habitats could be accomplished either in or adjacent to the Santa Cruz River and its major tributary washes. Specific opportunities may include:

- Planting riparian species
- Enhancing/widening stream courses
- Supplying additional water to stream courses
- Establishment of riparian woodlands adjacent to stream courses

Water Resource Management

Water resource management opportunities include:

- Storm water harvesting
- Groundwater recharge
- Provide areas for storage and infiltration of localized runoff
- Alternative uses of treated effluent
- Utilization of CAP and TARP water sources through future negotiated agreements

Recreation

The opportunity exists to provide recreational resources in conjunction with any Federal project implemented for ecosystem restoration purposes. In addition, limited passive recreational opportunities may be provided adjacent to restored habitat areas. Maintaining open space (recreation facilities) adjacent to restoration sites could help promote successful restoration in that it precludes the stress to habitat and wildlife associated with more intensive land use in adjacent areas. In general, facilities would likely consist of trails and interpretative signage.

Flood Damage Reduction

Flood damage reduction opportunities consist of structural and non-structural measures that could be implemented in association with environmental restoration features. Among those measures is the potential to purchase flood prone structures and remove them from the floodplain to reduce future flood damages.

Groundwater Recharge

Infiltration of storm runoff in the stream channels during the rainy seasons is the major source of recharge to the Tucson area groundwater basin (Davidson, 1973). Long-term groundwater withdrawal has resulted in a general decline in water levels in the Tucson area since the 1900's. Opportunities exist to improve storm water detention and increase localized groundwater recharge by reintroducing low flows into Santa Cruz River channel and water harvesting measures. With groundwater depths exceeding 150 feet in the study area, overall goals of the Tucson Active Management Area (AMA) are to balance the withdrawal and recharge and maintain existing depths to groundwater.

CHAPTER V
PLAN FORMULATION

A. Planning Objectives

1. Federal Planning Objectives

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

The purpose of this Feasibility Study is to determine if ecosystem restoration in this reach of the Santa Cruz River in Pima County, Arizona meets the Federal objectives stated above. An associated purpose is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements by providing incidental flood damage reduction. Planning objectives and constraints provide a framework for the development of alternative plans. As planning objectives for this investigation, it is in the Federal interest to:

- Contribute to National Ecosystem Restoration (NER) through restoration of degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition.
- Contribute to National Economic Development (NED) through the reduction of flood hazards.

2. Specific Planning Objectives

Specific planning objectives were developed to guide formulation of a restoration plan. Those objectives are:

- Increase the acreage of functional riparian and floodplain habitat within the study area.
- Increase wildlife habitat diversity by providing a mix of riparian habitats with an emphasis on restoration of riparian forests within the river corridor, riparian fringe and historic floodplain.
- Provide passive recreation opportunities.
- Provide reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration.
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

B. Planning Constraints

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

1. Availability of Water

A principal constraint on any ecosystem restoration project in the arid southwest is the limited availability of water to support establishment and maintenance of healthy riparian habitats. Because there are various sources of water available for restoration projects, a specific limit on the volume of water available cannot be established until the associated outputs are known. Therefore, to avoid predetermining the outcome of the alternatives selection, a full range of reasonable water demands and alternatives was developed.

2. Maintenance of Floodway Capacity

Restoration of riparian habitat cannot be done in such a way that it would substantially reduce the hydraulic capacity of the Santa Cruz River or its tributary washes to convey damaging flood flows.

3. Proximity of Recreation to Restoration

Projects must be formulated in such a way as to avoid impacts from existing and planned recreational facilities in adjoining areas.

4. Endangered Species

The study area is located in an urban area that is not known to contain endangered or threatened species. Any potential project would be required under the Endangered Species Act to not jeopardize the continued existence of threatened or endangered species or to destroy or adversely modify their habitat. Furthermore, ecosystem restoration projects may potentially attract endangered or threatened species. Projects should be sited so that their habitation by those species does not reduce the ability to preserve the flood control functions and maintenance of the channels.

5. Landfills and HTRW Sites

Numerous landfills and/or Hazardous, Toxic or Radioactive Waste (HTRW) sites are known to exist within the study area. Throughout the plan formulation process, these sites have been avoided, to the greatest extent possible, in accordance with Corps guidelines. Landfills are likely to be encountered with bank excavation for creating new slopes. However, environmental assessment data (Appendix G) indicates that landfill contents are benign. A remediation and management plan will need to be developed for unknown HTRW and other deleterious material encountered during bank excavations.

C. Alternative Development Rationale

The alternatives are developed for the purposes related specifically to the requirements for a Corps of Engineers Feasibility Report. 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, FEIS, and project authorization by Congress, if such action occurs, detailed design analysis and preparation of plans and specifications would take place. Alternatives were formulated to address a comprehensive Federal project for ecosystem restoration to:

a. Comply with NEPA and other environmental laws and regulations;
b. Restore a variety of riparian and associated floodplain fringe habitats to a less degraded more natural state;
c. Provide an acceptable means of detaining storm water and conveying it into restored habitat areas;
d. Maintain or improve existing conveyance of peak discharges and ensure that the system of storm water collection would not increase flood surface elevations or worsen flooding conditions upstream or downstream in the existing developed areas;
e. Provide flood damage reduction benefits where justified;
f. Produce NER benefits while positively contributing to the National Economic Development (NED) Account (if applicable), Regional (RED) Account, and the Other Social Effects (OSE) Account;
g. 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;
h. Provide a framework for responding to future urban development in the floodplain, consistent with Executive Order 11988; and
i. 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.

D. Alternative Development and Evaluation Process

The Paseo de las Iglesias feasibility study process involves successive iterations of alternative solutions to the defined ecosystem degradation problem. Those solutions are based upon the study objectives and designed to address the opportunities while remaining within the limitations imposed by the identified constraints. The general feasibility criteria that are required to be met are as follows:

Technical Feasibility: Solutions must be technically capable of performing the intended function, have the ability to address the problem, and conform to Corps of Engineers technical standards, regulations, and policies;

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

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

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

Initially, specific measures were developed to satisfy the four feasibility criteria. Measures are specific stand-alone features to address the defined problems. Numerous specific measures can be utilized to restore habitats depending upon site location, technical considerations, environmental conditions, and a host of other factors. In determining the set of measures to be evaluated for this study, specific consideration was given to public input and suggestions, Corps experience with similar restoration opportunities, technical considerations based upon the specifics of the area, and flood control considerations for improving or maintaining the existing level of protection.

E. Ecosystem Restoration Measures

A multitude of general and specific restoration measures have been articulated in a variety of public forums. More detailed lists are provided in the Public Involvement Appendix. These measures were evaluated for inclusion in the restoration alternatives to be developed as part of this study. Many of the measures reviewed were incorporated into this plan formulation effort. Those included:

- Utilize Natural Water Sources Through Water Harvesting
- Establish Perennial Low Flow Channel
- Lay Back Banks/Widen Channel
- Terracing of Banks
- Stabilizing and Planting Islands/Sand Bars/Oasis (place clay lenses)
- Modify Confluence/Distribute Incoming Flows
- In Channel, Bank and Floodplain Vegetation
- Soil Cement Removal
- Palisades/Fence Jetties/Root Wad Revetments
- Drop Structures/Weirs Aligned With Existing or New Grade Control Structures
- Elements Conducive to Wildlife/Fish Measure

These measures were organized into grouped actions aligned with the following areas of the habitat that could be restored within the ecosystem:

1) Active Channel: bundles, clay liners, stormwater harvesting basins, grade control, seasonal pools, low flow channel, palisades/jetties, increase sinuosity, cottonwood/willow, and perennial flow.
2) Terraces and Banks: tributary deltas, distributary floodplains, soil cement removal, terracing, gallery forest, palisades/jetties, and stormwater harvesting basins upstream of confluences.

3) Historic Overbank Floodplain: gallery forest, water harvesting, blue Palo Verde, Bosque floodplain, distributary floodplain.
4) Old West Branch: fish habitat, New West branch connection, and irrigation.

F. Flood Damage Reduction Measures

Flood damage reduction or National Economic Development (NED) opportunities were also evaluated to determine if a Federal interest existed in participating in a combined NER and NED plan. Structural and non-structural measures and alternatives were developed and evaluated for four reaches of the study area; the Santa Cruz River main stem, the Old West Branch and New West Branch tributaries, and the Los Reales Improvement District to determine the expected annual economic damages and benefits for the baseline and without-project conditions. Based on the evaluation and screening processes, flood damage reduction could not be justified as a project purpose within the study area. The results of this evaluation and screening process are summarized in this section.

The total number of structures by flood frequency for each of the above referenced reaches and respective Expected Annual Damages (EAD) are provided in Tables 5.1 and 5.2 below:

Table 5.1
Number of Impacted Structures by Frequency for Each Reach

Floodplain	50 yr	100 yr	200 yr	500 yr
Santa Cruz (SC)	0	0	132	1972
Old West Branch (OWB)	NA[1]	583	NA	NA
New West Branch (NWB)	0	222	503	1126
Los Reales (LR)	NA	47	NA	119

[1]NA means overflows were not available for the frequencies listed; therefore, structures could not be counted and included in Table 5.1.

Table 5.2
Total Without Project Condition Expected Annual Damages

Santa Cruz River		Old & New West Brach Rivers and Los Reales Floodplains	
Reach	*EAD*	*Reach*	EAD
1 SC	$69,870	OWB	$406,212
2 SC	$110,950	1 NWB	$141,330
3 SC	$258,480	2 NWB	$64,260
5 SC	$81,940	LR	$107,740
Total:	**$521,250**	**Total:**	**$719,542**

1. <u>Non-Structural Flood Damage Reduction Measures:</u>

A variety of non-structural flood damage reduction measures were identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Floodplain Management Regulations

The City of Tucson and Pima County participate in the National Flood Insurance Program (NFIP), which is administered through the Federal Emergency Management Agency (FEMA). FEMA has published Flood Insurance Rate Maps (FIRMs) for both jurisdictions that identify Special Flood Hazard Areas for the Santa Cruz River and tributaries. For local jurisdictions to maintain eligibility in the NFIP, minimum levels of floodplain management regulations must be adopted and enforced.

Due to the existence of floodplain management regulations and enforcement, this measure was not carried forward for alternative evaluation.

Flood Warning Systems

A flood warning and preparedness system is often the most cost effective flood mitigation measure comprised of computer hardware, software, technical activities and/or organizational arrangements aimed at decreasing flood hazards. Advanced warning is not generally effective in reducing structural damages (outside of sandbagging efforts, given early warning). The primary benefits of such a system are credited for providing early evacuation of residents and reduction in damages to vehicles and structure contents.

Pima County owns and operates an extensive flood-warning network. This network operates in the National Weather Service ALERT (Automated Local Evaluation in Real Time) format and is part of the Arizona Statewide Flood Warning System previously developed and constructed by the Corps under Section 205 of the Continuing Authorities Program.

Due to the existence the statewide and local flood warning systems, this measure was not carried forward for alternative evaluation.

Flood Proofing

Flood proofing offers the opportunity to provide flood protection on an individual structure-by-structure basis or a group of structures. Flood proofing techniques typically include buyouts, relocation, elevation, floodwalls or levees, and dry flood proofing. Elevation, buyout, and relocation are the most dependable of these flood proofing methods. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the structure(s). Flood proofing techniques considered for alternative development are:

1) <u>Relocation of Existing Structures</u>: Relocation is perhaps the most dependable flood proofing technique since it totally eliminates flood damages, minimizes the need for flood insurance and allows for the restoration/reclamation of the floodplain. This technique requires the physical relocation of flood prone structures outside of the

identified flood hazard area. This also requires purchase of the flood prone property, selecting and purchasing a new site, and lifting/moving the structure to the new site.

2) Buyout or Acquisition: This technique requires the purchase of the flood prone property and structure, demolition of the structure, relocation assistance, and applicable compensation required under Federal and State law. This alternative typically requires voluntary relocation by the property owners and/or eminent domain rights exercised by the non-Federal sponsor.

3) Retrofitting or Dry Flood Proofing: Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Installation of temporary closures or flood shields is a commonly used flood proofing technique. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to expected flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. It would also not be applicable to mobile homes, which comprise sixty-nine percent of the flood prone structures in the study area, due to the type of construction and typical lack of anchoring to a foundation.

Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution and, this action would have to occur in a relatively short time frame. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

4) Localized Levees or Floodwalls: Ring levees or floodwalls can be built around individual structures to protect single or small groups of structures. Ring levees are earthen embankments with stable or protected side slopes and a wide top. Floodwalls are generally constructed of masonry or concrete and are designed to withstand varying heights of floodwaters and hydrostatic pressure. Closures (e.g., for driveway access) are typically manually operated based on flood forecasting and prediction that would alert the operator.

Disadvantages of levees or berms are: 1) can impede or divert flow of water in a floodplain; 2) can block natural drainage; 3) susceptible to scour and erosion; 4) give a false sense of security; and 5) take up valuable property space.

Disadvantages of floodwalls are: 1) high cost; 2) closures for openings required, and 3) give a false sense of security.

5) Elevation of Structures: Existing structures can be elevated or raised above the potential flood elevation. Structures can be raided on concrete columns, metal posts, piles, compacted earth fill, or extended foundation walls. Elevated structures must be designed and constructed to withstand anticipated hydrostatic and hydrodynamic forces

and debris impact resulting from flooding. The access and utility systems of the structures to be raised would need to be modified to ensure they are safe from flooding.

2. Structural Flood Damage Reduction Measures:

A variety of structural flood damage reduction measures were also identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Detention

This measure would require construction of on-line (i.e., in-stream) or off-line regional detention facilities upstream of the study area designed to detain flood flows and release then at a lower rate. There are no lands identified for upstream detention that would provide adequate storage volume to detain the 100-500-year flood events. In addition, any such location would fall outside the study area and outside Pima County jurisdiction either on Tribal Lands or in Santa Cruz County. The location of a large-scale detention facility relative to the entire 2,222 square mile contributing watershed would have to be evaluated to determine what impacts, if any, there are on flood hydrographs through the study area. This measure was not carried forward for alternative evaluation.

Lined Channels & Covered Channels:

1) Rectangular Concrete Channels: Preliminary evaluation of this measure revealed no practical location along the large, entrenched Santa Cruz River channel where such a solution would be practical. Rectangular concrete channels are not carried forward for alternative evaluation.

2) Trapezoidal Rip-Rap/Soil Cement/Vegetation Lined Channels: A preliminary evaluation was performed for the potential for utilizing trapezoidal lined channels, due to the reduced construction costs and improved aesthetics of such channels. The Santa Cruz River contains the 100-year flood, and several reaches within the study area are currently protected from erosion with soil cement lined banks. This measure was carried forward for alternative evaluation.

3) Covered Channels: A preliminary evaluation indicated that there is no specific location where covered channels could be utilized and this measure is not carried forward for the alternative evaluation.

Levees and/or Floodwalls:

1) Levees: Levees can provide significant levels of protection in a cost effective manner, however, there are disadvantages such as increases of flood stages, real estate costs and access considerations, environmental impacts, and the potential for failure due to scour/erosion or overtopping. This measure was carried for alternative evaluation.

2) Floodwalls: Consideration was given to protective floodwalls in place of levees. Floodwalls may be provided at a lower cost than levees and provide significant levels of protection over and above the current channels, with or without widening and deepening. This measure was carried forward for alternative evaluation.

G. Evaluation of Measures

Each measure was evaluated in terms of the feasibility criteria. All criteria must be adequately met since any one criterion can serve to eliminate a measure from further consideration. Those measures satisfying all the criteria were carried forward for additional development and evaluation while those that were shown not to meet the criteria were eliminated from further consideration.

Measures that were carried forward were then combined in various configurations to form a preliminary set of alternatives, which was then subjected to a more rigorous evaluation against the criteria. Some measures became alternatives, while other measures were combined to form alternatives.

1. Restoration Measures

Based upon feasibility criteria, all but one of the identified restoration measures were carried forward for Plan Formulation in development of the alternatives. Soil cement removal was the only restoration measure eliminated from further consideration. This measure was eliminated due to the potential for increased erosion damages.

2. Flood Damage Reduction Measures

Measures were utilized to develop alternatives at the conceptual level. Alternatives were evaluated and screened using preliminary cost estimates based on costs developed for similar measures in other studies conducted in the region. Detailed cost estimates were not prepared because precise analyses of conceptual alternatives was not justifiable.

Old West Branch (OWB):

The Old West Branch is an entrenched natural channel. The average base width is 20 ft and the average bank height is 10 ft. There is a significant amount of vegetation (e.g., mesquite) growing along the banks and some vegetation growing in the channel bed. There is a large concrete drop structure at the confluence of with the Santa Cruz River. Bridge crossings are located at Silverlake Road, Ajo Way, and Via Ingresso.

Structural flood damage reduction alternatives along the OWB would result in the loss of the most highly valued riparian habitat and mesquite bosque within the study area, which is in direct conflict with the primary ecosystem restoration purpose. Previous proposals, by the non-Federal sponsor, for structural flood control channel improvements along the OWB resulted in a high degree of public opposition. In addition, 73 acres of the OWB channel and floodplain must be maintained as a "natural floodplain" under the mitigation provisions of an existing USACE Section 404 Permit and structural modifications of the natural channel are prohibited. Based on aforementioned constraints, structural flood damage reduction alternatives for the OWB were not developed and evaluated.

In light of the above, only non-structural flood damage alternatives were evaluated for the OWB. Approximately 583 structures are potentially damaged in the 100-year flood event and the expected annual damages are $406,212. The non-structural alternatives evaluated are:

OWB-1	Buyouts and/or Relocation
OWB-2	Elevation of Structures
OWB-3	Localized Floodwalls or Levees

Alternative OWB-1 (Buyouts/Relocation): Estimates for structure values (not including relocation assistance and demolition costs) in the OWB 100-year floodplain exceeded $23,000,000 (See Economic Appendix). Based on this estimate compared EAD level that might justify a $4.8 million project, Alternative OWB-1 is clearly not economically justified and was eliminated from further consideration.

Relocation would depend on whether alternative sites for 583 structures are available, the willingness of the residents to relocate, and other non-technical factors. There are no identified sites with equivalent zoning, existing infrastructure, and lot configuration that could accommodate relocating 583 structures. Assuming that such relocation sites were available, the cost to relocate these structures (1,000 sq. ft. each) was estimated at $10 per square foot to move the structures several miles. 10% contractor profit was also assumed per USACE National Flood Proofing Committee guidelines. Relocation and profit costs only are estimated at $6,400,000. The average annual cost is $384,949 for a B/C of 1.05 at a 5.625% interest rate. Required additional costs not incorporated would include cost of the new lot, new foundations, landscaping, and pertinent indirect costs. Based on this cost estimate and lack of relocation sites, relocation was eliminated from further consideration.

Alternative OWB-2 (Elevation): The economic benefits associated with elevating existing structures are measured by subtracting the value of the expected annual damages under improved conditions from the expected annuals damages under the Without-Project conditions.

Construction costs were estimated for raising structures with piers for manufactured/ mobile homes and stem walls for slab on grade homes. The mobile homes also require adequate tie-downs to prevent flotation. These costs considered the condition of the structure to be raised, the site preparations required, mobilization costs, and the approximate square footage of the structure. A constant cost of per square foot was used whether the structure is raised one foot or three feet. Commonly, the cost per square foot increases for each additional foot the structure is elevated. These costs (per NFPC data) are:

Wood Frame Building on Piles, Posts or Piers[1]	$26 per square foot
Wood Frame Building on Foundation Walls[1]	$19 per square foot
Brick Building[1]	$32 per square foot

[1]These costs include foundation, extending utilities, and miscellaneous items, such as sidewalks and driveways. They do not include the cost of fill or landscaping.

A profit of 10% was also included, as well as fixed engineering design, mobilization, and relocation costs of $7,000 for the mobile homes (MH) and $14,000 for each single family residential (SFR) home. All costs were based on a typical 1,000 square foot wood framed structure.

The cost to elevate 52 SFR and 528 MH residential structures was estimated at $15,451,000. This figure was then converted to an annual average equivalent value for purposes of comparison on a common basis with the estimate of the average annual benefits. The analysis shows that the net benefits generated by the alternative are -$523,141, therefore the B/C ratio is .43. Thus, this alternative is not economically justified and was not carried forward.

Alternative OWB-3 (Floodwalls): Installation of individual or groups of floodwalls or levees was analyzed for the residential structures only. Based on the small lot sizes, configuration of the subdivision(s) and clustered nature of the residential structures, construction of individual floodwalls or ring levees are not physically possible. Floodwalls constructed around the perimeter of individual subdivisions would act as ineffective flow areas that increase water surface elevations and divert flood flows onto adjacent properties, thus inducing damages. Based on this evaluation, this alternative was eliminated from further consideration.

New West Branch:

The New West Branch (NWB) is an entrenched, partially bank protected trapezoidal channel. The channel has a natural bottom with 3 to 1 concrete lined side slopes. The base width varies from 100 to 120 ft. The average bank height is 8 ft. There is a large concrete drop structure/energy dissipator at the confluence of with the Santa Cruz River; with another drop structure located approximately 1,925 feet upstream. Bridge crossings are located at Irvington, Drexel, and Valencia Roads.

222 structures are potentially damaged in the 100-year, 503 in the 200-year flood events and 1,126 structures are damaged in the 500-year event. The total expected annual damages are $205,590. Non-structural alternatives (i.e., dry flood proofing, elevation, and relocation) were eliminated from further consideration based on the non-structural alternatives analysis performed for the 583 structures on the Old West Branch.

Potential structural alternatives evaluated for the New West Branch were:

NWB-1:	Channel Dredging,
NWB-2:	Reconstruction of Existing Levees, and
NWB-3:	Floodwalls.

Alternative NWB-1 (Channel Dredging): The without project hydraulic model was modified to determine the impacts of channel dredging. The following impacts or concerns were identified:

- Excavation can increase the conveyance of the New West Branch up to the 100-yr flood event only. Up to two (2) ft of excavation is necessary.
- Excavation alone would not contain the 200- and 500-yr flood events.
- The existing grade control structure at Station 6.0 would need to be modified (lowered) as well as the existing bank protection.

- The existing footbridge upstream of Drexel Road would need to be removed or replaced.
- Excavation may result in undermining of the existing soil cement bank protection. The toe down depth(s) of the existing soil cement bank protection is unknown and cannot be verified. Additional field exploration will be required to determine structural integrity, toe-down depths, and subsurface conditions behind and under the soil cement.

For cost estimating purposes and alternatives analysis, the assumption was made that the existing soil cement would require structural measures to prevent undermining. At this time, a preliminary cost estimate cannot be developed without knowledge of toe-down depth. This alternative is unlikely to be justified even if excavation is the primary cost and structural modifications to the existing bank protection are not required. Cost for excavation alone is estimated at $2,838,486. Annualized over 50 years and a 5.625% interest is $170,730. This estimate does not include modification of the existing grade control structure, removal or replacement of existing pedestrian bridge or bridge improvements to Drexel and Irvington. Benefits were calculated using HEC-FDA without project output and an EAD spreadsheet. Benefits for the New West Branch floodplain are $85,781. If this preliminary analysis showed possible justification HEC-FDA would have been used for detailed analysis. However, the resulting benefit-to-cost ratio for excavation on Alternative NWB-1 is .50. Therefore, this alternative was not economically justified.

Alternative NWB-2 (Replace Levees): Levees (or berms) currently exist along both channel banks, however they do not contain the 100 to 500-year flows. An analysis was performed to determine effects of raising the existing levees to protect for the 100, 200, and 500-year flood events. As built drawings for the existing levee are not available therefore, for engineering design and cost estimating purposes, the existing levees were assumed to be structurally inadequate and completely new engineered levees were assumed. Due to the high velocities and possibility of run-up at the curve, rigid armoring (i.e., soil cement) would be required on the inside slopes of the levees. Costs for soil cement bank protection assumed a 14-foot bank height and 5-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by Pima County.

The cost (excluding additional real estate requirements) for reconstruction of approximately 14,200 lineal feet of new levee system on both sides of channel was estimated at $11,809,801. Annualized costs equal $710,340. With benefits equaling $204,120 for 100 years of protection, $205,240 for 200 years of protection and $205,450 for 500 years of protection, the resulting B/C ratio for Alternative NWB-2 and NWB-3 (described below) is .29; therefore, it is not economically justified.

Alternative NWB-3 (Floodwall): Based on the analysis for Alternative NWB-2, a floodwall determined to be impractical given the fact that the costs of floodwalls are typically in the range of five to seven (5-7) times the cost of the soil cement levee.

Santa Cruz River:

The Santa Cruz River main stem is characterized by a partially bank protected ephemeral river with a narrow 100-year floodplain. There is soil cement bank protection on both banks between Congress Street and Silverlake Road, Irvington Road and Ajo Way, and near Valencia Road. The rest of the study reach is unprotected. The river is entrenched with widths varying from 200 to 1000 ft. Bridge crossings are located at Congress Street, 22nd Street, Silverlake Road, Ajo Way, Irvington Road, Drexel Road, and Valencia Road. The Old West Branch joins the Santa Cruz River between 22nd Street and Silverlake Road. The New West Branch joins the Santa Cruz River between Ajo Way and Irvington Road.

The Santa Cruz River incised channel contains the 2 through 100-year flood events for the majority of the study area and no structures are affected by these flood frequencies. 132 structures are affected in the 200-year flood frequency and 1,972 structures are affected in the 500-year flood frequency. The total expected annual damages are $521,250 (see Table 5.2) for the four sub-reaches on the Santa Cruz River.

Non-structural Alternatives: Dry flood proofing was not considered due to fact that 1,040 of the existing 1,972 structures are mobile homes, which are not conducive to this technique. Non-structural alternatives (i.e., dry flood proofing, elevation, and relocation) were eliminated from further consideration based on the costs determined by the non-structural alternatives analysis performed for the 583 structures on the Old West Branch.

Structural Alternatives: Structural alternatives considered for the Santa Cruz River are:

SCRiver-A Channel Improvements / Widening

SCRiver-B Levee or Floodwalls

Table 5.3
Reach Delineation Breakdown: The Santa Cruz Floodplain

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
1 SC	Congress St. 22nd Street	Santa Cruz River	32.61	33.38
2 SC	22nd Street Ajo Way	Santa Cruz River	33.38	35.77
3 SC	Ajo Way Irvington Rd.	Santa Cruz River	35.77	36.630
4 SC[1]	Irvington Rd. Drexel Rd.	Santa Cruz River	36.630	37.87
5 SC	Drexel Rd. Valencia Rd.	Santa Cruz River	37.87	38.96

[1] 4 SC produced no damages.

Alternative SCRiver-A (Channel Widening): Channel improvements along the Santa Cruz River main stem would entail widening of existing vertical eroded banks and then constructing soil cement bank protection at 1 (horizontal):1 (vertical). Referencing Table 5.3, both river banks for sub-reaches 1 SC and 3 SC are protected with soil cement and would require removal of the existing soil cement to accommodate channel widening and new soil cement protection would then have to be reconstructed. Sub-reach 2 SC is bank protected from 22nd Street to Silverlake Road.

A preliminary lump sum cost estimate for bank protection was previously developed for the Gila River, Santa Cruz River Watershed Pima County, Arizona Final Feasibility Report (dated August 2001) for the remaining unprotected channel banks. Costs for soil cement bank protection assumed a 20-foot bank height and 10-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by the Pima County. The initial cost estimate, not including real estate and contingencies, was in excess of $14,960,000.

Channel widening alone will not provide a complete flood protection solution. The eight (8) existing roadway bridges would require improvements or replacement to convey design floods without overtopping.

Based on expected annual damage levels for the Santa Cruz River Sub-reaches, the initial cost estimate of $14,960,000, the impracticality of removing existing soil cement for channel widening, construction of new soil cement, and bridge replacements, Alternative SCRiver-A was not carried forward for detailed evaluation.

Alternative SCRiver-B (Levees or Floodwalls): Based on the cost estimates developed for the New West Branch Alternative NWB-2, construction of levees or floodwalls along both banks of the Santa Cruz River was deemed impractical. In addition, all bridge crossing would have to reconstructed and elevated to accommodate the top of any new levee or floodwall. This alternative was not carried forward.

Los Reales Alternatives:

The Pima County Department of Transportation and Flood Control District (FCD) formed the Los Reales Improvement District in 1987 in order to construct a flood-control levee and associated drainage ways. The purpose of this project was to divert flows around the development and dispose of these flood flows either into the Santa Cruz River or into the New West Branch channel. Along the south boundary of this Improvement District, there is a 4 ft high, 1400 ft long floodwall, which extends between the Tohono O'odham Indian Reservation Boundary and Indian Agency Road. On the west end of this floodwall, there is a partially lined concrete channel that would divert a portion of the flood flows northward into the New West Branch channel. A partially lined concrete channel is aligned along the south edge of the development and diverts all remainder flood flows into the Santa Cruz River approximately opposite Hughes Wash.

Forty-seven (47) structures are affected in the 100-yeat event and 119 structures are affected (primarily from shallow overland flows) in the 500-year event. Total expected annual damages are $107,740. Alternatives evaluated are:

LR-1 Flood Proofing
LR-2 Elevation of Structures

Alternative LR-1 (Flood Proofing): Sixty-six (66) percent of the existing structures are classified as mobile homes. Dry flood proofing techniques such as flood shields and sealing of exterior walls would not be applicable for mobile homes due to the type of construction and lack of adequate anchoring to a foundation. Therefore, this alternative was not carried forward.

Alternative LR-2 (Elevation): Costs to properly elevate and anchor the residential structures was estimated at $3,187,000. $191,693 is the annualized costs at a 5.625% interest rate. The resulting benefit-to-cost ration is .56 with benefits potentially equaling $107,740; therefore, this alternative is not economically justified.

Erosion Hazard Damage Evaluation:

The bank erosion study was limited to the Santa Cruz River. The New West Branch was not studied since its banks are lined with concrete/soil cement. This was the same case for the Los Reales Improvement District area. The Old West Branch was not studied due to plan formulation constrains that preclude structural channel modifications.

Santa Cruz River Results:

Approximately 70 structures could be affected based on the historic annual erosion rates in areas without soil cement bank protection. The total annualized expected annual damages for these 70 structures is estimated at $57,946 (see Table 5.4). At this level of economic damage, an estimated $963,000 project might be economically justified.

Table 5.4

Present Value and Annualized Damages for Affected Structures

Reach	Present Value	Annualized Damages
SC 2	$695,678	$43,937
SC 4	$80,153	$5,375
SC 5	$129,522	$8,634
Total	**$905,354**	**$57,946**

A preliminary lump sum cost estimate for bank protection was previously developed for the Gila River, Santa Cruz River Watershed Pima County, Arizona Final Feasibility Report, dated August 2001. This estimate for bank protection was made based on similar projects on the study area. Costs for soil cement bank protection assumed a 20-foot bank height and 10-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by Pima County. The initial cost estimate, not including real estate and contingencies, was in excess of $14,960,000. Based on the low EAD value of $57,946 and a resulting annualized cost of $899,820, a soil cement bank protection project would not be economically justified with a B/C ratio at .06.

H. Preliminary Ecosystem Restoration Alternatives

Extensive work to identify and conceptually describe restoration opportunities had been accomplished by Pima County before initiation of this feasibility study. Detailed information regarding Pima County planning efforts may be found in "Paseo de las Iglesias: Restoring Cultural and Natural Resources in the Context of the Sonoran Desert Conservation Plan, April 1993."

1. Alternative Formulation

The principal limiting constraint for ecosystem restoration in an arid environment is the availability of water; however, this formulation process initially assumed that sufficient volumes of water to support a full range of riparian communities could be made available. The kinds of restoration techniques and measures to be implemented were also used to define alternatives. Land was presumed to be available within the study area, particularly near the larger stream channels within the study area. Alternatives were developed by varying the volumes of water that could be supplied, the area of land utilized and the restoration measures that might be constructed within a carefully selected area of land adjacent to the Santa Cruz River and its major tributaries. This approach allowed decision makers to weigh the relative cost of the markedly different biologic outputs resulting from the commitment of various volume of water within a fixed area of land.

The selection of the areas of land in the study area where riparian ecosystem restoration alternatives might reasonably and appropriately be constructed was accomplished through an iterative process by the project team composed of District personnel, the non-Federal sponsor and their respective technical specialists and consultants. Geographic Information System mapping resources (particularly the Pima County Land Information System PCLIS), recent aerial photographs, field inspections, the local knowledge base and professional opinion were employed to delineate a rational project area. The following selection criteria were employed to yield an area of approximately 1350 acres that alternatives were formulated to fit within.

- Publicly owned lands were favored over privately held lands. The majority (more than 90 percent) of the lands in and immediately adjacent to the Santa Cruz River and its major tributaries are owned by public entities. The City of Tucson is the major landowner, followed by Pima County.
- The majority of existing residential and commercial areas and all street and road rights-of-ways and utility corridors were eliminated. These would not be

considered as part of a project unless there were unavoidable engineering requirements directing the need of a particular location.

- Areas presently platted for commercial or residential development were generally eliminated, unless reasonably needed for access or over-riding engineering considerations.
- Most overlaps with proposed Rio Nuevo redevelopment project were eliminated due to uncertainty regarding potential conflicts between redevelopment and restoration land uses.
- Known hazardous or toxic waste sites and landfills were avoided.
- Most lands that did not need to be restored were eliminated. These included lands currently supporting moderate to high quality examples of Sonoran Desert Cactus-scrub habitat.
- Existing, developed and manicured parks were eliminated. While not untrammeled native habitat, maintained parks support stands of vegetation that provide a suitable buffer between future restoration sites and urban uses.

Any lands that were clearly within limits of existing watercourses, as well as those immediately adjacent to areas of the associated historic floodplains were considered for the restoration alternatives. Parcels located within the historic floodplain and close to existing watercourses were evaluated on a case-by-case basis. Finally, the team agreed that the outer limit of the Project Area boundary should be adjusted to follow parcel boundaries in a manner that precluded taking unreasonably small portions of parcels or leaving parcels that were not large enough to be viable for other uses. The application of these criteria resulted in a potential Project Area of 1,341 acres.

This delineated area included the land most suitable for riparian corridor ecosystem restoration projects within the Paseo de las Iglesias study area. The area selected included distinct geomorphic areas within the active river channel, first and second terraces within the main erosion-defined channel, unstable banks above terraces (including the area required to lay them back) and an overbank area within the historic floodplain. Figure 5.1 shows the spatial relationship of this area to the study area. Table 5.5 provides a summary of land ownership of the project area. Table 5.6 summarizes lands by geomorphic classification.

Table 5.5
Land Ownership in the Paseo de las Iglesias Restoration Area

Land Owner Type	Acres	Percent of Area
City of Tucson	565	42.1
Pima County	138	10.3
State of Arizona	11	0.8
Other Public	4	0.3
Residential	75	5.6
Commercial/Industrial	497	37.1
Unclassified	51	3.8

Table 5.6
Geomorphic Conditions in the Paseo de las Iglesias Restoration Area

Geomorphic Condition	Acres	Percent of Area
Active Channel	173	12.9
Terraces	188	14.0
Unstable Slopes/Banks	146	10.9
Overbank/Historic Floodplain	785	58.5
Other (Soil Cement/Rio Nuevo)	49	3.7

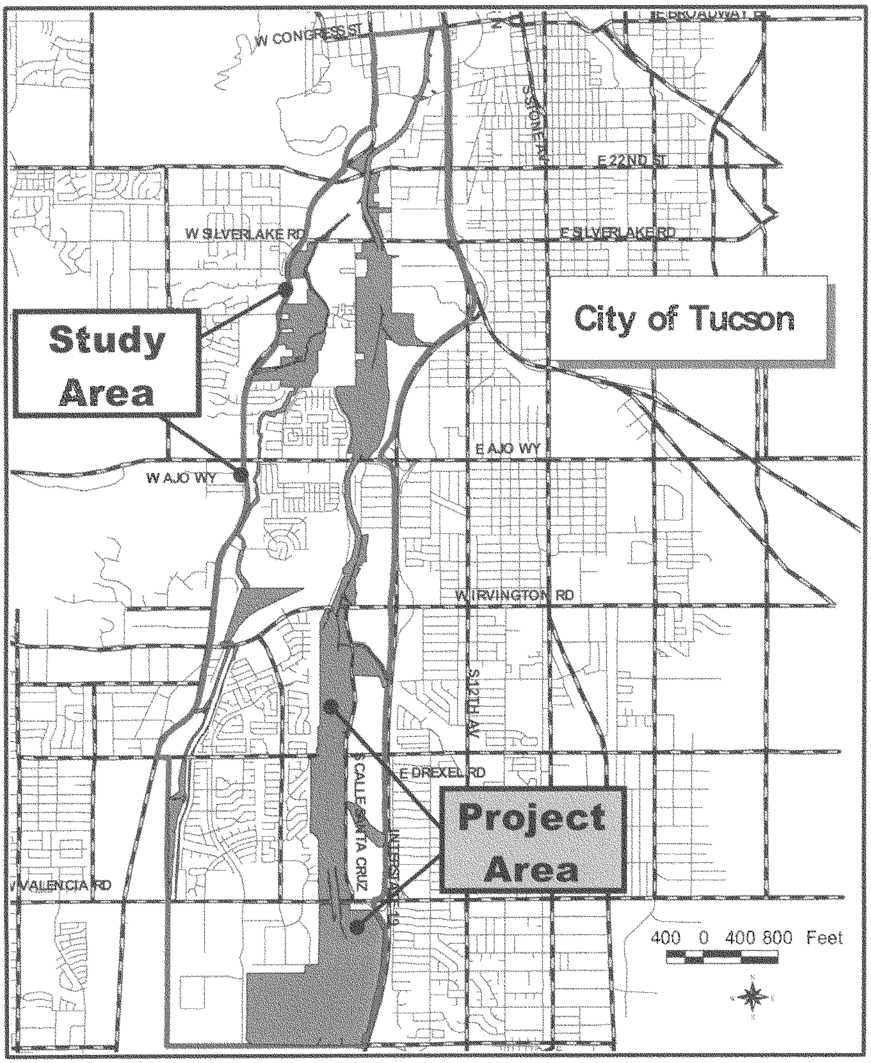


FIGURE 5.1 Project Area

Certain presumptions were established as the starting conditions for the development of restoration alternatives. These conditions included the following:

1. Restoration alternatives considered would utilize variable locations within the project area. Utilization would consist of all earth moving and grading practices, slope stabilization practices, water harvesting practices, planting, weed removal, irrigation, flooding features, ingress/egress routes, permanent and temporary storage areas and temporary infrastructure support features.
2. The most fundamental restoration plan for the area was presumed to be the application of minimal dry-land restoration practices. These include soil scarification, incorporation of nutrients and organic matter, mulching, ground patterning, water harvesting techniques for non-irrigated restoration, the placement of natural wind and sun-shading features and slope stabilization. Weed control and direct seeding of native species mixes would be applied for all lands included in the alternatives.
3. The presence and success of planted natural communities will be facilitated and maintained by the volume of water applied at a given location. Alternatives were formulated to have varying water requirements.
4. It was assumed that all of the area utilized by each alternative would be exposed to some level of restoration activity. While grading and excessive soil manipulation will be avoided in remnants of natural communities in the project area, most areas will require moderate to profound disturbance of the existing surface.

In addition to the Xeroriparian concept (number 2 immediately above), features were also placed into "Mesoriparian" and "Hydroriparian" groups. The project area was divided into three regions or geomorphic settings: 1) the active channel, 2) the adjoining terraces, and 3) the historic floodplain. The active channel refers to the area where water flows most frequently and where perennial flow would be found if it still existed. The terraces are the adjacent land features that are elevated only slightly above the active channel. Lower terraces might be flooded once or more in most years and the upper terraces would be flooded approximately every other year. The historic floodplain is the area adjacent to the entrenched channel of the Santa Cruz River. Although the historic floodplain has been cut off from the river due to down cutting resulting from human activities, in the past parts of this area would have been flooded by events greater than the 2-year event with most of the area being inundated in a 10-year event.

Using the concepts of riparian communities and geomorphic settings, a matrix of grouped measures was created. This matrix is included as Table 5.7. The matrix allowed initial consideration of potential combinations of feature groups, including "no action", to create forty-seven potential alternatives.

Table 5.7
Alternative Features Matrix

	Active Channel Features	Floodplain Terrace Features	Historic Floodplain Features
No Action* (Without Project) *Listed items are anticipated consequences rather than measures to be implemented as in the other rows.	1. Continued instability of channel due to erosion. 2. Continued refuse dumping. 3. Continued habitat degradation.	1. Continued erosion loss of lower terraces creating cliff-like banks. 2. Eventual application of soil cement on unprotected banks armoring entire reach.	1. With expanded soil cement bank protection, continued historic floodplain encroachment by development.
Xeroriparian (Establishment & Emergency Irrigation)	1. Construct water harvesting basins upstream of existing and new grade control structures. 2. Divert low flow from New West Branch into remnant headwaters of Old West Branch. 3. Plantings of riparian grasses/shrubs	1. Water harvesting from local runoff. 2. Create tributary water harvesting basin deltas with two-tiered water harvesting basins. 3. Plantings on terraces and water harvesting basins.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Water harvesting from local runoff. 3. Replace steep banks with stabilized planted terraces
Mesoriparian (Irrigation)	1. Construct and provide supplemental irrigation to water harvesting basins upstream of existing and new grade control structures. 2. Introduce periodic flow into the Old West Branch just upstream of its confluence with the Enchanted Hills Wash and on other tributaries downstream of that point. 3. Plantings of riparian grasses	1. Create tributary single-tiered aquitard deltas. 2. Irrigate and plant terraces with mesquite along upper terrace. 3. Stabilize active channel banks by establishing thickly rooted mesquite at the edge of the lower terraces.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Plant and irrigate historic floodplain. 3. Replace steep banks with stabilized planted terraces
Hydroriparian (Perennial Flow With Irrigation)	1. Restore perennial flow with multiple points of distribution into the main Santa Cruz and tributary channels. 2. Plant cottonwood-willow bundles at edges of perennial flow where erosion protection needed. 3. Construct perennial channel features (e.g., pools, runs, and riffles).	1. Create tributary water harvesting deltas with hydraulic link to perennial flow. 2. Irrigate and plant low terraces with riparian grasses to maintain flood conveyance and discourage colonization by invasive species. 3. Irrigate and plant upper terraces with mesquite and cottonwood-willow at tributary water harvesting basins.	Hydro Riparian plants do not occur in areas of the floodplain that are not subject to frequent inundation. Even so, measure 3 from the mesoriparian floodplain is carried forward to mitigate greater erosion risks associated with increased channel roughness in combinations where "No Action" is paired with Perennial Flow.

2. Alternative Screening:

Preliminary screening of these alternatives was accomplished by applying three factors that embodied the planning objectives and constraints identified in the early stages of the study. Based on these objectives, alternatives were discarded that:

- failed to maximize use of the delineated Project Area lands and lacked community interspersion,
- created unnatural habitat associations (i.e., they create habitat inappropriate for their geomorphic position), and
- were determined likely to reduce flood conveyance.

The number and interspersion of cover types restored and the total acreage restored were taken into consideration for assessing the application of the first criterion. The second criterion, "appropriateness with the geomorphic setting", selected against alternatives, which misplaced riparian communities. Hydroriparian communities occur in the lowest positions in the channel cross-section, where water is usually is at or near the surface. Mesoriparian communities occur vertically above channel flow but experience frequent flooding or surface saturation from high water levels in the channel. Xeroriparian communities experience brief and infrequent flooding or saturation, being sustained by rainfall and local surface runoff. In geomorphic terms, hydroriparian plants are most often found adjacent to the active channel or in the adjoining lower terraces. Mesoriparian plants would be found in the lower or upper terraces and xeroriparian plants would be found in the upper terraces or the historic floodplain. While diminished flows might lead to drier communities occurring near the active channel, hydroriparian plants would not be found in the historic floodplain and drier communities would not be found near the channel with a wetter one upgradient at a greater distance from the channel (See Figure 4.3). With a few exceptions described later, alternatives that violated this "natural logic" were eliminated.

While the Santa Cruz River channel has substantial capacity to convey flood flows, restoration measures that encourage the growth of thick stands of vegetation throughout the channel would reduce that capacity and run a high risk of inducing flood damages as a result. Therefore, alternatives that would create extensive new woody vegetation and obstructions in both the terraces and the active channel were eliminated. Application of these screening criteria resulted in elimination of thirty-three of the forty-seven possible alternatives. The results of this screening are presented in Table 5.8 and those alternatives eliminated from further consideration are gray shaded.

Table 5.8
Alternative Screening

Active Channel	Terraces	Floodplain	Reason for Elimination
No Action	Xeroriparian	Xeroriparian	Fails to Provide Sufficient Habitat Diversity
No Action	Xeroriparian	Mesoriparian	Not Consistent With Natural Pattern
No Action	Xeroriparian	No Action	Fails to Provide Sufficient Habitat Diversity
No Action	Mesoriparian	Xeroriparian	
No Action	Mesoriparian	Mesoriparian	
No Action	Mesoriparian	No Action	Fails to Provide Sufficient Habitat Diversity
No Action	Hydroriparian	Xeroriparian	Not Consistent With Natural Pattern
No Action	Hydroriparian	Mesoriparian	Not Consistent With Natural Pattern
No Action	Hydroriparian	No Action	Not Consistent With Natural Pattern
No Action	No Action	Xeroriparian	Fails to Provide Sufficient Habitat Diversity
No Action	No Action	Mesoriparian	Fails to Provide Sufficient Habitat Diversity
Xeroriparian	No Action	No Action	Fails to Provide Sufficient Habitat Diversity
Xeroriparian	No Action	Xeroriparian	Fails to Provide Sufficient Habitat Diversity
Xeroriparian	No Action	Mesoriparian	Not Consistent With Natural Pattern
Xeroriparian	Xeroriparian	No Action	Fails to Provide Sufficient Habitat Diversity
Xeroriparian	Xeroriparian	Xeroriparian	
Xeroriparian	Xeroriparian	Mesoriparian	Not Consistent With Natural Pattern
Xeroriparian	Mesoriparian	No Action	Not Consistent With Natural Pattern
Xeroriparian	Mesoriparian	Xeroriparian	Not Consistent With Natural Pattern
Xeroriparian	Mesoriparian	Mesoriparian	Not Consistent With Natural Pattern
Xeroriparian	Hydroriparian	No Action	Not Consistent With Natural Pattern
Xeroriparian	Hydroriparian	Xeroriparian	Not Consistent With Natural Pattern
Xeroriparian	Hydroriparian	Mesoriparian	Not Consistent With Natural Pattern
Mesoriparian	No Action	No Action	Fails to Provide Sufficient Habitat Diversity
Mesoriparian	No Action	Xeroriparian	Not Consistent With Natural Pattern
Mesoriparian	No Action	Mesoriparian	Not Consistent With Natural Pattern
Mesoriparian	Xeroriparian	No Action	
Mesoriparian	Xeroriparian	Xeroriparian	
Mesoriparian	Xeroriparian	Mesoriparian	Not Consistent With Natural Pattern
Mesoriparian	Mesoriparian	No Action	
Mesoriparian	Mesoriparian	Xeroriparian	
Mesoriparian	Mesoriparian	Mesoriparian	
Mesoriparian	Hydroriparian	No Action	Not Consistent With Natural Pattern
Mesoriparian	Hydroriparian	Xeroriparian	Not Consistent With Natural Pattern
Mesoriparian	Hydroriparian	Mesoriparian	Not Consistent With Natural Pattern
Hydroriparian	No Action	No Action	
Hydroriparian	No Action	Xeroriparian	Not Consistent With Natural Pattern
Hydroriparian	No Action	Mesoriparian	Not Consistent With Natural Pattern
Hydroriparian	Xeroriparian	No Action	
Hydroriparian	Xeroriparian	Xeroriparian	
Hydroriparian	Xeroriparian	Mesoriparian	Not Consistent With Natural Pattern
Hydroriparian	Mesoriparian	No Action	Too Much Reduction in Conveyance
Hydroriparian	Mesoriparian	Xeroriparian	Too Much Reduction in Conveyance
Hydroriparian	Mesoriparian	Mesoriparian	Too Much Reduction in Conveyance
Hydroriparian	Hydroriparian	No Action	
Hydroriparian	Hydroriparian	Xeroriparian	
Hydroriparian	Hydroriparian	Mesoriparian	

Note: "Natural Pattern" refers to maintaining the appropriate association of plan communities with geomorphic setting.

Recreation components will be considered in the design of the recommended plan. Passive recreation associated with restored areas may include trails, viewing areas, and kiosks. The need to establish equestrian and off-road vehicle areas in neighboring sites to reduce the likelihood of impacts to restored areas from those activities will be evaluated.

Initially, alternatives were designated by combinations of four characters into groups of three. The letters used are N for no action, X for xeroriparian, M for mesoriparian and H for hydroriparian. Each letter represents a row from the Alternative Features Matrix with the order of letter aligned to the columns. Each habitat designation is assigned to the geomorphic aspect of the riparian corridor cross section moving from the center of the river channel to the highest ground furthest from the river's centerline: active channel, terraced floodplain, and historic floodplain. For example, alternative HMN would be the result of combining hydroriparian active channel features and mesoriparian terrace features with no action in the historic floodplain. Results of the screening are discussed below.

Alternatives with No Measures in the Active Channel

Nine of the eleven alternative based on no action in the active channel were eliminated. Alternatives NXX, NXN, NMN, NNX and NNM were eliminated because they failed to produce sufficient area of diverse habitat. In addition, four of these include no action in two of the three geomorphic regions and as such, are inconsistent with natural patterns. Alternative NXM, NHX, NHM and NHN all have at least one wetter plant community located up gradient from a drier one and thus are inconsistent with natural patterns.

NMX and NMM were retained although they represent a departure from the screening criteria in that one would normally find a hydroriparian or mesoriparian plant community in the active channel if flow were frequent enough to support a mesoriparian community on the terraces. However, one of the other screening criteria was to avoid unacceptable reductions in flood conveyance. Leaving the active channel undisturbed represents the least possible impact to conveyance short of avoiding both the channel and the terraces.

Alternatives with Xeroriparian Measures in the Active Channel

Eleven of the twelve alternatives based on xeroriparian restoration in the active channel were eliminated. Alternatives XNM XXM, XMN, XMX, XMM, XHN, XHX, and XHM all have at least one wetter plant community located up gradient from a drier one and thus are inconsistent with natural patterns. Alternative XNX neither provides sufficient area of diverse habitat nor is consistent with natural patterns as the restored xeroriparian communities would be cut off from each other by an unrestored terrace region. Finally, alternatives XNN and XXN did not provide sufficient area of diverse habitat. Alternative XNN would consist of a total of six acres seasonally emergent marsh and 5 acres of riparian shrub for a total of 11 acres. Alternative XXN would add 174 acres of riparian shrub and 14 acres of mesquite for a total of 199 acres, 90 percent of which would be one cover type (riparian shrub. One alternative including xeroriparian features in the channel was carried forward. Alternative XXX (1125 acres with 77 percent riparian shrub) pairs xeroriparian channel features with xeroriparian restorations on the terraces and in the historic floodplain. The combination of a larger restoration area with the reduction of dominance by a single cover type leads to the retention of XXX.

Alternatives with Mesoriparian Measures in the Active Channel

Seven of the twelve alternatives based on mesoriparian restoration in the active channel were not carried forward. Alternatives MNX, MNM, MXM, MHN, MHX and MHM all have at least one wetter plant community located up gradient from a drier one and thus are inconsistent with natural patterns. Alternative MNN did not provide sufficient area of diverse habitat. Five alternatives including mesoriparian features in the active channel were carried forward. Those alternatives carried forward were MXN, MXX, MMN, MMX and MMM.

Alternatives with Hydroriparian Measures in the Active Channel

Six of the twelve alternatives based on hydroriparian restoration in the active channel were not carried forward. Alternatives HNX, HNM and HXM all have at least one wetter plant community located up gradient from a drier one and thus are inconsistent with natural patterns. Alternatives HMN, HMX and HMM would all have excessive impacts on conveyance of flood flows due to pairing of mesquite planted lower and upper terraces with the hydroriparian channel. Six alternatives including hydroriparian features in the active channel were carried forward. Those alternatives carried forward were HNN, HXN, HXX, HHN, HHX and HHM.

In summary, twenty-one of the forty-seven theoretical alternatives identified in the initial plan formulation matrix were not carried forward because they were inconsistent with the appropriate geomorphic setting of riparian communities; an additional nine were eliminated because they failed to provide sufficient area of diverse habitat (that is, they failed to maximize use of the delineated Project Area lands and lacked community interspersion); and three others were eliminated based on the impacts they would have on conveyance of flood flows.

Alternative Names

The adopted nomenclature (combinations of N, X, M and H into groups of three) worked well during the initial screening and was carried forward into the HGM based analysis of restoration outputs. However, in the alternatives that survived the screening process it became apparent that this nomenclature was somewhat misleading.

For example, as noted in Table 5.7, hydroriparian terrace features were modified to limit planting on the lower terraces to riparian grasses while upper terraces are planted with mesquite irrigated at hydroriparian levels. This action was taken to ameliorate potential conveyance impacts of the associated hydroriparian channel features. These were important distinctions to capture during the initial assembling and screening of alternatives. However, the resulting "hydroriparian terrace features", due to the limitations imposed, result in a restored habitat more representative of mesoriparian plant communities.

Another example is the decision to include stabilized terraces in the historic floodplain with all alternatives having a perennial channel. As a result, N for no action really meant no action except for the terraces. Therefore, it was decided to refer to alternatives that passed screening in terms of the plant communities to be restored in order to eliminate any confusion regarding habitats to be restored. Each alternative is assigned a number (1-4) for the channel treatment and a letter sequenced within each number grouping (Table 5.9).

Table 5.9
Alternative Names

Screening	Alternative Name	Screening	Alternative Name
NMX	1A	MMM	3E
NMM	1B	HNN	4A
XXX	2A	HXN	4B
MXN	3A	HXX	4C
MXX	3B	HHN	4D
MMN	3C	HHX	4E
MMX	3D	HHM	4F

I. First Array of Alternatives

Fourteen of the forty-seven possible alternatives remained after the initial screening. A brief description of each alternative is provided below with summary data regarding the alternatives immediately following in Table 5.10. For ease of presentation, the alternatives have been grouped based on the riparian community in the active channel (e.g., no action in the channel, etc).

1. <u>No Channel Features</u>

Two alternatives with no restoration measures in the active channel survived screening. Common features of both alternatives include construction and planting of subsurface water harvesting basins at the confluences of 11 tributaries, permanent irrigation systems for mesoriparian areas, temporary irrigation for xeroriparian areas and stabilized terraces in areas with steep unprotected banks. In addition, soil amendment would be common to both mesoriparian and xeroriparian areas with the latter having additional surface treatments to improve the soils ability to collect and retain rainfall.

The water harvesting features would involve excavating in the area where the tributaries enter the terraces. Excavation would be to a depth of approximately four feet, a liner membrane would be laid, and the excavated area would be filled with layers of appropriately sized gravel covered with granular fill. Permanent irrigation would combine construction of feeder pipelines to move water through the project area with use of gated pipe, flood or subsurface drip irrigation to distribute water at specific locations. In some cases, such as the tributary basins, a simple outflow would be sufficient.

Reaches of steep natural banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. The method of stabilization would be a function of the amount of land available for the new terrace area. Where available land is not a constraint, banks will be graded at a 5 foot horizontal to 1 foot vertical slope and planted. Vegetated slopes of this grade are considered stable. A different treatment will be used in areas where there is not enough land to create a 5:1 slope but sufficient space exists to create slopes between 5:1 and 2:1. In those cases, the banks will be laid back to the minimum slope that can be fit into the available space. These slopes will also be vegetated, however a geotextile layer will be installed before planting to increase slope stability. In areas where insufficient space exists to accommodate 2:1 slopes placement of rip rap or soil cement may be necessary for bank protection. Such applications will be decided on a case-by-case basis.

There are several differences between alternatives with respect to the measures to be implemented in the historic floodplain. In the xeroriparian floodplain there is no permanent irrigation. Two features added to compensate for this are the additional efforts at surface treatment and the creation of a number of shallow depressions to concentrate local run-off.

Xeroriparian plantings will include smaller mesquite planted less densely, blue palo verde, wolfberry, graythorn, creosote bush, fourwing saltbush, sacaton netleaf hackberry and desert hackberry. Mesoriparian plantings will have many of the same species planted with a higher density using larger specimens of mesquite and the addition of Fremont cottonwood, Goodding Willow, and velvet ash at the tributary water harvesting basins.

Each of these alternatives results in the restoration or rehabilitation of 1,119 acres of habitat. Both are dominated by xeroriparian shrub (Scrubshrub) and mesquite with a few small pockets of cottonwood-willow.

Alternative 1A, Mesoriparian Terraces with Xeroriparian Floodplain, is comprised of 693 acres of xeroriparian shrub, 416 acres of mesquite and ten acres of cottonwood-willow. This alternative has an estimated construction cost of $73,054,463 that, when annualized over a 50-year period of analysis yields an average annual cost of $4,394,110. Annual Operations, Maintenance Repair, Rehabilitation and Replacement (OMRR&R) costs are estimated at $893,863 so the total average annual cost of the alternative is $5,287,973. This alternative produces a net gain of 406 average annual Functional Capacity Units at a cost of $13,025 per unit.

In Alternative 1B, Mesoriparian Terraces and Floodplain, the addition of irrigation to the historic floodplain reverses the dominance of xeroriparian plants, producing 638 acres of mesquite, 471 acres of Scrubshrub and 10 acres of cottonwood-willow. This alternative has an estimated construction cost of $80,399,322 that, when annualized over a 50-year period of analysis yields an average annual cost of $4,835,892. Annual OMRR&R costs are estimated at $888,749 so the total average annual cost of the alternative is $5,724,641. This alternative produces a net gain of 451 average annual Functional Capacity Units at a cost of $12,693 per unit.

2. Xeroriparian Channel Features

The channel features for this alternative consist of two measures; construction of water harvesting basins on the upstream side of five existing grade structures and construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch.

The water harvesting basins would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to preclude significant impacts on flood flows.

The low flow diversion would be accomplished by placing a diversion structure in the New West Branch channel to pond low flows and placing a 24" diameter culvert through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The tributary basins discussed above would still be constructed. However, they would be expanded in size since, without irrigation, the plants in those areas would be much more dependent water harvesting.

Soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. Also, the off channel areas to concentrate local runoff would be created in the floodplain.

Alternative 2A restores or rehabilitates 1,125 acres of habitat. It is dominated by 867 acres of xeroriparian shrub (Scrubshrub) with 252 acres of mesquite and 6 acres of emergent marsh (Riverbottom). This alternative, Xeroriparian, has an estimated construction cost of $62,604,865 that, when annualized over a 50-year period of analysis yields an average annual cost of $3,765,583. OMRR&R costs are estimated at $428,518 so the total average annual cost of the alternative is $4,194,101. This alternative produces a net gain of 402 average annual Functional Capacity Units at a cost of $10,433 per unit.

3. Mesoriparian Channel Features

There are five alternatives sharing mesoriparian features in the active channel. The change in channel features associated with these alternatives consists of introduction of irrigation water into the lower reach of the Old West Branch and irrigation of the grade control harvesting basins. The irrigation would not be constant but would consist of adding water to extend the flow period following natural events. In this way, the volume and duration of flow in these areas would be increased to mimic mesoriparian conditions.

Two of the five mesoriparian channel alternatives have no restoration in the historic floodplain. Paired with the mesoriparian channel they produce only 199 acres of restored or rehabilitated habitat.

Alternative 3A, Mesoriparian Channel with Xeroriparian Terraces, restores 6 acres of emergent marsh, 174 acres of xeroriparian shrub and 19 acres of mesquite. 3A has an estimated construction cost of $18,179,435 that, when annualized over a 50-year period of analysis yields an average annual cost of $1,093,464. OMRR&R costs are estimated at $232,910 so the total average annual cost of the alternative is $1,326,375. This alternative produces a net gain of 62 average annual Functional Capacity Units at a cost of $21,393 per unit.

Alternative 3C, Mesoriparian Channel and Terraces, restores the same 6 acres of emergent marsh with the remaining 193 acres consisting of mesquite. 3C has an estimated construction cost of $17,128,553 that, when annualized over a 50-year period of analysis yields an average annual cost of $1,030,255. OMRR&R costs are estimated at $636,403 so the total average annual cost of the alternative is $1,666,659. This alternative produces a net gain of 115 average annual Functional Capacity Units at a cost of $14,493 per unit.

The other three alternatives with mesoriparian channel features each produce 1,125 acres of restored or rehabilitated habitat.

Alternative 3B, Mesoriparian Channel with Xeroriparian Terraces and Floodplain, is dominated by 862 acres of xeroriparian shrub with 257 acres of mesquite and 6 acres of emergent marsh. 3B has an estimated construction cost of $73,640,021 that, when annualized over a 50-year period of analysis yields an average annual cost of $4,429,331. OMRR&R costs are estimated at $493,394 so the total average annual cost of the alternative is $4,922,724. This alternative produces a net gain of 375 average annual Functional Capacity Units at a cost of $13,127 per unit.

Alternative 3D, Mesoriparian Channel and Terraces with Xeroriparian Floodplain, is predominantly xeroriparian shrub at 688 acres with 421 acres of mesquite, 10 acres of cottonwood-willow and 6 acres of emergent marsh. 3D has an estimated construction cost of $71,605,491 that, when annualized over a 50-year period of analysis yields an average annual cost of $4,306,957. OMRR&R costs are estimated at $896,887 so the total average annual cost of the alternative is $5,203,844. This alternative produces a net gain of 409 average annual Functional Capacity Units at a cost of $12,723 per unit.

Alternative 3E, Mesoriparian, continues the trend with mesquite becoming dominant at 643 acres, 466 acres of xeroriparian shrub, 10 acres of cottonwood-willow and 6 acres of emergent marsh. Alternative 3E has an estimated construction cost of $80,678,407 that, when annualized over a 50-year period of analysis yields an average annual cost of $4,852,678. OMRR&R costs are estimated at $866,625 so the total average annual cost of the alternative is $5,719,304. This alternative produces a net gain of 454 average annual Functional Capacity Units at a cost of $12,598 per unit.

4. <u>Hydroriparian Channel Features</u>

Implementation of these alternatives involves replacing the channel features discussed above with a perennial flow channel. It would require grading the active channel to create a low flow channel averaging six feet in width and one-half foot in depth. Grading would also create depressional areas on each side of the low flow channel about ten feet in width where soil saturation conditions resulting from infiltration would be conducive to emergent marsh. Finally, a band of cottonwood-willow varying in width from ten to twenty feet would be planted adjacent to the emergent marsh to further utilize infiltrating water from the perennial channel.

Because of the conveyance impacts that would result from such a feature, terrace features are limited to either xeroriparian (discussed above), or hydroriparian. In the hydroriparian terraces the upper levels are irrigated and planted with mesquite and pockets of cottonwood-willow. The lower terraces would be planted with riparian grasses and would be maintained as xeroriparian shrub with larger shrubs or medium sized trees periodically cut back to retain cross-sectional area for conveyance of larger flood flows.

Finally, the alternatives including No Action in the historic floodplain would still include the stabilized terraces described for the xeroriparian and mesoriparian floodplain. These graded reaches would be created by excavating historic floodplain, rather than be filling into the active channel. Even though this measure affects the historic floodplain and produces significant restoration benefits, it is carried forward here to mitigate greater erosion risks associated with increased channel roughness. Three of the six alternatives involve "no action" in the historic floodplain.

Alternative 4A, Hydroriparian Channel, produces 319 restored acres with 122 acres of mesquite, 69 acres of cottonwood-willow, 69 acres of riparian shrub and 59 acres of emergent marsh. Alternative 4A has an estimated construction cost of $40,303,387 that, when annualized over a 50-year period of analysis yields an average annual cost of $2,424,185. OMRR&R costs are estimated at $1,196,386 so the total average annual cost of the alternative is $3,620,570. This alternative produces a net gain of 155 average annual Functional Capacity Units at a cost of $23,359 per unit.

Alternative 4B, Hydroriparian Channel with Xeroriparian Terraces, produces 507 restored or rehabilitated acres with 243 acres of riparian shrub, 136 acres of mesquite, 69 acres of cottonwood-willow and 59 acres of emergent marsh. Alternative 4B has an estimated construction cost of $43,521,747 that, when annualized over a 50-year period of analysis yields an average annual cost of $2,617,764. OMRR&R costs are estimated at $1,276,285 so the total average annual cost of the alternative is $3,894,049. This alternative produces a net gain of 188 average annual Functional Capacity Units at a cost of $20,713 per unit.

Alternative 4C, Hydroriparian Channel with Xeroriparian Terraces and Floodplain, produces 1247 restored or rehabilitated acres with 867 acres of riparian shrub, 253 acres of mesquite, 69 acres of cottonwood-willow and 59 acres of emergent marsh. Alternative 4D has an estimated construction cost of $81,125,713 that, when annualized over a 50-year period of analysis yields an average annual cost of $4,879,583. OMRR&R costs are estimated at $1,376,997 so the total average annual cost of the alternative is $6,256,580. This alternative produces a net gain of 491 average annual Functional Capacity Units at a cost of $12,743 per unit.

Alternative 4D, Hydroriparian Channel with Mesoriparian Terraces, produces 487 restored or rehabilitated acres with 181 acres of riparian shrub, 168 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. 4C has an estimated construction cost of $59,151,422 that, when annualized over a 50-year period of analysis yields an average annual cost of $3,557,864. OMRR&R costs are estimated at $1,357,426 so the total average annual cost of the alternative is $4,915,291. This alternative produces a net gain of 194 average annual Functional Capacity Units at a cost of $25,337 per unit. The other three alternatives all include either xeroriparian or mesoriparian floodplain features.

Alternative 4E, Hydroriparian Channel with Mesoriparian Terrace and Xeroriparian Floodplain, produces 1227 restored acres with 805 acres of riparian shrub, 284 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. 4E has an estimated construction cost of $88,180,602 that, when annualized over a 50-year period of analysis yields an average annual cost of $5,303,923. OMRR&R costs are estimated at $1,430,254 so the total average annual cost of the alternative is $6,734,177. This alternative produces a net gain of 490 average annual Functional Capacity Units at a cost of $13,743 per unit.

Alternative 4F, Hydroriparian Channel with Mesoriparian Terraces and Floodplain, produces 1227 restored or rehabilitated acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. 4F has an estimated construction cost of $85,263,675 that, when annualized over a 50-year period of analysis, yields an average annual cost of $5,128,475. OMRR&R costs are estimated at $1,658,608 so the total average annual cost of the alternative is $6,787,083. This alternative produces a net gain of 519 average annual Functional Capacity Units at a cost of $13,077 per unit.

Table 5.10
Alternative Summary for the First Array

Alternative	Total Acres Restored	Annual Water Demand (Acre-Ft)	Average Annual Cost	Rank by Average Annual Cost	Net AAFCUs	Rank by Net AAFCUs	Cost Per AAFCU	Rank by Average Cost per AAFCU	Ranking of Cost Effective Plans (CEA)	Best Buys (ICA)
1A	1119	563	$5,287,973	9	406	7	$13,025	6		
1B	1119	1889	$5,724,641	11	451	5	$12,693	3		
2A	1125	253	$4,194,101	5	402	8	$10,433	1	1	1
3A	199	55	$1,326,375	1	62	14	$21,393	12	8	
3B	1125	262	$4,922,724	7	375	13	$13,127	8	6	
3C	199	475	$1,666,659	2	115	9	$14,493	10		
3D	1125	681	$5,203,844	8	409	6	$12,723	4	3	
3E	1125	1925	$5,719,304	10	454	4	$12,598	2	2	
4A	319	7394	$3,620,570	3	155	12	$23,359	13	9	
4B	507	7280	$3,894,049	4	188	11	$20,713	11	7	
4C	1247	7296	$6,256,580	12	491	10	$12,743	5	4	
4D	487	7843	$4,915,291	6	194	2	$25,337	14		
4E	1227	7963	$6,734,177	13	490	3	$13,743	9		
4F	1227	8978	$6,787,083	14	519	1	$13,077	7	5	2

J. Analysis of First Array

The evaluation of alternatives involves the consideration of the ability to meet planning objectives in the context of the identified constraints. The following discussions address the differences and similarities between the alternatives and the baseline conditions. Details of these topics are addressed in the Environmental, Cost Estimating and Economic Appendices. The four national objectives are also considered in the comparison and evaluation of alternative plans, as are the associated evaluation criteria.

1. Environmental Resources

The reference sites considered most representative of what might be accomplished in the Paseo de las Iglesias area were San Pedro, with an average FCI of .814, and Tumacacori with an average FCI of .824. Together, the two sites have an average FCI of .819. The average Functional Capacity Indexes (FCI) for the alternatives range from .286 to .493. Thus the alternatives produce habitat that functions at 35% to 60% of the targeted level. Under with project conditions, the average FCI would be improved over the future without project condition for all alternatives. All but two of the alternatives (3A and 3C) achieve at least double the average without project FCI of .182, with values ranging from .370 to .493. Alternative 3A produces the lowest average FCI at .286.

The functional outputs for the alternatives range from 62 FCU to 519 FCU. Alternative 4D restores the highest number of acres and Alternatives 3A and 3B restore the least number of acres. The top three functional (for hydrogeomorphic, biogeochemical and biological function) alternatives are 4F, 4D and 4E. Alternative 4F results in restoration of 1227 acres of riparian habitat, while 4D and 4E restore 1247 and 1227 acres, respectively. These alternatives would produce net AAFCU gains of 519, 491 and 490, respectively.

The net increases in acreage of cover types produced by the alternatives ranges from 199 acres for 3A to 1,247 acres for 4D. Alternative 3A produces 6 additional acres of emergent marsh, 19 additional acres of mesquite and 174 additional acres of xeroriparian shrub. Alternative 4D produces 867 acres of xeroriparian shrub, 252 acres of mesquite, 69 acres of cottonwood-willow forest and 59 acres of emergent marsh.

It is reasonable to expect that there may be both short and long-term changes to biological resources because of the implementation of alternatives. Possible short-term effects may include, but are not limited to, temporary disturbance to vegetation communities and species including the temporary displacement or inadvertent killing of wildlife during construction. Implementation of mitigation measures during construction would be designed to minimize these effects. No adverse impacts are expected to Federally listed species, since none are known to occur in the area.

Beneficial outcomes go beyond the increase in the amount and quality of native riparian vegetation detailed above. While no Federally listed species occur in the area, there is one USFWS Species of Concern, two USFS Sensitive Species, and five SDCP sensitive species that may directly benefit from the restoration of these habitats. These include two mammals, one reptile, four birds and one plant. In addition to benefiting locally resident species the restored areas will provide additional resting and forage habitat for the many migratory bird species that pass through the Santa Cruz Basin.

2. Hydraulics Effects

The effects on water surface elevation were evaluated for Alternative 4F only since it included the greatest increase in vegetation and resultant roughness coefficients within the incised channel of the Santa Cruz River. For the 1% exceedance (100-year) event there was no induced flooding resulting from the channel modifications.

3. Water Budget

The potential water sources including but not limited to groundwater, the Santa Cruz River and its tributaries, and wastewater treatment plant effluents (both secondary effluent and reclaimed water), were evaluated based on the quality, quantity, and seasonality of flow. The analysis of water sources shows that the wastewater treatment plant effluent is a reliable water source for the project; however additional water sources not evaluated herein may become available during project implementation. The Santa Cruz River, its tributaries, groundwater, and local surface run-off can serve as supplemental water sources.

Water demand associated with the various alternatives ranges from a low of 55 acre-feet per year for Alternative 3A up to 8,978 acre-feet per year for Alternative 4F (which provides perennial flow). The water budgets for non-irrigated areas reflect small deficits after subtracting water supplied from precipitation. For example, Alternative 2A shows a need for 253 acre-feet per year more than would be supplied by on-site rainfall. These deficits will be offset by the effects of ground patterning and water harvesting features.

4. Costs

Preliminary costs were developed for each alternative. Cost estimates utilized a contingency of twenty-five percent of the alternatives' First Cost and allowed ten percent of the First Cost for engineering and design. One percent and six and one-half percent of first costs were used in estimating engineering and design during construction and construction management. The Gross Investment for an alternative includes the first cost added to the other costs defined above plus interest during construction calculated at the current 5.625 % interest rate, October 2004 price levels.

Gross Investment costs for the alternatives ranged from a low of $17,128,553 to a high of $88,263,575. Average Annual Costs, including Operation Maintenance Repair Rehabilitation and Replacement, ranged from $1,326,375 to $6,787,083. Details of cost estimates for other alternatives can be found in the Cost Estimating Appendix.

5. Economics

Traditional benefit-cost analysis is not possible for planning ecosystem restoration projects because the cost and benefits are expressed in different units. Corps of Engineers guidance (ER 1105-2-100, Planning Guidance Notebook) requires cost effectiveness and incremental cost analyses for recommended ecosystem plans to provide decision makers with relative benefit-cost relationships of the various alternatives. While these analyses are not intended to lead to a single best solution, they do improve the quality of decision making by ensuring that a rational, supportable, focused, and traceable approach is used for considering and selecting alternatives to produce ecosystem outputs.

The first step is to conduct a cost effectiveness analysis. This analysis is conducted to ensure that the least cost solution is identified for each possible level of ecosystem output. First, the alternative with the lowest level of biological output (FCUs) is selected. This is the first cost effective alternative identified. Then, the alternative with the next highest level of output is identified. If there are no alternatives that provide an equal or greater output for less cost, it becomes the second cost effective alternative. The process is repeated until all alternatives have been considered and all cost effective alternatives have been identified. Cost effectiveness means that no plan can provide the same benefits for less cost or more benefits for the same cost.

Nine of the fourteen plans subjected to detailed analysis were identified as cost effective. Table 5.11 lists those plans along with their associated costs and outputs.

Table 5.11
Cost Effective Alternatives

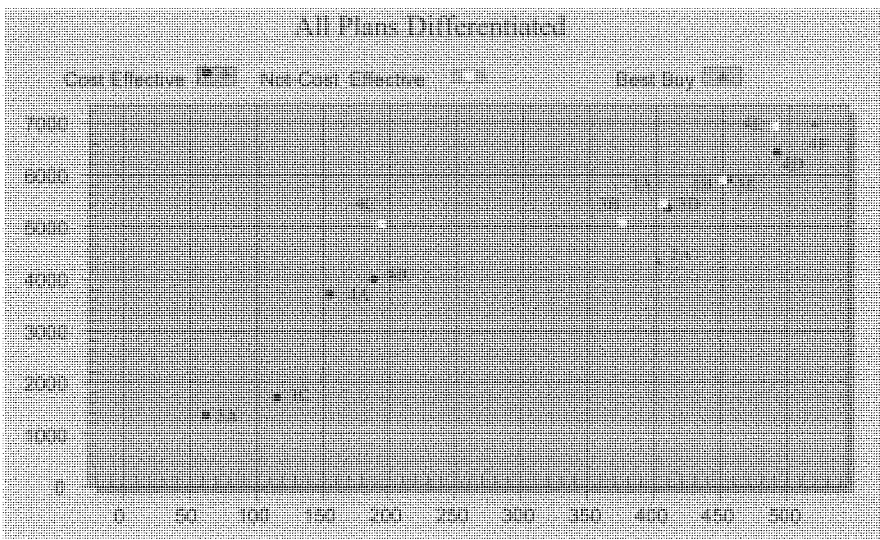
Alternative	Output Measured as FCUs	Average Annual Cost
3A	62	$1,326,375
3C	115	$1,666,659
4A	155	$3,620,570
4B	188	$3,894,049
2A	402	$4,194,101
3D	409	$5,203,844
3E	454	$5,719,304
4C	491	$6,256,580
4F	519	$6,787,083

After the cost effective alternatives have been identified, incremental analysis of the least cost solutions is conducted to reveal changes in cost for increasing level of outputs. In this case, the cost per unit of output is calculated and the alternative that has the lowest unit cost is identified. The cost effective alternative with the next lowest cost per unit of output is then identified. Any alternatives that produce the same output, or a lower output, for a higher unit cost are discarded. This analysis identifies the cost effective alternative with the lowest cost per unit of output and those alternatives that provide the greatest increase in benefits for the least increase in unit cost. These alternatives are called "Best Buys", and typically constitute the final array of alternatives from which the recommended plan is selected.

In applying incremental cost analysis to the eight cost effective alternatives, only two best buys were identified. This results from the fact that the alternative with the second cheapest unit cost is also the alternative with the highest total output. The alternative with the lowest cost per unit of output is Alternative 2A, which produces a net increase of 402 average annual FCU at a cost of $10,433 dollars per unit. The alternative with the next cheapest cost per unit of output is Alternative 4F, which produces an additional 117 average annual FCU at an incremental cost of $22,162 dollars per unit. Thus the second array of alternatives consists of these two alternatives. The results of these analyses are represented in Figures 5.2 and 5.3.

FIGURE 5.2 All Plans Differentiated

(CEA Plans and Best Buy Plans Labeled)



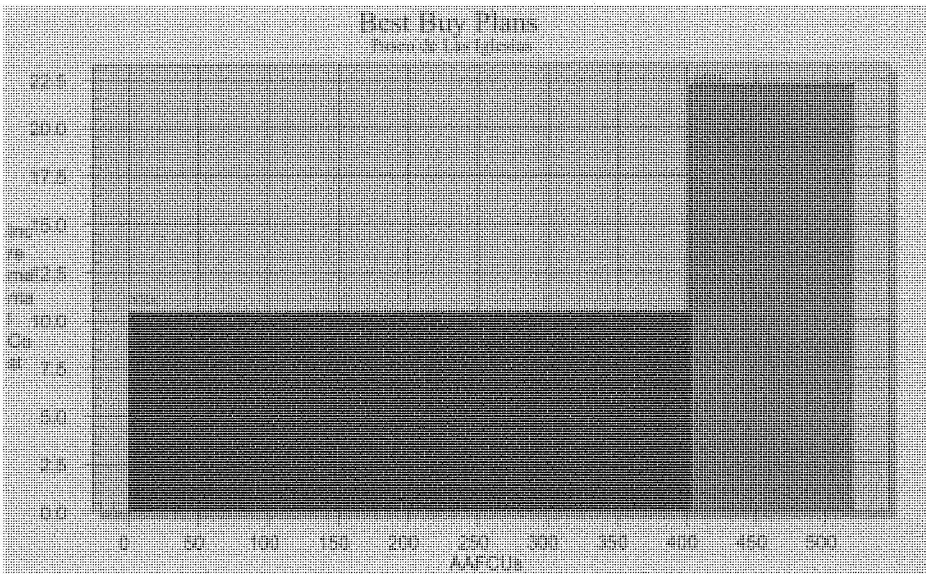


FIGURE 5.3 Final Incremental Cost Results

(Incremental Average Cost by Incremental Output)

6. Associated Evaluation Criteria

The selection of alternative plans for the final array required a combination of decision-making factors. For ecosystem restoration, the decision-making process attempts to incorporate human needs and values with our best understanding of the natural environment, recognizing a complex blend of social, economic, political and scientific information. Both quantitative and qualitative information is used including information about outputs, costs, significance, acceptability, completeness, effectiveness, partnership context, and reasonableness of costs. Policy and Guidance screening criteria are shown below.

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.

1. Plans have been formulated to ensure that investments necessary to ensure realization of planned effects have been identified.
2. Costs of investments have been thoroughly detailed by management measure and include: first costs, real estate costs, contingency, PED, engineering during construction, construction management, adaptive management, interest during construction, and OMRR&R.

Therefore, the completeness of all plans in the final array is a result of detailing all expected costs to accurately assess each alternative measure and allowing for extraneous factors by including an appropriate contingency.

Effectiveness: Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. In other words, it details the ability of the project to attain the planning objectives.

Planning objectives are listed as follows:

1. Increase the acreage of functional riparian and floodplain habitat within the study area.
2. Increase wildlife habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe and historic floodplain.
3. Provide passive recreation opportunities
4. Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration
5. Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

Efficiency: Efficiency is the extent to which an alternative plan is the most cost effective means to alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

IWR-Plan uses two techniques to address the question: is the alternative worth it in the cost evaluation process? First, the results of the habitat assessment were compared using Cost Effectiveness Analysis (CEA). When comparing alternatives using CEA, those alternatives that produce increased levels of output (AAFCUs) for the same or lesser costs were considered "effective" solutions and were retained. These alternatives were, in turn, compared based on cost efficiency (i.e. those alternatives that produce similar levels of output (AAFCUs at a lesser expense). The "efficient" solutions were submitted to Incremental Cost Analysis (ICA) (i.e. determining changes in costs for increasing levels of outputs). Once evaluated, through a computer program called IWR-Plan, on the basis of cost effectiveness and incremental cost analysis, the "best buy" solutions or alternatives resulting in the most output for the least cost were revealed (those that are both cost effective and incrementally efficient).

All of the plans in the Cost Effective and Efficient Array met all the criteria for completeness. Of these cost effective, efficient and complete alternatives, two were shown to be "best buy" solutions.

Acceptability: Acceptability is the workability and viability of the alternative plan with respect to acceptance by State, local entities and the public. Acceptability should also be compatible with existing laws, regulations, and public policies. The plans in the final array have features consistent with those identified as desirable by public work groups. These plans are also expected to comply with existing laws, regulations, and public policies.

7. Second Array of Alternatives

Two alternatives were identified to be carried forward based on the incremental analyses of the alternatives in the first array. These plans were the "Best Buy" plans as illustrated in Figure 5.1.

These alternatives were:

> *Alternative 2A*: This alternative focuses on water harvesting including soil amendment, surface grading, a low flow diversion and construction of subsurface water harvesting basins. Implementation of these measures will allow creation of new PWAAS, as well as supplemental Mesquite, Scrubshrub, and Riverbottom plantings in existing PWAAs. The alternative would require establishment irrigation and periodic irrigation during periods of prolonged drought (Figure 5.4).
>
> *Alternative 4F:* This alternative focuses on establishment of a low flow channel with perennial flow, laid back vegetated banks, soil amendment, surface grading, and construction of subsurface water harvesting basins. Implementation of these measures will allow creation of new PWAAS, as well as supplemental Cottonwood-Willow, Mesquite, Scrubshrub, and Riverbottom plantings in existing PWAAs. These planted areas will be irrigated (Figure 5.6).

K. Analysis of Third Array

Upon review of the second array of alternatives the non-Federal sponsor indicated that they were not prepared to support either of the "Best Buys" The general public and residents within the study area have expressed a desire for restoration beyond what might be accomplished without irrigation such as 2A. Furthermore, Alternative 2A, would predominately restore xeroriparian shrub without sufficient acreage of the riparian forest cover types; Mesquite and Cottonwood-Willow. Alternative 4F would restore substantial acreage of both Mesquite and Cottonwood-Willow. However, there are a number of restoration sites under study and committing such a large volume to a single project would be opposed by local citizens. In addition to public acceptability, there would be a substantial fiscal burden and complex political agreements associated with committing 9,000 acre-feet per year to a single restoration project.

First, the perennial flow included in 4F was reevaluated and found to provide two functions. One was to supply water to adjacent emergent wetlands and cottonwood-willow habitat through infiltration losses from the flow and the other was essentially aesthetic. The biologic outputs of the alternative (FCUs) were found to be independent of the presence or absence of perennial flow while the cost of having perennial flow (over two thirds of the water budget) was very high. Analysis indicated that the irrigation function of the perennial flow could be accomplished equally well utilizing an intermittent flow that would result in a reduction of over fifty percent in the water budget to an annual requirement of approximately 3683 acre-feet. While this was substantially less than the nearly 9000 acre-feet per year estimated with a perennial flow it still represented an extremely large commitment of water to a single restoration project.

It was at this point in the planning process that the non-Federal Sponsor, having considered types and quantities of habitat that might be restored with a full range of potential water budgets, determined that the maximum volume of water it could commit to ecosystem restoration in the Paseo de las Iglesias area was 2,000 acre-feet per year. In order to properly address the planning constraint introduced by this determination the first array of alternatives was reviewed and all alternatives requiring more than 2,000 acre-feet or irrigation water per year were eliminated. The following discussions address the differences and similarities between the remaining alternatives and the baseline conditions. Details of these topics are addressed in the Environmental, Cost Estimating and Economic Appendices. The four national objectives are also considered in the comparison and evaluation of alternative plans, as are the associated evaluation criteria.

1. Environmental Resources

The reference sites considered most representative of what might be accomplished in the Paseo de las Iglesias area were San Pedro, with an average FCI of .814, and Tumacacori with an average FCI of .824. Together, the two sites have an average FCI of .819. The average Functional Capacity Indexes (FCI) for the alternatives range from .286 to .493. Thus the alternatives produce habitat that functions at 35% to 60% of the targeted level. Under with project conditions, the average FCI would be improved over the future without project condition for all alternatives. All but two of the alternatives (3A and 3C) achieve at least double the average without project FCI of .182, with values ranging from .370 to .433. Alternative 3A produces the lowest average FCI at .286.

The functional outputs for the alternatives range from 62 FCU to 454 FCU. Alternative 4D restores the highest number of acres and Alternatives 3A and 3B restore the least number of acres. The top three functional (for hydrogeomorphic, biogeochemical and biological function) alternatives are 3E, 1B and 3D. Alternative 3E and 3D result in restoration of 1125 acres of riparian habitat, while 1B restores 1119 acres. These alternatives would produce net AAFCU gains of 454, 409 and 451, respectively.

The net increases in acreage of cover types produced by the alternatives ranges from 199 acres for 3A to 1,125 acres for 4D. Alternative 3A produces 6 additional acres of emergent marsh, 19 additional acres of mesquite and 174 additional acres of xeroriparian shrub. Alternative 3E produces 643 acres of mesquite, 466 acres of xeroriparian shrub, 10 acres of cottonwood-willow and 6 acres of emergent marsh.

It is reasonable to expect that there may be both short and long-term changes to biological resources because of the implementation of alternatives. Possible short-term effects may include, but are not limited to, temporary disturbance to vegetation communities and species including the temporary displacement or inadvertent killing of wildlife during construction. Implementation of mitigation measures during construction would be designed to minimize these effects. No adverse impacts are expected to Federally listed species, since none are known to occur in the area.

Beneficial outcomes go beyond the increase in the amount and quality of native riparian vegetation detailed above. While no Federally listed species occur in the area, there is one USFWS Species of Concern, two USFS Sensitive Species, and five SDCP sensitive species that may directly benefit from the restoration of these habitats. These include two mammals, one reptile, four birds and one plant. In addition to benefiting locally resident species the restored areas will provide additional resting and forage habitat for the many migratory bird species that pass through the Santa Cruz Basin.

2. Hydraulics Effects

No further analysis of hydraulic effects was performed beyond the evaluation of Alternative 4F since it included a greater increase in vegetation and resultant roughness coefficients than any of the remaining alternatives.

3. Water Budget

The potential water sources including groundwater, the Santa Cruz River and its tributaries, and wastewater treatment plant effluents (both secondary effluent and reclaimed water), were evaluated based on the quality, quantity, and seasonality of flow. The analysis of water sources shows that the wastewater treatment plant effluent is a reliable water source for the project. The Santa Cruz River, its tributaries, groundwater, and local surface run-off can serve as supplemental water sources.

Water demand associated with the various alternatives ranges from a low of 55 acre-feet per year for Alternative 3A up to 1925 acre-feet per year for Alternative 3E (which provides perennial flow). The water budgets for non-irrigated areas reflect small deficits after subtracting water supplied from precipitation. For example, Alternative 2A shows a need for 253 acre-feet per year more than would be supplied by on-site rainfall. These deficits will be offset by the effects of ground patterning and water harvesting features.

4. Costs

Preliminary costs were developed for each alternative. Cost estimates utilized a contingency of twenty-five percent of the alternatives' First Cost and allowed ten percent of the First Cost for engineering and design. One percent and six and one-half percent of first costs were used in estimating engineering and design during construction and construction management. The Gross Investment for an alternative includes the first cost added to the other costs defined above plus interest during construction calculated at the current 5.625 % interest rate, October 2004 price levels.

Gross Investment costs for the alternatives ranged from a low of $17,128,553 to a high of $80,678,407. Average Annual Costs, including Operation Maintenance Repair Rehabilitation and Replacement, ranged from $1,326,375 to $5,719,304. Details of cost estimates for other alternatives can be found in the Cost Estimating Appendix.

5. Economics

The alternatives in the third array were evaluated using the cost effectiveness and incremental cost analysis approach described in Section J.5. of the Chapter.

All of the eight remaining plans subjected to detailed analysis were identified as cost effective. Table 5.11 lists those plans along with their associated costs and outputs.

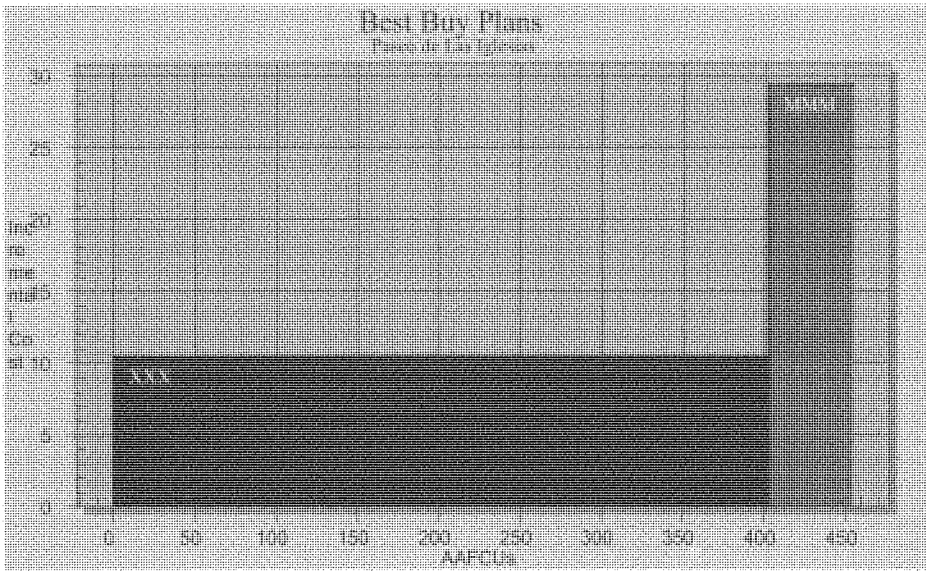
Table 5.12
Cost Effective Alternatives

Alternative	Output Measured as FCUs	Average Annual Cost
3A	62	$1,326,375
3C	115	$1,666,659
2A	402	$4,194,101
3B	375	$4,922,724
3D	409	$5,203,844
1A	406	$5,287,973
3E	454	$5,719,304
1B	451	$5,724,641

In applying incremental cost analysis to the eight cost effective alternatives, only two best buys were identified. This results from the fact that the alternative with the second cheapest unit cost is also the alternative with the highest total output. The alternative with the lowest cost per unit of output is Alternative 2A, which produces a net increase of 402 average annual FCU at a cost of $10,433 dollars per unit. The alternative with the next cheapest cost per unit of output is Alternative 3E, which produces an additional 52 average annual FCU at an incremental cost of $29,331 dollars per unit. Thus the final array of alternatives consists of these two alternatives. The results of these analyses are represented in Figures 5.2 and 5.3.

FIGURE 5.4 All Plans Differentiated

(CEA Plans and Best Buy Plans Labeled)



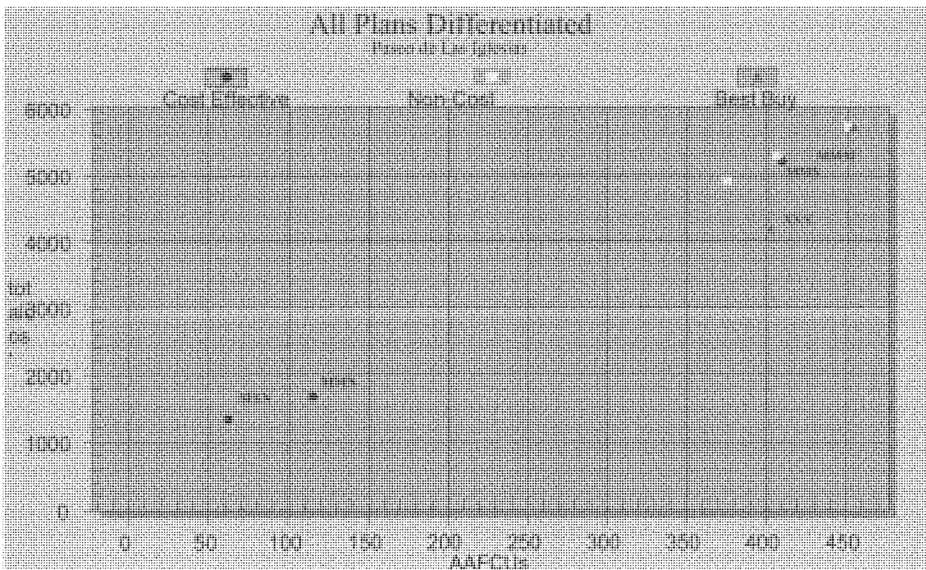


FIGURE 5.5 Final Incremental Cost Results

(Incremental Average Cost by Incremental Output)

6. Associated Evaluation Criteria

The selection of alternative plans for the final array required a combination of decision-making factors. For ecosystem restoration, the decision-making process attempts to incorporate human needs and values with our best understanding of the natural environment, recognizing a complex blend of social, economic, political and scientific information. Both quantitative and qualitative information is used including information about outputs, costs, significance, acceptability, completeness, effectiveness, partnership context, and reasonableness of costs. Policy and Guidance screening criteria are shown below.

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.

1. Plans have been formulated to ensure that investments necessary to ensure realization of planned effects have been identified.
2. Costs of investments have been thoroughly detailed by management measure and include: first costs, real estate costs, contingency, PED, engineering during construction, construction management, adaptive management, interest during construction, and OMRR&R.

Therefore, the completeness of all plans in the final array is a result of detailing all expected costs to accurately assess each alternative measure and allowing for extraneous factors by including an appropriate contingency.

Effectiveness: Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. In other words, it details the ability of the project to attain the planning objectives.

Planning objectives are listed as follows:

1. Increase the acreage of functional riparian and floodplain habitat within the study area.
2. Increase wildlife habitat diversity by providing a mix of riparian habitats with an emphasis on restoration of riparian forests within the river corridor, riparian fringe and historic floodplain.
3. Provide passive recreation opportunities
4. Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration
5. Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

Efficiency: Efficiency is the extent to which an alternative plan is the most cost effective means to alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

IWR-Plan uses two techniques to address the question: is the alternative worth it in the cost evaluation process? First, the results of the habitat assessment were compared using Cost Effectiveness Analysis (CEA). When comparing alternatives using CEA, those alternatives that produce increased levels of output (AAFCUs) for the same or lesser costs were considered "effective" solutions and were retained. These alternatives were, in turn, compared based on cost efficiency (i.e. those alternatives that produce similar levels of output (AAFCUs at a lesser expense). The "efficient" solutions were submitted to Incremental Cost Analysis (ICA) (i.e. determining changes in costs for increasing levels of outputs). Once evaluated, through a computer program called IWR-Plan, on the basis of cost effectiveness and incremental cost analysis, the "best buy" solutions or alternatives resulting in the most output for the least cost were revealed (those that are both cost effective and incrementally efficient).

All of the plans in the Cost Effective and Efficient Array met all the criteria for completeness. Of these cost effective, efficient and complete alternatives, two were shown to be "best buy" solutions.

Acceptability: Acceptability is the workability and viability of the alternative plan with respect to acceptance by State, local entities and the public. Acceptability should also be compatible with existing laws, regulations, and public policies. The plans in the final array have features consistent with those identified as desirable by public work groups. These plans are also expected to comply with existing laws, regulations, and public policies.

7. Final Array of Alternatives

Two alternatives were carried forward into the final array from which the recommended plan was selected. The alternatives were carried forward based on the incremental analyses of the alternatives in the third array. These plans were the "Best Buy" plans as illustrated in Figure 5.4. These alternatives were:

> *Alternative 2A*: This alternative focuses on water harvesting including soil amendment, surface grading, a low flow diversion and construction of subsurface water harvesting basins. Implementation of these measures will allow creation of new PWAAS as well as enhancement of existing PWAAS with plantings in Mesquite, Scrubshrub, and Riverbottom. The alternative would require establishment irrigation and periodic irrigation during periods of prolonged drought (Figure 5.6).
>
> *Alternative 3E*: This alternative builds on 2A by providing irrigation to the subsurface water harvesting basins in addition to water harvesting, soil amendment, surface grading, irrigation of the lower reaches of the Old West Branch. Implementation of these measures will allow creation of new PWAAS, as well as supplemental Cottonwood-Willow, Mesquite, Scrubshrub, and Riverbottom plantings in existing PWAAs. These planted areas will be irrigated (Figure 5.7).

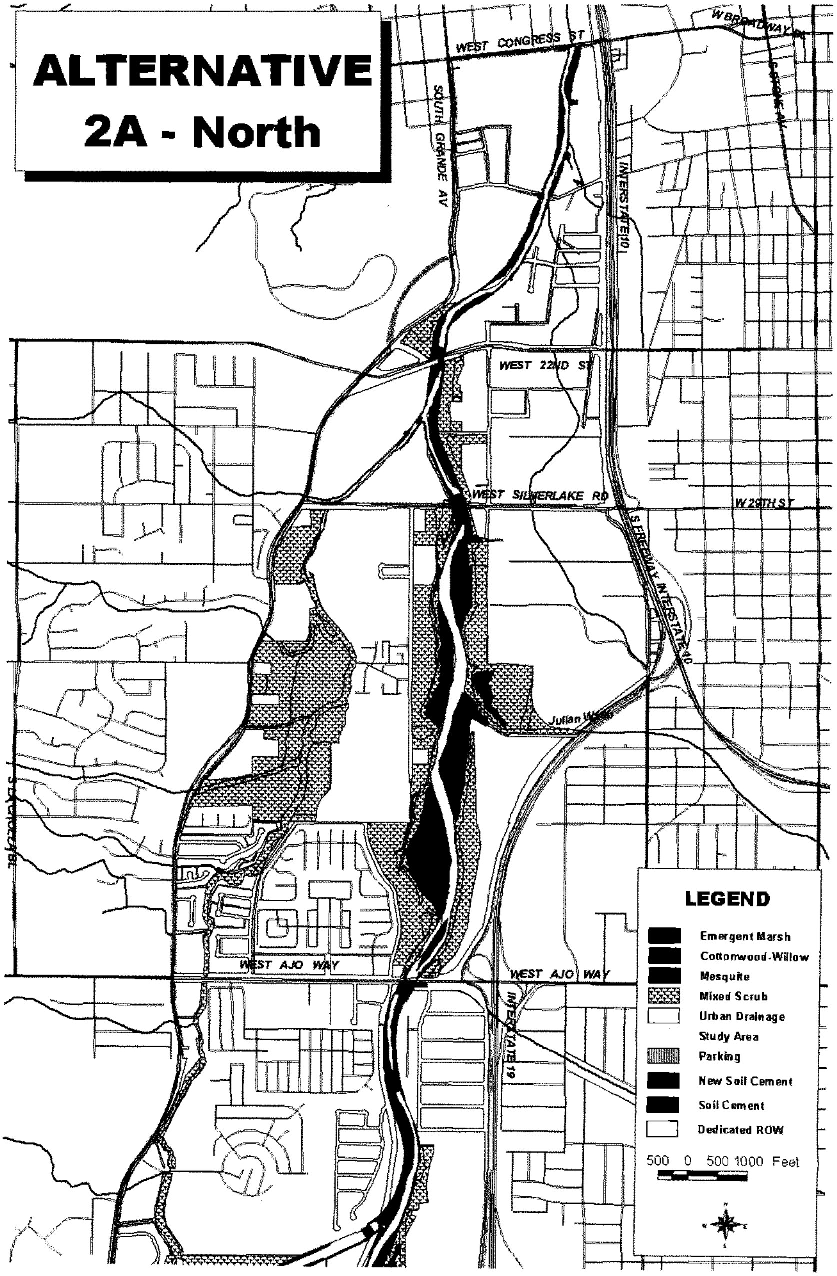


FIGURE 5.6a Alternative 2A

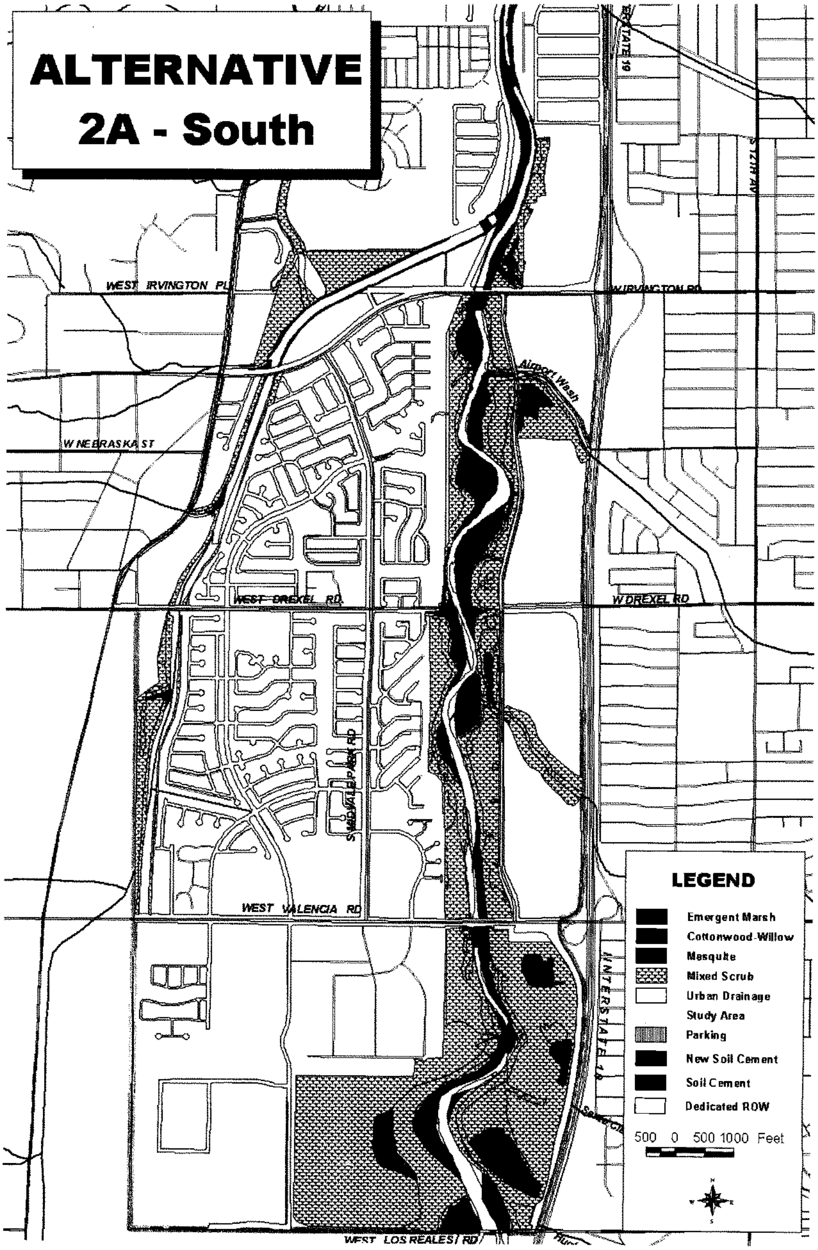


FIGURE 5.6b Alternative 2A

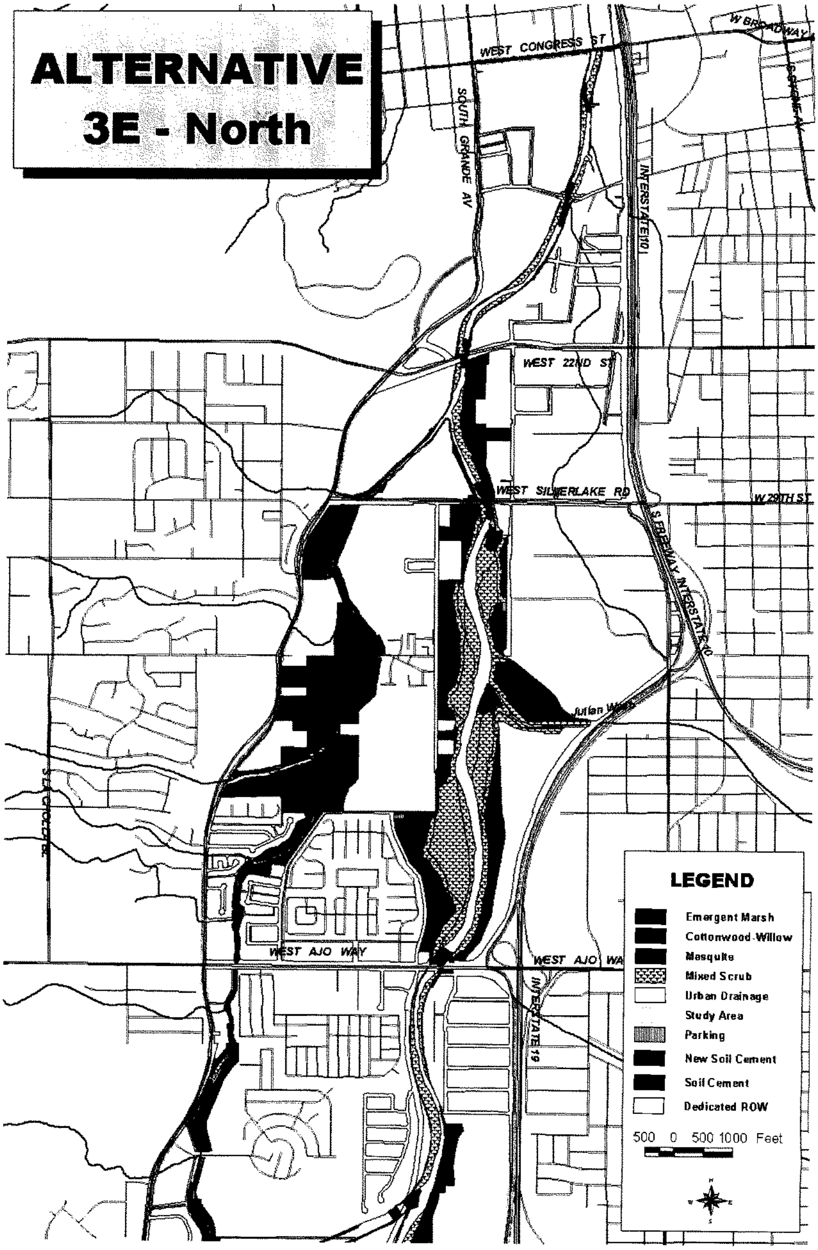


FIGURE 5.7a Alternative 3E

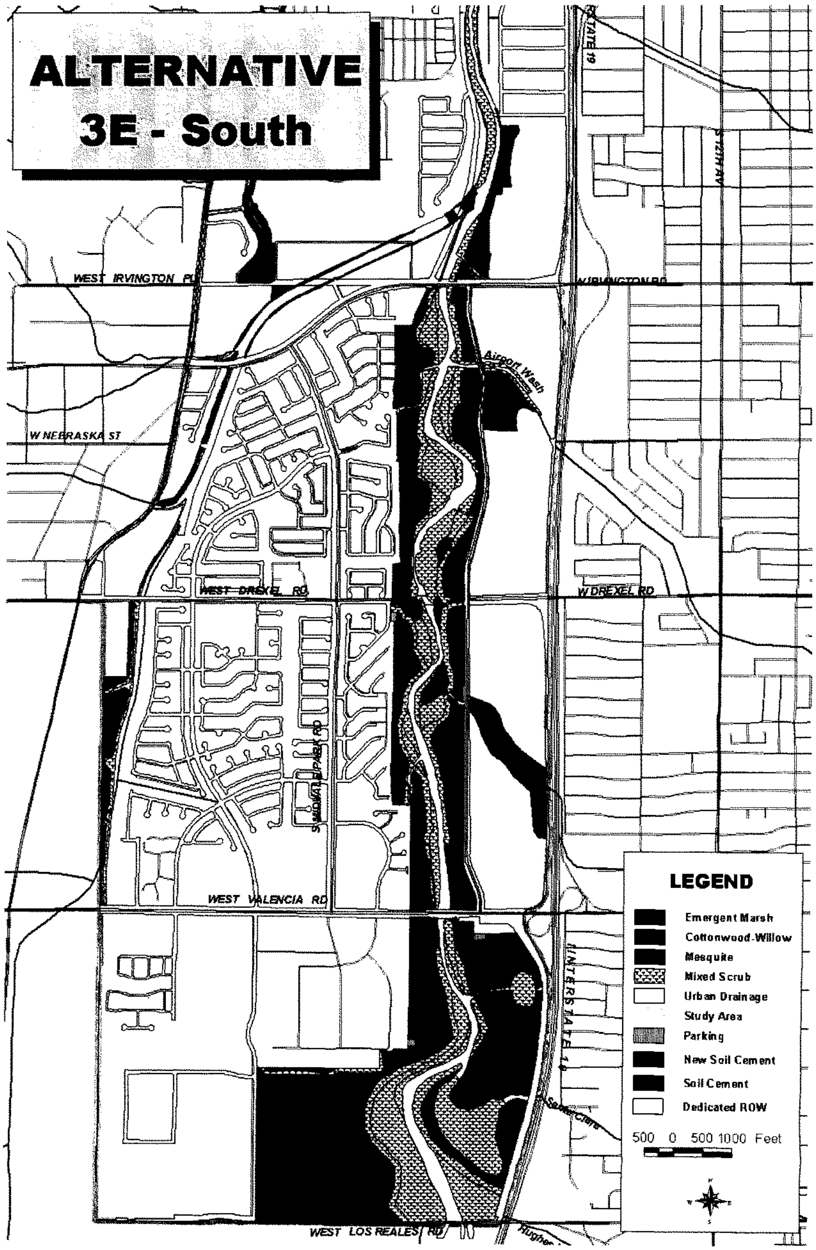


FIGURE 5.7b Alternative 3E

L. Selection of a Recommended Plan

1. Comparison and Evaluation of Alternative Plans

The comparison and evaluation of alternatives involves the consideration of the effects that the plans will have on planning objectives and constraints. The following discussions address the differences and similarities between the alternatives and the baseline conditions. The four national accounts are also considered in the comparison and evaluation of alternative plans, as are the associated evaluation criteria.

2. National Objectives

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. Based on these objectives, a method of displaying the positive and negative effects of alternatives is to use the System of Accounts recommended by the U.S. Water Resources Council. The accounts used are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). Policy in the 1970's regarded making contributions to only two of these, NED and EQ, as national objectives. Now only contributing to NED remains a national objective. However, these four categories of plan effects 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. 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 (P&G), which states: "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 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. Recommended ecosystem restoration measures do not need to exhibit net NED benefits, but will be based on non-monetary outputs compatible with the P&G selection criteria. Although alternatives may produce incidental NED benefits, for this study, the NED account is replaced with the National Ecosystem Restoration (NER) account. Ecosystem restoration has become one of the primary missions of the Civil Works program. The NER plan is the option with the greatest net ecosystem restoration benefits. The NER objective is to contribute to the Nation's ecosystems through restoration, with contributions measured by changes in the amounts and values of habitat. The four accounts used to compare the alternative plans have been modified to include the NER account, and the EQ, RED and OSE accounts.

3. NER Benefit Analysis of the Final Array

The NER account displays the monetary costs and the non-monetary benefits related to each alternative plan. The NER plan is identified by examining the net average annual functional capacity units (AAFCU's) for each alternative versus the net average annual costs for the alternative. Determination of the NER plan is typically the primary decision-making factor for identification of the recommended plan. The incremental cost analysis indicates that alternatives listed in Table 5.11 are cost effective and efficient incrementally. Alternative 2A ranks third based on average annual cost ($4.2 million) and ranks fifth in biological productivity but, at a cost of $10,433 annually per AAFCU, it ranks first in cost. Alternative 3E ranks seventh based on average annual cost ($5.7 million), ranks first in biological productivity and ranks second in cost at $12,598 annually per AAFCU. The incremental cost of selecting 3E is $29,331 per AAFCU.

4. Environmental Quality

The alternatives are forecast to have positive long term impacts when compared to the no action alternative. They could have short term negative impacts due to construction activities; however, these could be mitigated through implementation of Best Management Practices. Environmental analysis detected no notable differences between Alternatives 2A and 3E with respect to impacts on noise, cultural resources and aesthetics. However, the plans do differ with respect to water usage, the number of acres restored and the ecosystem function restored (AAFCUs).

Both alternatives would restore similarly large areas of habitat. However, Alternative 3E would possess the greatest diversity of habitat and would restore extensive areas of mesquite and areas of rare Cottonwood-willow vegetation. Alternative 3E would have the greatest potential benefits to the greatest number of wildlife species in the study area, especially to species that are regionally rare or declining. This alternative would result in the creation of Emergent Marsh and Cottonwood-willow vegetation that is potentially suitable habitat for several species that are Federally-listed, candidates for listing, of concern to Federal and state agencies, and regionally rare, endemic, or otherwise sensitive. Alternative 2A includes the same acreage of Emergent Marsh as Alternative 3E, but restores less than half the acres of mesquite and does not provide for the restoration of any of the rare Cottonwood-willow habitat. More species of concern would benefit under Alternative 3E than under Alternative 2A.

5. Regional Economic Development and Other Social Effects

None of the alternatives is forecast to have any quantifiable long-term effects on employment, causing growth or public health and safety when compared to the no action alternative. The plans are differentiated with respect to their annual operating costs and so have different effects on Local Government Finance as well as on Relocations Required and Open Space. When compared to the no action alternative, implementation of any of the alternatives, in concert with other proposed restoration actions, may help to sustain tourism related to bird watching and enjoyment of the environment.

Implementation of any of the alternatives is expected to have positive long-term impacts on recreation and tourism, as detailed in the economic analysis.

These accounts and the rankings of the No Action Alternative, Alternative 2A, and Alternative 3E for achievement in making contributions to the accounts are shown in Table 5.13 below. Although rankings for some of the variables are the same for each alternative, they have been included to preserve the distinction between the alternatives and the No Action Plan. Other "cost effective" plans that did not rate as "best buys" were not carried forward into the final array.

Table 5.13
Summary Ranking of Alternatives – System of Accounts
(Final Array: 1 is superior, 3 is average, 5 is poor)

FEATURES	No Action	Alt 2A	Alt 3E
Water Quality	4	3	2
Air Quality	3	2	2
Acres Restored	5	2	1
Balance of PWAAs Restored	5	3	2
Acres of Scarcer PWAAs	5	3	2
Overall Ecosystem Function Restored (AAFCUs)	5	2	2
NER Average Annual $/AAFCU	1	2	2
CEA ranking	1	2	2
Total Average Annual Costs	1	2	3
Local Government Finance for O&M	1	2	2
Public Acceptability	4	3	1
Relocations	1	2	3
Open Space	5	2	1
SUMMARY TOTAL (less is better)	41	30	25

6. Selection of a Recommended Plan

After consideration of the National Objectives and other associated evaluation criteria Alternative 3E is selected as the recommended plan. Alternative 3E was tentatively selected because:

1. It rated second for average cost among cost effective plans and first for biological output. It was effective, biologically productive and ranked highly on public acceptability.
2. Commitments of water resources associated with Alternative 3E are within the constraint identified by the non-Federal Sponsor.

3. Alternative 3E appropriately addresses the balance between ecosystem restoration and the need to maintain the existing level of flood protection

Non-Federal Sponsor Views of the Recommended Plan

From a partnership context and acceptability aspect, Alternative 3E best meets the objectives of the Non-Federal Sponsor, the Pima County Department of Transportation and Flood Control District.

CHAPTER VI
DESCRIPTION OF THE RECOMMENDED PLAN

A. Plan Description

The recommended plan, selected from those discussed in the previous chapter, is Alternative 3E. The plan is shown in Figure 6.1. Alternative 3E is expected to increase all ecosystem functions assessed to a moderate to good function. Alternative 3E is characterized by irrigated plantings of mesquite and riparian shrub on terraces above the low flow channel and in the historic floodplain with small areas of emergent marsh and cottonwood-willow habitat located at water harvesting features scattered throughout the project. Riparian shrub would be the dominant cover type on the banks and terraces while mesquite would be the dominant cover in the historic floodplain. Specific plan features include:

1. Water Harvesting Basins

Implementation of this alternative involves construction and irrigation of subsurface water harvesting basins on the upstream side of five existing grade structures and of introduction of irrigation water into the lower reach of the Old West Branch. Most of the existing grade control structures are located in the downstream portion of the project area between Silverlake and Congress with one located immediately upstream of Ajo Way. In addition to the basins collocated with existing grade control structures basins would be constructed in the area where the tributaries enter the terraces at the confluences of eight tributaries of the Santa Cruz River. Those basins are located at the confluence of the unnamed wash along the east bank of the river immediately upstream of the Silverlake Bridge, at the confluence of Julian Wash, at the confluence of the New West Branch, near the confluence of Airport Wash, and at the confluences of four small washes providing local drainage in the vicinity of Drexel Road.

The water harvesting basins would involve excavating to a depth of approximately four feet, compacting the soil to reduce infiltration rates, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. These areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to preclude significant impacts on flood flows.

Two other water harvesting features will be included south of Valencia in the historic floodplain along the east bank of the Santa Cruz. These features will involve regrading to take advantage of existing surface depressions near the confluences of Santa Clara Wash and an unnamed drainage immediately north of Santa Clara Wash. Grading of the depressions and connection of the depressions to the adjacent washes will allow capture of additional local runoff facilitating denser riparian habitat.

2. Irrigation System

Three methods of irrigation are planned for different areas of the project. Flood irrigation would be used for all restored areas in the historic floodplain. Furrows with a maximum length of 600 feet would be created on eight foot centers running roughly parallel to the south to north flow of the Santa Cruz. The bottoms of the furrows would be compacted to promote lateral infiltration of irrigation water. Water would be released into the furrows for a period of time sufficient to allow each furrow to fill.

A second method of water delivery, irrigation leach field or subsurface drip irrigation, would be used to provide water to habitat on natural or created slopes and on upper terraces. This approach utilizes leach pipe placed in the shallow trenches (approximately 12 inches deep) on ten foot centers. Irrigation water is fed into the pipes and allowed to soak into the root zone of the plants. A layer low permeability geotextile would be placed under the pipes in sloped areas to promote infiltration parallel to the surface.

Finally, for the low terraces that experience the most frequent flooding, sprinklers would be mounted on the higher adjacent banks. Irrigation would occur overnight to limit evaporation losses. These irrigation measures would be supplied by three irrigation mains running parallel to the Santa Cruz on each bank and along the Old West Branch. In the northernmost reach of the project, where no restoration is planned outside of the channel, water would be drawn from existing reclaimed water lines paralleling the trails on each bank. The end points of irrigation furrows and leach pipes will be modified to drain into water harvesting basins in those areas where they both occur.

3. Stabilized Banks

The reaches of steep eroded banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. The method of stabilization would be a function of the amount of land available for the new terrace area. Where available land is not a constraint, banks would be graded at a 5 foot horizontal to 1 foot vertical slope and planted. The regarded banks total approximately 56,000 liner feet on either bank of the river. The proposed locations of the regarded banks are depicted in Figures 24 through 31 of the Design Appendix. Vegetated slopes of this grade are considered stable. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it would reestablish a hydrologic connection to the river, reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout.

The excess material generated by cutting back these banks would be trucked down the channel to southernmost reach of the project. The material would be placed into abandoned gravel pits located in the historic floodplain to the west of the Santa Cruz River. In addition to eliminating the need for off-site disposal of the cut material this placement would make the area more suitable for restoration by reducing extreme variation in elevation created by past mining.

There are five short reaches of eroded bank where insufficient space exists to accommodate 5:1 slopes. These areas, totaling approximately 3,700 linear feet of bank, cannot be regraded; however, in their current state, they pose a threat of increased erosion and consequent destruction of plantings in adjacent areas. In order to preclude these risks, the areas would be stabilized using soil cement.

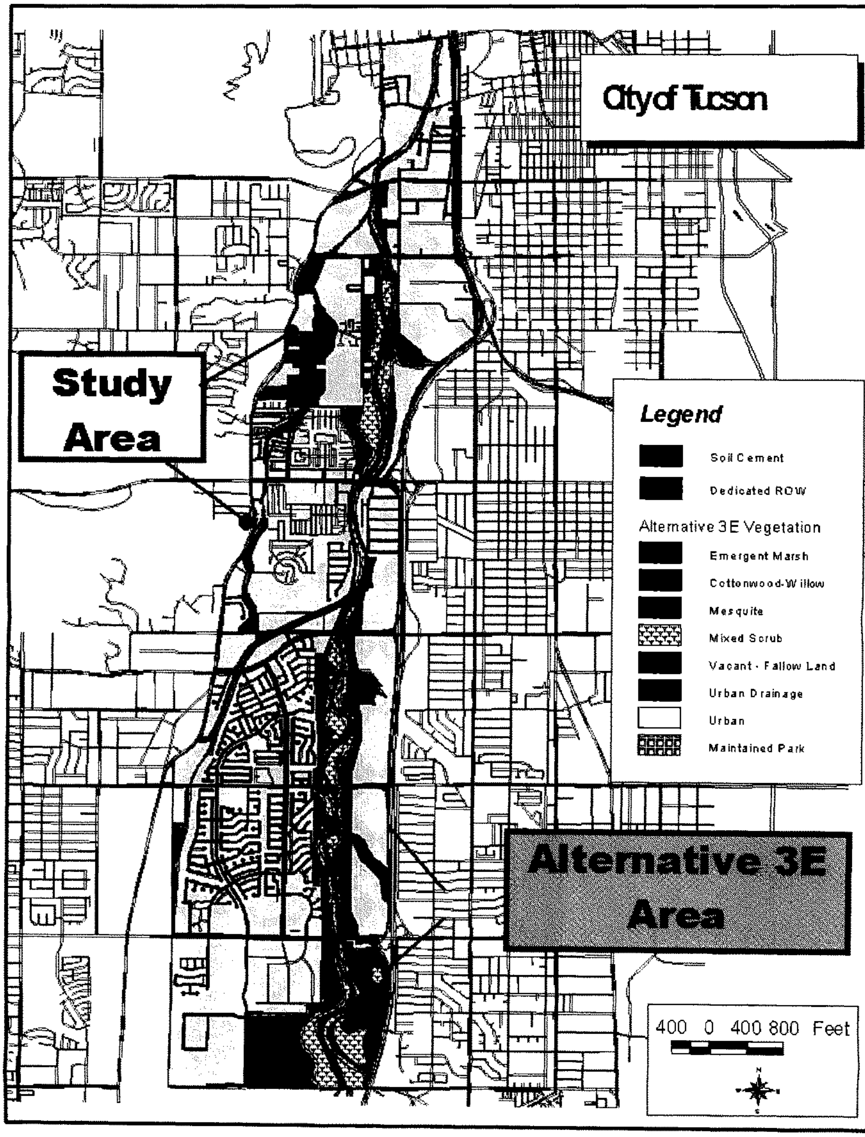


FIGURE 6.1 Recommended Plan

4. Other Features

Five tributaries have been identified where expected future erosion due to head cutting would represent a threat to adjacent restored habitat. In order to reduce the risk of future erosion pipe slope drains would be installed to intercept flows and convey them down the existing slope through while preventing additional erosion in the area.

5. Plant Communities

Prior to planting soil amendment would include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. Hydro-seeding would be used to spread a mix of native seed, mulch and fertilizer over all areas.

Plantings of mesquite and riparian shrubs would be interspersed throughout the project area; however, one or the other will provide the dominant cover in each geomorphic area where they occur. In the terraces and on the vegetated banks riparian shrub would be the dominant cover type while mesquite would dominate in the historic floodplain. This distribution, together with plantings at the harvesting basins, will yield 718 acres of mesquite habitat, 356 acres of riparian shrub (scrub-shrub), 18 acres of cottonwood-willow and 6 acres of emergent marsh (new riverbottom).

Plantings would include mesquite planted with a high density using larger specimens of mesquite, blue palo verde, netleaf hackberry, wolfberry, graythorn, catclaw acacia, fourwing saltbush, and sacaton. Fremont cottonwood, Gooding's Willow, and velvet ash would be added to the plantings at the tributary water harvesting basins. Native herbaceous grasses would be planted in the water harvesting basins upstream of existing grade-control structures.

6. Additional Water Sources

For as long as the project remains authorized, the non-Federal sponsor must provide sufficient water for construction, operation and maintenance of the project. Tertiary effluent accessed from reclaimed water mains would be distributed through an irrigation system in the restored areas. The annual water budget for the tentatively recommended plan is estimated at 1,925 acre-feet per year. The cost of providing such water is an associated non-Federal cost of the project and 100 percent of these costs will be paid by the non-Federal sponsor. These costs are currently estimated at $1,099,175 annually. These costs are not shared as part of the total project costs.

7. Real Estate Plan

A Real Estate Plan has been developed and is included in Appendix I. A real estate cost estimate has been prepared for Alternative 3E and has been used in the MCACES cost analysis provided in the Cost Appendix. Throughout the project area the low-flow channel is surrounded by areas to be restored, and so would be acquired as part of the restoration project. The total area to be acquired for the project is 1,223 aces.

8. Costs of Recommended Plan

The recommended plan has an estimated First Cost of $90,916,632. The First Cost is determined adding construction costs to real estate costs and then applying a contingency factor plus factors for design, engineering during construction, construction management and adaptive management to arrive at the First Cost. Details concerning costs of the recommended plan are presented in Table 6.1 below.

Table 6.1
Economic Cost Summary for the Recommended Plan

Cost Type	Amount
Construction & Real Estate	$72,828,371
Contingency at 15%	$6,987,940
PED at 10%	$4,658,627
EDC at 1%	$465,863
Construction Mgmt at 6.5%	$3,482,323
Adaptive Management	$1,870,205
Monitoring	$623,304
Total First Costs	$90,916,632
OMRR&R	$770,786
Water	$1,099,175

B. Project Outputs

1. National Ecosystem Restoration

The tentatively selected plan produces 454 AAFCUs at a cost of $16,819 per unit. This output is indicative of medium size healthy arid region riparian ecosystem. As noted earlier in the report, such ecosystems are increasingly rare and are necessary to provide critical habitat for many native and migratory species.

2. National Economic Development

NED benefits resulting from implementation of the tentatively selected plan are incidental and were not quantified. However, analysis of the with-project floodplain for the 1% exceedance event indicates a reduction in the extent and depth of overbank flooding.

C. Associated Costs

As noted above, the cost of providing water is an associated non-Federal cost of the project and 100 percent of these costs will be paid by the non-Federal sponsor. These costs are estimated at $1,099,175 annually. These costs are not shared as part of the total project costs.

D. Maintenance Considerations

The features of the Paseo de las Iglesias project are subject to damage by recurrent flood flows and periods of inundation. This will result in the need for periodic maintenance to insure successful habitat restoration. Operation and maintenance costs will include periodic channel clearance, control of invasive plant species, pumps and irrigation maintenance. Operation and maintenance also include periodic replanting of habitat areas damaged by flood.

In compliance with authorizing legislation and cost-sharing requirements, the non-Federal sponsor must assume responsibility for operation and maintenance of project features for as long as the project remains authorized. Maintenance and operation of the project will generate the following costs:

Table 6.2
Restoration Operation and Maintenance Costs

O&M Activities	Annual Cost
Invasives Control	$64,782
Biological Survey	$21,120
Vegetation Management	$4,320
Irrigation System Maintenance	$175,734
Replace Active Channel Features (YR 25/40)	$3,687
Replace Terrace Features (YR 25/40)	$501,143
Subtotal - OMRR&R	$770,786
Associated Water Costs	$1,099,175
Total	$1,869,961

E. Recreation Plan

The Recreation Plan proposed in conjunction with the recommended restoration plan consists of decomposed granite (DG) multipurpose trails, parking, and trail links that serve a recreation purpose by connecting existing unlinked trail segments and providing opportunities to a variety of recreational users. Comfort stations will serve the basic safety needs of the recreational user. All road segments designated as maintenance provide access to areas in case of emergencies such as flooding and fire. Access will also provide a means to maintain vegetation in the newly restored area and park facilities. Warning signs are also added to direct pedestrians off the newly restored area and guide pedestrians away from any potential danger. These changes will provide a unique opportunity for resource-based recreation and environmental education. Trail alignments and parking locations are shown on Figure 6.2. Placement of comfort stations will be determined during detailed design.

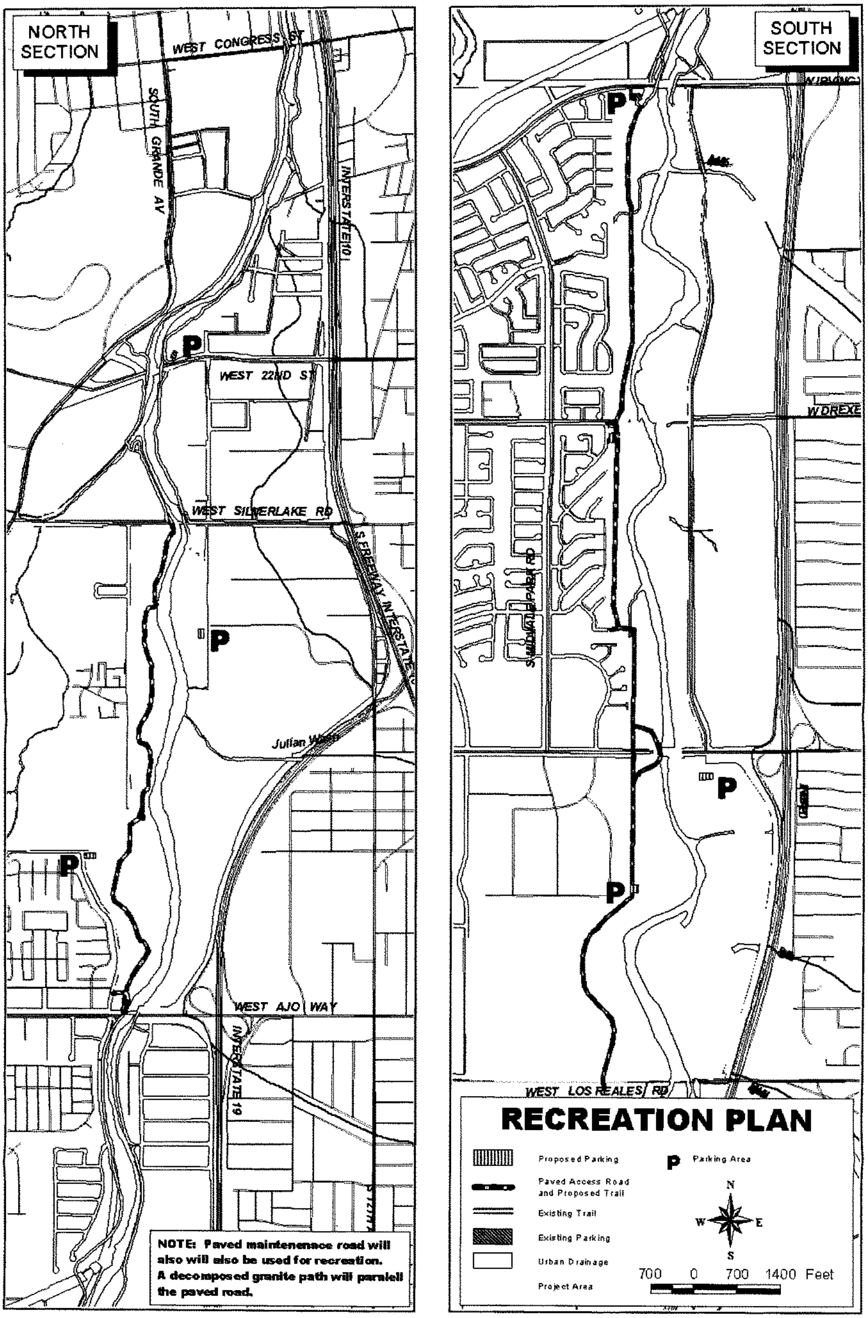


FIGURE 6.2 Recreation Plan

With the recreation improvements identified and described above, the unit day value (method described in the recreation component of this report under the Existing Condition) can be derived by selecting point values for recreation criteria and with the input of the US Army Corps of Engineers, LA District and local government agencies. These values are then applied to projected visitation. Because visitation figures have already been adjusted for double counting and projected over fifty years using a relationship to projected population growth, they will be used as a basis. However, further adjustments will be made to account for changes in visitation due to the construction of the project. These adjusted visitation figures will again be compared to capacity limits established by the National Recreation Parks Association.

The recreation criteria described in the Economic Appendix remain the same for the with project condition. The only changes will include impacts of the proposed recreation improvements to the Santa Cruz River Park and De Anza Historic Trail. They include:

1. ***Recreation Experience***--Same as Without Project Condition
2. ***Availability of Opportunity***--Same as Without Project Condition
3. ***Carrying Capacity***--As previously discussed, Pima County will experience rapid population growth. To accommodate this increase in population, additional parking lots, along with areas for five rest stops, three comfort stations and 20 benches are being proposed for the Santa Cruz River Park. DG multipurpose trail segments will also increase carrying capacity along the Santa Cruz. These proposed facilities would allow for future population growth.
4. ***Accessibility***--Same as Without Project Condition
5. ***Environmental***--Since there is no significant thriving riparian areas located in the study area, the restoration of the Santa Cruz River would prove to be a highly valued recreational area. Visitors could recreate near a thriving habitat for plants and animals. Restoration of this area could mean some of the significant unmet recreational demand for riparian areas could be met. Restoration features would also create more passive opportunities for wildlife viewing, aesthetic experience, and education. Recreational trails, signs, and access will be located so as to allow for recreation activities in such a way as to discourage interference and recreation in habitat areas.

The increase in the monetary value of the recreation experience derived from the Unit Day Value analysis of the changes in the recreation experience was applied to the projected visitation to calculate the economic benefits resulting from the recreation plan. That value was determined to be $135,484.

The US Army Corps of Engineers, Los Angeles District prepared the following cost estimates for the recreation project improvements. Estimated First Cost of the recreation plan is $1,141,914. Details regarding recreation costs may be found in the Cost Estimating Appendix. The average annual cost of the recreation plan was computed to be $69,474. Annual operations and maintenance costs for the recreation plan are estimated to be $36,260. Thus, the total average annual cost of the recreation plan is $105,734. Table 6.3 summarizes the economic analysis of the recreation plan. Details regarding the analysis of the recreation plan may be found in the Economic Appendix.

Table 6.3 Summary of Recreation Benefits and Costs

Benefits	
Recreation Value Without the Recreation Plan	$210,682
Recreation Value With the Recreation Plan	$346,166
Net Benefits of the Recreation Plan	$135,484
Costs	
Average Annual Costs	$69,474
OMRRR	$36,260
Total Average Annual Costs	$105,734
Benefit to Cost Ratio	1.29
Net Benefits	$29,750

F. Monitoring and Adaptive Management Plan

Uncertainty and variability are inherent in water resources planning 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.

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.

A higher than normal amount of uncertainty exists regarding landscape scale ecosystem restoration in the arid southwest. This is because very few such projects have been completed and those that have are of recent origin. Given the lack of precedent and scarcity of empirical data regarding restoration of Sonoran riparian systems there is a great degree of uncertainty regarding a number of aspects of the design, construction and operation of the recommended alternative. Uncertainty exists regarding:

- The volumes, frequency, and method of application used for irrigation
- The densities of initial plantings and the associated success rates
- The frequency of flood events and their impacts on restored habitat
- The design of the drainage features for water harvesting basins
- The design of bank stabilization measures
- Planned invasive plant management activities and schedules

Due to the number of project elements subject to uncertainty and the high degree of uncertainty associated with them a Monitoring and Adaptive Management Plan will be established to evaluate the effectiveness of the restoration measures implemented in this project and make adaptive changes, if required, to obtain project objectives. The cost of the first five years 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. The cost of the adaptive management action will be limited to three percent of the total project cost excluding monitoring costs.

1. Purpose

The purpose of the Monitoring and Adaptive Management Plan is to provide a mechanism to evaluate the effectiveness of the restoration measures implemented in this project and implement adaptive changes, if required to obtain project objectives. As outlined in EC 1105-2-210 (para. 21.b.), the Monitoring Plan is intended to ascertain whether: the project is functioning as per project objectives; adjustments for unforeseen circumstances are needed; and changes to structures or their operation or management techniques are required.

The Monitoring and Adaptive Management Plan will provide a description of: the habitats to be restored, the density and composition of the plantings to restore habitat, surveys to monitor the expected, natural re-introduction of native wildlife into the restored habitats, the performance criteria and monitoring protocol to evaluate success of the restoration effort, adaptive management actions (or maintenance activities) that may be performed to ensure a successful restoration effort, and reporting requirements.

The Monitoring and Adaptive Management Plan covers monitoring and adaptive management actions during the first 5 years after initial construction. (After the first 5 years, monitoring and/or adaptive management becomes the responsibility of the non-Federal Sponsor.) Note that during the preconstruction engineering and design [PED] phase, more specific monitoring details [e.g., exact monitoring transect locations, reference site locations, more specific performance/success criteria, more specific monitoring protocols, etc...] may be added to this Monitoring and Adaptive Management Plan).

2. Goal

The goal of this effort is to restore riparian vegetation typical of the Sonoran desert to obtain habitat values consistent with those predicted in the Habitat Analysis Appendix. It is expected that the habitat value of the restored habitat will have good to above average quality. It is also expected that the restored habitat will be suitable for native wildlife. The quality of the habitats (i.e., average or high) is expected to dictate the abundance or density of wildlife.

3. Restored Habitats

A description of the habitats to be restored, the density and composition of the plantings to restore habitat along with a quantitative discussion of the surveys to monitor the restoration is provided earlier in this chapter. Since only the habitat restored on the overbank are located outside of the 100-year flood zone some restoration features have the potential to be impacted by long periods of flood inundation and are subject to being uprooted during significant high flows - as would any natural riparian ecosystem. Monitoring protocols defined below will assist in determining whether replanting of the various habitats are needed following flood events. Prior to active restoration commencement, an assessment of the chosen restoration sites will be conducted to determine their suitability for the establishment and regeneration of native riparian plants.

The Corps intends to coordinate with and directly fund the Arizona Game and Fish Department (AZGFD) to perform baseline ecological assessments of existing biotic conditions within the area of potential affect (APE) for the Paseo de las Iglesias ecosystem restoration project. The Corps intends to retain the expertise of AZGFD as it pertains to the conservation and management of Federally listed threatened and endangered species, wildlife species of concern to the State of Arizona, and their respective riparian habitats. The Corps also intends to retain and directly fund the AGFD in the development and implementation of a Monitoring & Adaptive Management Plan for this riparian ecosystem restoration project along the Santa Cruz River.

Therefore, as AZGFD documents such baseline ecological conditions within the APE, their determinations will provide a scientific basis for strategically planning restoration measures, elements and features that will provide a framework for achieving a sustainable assemblage of native vegetation associations that will restore ecological processes and functions to degraded riparian habitats along this portion of the Santa Cruz River. Both the Corps and AZGFD have statutory guidelines regarding the conservation of diminishing native fish and wildlife habitats and it would be mutually beneficial to work together in restoring the State of Arizona's native riparian ecosystems.

4. Habitat & Wildlife Monitoring - Frequency and Protocol

Habitat (Vegetation) Monitoring

The monitoring protocols and frequencies described below will be reviewed and adjusted based upon the results of the baseline ecological assessments discussed above and the input of the Technical Committee.

Cottonwood/Willow Riparian Areas

For the first 6 months after planting the site, it would be monitored monthly; thereafter, the site would be monitored every other month for a year. The site will remain free of all non-native shrubs throughout this 18 month period. Should the survival rate of plantings indicate that the species composition is less than prescribed, replanting will be undertaken to ensure that the species composition is maintained.

All plantings shall have a minimum of 80% survival the first year and 100% survival the second and third years and/or attain 40% cover after 5 years. Ninety percent cover is expected in the Riparian Areas after 10 years. There will be zero tolerance of exotic shrubs the first 5 years. If the survival and cover requirements are not met during the initial 5 years, the Corps is responsible for replacement planting to achieve these requirements. (Note that the replacement planting cost would be a cost-shared project cost for the first 5 years.)

After 5 years, the non-Federal Sponsor will be responsible for maintaining the restoration sites for the remaining life of the project. The species composition shall be maintained throughout the life of the project. Site monitoring would be performed yearly throughout the life of the project (also see Section 5, below).

All of Cottonwood/Willow Habitat will be planted in the flood-prone tributary confluences. As such, it is expected to be regularly affected by flooding events (as typical of natural cottonwood/willow habitats). The Cottonwood/Willow sites will be evaluated after large storm events to determine the need for revegetation.

Mesquite Bosques

The monitoring frequency and survival protocols outlined for the Cottonwood/Willow Riparian Area restoration sites would be followed for the Mesquite Bosque sites.

Riparian Shrub

The monitoring frequency and percent survival outlined for the Cottonwood/Willow Riparian areas will be followed for the riparian shrub lands. Most of the riparian shrublands will be out of the more frequently inundated areas of the floodplain. The sites will be evaluated after large storm events to determine the need for revegetation.

Wildlife Monitoring

Restored habitats are expected to support native wildlife. The good quality riparian shrub lands, mesquite bosques and cottonwood/willow habitats are expected to support the diverse assemblage of wildlife that are associated with these habitat-types. Monitoring of wildlife abundance and diversity is proposed to assess whether habitats actually attract and support significant populations of a wide variety of native wildlife, as expected.

Bird surveys will be performed in the restored riparian areas during each of the four seasons for the first 5 years following construction. The abundance/ diversity of bird species will be used as an indicator of whether wildlife habitat has developed as predicted and supporting a diverse assemblage of native avifauna. After the first five years, summer/spring bird surveys will be performed every other year to document the abundance and diversity trends. Small mammal trapping (live or snap) will be conducted during the summer for the first five years to document the diverse species expected to re-colonize restored habitats.

5. Success Criteria, Reporting & Adaptive Management

Success Criteria

The success or failure of the restoration effort will be measured against three parameters which should indicate whether the goal of this restoration effort is being achieved; they are: 1) whether the plant species compositions and/or percent cover requirements outlined for the various habitat types are met, 2) whether native wildlife re-colonize the restored habitats, and 3) whether the restoration sites naturally regenerate. Monitoring will occur as identified above. Monitoring reports would be prepared jointly at the end of the year by the Corps and the non-Federal Sponsor during the first 5 years after initial construction. The need to make adjustments to the constructed project will be based on the results of the monitoring reports. If the restored habitats achieve the plant species composition identified and achieve a diverse native wildlife assemblage, no modifications will be made. After the first five years, the non-Federal Sponsor will prepare the Monitoring Reports.

Monitoring Reports and Adaptive Management

The Corps and/or the non-Federal Sponsor will be responsible for collecting monitoring data and preparing annual Monitoring Reports. A Technical Committee consisting of, at least, the U.S. Fish and Wildlife Service, USACE, the non-Federal Sponsor, and the Arizona Department of Game and Fish, will assist in collection of monitoring data, review monitoring data results, and providing recommendations of possible adaptive management measures.

The Technical Committee will recommend adaptive management measures to the existing project's design should habitat not achieve the identified goal and objectives. The Committee will judge the restoration sites ability to revegetate naturally and recommend what conditions should trigger a need to replant restoration areas. If designed vegetation species composition are not achieved: replanting, additional irrigation, and/or removal of vegetation (especially exotics) may be necessary. (Note that the use of herbicides should only be used if more natural options are unsuccessful.)

Annual Monitoring Reports and any adaptive management measures recommended by the Technical Committee will be forwarded to an Executive Committee which will consist of, at least, a representative of the non-Federal Sponsor and the U.S. Army Corps of Engineers. The Executive Committee will decide whether to adopt adaptive management measures recommended by the Technical Committee.

CHAPTER VII
PLAN IMPLEMENTATION

This chapter summarizes the cost-sharing requirements and procedures necessary to implement the restoration features of the selected plan.

A. Study Recommendation

The Selected Plan is an ecosystem restoration project that also provides recreation benefits. Because of its positive environmental contribution selected plan is recommended.

B. Division of Plan Responsibilities

The Water Resources Development Act (WRDA) of 1986 (P.L. 99-662) and various other 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. This is discussed in detail below.

C. Cost Allocation

Cost sharing for construction of this project would be in keeping within current Corps of Engineers policy whereby for environmental restoration projects, the non-Federal sponsor shall provide all lands, easements and rights-of-way and dredged material disposal areas, provide relocations of bridges and roadways, provide alteration of utilities which do not pass under or through the project's structure, and maintain and operate the project after construction. All water rights and costs associated with providing water to the project shall be borne by the non-Federal sponsor. The value of this water has been estimated at $1,099,175 annually. Additional studies and analysis of the selected plan will be accomplished during Preconstruction Engineering and Design (PED). As a result of these studies, additional necessary project features may be identified that could be part of the Federal cost sharing for this project. In this event, Federal project cost sharing would be adjusted in accordance with the terms that will be included in the Project Cooperation Agreement.

Corps guidance (PGL Nos. 36 and 59) specifies that the level of financial participation in recreation development by the Corps at an otherwise justifiable project may not increase the Federal cost of the project by more than ten percent. This cost would be cost shared between the Corps and the non- Federal sponsor. Recreation costs are cost shared on a 50%/50% basis between the Corps and the non-Federal sponsor. Table 7.1 presents a summary of apportionment of project first costs between Federal and non-Federal interests for the Recommended Plan using current (2004) price levels

Table 7.1 Cost Apportionment Table
Paseo de las Iglesias, Pima County, Arizona
Ecosystem Restoration Project
(Costs x $1000)

Item	Allocation		
	Federal	Non-Federal	Total
Construction* (Construction, S&A, PED/EDC, Contingency)	$59,096	$5,579	$64,675
Construction LEERDs* (Lands and credits, easements, rights-of-way, relocations and disposal sites		$26,242	$26,242
Total First Cost (Percentage of total cost)	$59,096 65	$31,821 35	$90,917
Recreation Costs	$571	$571	$1,142
Total First Costs	$59,667	$32,392	$92,059

* Does not include IDC nor annual O&M, the latter of which is fully a non-Federal Cost

D. Current and Future Work Eligible for Credit

There is no current or future work planned or in construction which is part of the Corp' Selected Plans, or which would be eligible for Section 104 credit.

E. Institutional Requirements

Upon implementation of the cost-shared project, 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, and repair/rehabilitation responsibilities;

(3) Investigate the means for raising additional non-Federal financial resources including but not limited to special assessment districts; and

(4) Complete any other necessary steps to ensure that they are prepared to execute their project-related responsibilities at the time of project implementation.

In addition, as part of any Project Cooperation Agreement, the Non-Federal Sponsor would be required to hold and save the Government free from all damages arising from 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 its contractors.

F. Environmental Requirements

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, is in compliance with the Clean Water Act, and meets the Section 404(r) exemption criteria. The Corps plans to seek an exemption from the requirement to obtain State water quality certification under Section 404(r) of the Clean Water Act. The 404(b)(1) evaluation is included in the Final EIS as Appendix 14.3.

In order for a Federal project to meet the conditions for exemption under Section 404(r) of the Clean Water Act, it must comply with NEPA, through submittal of an EIS to Congress prior to authorization or appropriation of funds for construction, and Section 404 of the Clean Water Act, including Section 404(b)(1). 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 will determine what type of permit (if any) is needed, and whether or not all or part of the required OMRR&R activities may proceed under exemption as described in Section 404(r) of the Clean Water Act. The Corps will assist the non-Federal sponsor with preparation of any permit application that may be needed.

The Corps will coordinate with and provide funding to the Arizona Game and Fish Department (AZGFD) to conduct baseline ecological surveys and document the environmental assessment of existing biotic conditions within the area of potential affect (APE) immediately preceding initiation of construction of the Paseo de las Iglesias ecosystem restoration project through a Memorandum of Agreement (MOA) and a detailed scope of work (SOW).

The Corps will also coordinate with and provide funding to the AZGFD to develop and implement a Monitoring & Adaptive Management Plan for the Paseo de las Iglesias ecosystem restoration project through a MOA and detailed SOW.

Under direction from the Corps and Pima County, Statistical Research, Inc. performed a literature search and cultural resources overview of the proposed project area (area of potential effects [APE]) through the Arizona State Museum (ASM) (O'Mack, et al. 2002). This search indicates that less than 50 percent of the area has been surveyed by archeologists.

Given the project's association with the Santa Cruz River floodplain, the overall archeological sensitivity and potential are very high. Therefore, complete avoidance of all cultural resources by project alternatives may not be possible. A determination of effect will not be made however, until more detailed plans are available and after testing and consideration of buried prehistoric resources along the bank of the river, in consultation with tribes and Pima County.

The known resources are potentially avoidable by the project. The floodplain may contain buried resources, however. If additional sites cannot be avoided, they will be evaluated regarding eligibility for the National Register. All NRHP sites that will be impacted by project construction will be subjected to data recovery (i.e., mitigated). Environmental Commitments are:

1. Qualified archeologists will perform a survey of previously unsurveyed areas within the project's area of potential effects. Subsurface exploration to determine the presence/absence of buried cultural deposits may also be necessary.

2. If cultural resources cannot be avoided, they will be evaluated regarding eligibility for listing in the National Register of Historic Places.

3. Identification, evaluation, and data recovery (i.e., mitigation) efforts will be coordinated with Pima County and interested Native American Indian Tribes.

4. Archeologists from Pima County and the Corps will participate in the design of water conveyance features across the landform in an effort to minimize adverse effects.

5. Since it is likely that National Register listed or eligible properties will be adversely affected by the project, a Memorandum of Agreement, to include monitoring during construction, will be negotiated with the Arizona State Historic Preservation Officer (SHPO), Pima County, and interested Native American Indian tribes. An archeological site treatment plan will also be developed in consultation with the SHPO, Pima County and interested Native American Indian tribes.

Compliance with the National Historic Preservation Act of 1966 (36 CFR 800): As stated above, in accordance with 36 CFR 800, regulations implementing Section 106 of the National Historic Preservation Act, a records search has been performed. Corps identification and evaluation studies will be coordinated with Pima County and interested Native American Indian tribes. The Corps' determinations of eligibility and effect will be coordinated with the Arizona State Historic Preservation Officer (SHPO). It is expected that a Memorandum of Agreement (MOA) will be negotiated with the Arizona SHPO, Pima County, and interested Native American Indian tribes. An archeological site (historic properties) treatment plan will be developed in consultation with the SHPO, Pima County, and interested Native American Indian tribes as stipulated in the MOA. Until the field studies, consultation, and determinations of resource eligibility and project effect are completed, the project is not in compliance with the Act.

Coordination: Arizona State Historic Preservation Officer (SHPO) - A letter will be sent to the SHPO with our determination of eligibility and effect in accordance with 36 CFR 800.4(d). All supporting documentation required under 36 CFR 800.11(d) will be sent to the SHPO. This includes the Final EIS. The Final EIS will also be sent to the following for comment along with all identification, evaluation, and data recovery (i.e., mitigation) documentation:

Pima County - Ms. Linda Mayro/Mr. Roger Anyon, County Archeologists

Tohono O'odham Nation - Mr. Peter Steere, Program Manager, Cultural Affairs Department

Hopi Tribe - Mr. Leigh Kuwanwisiwma, Cultural Preservation Office

Pascua Yaqui - Ms. Amalia A.M. Reyes, Language and Culture Preservation Specialist

Other requirements relating to the Arizona Game & Fish Department and the Arizona Department of Environmental Quality would need to be addressed by the non-Federal sponsor.

G. Non-Federal Requirements

The presently estimated non-Federal share of the total first cost of the project is $32,392,000. which includes $26,242,000 in estimated LERRDs credits and $5,579,000 in non-Federal contribution.

In addition, maintenance and operation of the environmental restoration project is estimated to cost the non- Federal sponsor $1,869,961 annually.

Requirements of non-Federal cooperation are specified below:

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, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

(5) Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the total project costs, including design, allocated to environmental restoration and 50 percent of the total project costs, including design, 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 and the provision of water, at no cost to the Government, in a manner compatible with the project's authorized purpose and that it will comply 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 non-Federal 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, Pub. L. No 91-611, as amended, 33 U.S.C. 2213(j), and Section 103(j) of the Water Resources Development Act of 1986, Pub. L. 99-662, as amended, 42 U.S.C 1962d-5b., which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

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

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

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

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

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

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

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

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

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

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

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

H. Sponsorship Agreements

Pima County, the non-Federal sponsor, has provided a Letter of Intent acknowledging sponsorship requirements for the Paseo de las Iglesias Project (included in Chapter XI, Letters of Support and Financial Capability). Prior to the start of construction, the non-Federal sponsor will be required to enter into an agreement with the Federal Government that it will comply with Section 221 of the Flood Control Act of 1970 (P.L. 91-611), and the Water Resources Development Act of 1986 (P.L. 99-662), as amended.

I. Procedures for Implementation

Future actions necessary for authorization and construction of the selected plans are summarized as follows:

(1) This report will be reviewed by the Headquarters of the U.S. Army Corps of Engineers, Washington, D.C.

(2) The Chief of Engineers will seek formal review and comment 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 (0MB) 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 a 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, the non-Federal sponsor would enter into a binding agreement to furnish the required cooperation. This agreement is the Project Cooperation Agreement (PCA).

(11) Bids for construction would be initiated and contracts awarded.

CHAPTER VIII
PUBLIC VIEWS AND COMMENTS

A. Non-Federal Views and Preferences

The non-Federal views and preferences regarding environmental restoration were in general obtained through coordination with the non-Federal sponsor, various local and regional agencies and organizations, neighborhood associations, and the general public. These coordination efforts consisted of a series of public meetings held during the reconnaissance and feasibility study phases, through surveys, through the maintenance of a 'point- of-contact' with whom any interest could discuss matters, and a mailing list by which invitations to public meetings were distributed. Announcements for public meetings were made in local newspapers, including date, time, place, and subject matter.

B. Views of the Non-Federal Sponsor

Pima County has expressed willingness in continuing to be the non-Federal sponsor for project implementation. The County has indicated its support for the project and a willingness to assume cost-shared financial obligations for its implementation.

The non-Federal sponsor fully supports the results of the feasibility study. The non-Federal sponsor's interest in implementing environmental restoration solutions for the Paseo de las Iglesias area is reflected in the many previous studies and reports prepared by the County and by their willingness to enter into a cost-shared feasibility study to determine Federal interest.

There currently exists within the community, and with the non-Federal sponsor, significant interest for providing environmental restoration solutions for the Paseo de las Iglesias area. This is demonstrated by their desire to pursue environmental restoration options for the project, and their willingness to accommodate Federal guidance in the selected plan. The DEIS addresses existing resources and potential impacts to these resources from implementation of the desired environmental restoration alternative. It indicates that the selected plan would have temporary impacts to environmental resources associated with construction activities. These impacts are mitigable through adoption of Best Management Practices that reduce or eliminate the impacts. This is discussed in detail in the Final EIS.

Locally-preferred options within the study area are consistent with the Selected Plan. The non-Federal sponsor has related its acceptance of the selected plan and is willing to accept the Corps of Engineers identified NER plan as the Locally Preferred Plan.

C. Financial Analysis

Further project engineering, design, and construction would be conducted in accordance with the cost-sharing principles provided by the Water Resources Development Act of 1986, as amended. The non-Federal sponsor has indicated its ability and willingness to participate in the planning, engineering and design of the selected plan, and to participate in construction of the project. The statement of financial capability is provided in Chapter XI, Letters of Support and Financial Capability.

D. Summary of Study Management, Coordination, Public Views and Comments

The study team was 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 efforts described above. Agencies contacted included the United States Fish and Wildlife Service (USFWS), the Arizona Department of Game and Fish (AGFD), the City of Tucson Parks and Recreation, Tucson Water Department, City of Tucson Department of Transportation, Pima County Department of Transportation, Pima County Cultural Resources, and Pima County Parks and Recreation. In addition to the above, local stakeholders included local Homeowners Associations, Tucson Audobon Society, and Santa Cruz River Alliance.

Representatives from USFWS and AGFD participated in development of the functional assessment model and its application. USFWS also participated in development of alternatives and their design. USFWS has provided a Coordination Act Report for this study, which is reproduced in Appendix 14.1 of the Final EIS.

Throughout the planning process for this project, public input has been solicited utilizing a variety of avenues including local newspaper articles, public information mailings, and coordination with special-interest groups, public workshops and formal public hearings. The initial planning process began with a meeting March 31, 2001 to identify and review the primary issue areas involved in the Paseo de las Iglesias study area. As a result of that initial meeting, further meetings were scheduled to establish a process for development of public involvement in planning for restoration of the Paseo de las Iglesias study area. Issues addressed included habitat restoration, water budget, water quality, wildlife habitat, recreation, environmental education and tributary flood control. The principal participants in this public workshop planning process were representatives from Federal, state, and local agencies, citizens from the local area, and other stakeholders.

CHAPTER IX
CONCLUSIONS

The major conclusions of the Paseo de las Iglesias Ecosystem Restoration Feasibility Study to date are:

a. Developmental pressures combined with increasing appropriation of groundwater and surface water flows have been the most significant contributors to increasing degradation and loss of riparian habitat along the Santa Cruz River in the last century. Future without project conditions will see the loss of the remaining pockets of habitat as adjacent vacant lands develop. The local species of concern, as well as birds migrating along the Pacific Flyway, will lose more of their forage base and will be much more vulnerable to terrestrial disturbances and predation.

b. Alternative measures developed to address the study objectives and constraints include construction of subsurface water harvesting basins including soil amendment, surface grading including regrading of unstable vertical banks, planting of native riparian species, and providing irrigation to restored areas including periodic flow along the lower reaches of the Old West Branch.

c. The recommended plan will result in a total increase of 454 average annual functional capacity units at a total average annual cost of $7,635,648 an average annual cost of $16,819 per average annual functional capacity unit.

d. The total first cost of implementing the plan is $92,059,000 ($90,917,000 environmental restoration and $1,142,000 recreation). The Federal share is currently estimated at $59,667,000 (59,096,000 environmental restoration and $571,000 recreation). Annual Operation and Maintenance costs are estimated to be about $1,906,000 ($1,870,000 environmental and $36,000 recreation) and are a 100% non-Federal responsibility.

e. Pima County is the non-Federal sponsor for the feasibility study and fully supports the recommended plan as the locally preferred plan. The sponsor is willing and able to cost-share in the PED phase and is willing to participate in the cost sharing for the construction of the project.

f. The resource agencies and local interests also support this project.

CHAPTER X
RECOMMENDATIONS

I recommend that the plan described herein for environmental restoration, flood control, and recreation, be authorized for implementation as a Federal project. The total first cost of the project is currently estimated at $92,059,000 under October 2004 prices. The Federal share is currently estimated at $59,667,000.

I recommend that the Corps of Engineers participate in cost-shared monitoring and minor modifications, as maybe 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

CHAPTER XI
LETTERS OF SUPPORT AND FINANCIAL CAPABILITY

As required by Section 905 of the Water Resources Development Act, of 1986 a financial capability statement from Pima County will be included in the final report to show non-Federal cost sharing capability and intent.

COUNTY ADMINISTRATOR'S OFFICE

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C. H. HUCKELBERRY
County Administrator

July 6, 2005

Colonel Alex C. Dornstauder
U.S. Army Corps of Engineers
Los Angeles District
915 Wilshire Boulevard, Suite 14P00
Los Angeles, California 90017

Re: Letter of Support for Santa Cruz River, Paseo de las Iglesias Ecosystem Restoration Feasibility Study – Pima County, Arizona

Dear Colonel Dornstauder:

Pima County, as the non-Federal sponsor, extends its support of the Recommended Plan contained in the Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona Feasibility Report as an appropriate alternative to restore riparian habitat to the Santa Cruz River. A majority of Pima County's habitat has been lost due to urban development and groundwater usage in the Tucson basin. This restoration project is consistent with the County's overall goal of protection of our natural resources and will augment the Sonoran Desert Conservation Plan.

As identified in the feasibility report, irrigation water is required for the success of this restoration project. Pima County has identified numerous potential sources of irrigation water including but not limited to reclaimed water, water harvesting, groundwater, and Central Arizona Project allocations and is prepared to commit the necessary water allocation required for implementation, operation, and maintenance activities.

Pima County is prepared to move forward, as the non-Federal sponsor, with the U.S. Army Corps of Engineers to design and construct the Santa Cruz River, Paseo de las Iglesias Ecosystem Restoration project. Anticipating Congressional authorization of the project, the County is prepared to commit to its local share of 25% of the pre-construction engineering and design (PED) costs.

Pima County will assume its obligation to acquire all lands, easements rights-of-way, relocations, and disposal areas and upon completion of construction, operate and maintain the project. We are prepared to meet our financial obligations to ensure completion of this project and look forward to executing the PED Agreement for the Paseo de las Iglesias project.

Sincerely,

John M. Bernal
Deputy County Administrator – Public Works

Cc: C.H. Huckelberry, County Administrator
Suzanne Shields, Director, Regional Flood Control District

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US Army Corps
of Engineers
Los Angeles District

Paseo de las Iglesias Ecosystem Restoration

Final Environmental Impact Statement (EIS)

SANTA CRUZ RIVER
PIMA COUNTY, ARIZONA

July 2005

Cover Sheet

Responsible Agency and Lead Federal Agency: U.S. Army Corps of Engineers
Title: Paseo de las Iglesias Ecosystem Restoration, Final Environmental Impact Statement (FEIS)
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Abstract:

This environmental impact statement (EIS) analyzes the potential environmental impacts associated with the proposed Paseo de las Iglesias project on the Santa Cruz River in Pima 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 Pima County Flood Control District is the non-Federal sponsor for the project.

The study area for the project consists of a 7.5-mile reach of the Santa Cruz River and adjacent lands, totaling 5,005 acres, in south-central Arizona. More specifically, the study area consists of the Santa Cruz River Valley between Los Reales Road and West Congress Street, immediately south and west of downtown Tucson. Interstate highways 10 and 19 define the eastern boundary of the study area and Mission Road the western boundary.

This document addresses the no action, the preferred action and two alternative plans developed to restore and improve native vegetation and overall wildlife habitat values in the project area, and to provide a greater diversity of habitat for threatened and endangered species. Incidental benefits would include both passive and active recreational opportunities, general improvement in the aesthetic quality of the project area, and a slight reduction in the potential for flood damage. Each 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 and other applicable laws, regulations, and policies, and have been conducted in coordination with the Pima County Flood Control District, the City of Tucson,

and concerned resource agencies and members of the public. Information referred to in this document, as well as in the accompanying feasibility report and appendices, is incorporated by reference.

Public Comments:
In preparing the Draft EIS, the Corps of Engineers considered comments received by letter and formal statements made at public scoping meetings. A 45-day comment period on the Paseo de las Iglesias Ecosystem Restoration, Draft Environmental Impact Statement (EIS) began with the publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register on October 8,2004. A public hearing to discuss and receive comments on the Draft EIS was held at the Desert Vista Campus of Pima Community College in Tucson, Arizona on the evening of October 26, 2004. 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 14.5 of the Final EIS. Unless otherwise requested, copies of the Final EIS will be provided on CD-ROM.

Summary

The Arizona/Nevada Area Office of the Los Angeles District of U.S. Army Corps of Engineers is conducting a feasibility study to assess opportunities for riverine ecosystem restoration for the seven-mile Paseo de las Iglesias reach of the Santa Cruz River in Tucson, Arizona. The study is being conducted in partnership with the Pima County Flood Control District, the non-Federal sponsor.

The Paseo de las Iglesias Study Area, as identified in the accompanying feasibility report, consists of a segment of the Santa Cruz River and its tributaries, including the Old and New West Branch, extending downstream from Los Reales Road to Congress Street in the City of Tucson, Pima County, Arizona. The study area boundary encompasses an area approximately seven miles long varying from 0.5 miles to 1.6 miles wide, and contains approximately 5,005 acres.

The primary process within the Study Area is systematic and severe ecosystem degradation and loss of riparian habitat that has persisted since the early 20th century. Before 1900, the Santa Cruz channel maintained perennial water flow that supported dense growths of native riparian trees such as cottonwood, willow, and mesquite. Historical accounts of conditions on the Santa Cruz River (circa 1900) describe a tree-lined, river, with dense vegetation, winding throughout a wide flood plain. The river channel formerly provided sufficient water to support rapidly increasing European settlement, increasing uses of the Santa Cruz waters for agricultural irrigation and sustained surface flow. Sustained surface flow has not existed in the Paseo de las Iglesias reach for more than half a century.

The once verdant Santa Cruz riparian corridor has been transformed into a deeply incised, ephemeral ditch with either artificially hardened or unstable and eroding banks, that supports flow only briefly in response to storm runoff. These changes came about as a result of the uncontrolled appropriation of surface and groundwater to support expansion of agriculture and nascent industry, acceleration of head cutting resulting from human manipulation of the channel, and transformation of large areas of the landscape to increasingly urban land uses.

As a result, native riparian habitat is nearly absent in the Study Area. Historically comprising about 1% of the landscape historically, over 95% of riparian habitat has been destroyed in Arizona. This type of river-connected riparian and fringe habitat is of an extremely high value; a large percentage of wildlife in the arid southwest is riparian-dependent during some part of its life cycle. As a consequence of the loss or degradation of riparian habitat, the area has suffered a concomitant reduction in species abundance and diversity with non-native (exotic) vegetation dominant in the Study Area.

Flood damage reduction opportunities were analyzed for the Without-Project Conditions (No Action Alternative). Based on the results of environmental, hydrologic/hydraulic, and economic analyses, flood damage reduction, as a project purpose could not be justified.

While the majority of lands in the Study Area are dedicated to residential land use, the majority of lands immediately adjacent to the Santa Cruz River channel are undeveloped. This condition offers an opportunity to accomplish important ecosystem restoration in the Study Area.

The Federal planning objective for ecosystem restoration studies is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. The specific objectives for environmental restoration within the Study Area have been identified as follows:

- Increase the acreage of functional riparian and floodplain habitat within the Study Area.
- Increase wildlife habitat diversity by providing a mix of riparian habitats with an emphasis on restoration of riparian forests within the river corridor, riparian fringe and historic floodplain.
- Provide passive recreation opportunities.
- Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration goal.
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

A number of ecosystem restoration measures have been developed based upon those originally identified in Reconnaissance Phase of the study, with additional restoration measures added based upon the results of public input and on other similar studies in the region. Once compiled, potential restoration approaches were evaluated for feasibility, with some screened out and others refined.

The initial conceptual alternatives presented in the draft Feasibility Study document (USACE, 2002) were recombined with new restoration approaches and expanded into an array of 14 alternatives that were subjected to more detailed analyses. Through this process, a final array of alternatives was produced consisting of the two "best buy" alternatives (Alternative 2A and 4F), a mid-point water use alternative (Alternative 3E), and the no action alternative.

Alternative 2A

Alternative 2A uses the basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading, a low flow diversion and construction of subsurface water harvesting basins. Implementation of these measures would allow creation of new habitat as well as improvement of existing habitat with plantings in mesquite, scrub/shrub, and river bottom community types. The alternative would require irrigation for establishment and periodic irrigation during periods of prolonged drought.

The channel features for this alternative consist of two measures; construction of water harvesting basins on the upstream side of five existing grade structures and construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch. The water harvesting basin features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to minimize effects on flood flows.

The low flow diversion would be constructed by placing a diversion structure in the New West Branch channel to pond low flows and placing a conduit through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The tributary water harvesting basins discussed above would continue to be constructed, however, they would be increased in size. The off-channel areas would be created in the floodplain to concentrate local runoff. This alternative restores rehabilitates 1,125 acres of habitat. It includes 867 acres of xeroriparian shrub (shrub scrub) with 252 acres of mesquite and 6 acres of emergent marsh (river bottom). This alternative produces a net gain of 402 average annual Functional Capacity Units (AAFCUs or FCUs; Appendix 14.4) compared to the No Action Alternative.

The features of the Paseo de las Iglesias project are subject to damage by recurrent flood flows and periods of inundation. This would result in the need for periodic maintenance to insure successful habitat restoration. Operation and maintenance costs would include periodic channel clearance, control of invasive plant species, and irrigation system maintenance. Operation and maintenance also include periodic replanting of large habitat areas eliminated by flood flow erosion.

Alternative 3E (Preferred Alternative)

Mesquite bosque creation is the dominant feature of Alternative 3E. Alternative 3E provides a nearly uniform mesoriparian hydrologic regime (through various means of supplemental irrigation) to all geomorphic positions in the floodplain above the low flow channel. This alternative creates approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub, 18 acres of cottonwood-willow, and almost six acres of emergent marsh. This alternative produces a net gain of 454 FCUs compared to the No Action Alternative.

This alternative maintains the low flow channel in an unplanted condition similar to the without project condition. Lower channel terraces (those vegetated areas above the low flow channel but approximately below the 2-year recurrence interval flow event) are planted with a mixed shrub-scrub community, suitable for a mesoriparian regime, with supplemental water delivered by bank-mounted sprinklers. Upper channel terraces (those above the 2-year storm), natural and regraded banks and the historical floodplain would be planted to mixed riparian communities, within which mesoriparian shrub composes more than 50 percent of the planted community, and irrigated to at a mesoriparian hydrologic regime.

Water harvesting basins would be constructed in the channel at the confluence of tributaries with the main Santa Cruz channel at eight locations. These basins would support cottonwood-willow and emergent marsh vegetation with cottonwood-willow composing more than 50 percent of the community. Adequate water would be supplied through the maintenance of a hydroriparian hydrologic regime using supplemental discharges from buried irrigation pipes. Similarly, five grade control basins would be created in the Santa Cruz main channel using reinforced or newly constructed at-grade barriers to detain channel runoff. These basins, approximately one-acre in area each, would support emergent marsh vegetation.

Both the tributary basins and the grade control basins are harvesting basin features involving excavation in channel bottoms. Excavation would be to a depth of approximately four feet, with bottoms mechanically compacted to impede exfiltration. The excavated void would be filled with layers of appropriately sized boulders, cobbles and gravel to create inter-particle interstices for water storage. This material would be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of pipe flood or subsurface drip irrigation to distribute water at specific locations.

Approximately 56,000 linear feet of overly-steep, highly eroded banks would be regraded to an approximate maximum of 5:1 horizontal to vertical ratio slopes and planted to improve channel stability. The graded reaches would be created by excavating historic floodplain, rather than be filling into the active channel. This would provide an ancillary effect of increased in-channel flood storage capacity. Approximately 3,700 linear feet of unstable, eroding slopes would be stabilized using conventional soil cement slope protection along selected reaches for which there is insufficient distance from the active channel to the Project Area boundary to create a stable graded and vegetated slope.

Alternative 4F

Alternative 4F is characterized by creating an intermittent flow environment and channel to support adjacent growth of emergent wetlands and cottonwood-willow gallery forest. Additional areas on terraces above the channels and in the historic floodplain would be irrigated to sustain mesquite bosques interspersed with riparian shrub.

Implementation of this alternative involves constructing a low flow channel that would convey intermittent flows through the entire length of the project boundaries. This feature would be constructed in a manner to help direct infiltration losses from the intermittent flow toward restored habitat areas to be created on either side of the channel.

The areas on each side of the low flow channel would include a narrow band where soil saturation conditions resulting from infiltration would be conducive to emergent marsh. Cottonwood and willow would be planted on low terraces adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.

To prevent flood conveyance impacts that could result from such features, plantings on lower terraces in the channel would be limited to riparian grasses and managed to limit growth of denser more resistant vegetation. The higher terraces would be planted with mesquite and riparian shrubs. The plan also includes construction and planting of water harvesting basins at the confluences of 11 tributaries and permanent irrigation systems for all planted areas including the water harvesting basins.

The reaches of steep eroded banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. Where available land is not a constraint, banks would be graded at a five-foot horizontal to one-foot vertical slope and planted. In those where sufficient land is not available the banks would be laid back to the minimum slope that can be fit into the available space. These slopes would also be vegetated; however, a geotextile layer would be installed before planting to increase slope stability. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it would reestablish a hydrologic connection to the river, reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout. Alternative 4F produces 1,227 restored acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. This alternative produces a net gain of 519 FCUs compared to the No Action Alternative.

No Action

Under the No Action Condition, the loss of riparian and floodplain fringe habitat is likely to continue as development continues throughout the Santa Cruz watershed. Fragmented enclaves of native species will likely vanish. The absence of native riparian and associated floodplain fringe habitat will result in the continued rarity of native wildlife in the area. In addition, unstable riverine morphology will continue to prevail the Study Area.

Issues and Concerns

Within their Coordination Act Report (USFWS, 2005) the U.S. Fish and Wildlife Service indicated, "We are unaware of the occurrence [of] any Federally threatened or endangered species within the Project Area." The USFWS further recommended that the Corps "focus significant attention on identifying and, if necessary, securing a permanent and adequate source of water to support the desired biotic communities" and "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."

The Arizona Game and Fish Department (AGFD, 2003) indicated that "the Department's Heritage Data Management System has been accessed and current records show that special status species have been documented as occurring in or near (within a 3-mile buffer) the Project Area. The nearest point at which the proposed critical habitat approaches the Study Area is nearly 4,000 ft west of the west boundary of the Study Area. Site-specific searches for biota resulted in no confirmed sightings of these special concern species.

A principal constraint on any ecosystem restoration project is the limited availability of water to support establishment and maintenance of healthy riparian habitats. The potential water sources including groundwater, Santa Cruz River and its tributaries water, and wastewater treatment plant effluents (both secondary effluent and reclaimed water) were evaluated based on the quality, quantity, and seasonality of flow. The analysis of water sources shows that the wastewater treatment plant effluent is a reliable water source to the project. The Santa Cruz River, its tributaries water, groundwater and local surface run-off can serve as supplemental water sources.

The overall archeological sensitivity of the Project Area is very high and there is a high potential that the floodplain may contain buried resources. Therefore, complete avoidance of all cultural resources by project alternatives may be unsuccessful. Implementation of either of the restoration alternatives would have potentially adverse effects on resources potentially eligible for listing in the National Register of Historic Places (NRHP).

When carrying out any action alternative, the Corps would implement the following:

- Qualified archeologists would perform a survey of previously un-surveyed areas within the area to be disturbed.
- Subsurface exploration to determine the presence/absence of buried cultural deposits may be necessary.
- If cultural resources cannot be avoided, they would be evaluated regarding eligibility for listing in the NRHP.
- Identification, evaluation, and mitigation studies would be coordinated with Pima County and interested Native American Indian Tribes.
- All NRHP-eligible sites that would be impacted by project construction would be mitigated.

After the required surveys and evaluation efforts have been implemented, and after consideration of buried prehistoric resources within the floodplain terraces, a determination of effect would be made in consultation with Native American Indian Tribes and Pima County. The Corps' determinations of resource eligibility and project effect would be coordinated with the Arizona State Historic Preservation Officer (SHPO). If National Register listed or eligible properties would be adversely affected by the project, a Memorandum of Agreement would be negotiated with the SHPO, Pima County, and interested tribes and an archeological site treatment plan would be developed in consultation with the SHPO, Pima County, and interested tribes.

The key issues raised during the public scoping process are summarized below.

Process: Comments indicated the desire to assemble a diverse group of people (government officials, scientists, citizens, nonprofits, and schools) to address the technical, ecological, political, community, and business issues affecting river restoration.

River Channel and Banks: Removal of soil cement banks completely where possible and re-evaluating their use was recommended as well as allowing a more natural meandering pattern and establishing terraces along the banks.

Natural Habitat Restoration: Many comments recommended restoration of natural habitats along the river to include rubbish clean-up and native vegetation plantings were suggested and the need to control invasive plants was noted. No one source of water (e.g., by rain, flood, and/or reclaimed water) was favored.

River Flow and Water: Comments regarding the use and presence of water in the river varied. Some called for the addition of water in some form (e.g., effluent, Central Arizona Project water and reclaimed water) while others recognized the potential problems in committing substantial volumes of water to restoration. Concerns were also raised about restoration alternatives that would create standing water because of the concern of creating habitat for mosquito breeding.

Recreation: Restoration alternatives that provided an opportunity to integrate recreation including trails, interpretive signage, and picnic/resting spots were favored.

Rio Nuevo and Redevelopment: Comments were also raised expressing concerns over how restoration might be integrated with the Rio Nuevo re-development project just downstream of the Paseo de las Iglesias.

Major Conclusions and Findings

The proposed ecosystem restoration within the Paseo de las Iglesias would restore important riparian habitat through this reach of the Santa Cruz River, and would provide improved habitat connectivity along the entire main stem. The restoration would be accomplished while causing no increase in predicted flood surface elevations.

The detrimental effects of implementing the Preferred Alternative would be primarily construction related as a consequence of very minor increase in traffic to and from the site, fugitive dust emissions, and construction related noise.

Impact Analysis Summary

Section 5 describes the potential effects from project-related activities on the physical resources (e.g., geology, soils, hydrology), biological resources, cultural resources, recreational resources, aesthetic resources, socioeconomics, noise, and environmental justice effects of implementing the alternatives, including the Preferred Alternative. The estimated effects are quantified where possible and otherwise described qualitatively. The significance of each change is also described based on the magnitude of change resulting from the proposed action and the importance of the resource. To ensure that small potential effects are not over-analyzed, potential effects have been assessed at a level of detail commensurate with the potential significance. Detailed description and evaluation is found in Section 5, Environmental Consequences, but the following list is provided in summary.

Implementing the PREFERRED ALTERNATIVE (Alternative 3E) would likely result in the following environmental effects:

- Permanent minor re-grading to steep sided riverbanks at locations within the Project Area that would not demonstrably alter the geomorphic patterns of the Santa Cruz River. There would be no effects to the geologic conditions.

- Once the bank stabilization has been completed, land use changes could take place adjacent to the Project Area that currently not permitted because of mandatory setbacks from unprotected riverbank within the City of Tucson floodplain regulations. With the completion of the project, those areas currently within that setback, but outside the Project Area may become eligible for commercial, light-industrial, or residential use.

- The entire area utilized to implement Alternative 3E would be temporarily disturbed by soil restoration activities. Grading and excessive soil manipulation would be avoided in remnant natural communities, but most areas would require moderate to profound disturbance of the existing surface soils to improve them. Changes include soil scarification, incorporation of nutrients and organic matter, mulching, ground patterning, water harvesting techniques for non-irrigated restoration, the placement of natural wind and sun-shading features and slope stabilization. The long-term result of the soil modifications would be a permanent increase the ability of soils to support healthy native vegetation and resist erosion.

- There would be no measurable change to the surface water hydrology in the Santa Cruz mainstem because of the small Project Area relative to the overall watershed size. Local effects to surface water hydrology within the Project Area would include a reduction in overland flow and an increase in water retention because of the establishment and maintenance of vegetation.

- The water quality of surface water flow in the main channel would not be affected by the local modifications for the Preferred Alternative. The surface water quality of runoff in the mainstem Santa Cruz River is dictated by landscape-level factors that could not be changed on the small-scale restoration. Local changes to the overland flows and improvements in water quality from the tributary washes could be realized. Improvement would occur as a result of stabilizing eroding banks, and identifying and removing illegally dumped materials. In addition, new habitat created to support vegetation development would enhance water quality through natural filtration.

- Minor permanent changes to the flood conveyance ability of the Santa Cruz River are predicted. Stream channel re-grading would be completed for habitat creation and riverbank stabilization. Detailed design would ensure that implementation would not create conditions that would increase the potential for flooding.

- With the introduction of irrigation water and soil treatment throughout the Project Area, the groundwater hydrology would be expected to receive an immeasurably small increased infiltration in the historic floodplain, terraces, and active channel areas. The expected long-term effect on regional groundwater hydrology would be an indiscernible decrease in the current trend of lowering for regional groundwater levels.

- Groundwater recharge would increase very slightly within the Project Area due to the irrigation and soil treatment throughout the Project Area. Although the irrigation water could originate as secondary treatment water, the cleansing effect of infiltration through overburden material would result in no changes to local groundwater quality.

- With the introduction of irrigation watering under this regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. The relatively small amount of water involved, relative to the regional groundwater aquifer, would predict that regional groundwater sources and groundwater budgets would be unchanged under this alternative.

- This alternative would result in the permanent restoration of approximately 1,100 acres of riparian habitat including approximately 718 acres of mesquite, approximately 356 acres of mixed mesoriparian shrub-scrub acres, 18 acres of cottonwood-willow, and almost six acres of emergent marsh. This restoration effort would produce a net gain of 454 average annual Functional Capacity Units (AAFCUs or FCUs; Appendix 14.4) compared to the No Action Alternative.

- Regionally rare wetlands would be restored by the permanent creation of 6 acres of emergent marsh in 5 water harvesting basins located immediately upstream of existing grade control structures. In addition, approximately 18 acres of cottonwood-willow forested wetlands would be created in additional water harvesting basins located at the confluences of the Santa Cruz River and 8 of its tributaries. This would contribute to the restoration of ecologically important wetlands that have been lost from the Study Area. The creation of this habitat may also provide habitat suitable for mosquitoes in the emergent marsh community. This should be addressed in the final planning and operational phases of this alternative.

- Habitat that is regionally rare and declining would be created, improved, and/or protected. Habitat that existed at baseline as small isolated blocks would become contiguous with larger blocks, reducing the adverse effects of fragmentation. New habitat would be created that would provide for many species of native wildlife, including Arizona's Neotropical migrants that breed or winter elsewhere and utilize the Arizona portion of the Pacific Flyway.

- No Federally listed threatened or endangered species are likely to occur in the Study Area under current conditions and no critical habitat for any listed species is present within the Study Area. Therefore, none of the alternatives considered would adversely affect listed species or critical habitat.

- Qualified archeologists would perform a survey of previously un-surveyed areas within the area to be disturbed. If cultural resources cannot be avoided, they would be evaluated regarding eligibility for listing in the NRHP. Identification, evaluation, and mitigation studies would be coordinated with the State Historic Preservation Officer (SHPO), Pima County and interested Native American Indian Tribes and all NRHP-eligible sites that would be impacted by project construction would be mitigated.

- Views from Sentinel Peak Park, the Santa Cruz River Park, and within the Study Area would be improved by replacing barren eroded ground with native vegetation within the Project Area. This does not conflict aesthetically with current or likely regulations or plans for the area, or result in adverse visual contrast with adjacent scenery and land uses currently present or proposed. It would not result in the adverse modification of the existing viewshed, or obstruct or substantially alter the visual character of any designated public viewpoints.

- The project would be implemented within attainment areas for all National Ambient Air Quality Standards (NAAQS) criteria pollutants. Potential adverse effects to air quality include short-term construction-related effects such as emissions from construction vehicles and fugitive dust from construction activities. Use of Best Management Practices would reduce these effects. This alternative would not contribute to new violations of Federal, state or local air quality standards.

- Ambient noise levels within the Project Area would increase for a short duration as a result of the construction-related noise from implementing the restoration. However, once completed, ambient noise levels would likely not increase as much as they would under the No Action Alternative because urbanization of the area would not be as great. This alternative would likely not contribute directly to sources of noise within or outside the Project Area. Increased density of vegetation would likely result in some localized attenuation of noise from outside the Project Area.

- The proposed action forecasts no quantifiable, long-term effects on demographics, employment, transportation, infrastructure or other socioeconomic indicators associated with growth or public health and safety. Minor effects during the active construction period are predicted.

- Recreational resources would likely improve as vegetation restoration makes the area more attractive to pedestrians and equestrians. Recreation for wildlife observation is expected to improve with the increase in quality habitat.

- Implementing the Preferred Alternative would not result in any change to environmental resources that individuals involved in subsistence fishing or hunting utilize or involve the release of hazardous, toxic, or radioactive materials to which minority or low-income populations could be exposed. As such, the nature of the action being considered precludes the potential to create disproportionately high and adverse human health or environmental effects on low-income populations, minority populations, or Indian tribes.

- Locations for implementing restoration alternatives were selected to avoid known hazardous, toxic, and radioactive waste (HTRW) sites and as such, no contact with HTRW materials is expected.

Relationship to Environmental Requirements

As part of the National Environmental Policy Act (NEPA) process, the applicable environmental laws, statutes, and executive orders were reviewed relative to the proposed project.

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements

Federal Statutes	**Level of Compliance[1]**
Anadromous Fish Conservation Act	N/A
Archeological and Historic Preservation Act	Ongoing
Clean Air Act	Full
Clean Water Act	Full[2]
Coastal Barrier Resources Act	N/A
Coastal Zone Management Act	N/A
Comprehensive Environmental Response, Compensation and Liability Act	Full
Endangered Species Act	Full
Estuary Protection Act	N/A
Farmlands Protection Policy Act	N/A
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act	Full
Magnuson-Stevens Act	N/A
Marine Mammal Protection Act	N/A
National Historic Preservation Act	Ongoing
National Environmental Policy Act	Full
Resource Conservation and Recovery Act	Full
Wild and Scenic Rivers Act	N/A
Executive Orders, Memoranda, etc.	
Migratory Bird (E.O. 13186)	Full
Protection and Enhancement of Environmental Quality (E.O. 11514)	Full
Protection and Enhancement of Cultural Environment (E.O. 11593)	Full
Floodplain Management (E.O. 11988)	Full
Protection of Wetlands (E.O. 11990)	Full
Prime and Unique Farmlands (CEQ Memorandum, 11 Aug. 80)	N/A
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)	Full
Invasive Species (E.O. 13112)	Full
Protection of Children from Health Risks & Safety Risks (E. O. 13045)	Full

[1] Level of Compliance:
Full Compliance (Full): Having met all requirements of the statute, E.O., or other environmental requirements for the current stage of planning.
Ongoing Compliance (Ongoing): Compliance requires continuing actions through later stages of project.
Non-Compliance (NC): Violation of a requirement of the statute, E.O., or other environmental requirement.
Not Applicable (N/A): No requirements for the statute, E.O., or other environmental requirement for the current stage of planning.

[2] Section 404(r) of the Clean Water Act exempts Federal projects from the requirement to obtain State 401 Water Quality Certification, if they meet specific criteria. The Corps believes that this project would meet the criteria for 404(r) exemption in that it is (1) a Federal construction project that (2) requires Congressionally authorized funds and (3) for which an EIS and a Section 404(b)(1) Evaluation have been prepared.

Table of Contents

1 Introduction

The Paseo de las Iglesias Feasibility Study and Environmental Impact Statement (EIS) are being prepared by the Los Angeles District of the U.S. Army Corps of Engineers (USACE). The purpose of the study is to identify the most economically practicable and ecologically sustainable means to achieve restoration objectives along a seven-mile-long portion of the Santa Cruz River, and its tributaries, within and south of the City of Tucson, Pima County, Arizona.

1.1 Study Location

The Study Area is located within the City of Tucson, an urbanized portion of the Sonoran Desert. It is bounded on the north by Congress Street, on the south by Los Reales Road, on the east by Interstate Highways 10 and 19, and on the west by Mission Road (Figure 1.1). Figure 1.2 illustrates the regional context of the Santa Cruz River and the Study Area.

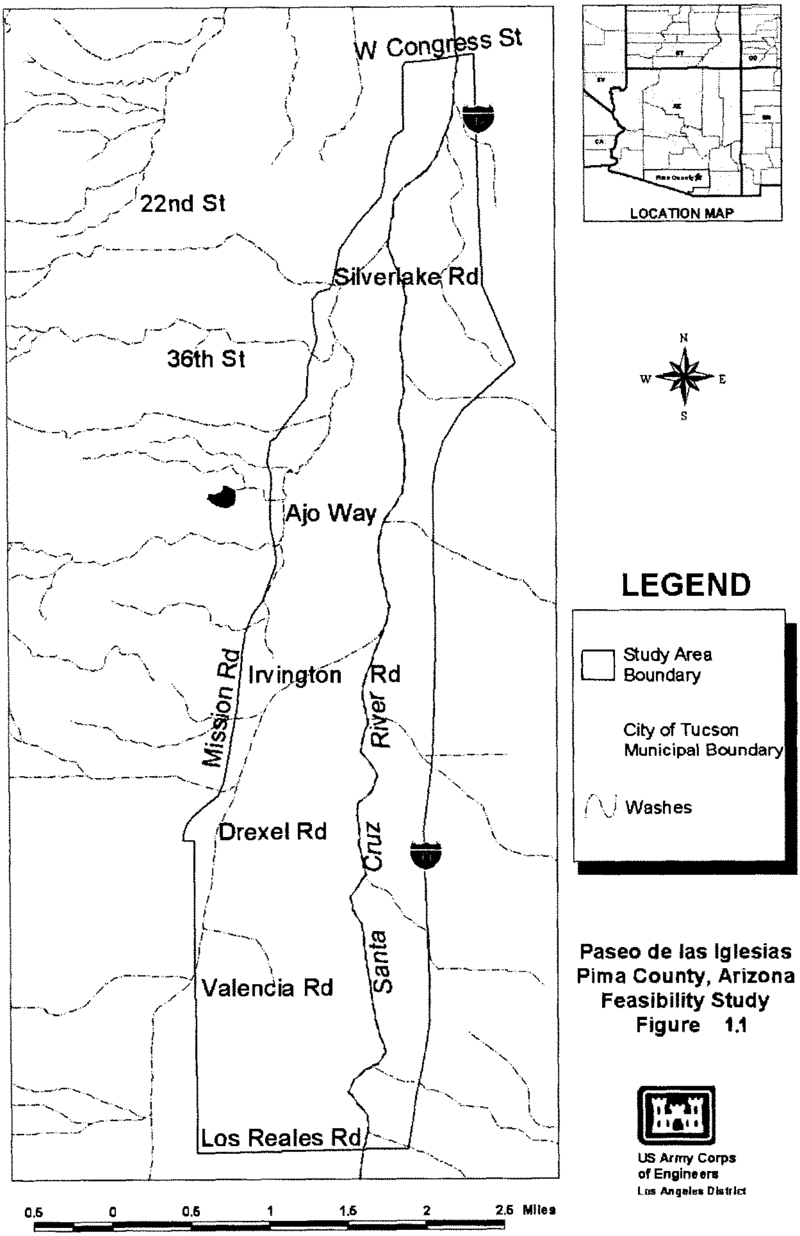
1.2 Compliance with National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires that agencies, such as the Army Corps of Engineers, integrate the NEPA process into their activities at the earliest possible time. For that reason, this analysis was initiated during the early project planning stages and the conceptual designs described herein are based on preliminary information and would be refined during the planning and analysis process; a final design has not been selected. Modifications in the project design are likely based on detailed engineering, cost evaluations, and environmental considerations, but the functionality of the project's features and the footprint for their construction are expected to remain essentially the same. The habitat restoration features considered in each of the restoration alternatives are described in Chapter 3.

1.3 Relationship of Paseo de las Iglesias to other Projects

The U.S. Army Corps of Engineers is currently involved in planning the following other restoration projects on the Santa Cruz River and its tributaries:

- El Rio Medio. This is a project that is currently in its early planning stages. It treats the reach of the Santa Cruz River immediately downstream from the Paseo de las Iglesias Study Area, extending approximately five miles.
- Tres Rios del Norte. This project is in an advanced planning stage. It treats the reach of the Santa Cruz River beginning approximately five miles downstream from the Paseo de las Iglesias Study Area and extends downstream approximately 19 miles.
- El Rio Antiguo. This proposed project treats a major tributary of the Santa Cruz River, a portion of the Rillito River.



Paseo de las Iglesias
Pima County, Arizona
Feasibility Study
Figure 1.1

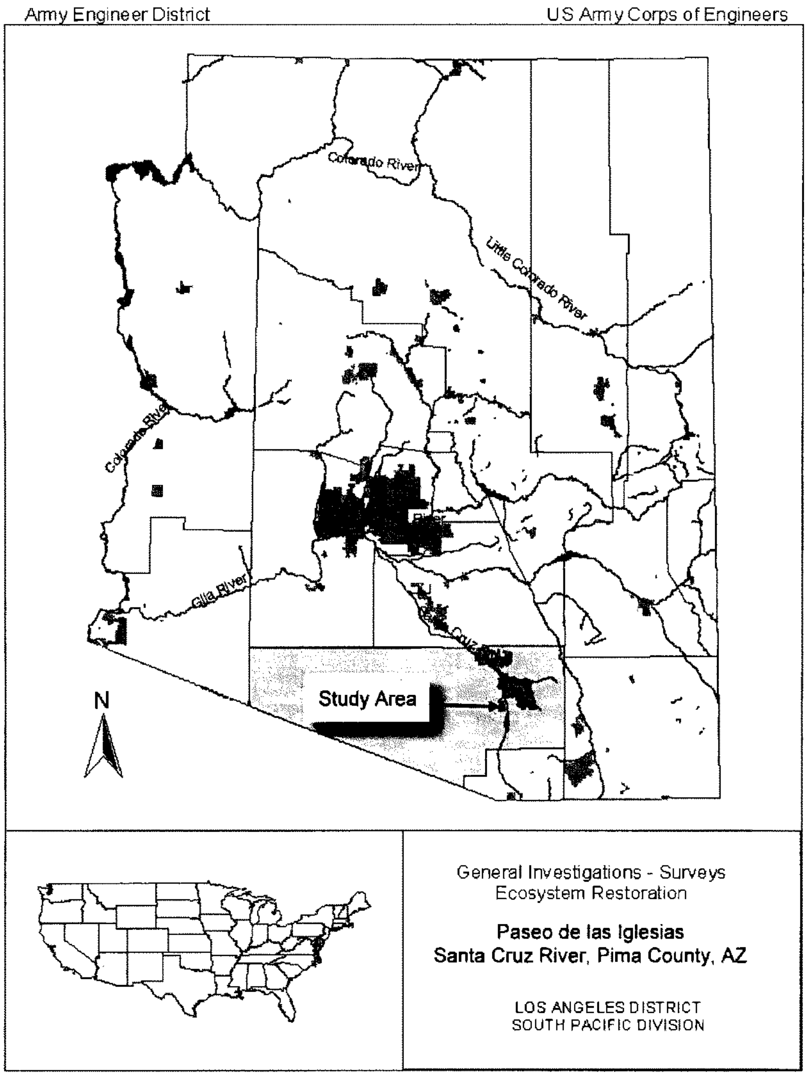


Figure 1.2 Study Area Location

1.4 Technical and Environmental Reports Preceding this EIS

Many studies have been conducted pertaining to water and related land resources within the Study Area. These studies have examined themes including development trends, environmental resources, water supply, groundwater recharge, wastewater management, flooding and erosion, geology, cultural resources, history, and recreation. The following is not intended to be a comprehensive list of previous reports, but to provide a sample of the types of studies that have been completed in the Study Area.

- SFC Engineering Company. 1996. Arizona Stream Navigability Study for the Santa Cruz River (Gila River Confluence to the Headwaters) Final Report, Prepared by SFC Engineering Company for the Arizona State Land Department.
- Pima County. 2000. Relationships Between Land and People –The Cultural Landscapes Approach in Archaeology and History. Report in the Sonoran Desert Conservation Plan Series.
- Pima County. 1999-2000. Reports in the Sonoran Desert Conservation Plan Series.
    - Overview of Traditional Cultural Places in Pima County.
    - Preserving Cultural and Historic Resources – A Conservation Objective of the Sonoran Desert Conservation Plan.
    - Pygmy Owl Update
    - Mountain Parks
    - Sonoran Desert Conservation Plan Update – Focus on Riparian Areas
    - Paseo de las Iglesias – Restoring Cultural and Natural Resources in the Context of the Sonoran Desert Conservation Plan
- Pima County. Final Documentation October, 1993 Flood Damage Report, Pima County Department of Transportation and Flood Control District.
- Pima County Department of Transportation and Flood Control District, Planning and Development Division. 1990. Pima County Flood Control District Comprehensive Program.
- Pima Association of Governments. 1986. Santa Cruz River Alignment Recharge Study - Final Report Prepared for City of Tucson.
- Simons, LI & Associates, Inc. 1995. Existing Conditions Hydrologic Modeling for the Tucson Stormwater Management Study (TSMS), Phase II, Stormwater Master Plan, Task 7, Subtask 7A3. Prepared for the City of Tucson.
- Pima Association of Governments. 1995. Landfills and Waste Disposal Sites along the Lower Santa Cruz River - Final Report Prepared for Pima County Flood Control District.
- Pima Association of Governments. 1995. Landfills Along the Santa Cruz River in Tucson and Avra Valley – Final Report for City of Tucson Office of Environmental Management
- Planners Ink. 1996. Pima County River Parks Master Plan (December 1996) Prepared for Pima County Department of Transportation and Flood Control District
- U.S. Army Corps of Engineers Los Angeles District. 1999. Paseo de las Iglesias, Pima County, Arizona - Reconnaissance Phase Study, 905B Analysis (1999) Pima County, Arizona.
- U.S. Army Corps of Engineers Los Angeles District. 2000. Reconnaissance Phase Study, 905B Analysis (includes Tres Rio del Norte and Agua Caliente).

- U.S. Army Corps of Engineers Los Angeles District. 2001. Gila River, Santa Cruz River Watershed, Pima County Arizona – Final Feasibility Report (August 2001).
- Documents prepared or included in the Draft Feasibility Report (USACE, 2002) level process:
  - Pima County Flood Control Planning Division. 2001. Santa Cruz River Paseo de las Iglesias, Pima County, Arizona Feasibility Study Hydraulic Report.
  - Pima County Floodplain Management Division. 2001. Santa Cruz River Paseo de las Iglesias, Pima County, Arizona Feasibility Study Hydrology Report.
  - LMT Engineering, Inc. 2002. Paseo de las Iglesias Environmental Restoration Study. Feasibility Study Geotechnical Appendix. Report submitted to Pima County Flood Control District.
  - Tetra Tech, Inc. Infrastructure Southwest Group and SWCA, Inc. Environmental Consultants. 2002. Paseo de las Iglesias Draft Biological Resources Report (Modified Habitat Evaluation Procedure). Report submitted to U.S. Army Corps of Engineers Los Angeles District Planning Division.
  - Tetra Tech, Inc. Infrastructure Southwest Group and SWCA, Inc. Environmental Consultants. 2002. Phase I Environmental Site Assessment for the Paseo de las Iglesias Project, Pima County, Arizona.
  - Tetra Tech, Inc. Infrastructure Southwest Group and SWCA, Inc. Environmental Consultants. 2002. Paseo de las Iglesias Draft Report: Areas with Restoration Potential. Report submitted to U.S. Army Corps of Engineers Planning Division.
  - U.S. Army Corps of Engineers Los Angeles District. 2002. Economic Appendix to the Feasibility Report for Paseo de las Iglesias, Tucson, Arizona.
  - Pima County Real Property Services, Public Works. 2001. Santa Cruz River Paseo de Las Iglesias, Arizona Feasibility Study Real Estate Report.

1.5 Agency Coordination

Formal and informal coordination occurred with a variety of Federal, state and local agencies in addition to the public involvement efforts described above. Agencies contacted included the United States Fish and Wildlife Service (USFWS), the Arizona Game and Fish Department (AGFD), the City of Tucson Parks and Recreation, Tucson Water Department, City of Tucson Department of Transportation, Pima County Department of Transportation, Pima County Cultural Resources, Pima Association of Governments, and Pima County Parks and Recreation. Representatives from USFWS and AGFD participated in development and application of the model for habitat evaluation. The USFWS also participated in development and design of alternatives. The USFWS has prepared a Planning Aid Letter (USFWS, 2003) and a Coordination Act Report for this study (USFWS, 2005).

2 Need for and Purpose of the Proposed Action

2.1 Study Authority

Ecosystem restoration is one of the primary missions of the USACE Civil Works program (USACE, 2000). The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems mimic, as closely as possible, conditions that would occur in the area in the absence of human changes to the landscape and hydrology. USACE incorporated ecosystem restoration as a project purpose within the Civil Works program in response to increasing national emphasis on environmental restoration and preservation.

Ecosystem restoration projects are formulated in a systems context to improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating, functioning systems. Indicators of success include the occurrence of a diversity of native plants and animals, the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species, and the ability of the restored area to continue to function and produce the desired outputs with a minimum of continuing human intervention. Restoration projects that are associated with wetlands, riparian, and other floodplain and aquatic systems are most appropriate for USACE involvement.

Section 206 of the Water Resources Development Act of 1996 (P.L. 104-300), as amended, authorizes the Secretary of the Army to carry out aquatic ecosystem restoration and protection projects if the Secretary determines that the project will improve the quality of the environment, is in the public interest, and is cost-effective.

A Paseo de las Iglesias, Pima County, Arizona Feasibility Report was specifically authorized by section 212 of the Water Resources and Development Act of 1999, P.L. 106-53, 33 U.S.C. 2332. Section 2332(a) states:

> The Secretary [of the Army] may undertake a program for the purpose of conducting projects to reduce flood control hazards and restore the natural functions and values of rivers throughout the United States.

Subsection (b)(1), 33 U.S.C. 2332(b)(1), provides authority to conduct specific studies "to identify appropriate flood damage reduction, conservation, and restoration measures." Subsection (c), 33 U.S.C. 2332(c), states the cost-sharing requirement applicable to studies and project conducted pursuant to section 2332. Subsection (e), 33 U.S.C. 2332(e), identifies priority areas. It states in pertinent part:

> In carrying out this section, the Secretary shall examine appropriate locations, including--
>
> (1) Pima County, Arizona, at Paseo de las Iglesias and Rillito River; . . . .

2.2 Purpose and Need for the Project

The purpose of the Paseo de las Iglesias project is to create riparian habitats for native plants and animals along an approximately seven-mile segment of the Santa Cruz River, and related tributary washes and vacant lands, by restoring, to the extent possible, the natural ecosystem functions and processes. Secondary benefits of the project are reduction of future flood potential through the improvement of soil stability, reduction of erosion and lateral migration of the river channel, aesthetic improvements, and reduction of air pollution by increasing soil stabilization through revegetation.

The project is needed because past flood control and water supply projects within the Santa Cruz River watershed have resulted in substantial alterations of the hydrological regime over a period of decades. These alterations, combined with historic agricultural activity and urbanization of metropolitan Tucson and surrounding areas, has resulted in substantial changes to the native vegetation. Without restoration, the native vegetation within the Study Area is expected to further decline.

The National Environmental Policy Act (NEPA) requires that agencies such as the USACE integrate the NEPA process into their decision-making activities at the earliest possible time. For that reason, this analysis was initiated during the early project planning stages and the conceptual designs described herein are based on preliminary information. These plans would be refined during the planning and analysis process and a final design would be selected. Future modifications to the project design would likely be based on engineering constraints, cost evaluations, and environmental considerations, but the Purpose and Need for the project and the footprint for construction is expected to remain essentially the same.

2.3 Project Objectives

In the absence of the Paseo de las Iglesias project, it is likely that future development pressures and continued bank erosion would result in the construction of structural protection for remaining undeveloped banks of the Santa Cruz River in the Study Area. This would further degrade remaining stands of native mesquite and preclude opportunities for future habitat restoration in the Study Area. Even today, due to groundwater use during the last 50 years, the average depths to groundwater are over 100 feet, well below the root zone of most riparian vegetation. Also, loss of a natural flow and flood regime has impacted the surface/groundwater interactions and sedimentation dynamics that are important for sustaining and regenerating riparian vegetation and flood-dependent seed transportation.

These resource challenges serve as the basis for the specific project objectives listed below. The project objectives were formulated to arrest the continued degradation of the riverine environment in the Paseo de las Iglesias Project Area and restore ecosystem functions. These objectives in turn provide a framework for the development of project alternatives.

- Increase the acreage of functional riparian and floodplain habitat within the Study Area.

- Increase wildlife habitat diversity by providing a mix of riparian habitats with an emphasis of restoration of riparian forests within the river corridor, riparian fringe and historic floodplain.
- Provide passive recreation opportunities.
- Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration goals.
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

3 Alternatives

The Federal planning objective for ecosystem restoration studies is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. The specific objectives for environmental restoration within the Study Area have been identified as follows:

- Increase the area of functional riparian and floodplain habitat within the Study Area;
- Increase the wildlife and habitat diversity by providing a mix of riparian habitats with an emphasis on restoration of riparian forests within the river corridor, riparian fringe and historic floodplain;
- Provide passive recreation opportunities;
- Provide incidental benefits of flood damage reduction, reduced bank erosion, reduced sedimentation and improved surface water quality consistent with the ecosystem restoration; and
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

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

1. <u>Availability of Water</u>

A principal constraint on any ecosystem restoration project in the arid southwest is the limited availability of water to support establishment and maintenance of healthy riparian habitats. Because there are various sources of water available for restoration projects, a specific limit on the volume of water available cannot be established until the associated outputs are known. Therefore, to avoid predetermining the outcome of the alternatives selection, a full range of reasonable water demands and alternatives was developed.

2. Maintenance of Floodway Capacity

Restoration of riparian habitat cannot be done in such a way that it would substantially reduce the hydraulic capacity of the Santa Cruz River or its tributary washes to convey damaging flood flows.

3. Proximity of Recreation to Restoration

Projects must be formulated in such a way as to avoid impacts from existing and planned recreational facilities in adjoining areas.

4. Endangered Species

The study area is located in an urban area that is not known to contain endangered or threatened species. Any potential project would be required under the Endangered Species Act to not jeopardize the continued existence of threatened or endangered species or to destroy or adversely modify their habitat. Furthermore, ecosystem restoration projects may potentially attract endangered or threatened species. Projects should be sited so that their habitation by those species does not reduce the ability to preserve the flood control functions and maintenance of the channels.

5. Landfills and HTRW Sites

Numerous landfills are known to exist within the study area. Throughout the plan formulation process, these sites have been avoided, to the greatest extent possible, in accordance with Corps guidelines. Landfills are likely to be encountered with bank excavation for creating new slopes. However, environmental assessment data (Appendix G of the Feasibility Report) indicates that landfill contents are benign. A remediation and management plan would need to be developed for unknown HTRW and other deleterious material encountered during bank excavations.

A number of measures have been developed based upon those originally identified in Reconnaissance Phase of the study, with additional potential measures added based upon the results of public involvement efforts and upon other similar studies in the region. The initial conceptual alternatives presented in the Draft Feasibility Report (USACE, 2002) document were expanded into an array of 14 alternatives that were subjected to detailed analysis. Through this process, a final array of alternatives was produced consisting of the two "best buy" alternatives (Alternatives 2A and 3E). In addition to the two "best buy" alternatives, Alternative 4F and No Action were the remaining alternatives presented in the FEIS for detailed analysis.

Additional refinement of those alternatives and subsequent analysis of costs and ecosystem restoration benefits relative to their effectiveness, acceptability, completeness, and incremental economic cost analysis led to the selection of a tentatively recommended plan. Chapter V of the accompanying Final Feasibility Report provides a detailed description of the deliberative process used to evaluate and select the alternatives to be considered in the EIS.

3.1 Alternative Formulation

The availabilities of water and land are the primary limiting constraints to ecosystem restoration in the Paseo de Las Iglesias reach of the Santa Cruz River. This alternative formulation analysis evaluated a range of water quantity delivery alternatives from reliance on the availability of unconstrained volumes of wastewater to reliance on atmospheric precipitation only. Land was presumed to be available only within the Study Area, and only in undeveloped parcels within and contiguous with the river channel. Land ownership was not initially considered a constraint, however the project implementation area was continually modified to exclude slivers or highly developed fractions of parcels. A fixed project implementation area was identified and used as the implementation "footprint" for all water application and planting variations (the Project Area). This approach did not limit restoration alternatives but defined the most rational location for project implementation using the following screening criteria.

The selection of the fixed area of land from the Study Area within which a riparian ecosystem restoration project might reasonable be constructed (the Project Area) was accomplished through an iterative process by District personnel, the non-Federal sponsor and their respective technical specialists and consultants. Geographic Information System (GIS) mapping resources (particularly the Pima County Land Information System PCLIS), recent aerial photographs, field inspections, the local knowledge base and professional opinion were employed to delineate a rational Project Area. The following selection criteria were employed to yield an approximately 1,350 acre working Project Area.

- Publicly owned lands were favored over privately held lands. The majority (>90%) of the lands in and immediately adjacent to the Santa Cruz River and its major tributaries are owned by public entities. The City of Tucson is the major landowner, followed by Pima County. Lands administered by the non-Federal sponsor (Pima County) were particularly favored for selection.
- The existing residential and commercial areas and all street and road rights-of-ways and utility corridors were eliminated. These would not be considered as part of a project unless there were unavoidable engineering requirements directing the need of a particular location.
- Areas platted for commercial or residential development were generally eliminated, unless reasonably needed for access or over-riding engineering considerations.
- Overlaps with proposed Rio Nuevo redevelopment project were eliminated due to uncertainty regarding potential conflicts between redevelopment and restoration land uses.
- Existing potentially hazardous or toxic waste sites were identified in a Phase I Environmental Site Assessment (Appendix G to the Feasibility Report). Based on that assessment, known hazardous or toxic waste sites and landfills were avoided.
- Lands that did not need to be restored were eliminated. These included lands currently supporting moderate to high quality examples of Sonoran Desert Cactus-scrub habitat.

- Existing parks were eliminated. While not pristine, native habitat, maintained parks support stands of vegetation that provide a suitable buffer between future restoration sites and urban uses.

Any lands that were clearly within limits of existing watercourses, as well as those immediately adjacent areas of the associated historic floodplains were considered for the restoration Project Area. Parcels located within the historic floodplain and close existing watercourses were evaluated on a case-by-case basis. The outer limit of the Project Area boundary was adjusted to follow parcel boundaries in a manner that precluded taking unreasonably small portions of parcels or leaving parcels that were not large enough to be viable for other uses. The application of these criteria resulted in a Project Area of approximately 1,341 acres. Maximized use of the Project Area also became a criterion for plan selection. The relationship between the Study Area and Project Area are depicted on Figure 3-1 where the study area is located within the red outline, while the Project Area is shown within the shaded area

3.1.1 Habitat-Water Volume Relationships Used in Alternative Segregation

A well-documented association exists between plant species grouping (habitats) and water availability in desert riparian ecosystems. Figure 3-2 depicts the natural relationships between geomorphology, hydrologic regimes, and habitat Figure 3-3 depicts the present hydrological and geomorphology of the degraded system in the Project Area. Riparian vegetation zones are correlated with the frequency and duration of the presence of water using the terms "Xeroriparian", "Mesoriparian" and "Hydroriparian". Xeroriparian (xero or xeric, indicating dryness) habitats receive water from rainfall and runoff from adjacent higher areas and are subject to infrequent riverine flooding. Mesoriparian (meso or mesic, indicating middle) habitats receive water from rainfall, surface runoff, infrequent shallow groundwater discharge and moderately frequent riverine flooding. Hydroriparian (hydro or hydric, indicating wet) habitats receive water from rainfall, surface runoff, and frequent groundwater discharge. Hydroriparian habitats require water at or near the surface almost constantly and include species typically found in wetlands.

These concepts were applied to segregate restoration alternatives. Restoration features that could be supported entirely by concentration of rainfall and harvesting of runoff were named "Xeroriparian restoration". The Xeroriparian features were assumed to need irrigation for a short period during the initial establishment of habitat and during periods of extended drought, but would be expected to survive without supplemental water or major maintenance once established. Restoration features that would be supported by infrequent but consistently applied supplemental water were characterized as "Mesoriparian restoration". Restoration features that would receive continuous supplemental water where characterized as "Hydroriparian" groups. Each of these would be presumed to support a natural Sonoran Desert plant community adapted to the restored hydrologic regime.

The Xeroriparian features are assumed to rely on rainfall and storm water harvesting to provide water to support habitat restoration. Water to support restored habitat would come from eight large-scale storm water harvesting sites appropriately designed and located at confluences of tributary washes with the Santa Cruz River, the Old West Branch and the New West Branch. Figure 3-4 depicts the tributary subsurface water retention basins. Confluences would be modified to capture and distribute storm water. Five additional storm water harvesting sites would be located immediately upstream of existing grade control structures in the Santa Cruz River.

Figure 3-1. The Study Area and the Project Area

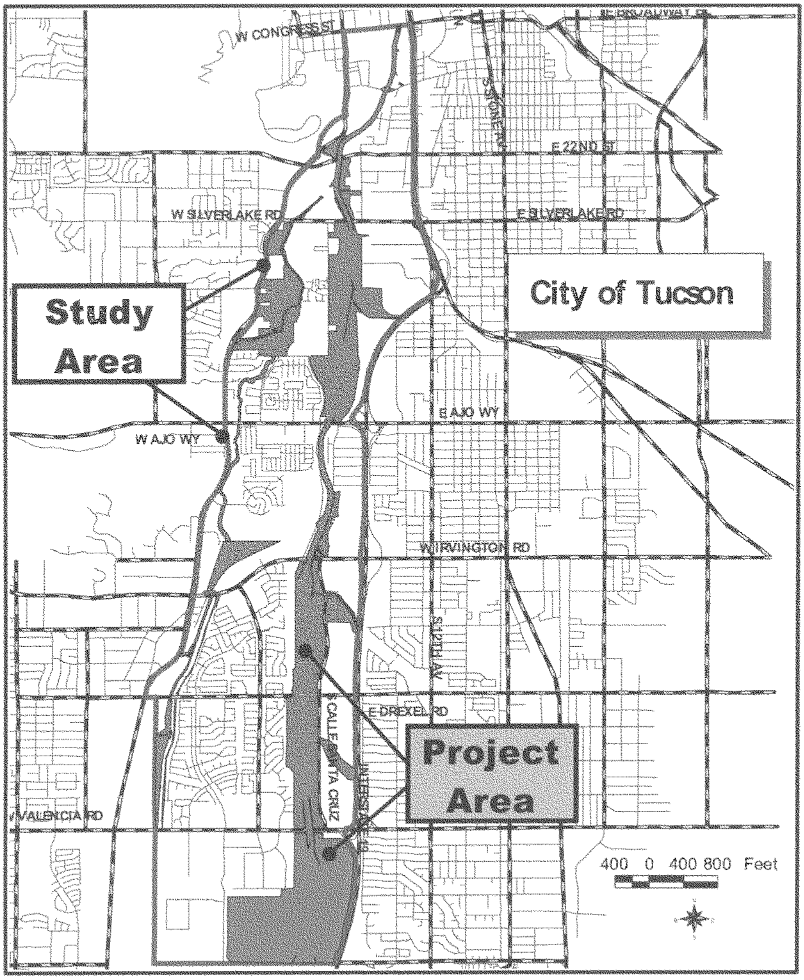


Figure 3-2 Natural Riparian Hydrologic Regimes

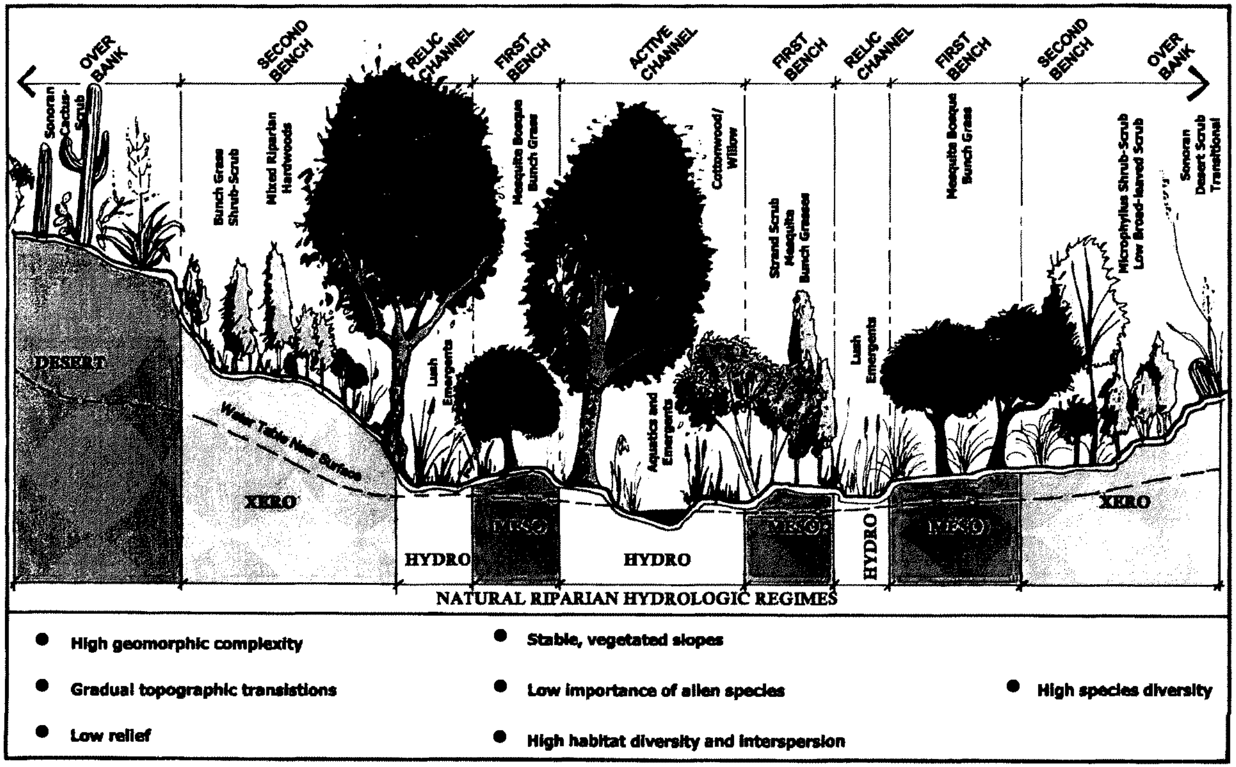
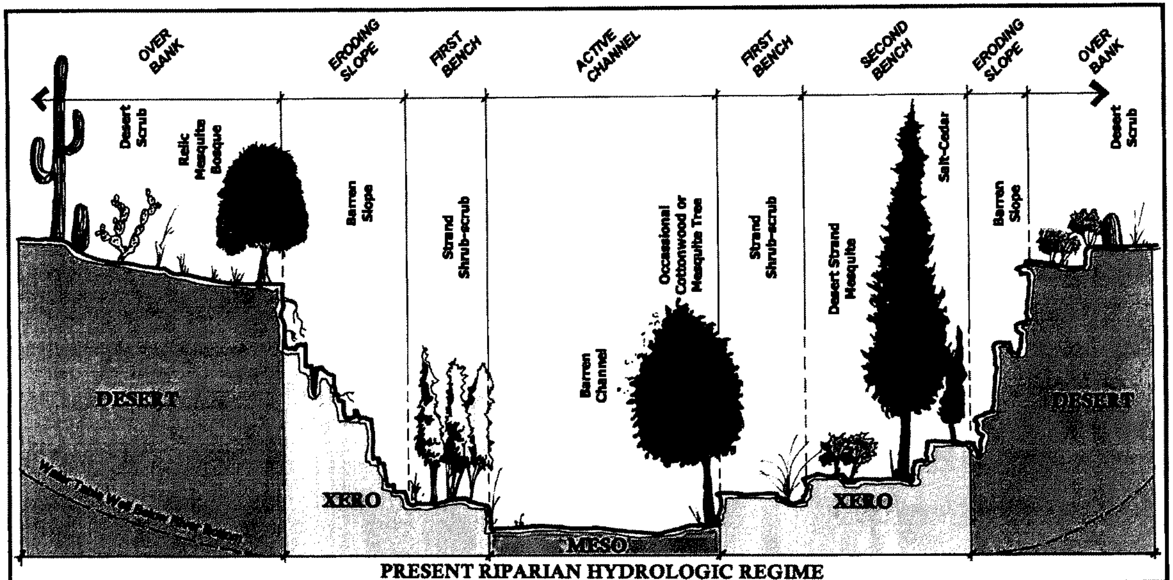


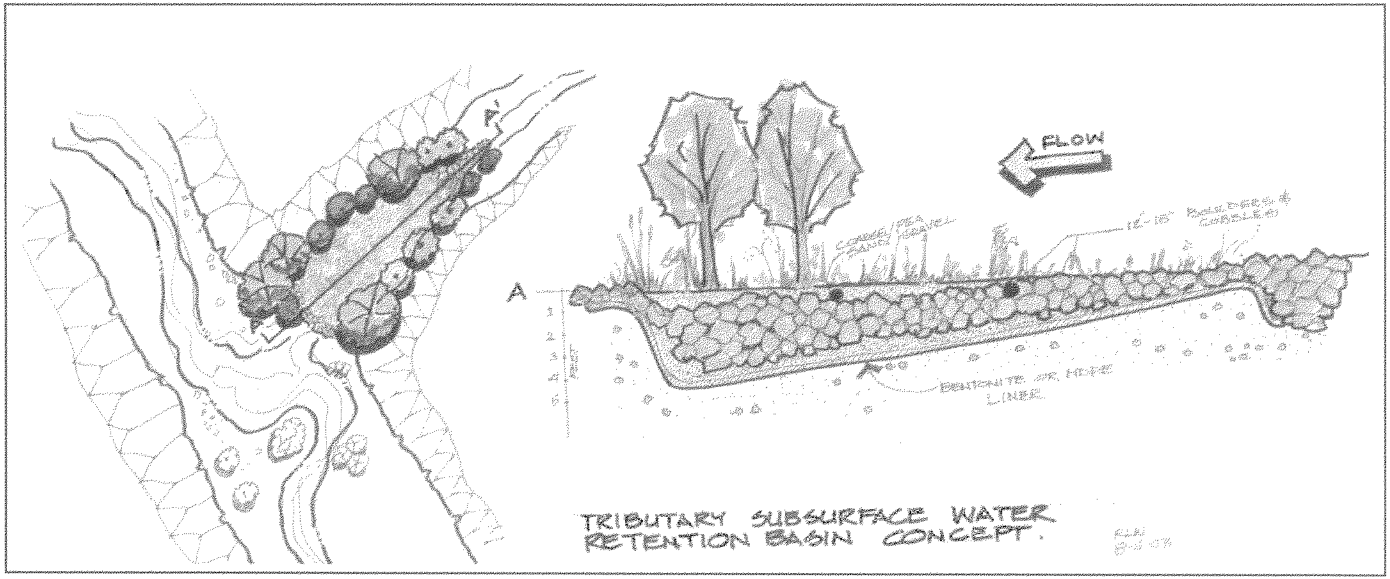
Figure 3-3 Present Riparian Hydrologic Regime



DEGRADED SANTA CRUZ RIPARIAN SYSTEM

- High, steep relief
- Eroded, barren slopes
- Low geomorphic complexity: simplified to cliffs and flats
- Abrupt topographic transitions
- Low species diversity
- Dominance of alien species
- Low habitat diversity
- Simplified hydrologic regime of extremes: drought or flood

Figure 3-4 Tributary Subsurface Water Retention Basin



Establishment of banks and terraces vegetated with a mix of riparian species was included on both banks of the river between Valencia Road and Irvington Road and on both banks from Ajo Way north through the Cottonwood Lane area.

The Mesoriparian features would be similar to those of the Xeroriparian (e.g., storm water harvesting sites located at confluences of tributary washes) but would differ in that continuous irrigation at a volume to support typical mesoriparian plants would be provided to the restored areas.

The Hydroriparian features were assumed to include: (1) modifications to the Santa Cruz River itself through construction of semi-permanent drop structures with associated weirs to create ponding of low flows, (2) widening of the Santa Cruz River channel between Valencia Road and Irvington Road to allow reintroduction of in-channel vegetation and a more sinuous channel form, (3) channel widening or terracing between Los Reales Road and Valencia Road, and (4) modification of tributary confluences to facilitate habitat restoration throughout the Project Area.

Water was assumed introduced through intermittent release into the main stem Santa Cruz River as well as tributary streams of the Santa Cruz River. In addition to supporting restoration of habitat along those watercourses, the water was intended to help maintain and expand the relic mesoriparian habitat area along the Old West Branch.

3.1.2 Geomorphic Considerations in Alternative Segregation

The Project Area was divided into three geomorphic positions relative to natural channel formation processes to further segregate alternatives. These geomorphic positions 1) the active (although rarely flowing) channel bottom, 2) the adjoining terraces (or bars), and 3) the historic floodplain (or overbank area). These are separated vertically by flow and erosion events that are both historical and on going. The active channel bottom is the area where water flows most frequently and where perennial flow would be found in a similar undisturbed system. Its present condition is typically barren and scoured sand and gravel, resulting from high-energy floodwaters. The terraces are the adjacent land features, composed of sand, gravel and cobbles that are elevated only slightly above the active channel bottom, but fully within the confines of the channel. Lower terraces might be flooded once every 2-5 years and the upper terraces might be flooded once every 5-10 years. Moving further laterally from the river channel centerline, a moderately steep to very steep and rapidly eroding bank extends 10 to 40 feet vertically to the historic floodplain. Adjacent to the entrenched channel of the Santa Cruz River, the historic floodplain has been cut off from the active channel due to down cutting and subsequent destabilization of storm runoff characteristics. This area was formerly flooded once every 25 years or less.

Identification of the geomorphic positions assisted the definition of alternatives by facilitating recognition of the appropriateness for implementing a limited set of restoration practices in these locations. It is also noted in unperturbed settings that hydroriparian plant communities correlated closely with geomorphic positions and that a natural appropriateness dictates the location of restoration practices. For example, the restoration of natural channel sinuosity or hydric plant communities would obviously be inappropriate for the historical floodplain. The use of xeroriparian land-patterning would be similarly inappropriate in the active channel. This recognition of the appropriateness of certain restoration measures and community types for a geomorphic setting allowed geomorphic position to function as a screening criterion for alternative restoration plans.

Two aspects of the geomorphic setting were not used as selection or screening criteria; the existence and restoration of over-steep and eroding channel banks and the application of surface amendments and earth form modifications included in the practice of dry-land restoration. It was assumed that channel restoration would include reducing the grade and mechanical or vegetative stabilization of all eroding, over-steep banks unless no action was planned in the overbank and only mesic or xeric features were to be implemented in the active channel. It was also assumed that minimum restoration would include appropriate surface re-grading, land patterning and void creation for water-harvesting, tilling or other mechanical breakup of surface crusts, the applications of fertilizer, mulch and native seed and the placement of wind and sun protection structures (such as large woody debris and boulders). The application of these practices throughout the Project Area (with consideration for the geomorphic position) and a reliance on only atmospheric water sources is considered equal to a dry-land restoration approach and approximately equal to the xeroriparian alternative.

3.1.3 Restoration Alternative Segregation and Screening

Riparian community types (Xeroriparian, Mesoriparian, and Hydroriparian) and the distinction between geomorphic positions (active channel, lower terraces, historic floodplain), allows the development of a matrix of restoration conditions. This matrix is presented as Table 3.1. The matrix allows initial consideration of potential combinations of feature groups, including "no action". There were initially 47 combinations identified. These combinations were evaluated screened out based on the following three factors:

- Fails to maximize use of the Project Area and lacked community interspersion,
- Creates unnatural habitat associations (i.e., they create habitat inappropriate for their geomorphic position), and
- Likely to reduce flood conveyance.

The number and diversity of cover types restored and the total acreage restored were taken into consideration for assessing the application of the first criterion. The second criterion, "appropriateness with the geomorphic position", selected against alternatives that did not replicate the natural transition from wettest at the channel centerline to driest farther from the channel. Hydroriparian communities occur in the lowest positions in the channel cross-section, where water is usually at or near the surface. Mesoriparian communities occur vertically above channel flow but experience frequent flooding or surface saturation from high water levels in the channel. Xeroriparian communities experience brief and infrequent flooding or saturation, being sustained by rainfall and local surface runoff.

In geomorphic terms, hydroriparian plants are most often found adjacent to the active channel or in the adjoining lower terraces. Mesoriparian plants would be found in the lower or upper terraces and xeroriparian would be found in the upper terraces or the historic floodplain. While diminished flows might lead to drier communities occurring near the active channel, hydroriparian plants would not be found in the historic floodplain and more xeric communities would not be found near the channel with a wetter one upgradient at a greater distance from the channel.

The Santa Cruz River channel has substantial capacity to convey flood flows. However, restoration measures that produce dense vegetation throughout the channel could reduce flood capacity and induce flooding. Alternatives that would foster the establishment of dense woody vegetation and obstructions in both the terraces and the active channel were eliminated unless they were combined with widening of the flood-flow cross-sectional area through re-grading of channel banks. Application of these screening criteria resulted in elimination of the majority of combinations. The results of this screening are presented in Table 3.2; combinations eliminated from further consideration are gray shaded. Those combinations passing the screening process are identified in the white areas.

Combinations are designated by the grouping of four letters into groups of three representing the hydrologic plant community type to potentially be placed on each of the three geomorphic positions. The letters used are N for no action, X for xeroriparian, M for mesoriparian and H for hydroriparian. Each letter represents a row from the Alternative Features Matrix with the order of letter aligned to the columns. Each habitat designation is assigned to the geomorphic position of the riparian corridor cross section moving from the center of the river channel to the highest ground furthest from the river's centerline: active channel (channel bottom), terraced floodplain (first and second terraces), and historic floodplain (overbank). For example, alternative HMN would be the result of combining hydroriparian active channel features and mesoriparian terrace features with no action in the historic floodplain. The results of the selection are discussed below and presented in Table 3.2.

TABLE 3.1 Features Matrix

	Active Channel Features	Floodplain Terrace Features	Historic Floodplain Features
No Action* (Without Project) *Listed items are anticipated consequences rather than measures to be implemented as in the other rows.	1. Continued instability of channel due to erosion. 2. Continued refuse dumping. 3. Continued degradation of habitat.	1. Continued erosion loss of lower terraces creating cliff-like banks. 2. Eventual application of soil cement on unprotected banks armoring entire reach.	1. With expanded soil cement bank protection, continued historic floodplain encroachment by development.
Xero-Riparian (Establishment and Emergency Irrigation)	1. Construct water harvesting basins upstream of existing and new grade control structures. 2. Divert low flow from New West Branch into remnant headwaters of Old West Branch. 3. Plantings of riparian grasses/shrubs	1. Water harvesting from local runoff. 2. Create tributary water harvesting basin deltas with two-tiered water harvesting basins. 3. Plantings on terraces and water harvesting basins.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Water harvesting from local runoff. 3. Replace steep banks with stabilized planted terraces
Meso-Riparian (Irrigation)	1. Construct and provide supplemental irrigation to water harvesting basins upstream of existing and new grade control structures. 2. Introduce periodic flow into the Old West Branch just upstream of its confluence with the Enchanted Hills Wash and on other tributaries downstream of that point. 3. Plantings of riparian grasses	1. Create tributary single-tiered water harvesting basin deltas. 2. Irrigate and plant terraces with mesquite along upper terrace. 3. Stabilize active channel banks by establishing thickly rooted mesquite at the edge of the lower terraces.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Plant and irrigate historic floodplain. 3. Replace steep banks with stabilized planted terraces
Hydro-Riparian (Perennial Flow With Irrigation)	1. Restore perennial flow with multiple points of distribution into the main Santa Cruz and tributary channels. 2. Plant cottonwood-willow bundles at edges of perennial flow where erosion protection needed. 3. Construct perennial channel features (e.g., pools, runs, and riffles).	1. Create tributary water harvesting basin deltas with hydraulic link to perennial flow. 2. Irrigate and plant low terraces with riparian grasses to maintain flood conveyance and discourage colonization by invasive species. 3. Irrigate and plant upper terraces with mesquite/cottonwood-willow.	Hydro Riparian plants do not occur in areas of the floodplain that are not subject to frequent inundation. Even so, feature 3 from the mesoriparian floodplain is carried forward to mitigate greater erosion risks associated with increased channel roughness in combinations where "No Action" is paired with Perennial Flow.

Table 3.2 Alternative Screening

Active Channel	Terraces	Floodplain	Screen Out	Reason	Alternative
No Action	Xero	Xero	Yes	Fails to Provide Sufficient Habitat Diversity	
No Action	Xero	Meso	Yes	Not Consistent With Natural Pattern	
No Action	Xero	No Action	Yes	Fails to Provide Sufficient Habitat Diversity	
No Action	Meso	Xero			1A
No Action	Meso	Meso			1B
No Action	Meso	No Action	Yes	Fails to Provide Sufficient Habitat Diversity	
No Action	Hydro	Xero	Yes	Not Consistent With Natural Pattern	
No Action	Hydro	Meso	Yes	Not Consistent With Natural Pattern	
No Action	Hydro	No Action	Yes	Not Consistent With Natural Pattern	
No Action	No Action	Xero	Yes	Fails to Provide Sufficient Habitat Diversity	
No Action	No Action	Meso	Yes	Fails to Provide Sufficient Habitat Diversity	
Xero	No Action	No Action	Yes	Fails to Provide Sufficient Habitat Diversity	
Xero	No Action	Xero	Yes	Fails to Provide Sufficient Habitat Diversity	
Xero	No Action	Meso	Yes	Not Consistent With Natural Pattern	
Xero	Xero	No Action	Yes	Fails to Provide Sufficient Habitat Diversity	
Xero	Xero	Xero			2A
Xero	Xero	Meso	Yes	Not Consistent With Natural Pattern	
Xero	Meso	No Action	Yes	Not Consistent With Natural Pattern	
Xero	Meso	Xero	Yes	Not Consistent With Natural Pattern	
Xero	Meso	Meso	Yes	Not Consistent With Natural Pattern	
Xero	Hydro	No Action	Yes	Not Consistent With Natural Pattern	
Xero	Hydro	Xero	Yes	Not Consistent With Natural Pattern	
Xero	Hydro	Meso	Yes	Not Consistent With Natural Pattern	
Meso	No Action	No Action	Yes	Fails to Provide Sufficient Habitat Diversity	
Meso	No Action	Xero	Yes	Not Consistent With Natural Pattern	
Meso	No Action	Meso	Yes	Not Consistent With Natural Pattern	
Meso	Xero	No Action			3A
Meso	Xero	Xero			3B
Meso	Xero	Meso	Yes	Not Consistent With Natural Pattern	
Meso	Meso	No Action			3C
Meso	Meso	Xero			3D
Meso	Meso	Meso			3E
Meso	Hydro	No Action	Yes	Not Consistent With Natural Pattern	
Meso	Hydro	Xero	Yes	Not Consistent With Natural Pattern	
Meso	Hydro	Meso	Yes	Not Consistent With Natural Pattern	
Hydro	No Action	No Action			4A
Hydro	No Action	Xero	Yes	Not Consistent With Natural Pattern	
Hydro	No Action	Meso	Yes	Not Consistent With Natural Pattern	
Hydro	Xero	No Action			4B
Hydro	Xero	Xero			4C
Hydro	Xero	Meso	Yes	Not Consistent With Natural Pattern	
Hydro	Meso	No Action	Yes	Too Much Reduction in Conveyance	
Hydro	Meso	Xero	Yes	Too Much Reduction in Conveyance	
Hydro	Meso	Meso	Yes	Too Much Reduction in Conveyance	
Hydro	Hydro	No Action			4D
Hydro	Hydro	Xero			4E
Hydro	Hydro	Meso			4F

3.2 Final Alternatives

As discussed above, Chapter V of the accompanying Feasibility Report provides a detailed description of the deliberative process used to select the alternatives considered in the EIS. The array of 14 alternatives identified in Table 3-2 was subjected to detailed analyses including evaluation of the water budget, effect on flood conveyance, environmental benefit of the restored habitat, and overall cost effectiveness. The first stage of analysis resulted in the identification of Alternatives 2A and 4F as "best buy" alternatives.

Following that analysis the non-Federal Sponsor--having thoroughly considered the types and quantities of habitat that might be restored with a full range of potential water budgets--determined that the maximum volume of water it could commit to ecosystem restoration in the Paseo de las Iglesias area was 2,000 acre-feet per year. This water-use constraint introduced a new limiting factor in considering the alternatives and required that the array of 14 alternatives be re-evaluated, eliminating alternatives requiring more than 2,000 acre-feet or irrigation water per year. Including the water-use constraint for the re-analysis resulted in the identification of Alternatives 2A and 3E as "best buy" alternatives. In addition to the two "best buy" alternatives, Alternative 4F and No Action were the remaining alternatives presented in the EIS for detailed analysis.

All of the action alternatives fully modify (re-disturb) the entire Project Area. The basic dry-land restoration practices are applied where appropriate. The needs for ingress, egress, lay-down areas, equipment storage areas and sediment and erosion control measures are assumed to utilize all available lands within the Project Area. Irrigation practices vary, resulting in widely differing water allocations, variations in the time to achieve optimum habitat conditions, and subsequently widely varying absolute outputs of habitat functional capacity units. As would be expected, costs also vary widely for the action alternatives as presented in Table 3.3.

Table 3.3 Alternative Cost Comparisons

Alternative	Total Acres Restored	Annual FCUs Obtained	Total Construction Cost	Average Annual Cost including OMRR&R[1]	Cost per FCU
2A	1,125	402	$62,604,865	$4,194,101	$10,433
3E	1,098	454	$80,678,407	$5,719,304	$16,819
4F	1,227	519	$85,263,675	$6,787,083	$13,077

[1]Operation, maintenance, repair, rehabilitation and replacement activities

The features of the Paseo de las Iglesias project within the active channel and lower terraces would be subject to the damaging and beneficial effects of recurrent flood flows and periods of inundation. This would predictably result in the need for periodic maintenance of the restoration features. Operation and maintenance costs include periodic removal of channel obstructions (e.g., tree trunks/logjams), control of non-native plant species, and water supply infrastructure. Operation and maintenance also includes periodic replanting of habitat damaged by flooding.

3.2.1 Alternative 2A

This alternative uses the basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading, a low flow diversion and construction of subsurface water harvesting basins. Implementation of these measures would allow creation of new Partial Wetland Assessment Areas (PWAAS), as well as improvement of existing PWAAS with plantings in Mesquite, Scrub/Shrub, and Riverbottom community types. This alternative would require irrigation for establishment and periodic irrigation during periods of prolonged drought.

The channel features for this alternative consist of two measures; construction of water harvesting basins on the upstream side of five existing grade structures and construction of a low flow diversion to direct water from the New West Branch (NWB) back into the Old West Branch (OWB). The water harvesting basin features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to minimize effects on flood flows.

The low flow diversion would be constructed by placing a diversion structure in the New West Branch channel to pond low flows and placing a conduit through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The tributary water harvesting basins discussed above would continue to be constructed, however, they would be increased in size. The off-channel areas would be created in the floodplain to concentrate local runoff.

This alternative restores 1,125 acres of habitat. It includes 867 acres of xeroriparian shrub (Shrubscrub) with 252 acres of mesquite and 6 acres of emergent marsh (Riverbottom). This alternative has an estimated construction cost of $62,604,865 that, when annualized over a 50-year project life yields an average annual cost of $3,765,583. OMRR&R costs are estimated at $428,518 so the total average annual cost of the alternative is $4,194,101. This alternative produces a net gain of 402 AAFCUs at a cost of $10,433 per unit.

The features of the Paseo de las Iglesias project are subject to damage by recurrent flood flows and periods of inundation. This would result in the need for periodic maintenance to ensure successful habitat restoration. Operation and maintenance costs would include periodic channel clearance, control of invasive plant species, and irrigation system maintenance. Operation and maintenance also include periodic replanting of large habitat areas eliminated by flood flow erosion.

3.2.2 Alternative 3E (Preferred Alternative)

Mesquite bosque creation is the dominant feature of Alternative 3E. Alternative 3E provides a nearly uniform mesoriparian hydrologic regime (through various means of supplemental irrigation) to all geomorphic positions in the floodplain above the low flow channel. This alternative creates approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub, 18 acres of cottonwood-willow, and almost six acres of emergent marsh.

This alternative maintains the low flow channel in an unplanted condition similar to the without project condition. Lower channel terraces (those vegetated areas above the low flow channel but approximately below the 2-year recurrence interval flow event) are planted with a mixed shrub-scrub community, suitable for a mesoriparian regime, with supplemental water delivered by bank-mounted sprinklers. Upper channel terraces (those above the 2-year storm), natural and regraded banks and the historical floodplain would be planted to mixed riparian communities, within which mesoriparian shrub composes more than 50 percent of the planted community, and irrigated to at a mesoriparian hydrologic regime.

Water harvesting basins would be constructed in the channel at the confluence of tributaries with the main Santa Cruz channel at eight locations. These basins would support cottonwood-willow and emergent marsh vegetation with cottonwood-willow composing more than 50 percent of the community. Adequate water would be supplied through the maintenance of a hydroriparian hydrologic regime using supplemental discharges from buried irrigation pipes. Similarly, five grade control basins would be created in the Santa Cruz main channel using reinforced or newly constructed at-grade barriers to detain channel runoff. These basins, approximately one-acre in area each, would support emergent marsh vegetation.

Both the tributary basins and the grade control basins are harvesting basin features involving excavation in channel bottoms. Excavation would be to a depth of approximately four feet, with bottoms mechanically compacted to impede exfiltration. The excavated void would be filled with layers of appropriately sized boulders, cobbles and gravel to create inter-particle interstices for water storage. This material would be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of pipe flood or subsurface drip irrigation to distribute water at specific locations.

Approximately 56,000 linear feet of overly-steep, highly eroded banks would be regraded to an approximate maximum of 5:1 horizontal to vertical ratio slopes and planted to improve channel stability. The graded reaches would be created by excavating historic floodplain, rather than be filling into the active channel. This would provide an ancillary effect of increased in-channel flood storage capacity. Approximately 3,700 linear feet of unstable, eroding slopes would be stabilized using conventional soil cement slope protection along selected reaches for which there is insufficient distance from the active channel to the Project Area boundary to create a stable graded and vegetated slope.

3E has an estimated construction cost of $90,916,632 that, when annualized over a 50-year project life yields an average annual cost of $5,765,687. OMRR&R costs are estimated at $1,869,961 so the total average annual cost of the alternative is $7,635,648. This alternative produces a net gain of 454 average annual Functional Capacity Units at a cost of $16,819 per unit.

For as long as the project remains authorized, the non-Federal sponsor must provide sufficient water for construction, operation and maintenance of the project. The cost of providing such water is an associated non-Federal cost of the project and the non-Federal sponsor would pay 100 percent of these costs. These costs are currently estimated at $1,099,175, annually. These costs are not shared as part of the total project costs.

3.2.3 Alternative 4F

This alternative results in establishment of a low flow channel with intermittent flow, graded vegetated banks, soil amendment, surface grading, and construction of subsurface water harvesting basins. Implementation of these measures would allow creation of new PWAAS, as well as improvement of existing PWAAS with plantings in Cottonwood-Willow, Mesquite, Scrub/Shrub, and Riverbottom. These planted areas would be irrigated.

Alternative 4F has hydroriparian communities in the active channel. Implementation of this alternative involves constructing a low flow channel that would convey intermittent flows through the entire length of the Santa Cruz River within the project boundaries. The existing low flow channel would require grading to create a new low flow channel averaging six feet in width and one-half foot in depth. The soil comprising the bed of the new low flow channel would be amended to accelerate formation of a near surface water harvesting basin below the streambed. This feature would help direct infiltration losses from the intermittent flow laterally toward restored habitat areas to be created on either side of the channel.

Grading would also create depressional areas on each side of the low flow channel approximately ten feet in width where soil saturation conditions resulting from lateral percolation would support emergent marsh communities. A low terrace (first bench) varying in width from ten to twenty feet would be constructed adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.

Because of the conveyance impacts that would result from such a feature, hydroriparian terrace features are limited to the upper level terraces. This includes construction and planting of water harvesting basins at the confluences of 11 tributaries and permanent irrigation systems for all planted areas including the water harvesting basins. The water harvesting basin features would involve excavating in the area where the tributaries enter the terraces. Excavation would be to a depth of approximately four feet; a liner membrane would be placed on prepared substrate. The excavated, membrane covered void would be filled with layers of appropriately sized cobble and gravel to create large inter-particle interstices for water storage. This material would be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of gated pipe flood or subsurface drip irrigation to distribute water at specific locations. In some cases, such as the tributary water harvesting basins, a simple outflow would be sufficient.

The reaches of steep natural banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. The method of stabilization would be based on the distance to the Project Area boundary and a maximum slope gradient. Typically, banks would be re-constructed at a 5-foot horizontal to 1-foot vertical grade and planted. A different treatment would be used in areas where there is not enough land to create a 5:1 slope but sufficient distance to the Project Area boundary exists to create slopes between 5:1 and 2:1. In those situations, the banks would be constructed as the minimum slope that can be accommodated and hardened as necessary to prevent further erosion and collapse. In areas where insufficient distance exists to accommodate 2:1 slopes placement of rip rap or soil cement may be necessary for bank protection. Such engineering solutions would be designed on a case-by-case basis. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it would reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout.

This plan has an estimated Gross Investment of $85,263,675. The Gross Investment is determined by adding construction costs to real estate costs to arrive a "First Cost"; applying a contingency factor plus factors for design, engineering during construction, construction management and adaptive management to the First Cost; and adding the cost of Interest during Construction.

The plan produces 1,227 restored acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. The plan produces 519 AAFCUs at a cost of $13,077 per unit. This output is indicative of medium size healthy arid region riparian ecosystem. As noted earlier in the report, such ecosystems are increasingly rare and are necessary to provide critical habitat for many native and migratory species.

For as long as the project remains authorized, the non-Federal sponsor must provide sufficient water for construction, operation and maintenance of the project. The cost of providing such water is an associated non-Federal cost of the project and 100 percent of these costs would be paid by the non-Federal sponsor. These costs are currently estimated at $947,806 annually. These costs are not shared as part of the total project costs.

3.2.4 No Action (Without-Project Condition)

Under the No Action Alternative, the remaining vestiges of riparian and floodplain fringe habitat would likely disappear. Fragmented enclaves of native species would predictably vanish as well. The absence of native riparian and associated floodplain fringe habitat would result in the low abundance and diversity of native wildlife in the area. In addition, unstable river geomorphology would continue to prevail in the Study Area.

3.3Alternatives Eliminated from Detailed Consideration

For the Paseo de las Iglesias study, a multitude of general and specific restoration measures were considered for alternatives. These measures were evaluated for inclusion in the restoration alternatives to be developed as part of this study. Many of the measures reviewed were incorporated into this plan formulation effort. Those included:

- Utilize Natural Water Sources Through Water Harvesting
- Establish Perennial Low Flow Channel
- Lay Back Banks/Widen Channel
- Terracing of Banks
- Stabilizing and Planting Islands/Sand Bars/Oasis (place clay lenses)
- Modify Confluence/Distribute Incoming Flows
- In Channel, Bank and Floodplain Vegetation
- Soil Cement Removal.
- Palisades/Fence Jetties/Root wad revetments
- Drop Structures/Weirs aligned with existing or new grade control structures.
- Elements Conducive to Wildlife/Fish measure

These measures were organized into grouped actions aligned with the following areas of the habitat that could be restored within the ecosystem:

1) Active Channel: bundles, clay liners, stormwater harvesting basins, grade control, seasonal pools, low flow channel, palisades/jetties, increase sinuosity, cottonwood/willow, and perennial flow.
2) Terraces and Banks: tributary deltas, distributary floodplains, soil cement removal, terracing, gallery forest, palisades/jetties, and stormwater harvesting basins upstream of confluences.
3) Historic Overbank Floodplain: gallery forest, water harvesting, blue Palo Verde, Bosque floodplain, distributary floodplain.
4) Old West Branch: fish habitat, New West branch connection, and irrigation.

In the process of formulating detailed alternatives many of these measures were dropped from consideration. Establishing terraces on the banks was eliminated due to a desire to minimize new hardscape such as would be necessary at the terrace boundaries. Stabilizing terraces or islands in the channel beyond what would be achieved through planting was deemed too expensive and prone to failure. Removal of soil cement was eliminated due to resulting increased erosion risks to existing development. Seasonal pools were eliminated as a result concerns regarding of vector control. Finally, establishment of fish habitat was not considered feasibile.

3.4 Alternatives Outside the Corps Jurisdiction

The setting and urban circumstances of the Santa Cruz River and most lands immediately bordering it practically invite concepts for extensive and appropriate changes of land use. These would span the gamut from promotion of service oriented commercial enterprises and additional residential development, to efforts aimed at recreation of historical land uses, and undertakings geared more toward ecological features adapted to riverine systems in the Sonoran Desert. Any proposals, which incorporate the existing channel of the Santa Cruz River, would be constrained by extant design characteristics. Authorization would be required of the Corps to implement such concepts in the river itself.

Planning objectives might be partially addressed if the need for additional recreational facilities led the City of Tucson or Pima County agencies to develop additional parklands adjacent to the river or on overbanks and available uplands. Planning objectives might also be partially addressed should the Natural Resources Conservation Service be engaged to restore native grasslands on upland areas where lands were available. Finally, planning objectives might also be partially addressed if the U.S. Fish and Wildlife Service were to attempt restoration of mesquite and upland communities in hopes of creating suitable nesting territory for cactus ferruginous pygmy owls, again where available lands could be secured.

None of these potential outcomes suggest an alternative approach to meeting planning objectives that would be outside the Corps jurisdiction. The Corps jurisdiction with respect to environmental restoration and recreation permits it to address any of these opportunities and in an integrated fashion.

4 Affected Environment

This chapter describes the existing natural and human environment of the area potentially affected by the project alternatives. Baseline data are provided for the 5005-acre Study Area but it is important to note that project alternatives may involve activities that would only affect a portion of the Study Area.

4.1 Geomorphic and Geological Setting

The 5005-acre Study Area is situated within the Sonoran Desert subprovince of the Basin and Range physiographic province. More specifically, the Study Area lies in the Tucson Basin of south-central Arizona, and encompasses an approximately 7-mile-long reach of the Santa Cruz River and adjacent uplands between Los Reales Road at the south end of the Study Area and Congress Street at its north. Along this reach, the Santa Cruz River floodplain ranges in elevation from approximately 2,500 feet above sea level at the southern end of the Study Area to approximately 2,340 feet at the northern, downstream end.

Surficial geologic units exposed in the Study Area consist almost entirely of alluvial (deposited by flowing water) sediments deposited during the last 10,000 years. These alluvial deposits can be further classified as either channel deposits or floodplain deposits. Channel deposits tend to be coarser, consisting of gravels and gravelly sand, whereas floodplain deposits consist primarily of fine sands and silt. Both of these surficial geologic units in the Study Area are mostly unconsolidated with little soil development. Lithified (well-consolidated, usually cemented) sediments are not exposed along the Santa Cruz River, and for the most part they are not expected to be present within the channel at depths necessary for structure installation, though such formations do approach the riverbed elevation in the vicinity of 22nd Street. In the Tucson Basin, surficial deposits are generally less than 100 feet thick (USACE, 2001).

Underlying the surficial geologic units within the Tucson Basin is a series of Tertiary (63 to 2 million years ago) and early Quaternary Period (2 million years ago to present) alluvial deposits with intercalated evaporites (minerals precipitated from solution) and volcanic units. The evaporites attest to a period during the middle Tertiary when the Tucson Basin was a closed drainage system containing pluvial (pertaining to rain) lakes. Below the alluvial, volcanic, and evaporite units, there is an impermeable complex of bedrock, which extends to the surrounding mountainsides (USACE, 2001). Bedrock volcanic units of the Tucson Mountains and Sentinel Peak (also called A-Mountain) to the west of the Study Area are exposed along Mission Road, which forms the western boundary of the Study Area.

The increased demand for surface and groundwater as well as hardening of surfaces within the Santa Cruz River watershed accelerated head cutting and resulted in the transformation of the verdant Santa Cruz riparian corridor to a dry ephemeral wash with both hardened and unstable banks that flows only in response to storm runoff. Prior to this channel entrenchment and subsequent twentieth century groundwater pumping, flow along the Santa Cruz River was mostly intermittent, although perennial reaches were present where springs persisted where the geology forced groundwater to the surface. One such perennial reach was located just south of Sentinel Peak within the current Study Area. Today the Santa Cruz River channel is entrenched throughout the Study Area and within its entire length in the Tucson Basin.

4.2 Land Use

Ninety-five percent of the 5005-acre Paseo de las Iglesias Study Area is within the City of Tucson limits, with the remaining 5% within unincorporated Pima County (Pima County Real Property Services, 2001). Ownership is divided between private (3,294 acres, 66%) and public (approximately 1,711 acres, of which 650 acres are highways, roads, streets, alleys, and drainage ways). Public entities that own land within the Study Area include the City of Tucson, Pima County, Tucson Unified School District, State of Arizona, and Pima Community College. Approximately 95% of the land adjoining the river is publicly owned, principally by the City of Tucson. As depicted in Figure 4.1, land use within the Study Area is diverse, reflecting the historic progression of land use and development from Tucson's original settlements in the area, and includes, but is not limited to, mining, landfills, light industrial, commercial, residential, transportation, recreation, and vacant. Each of these uses is briefly characterized below.

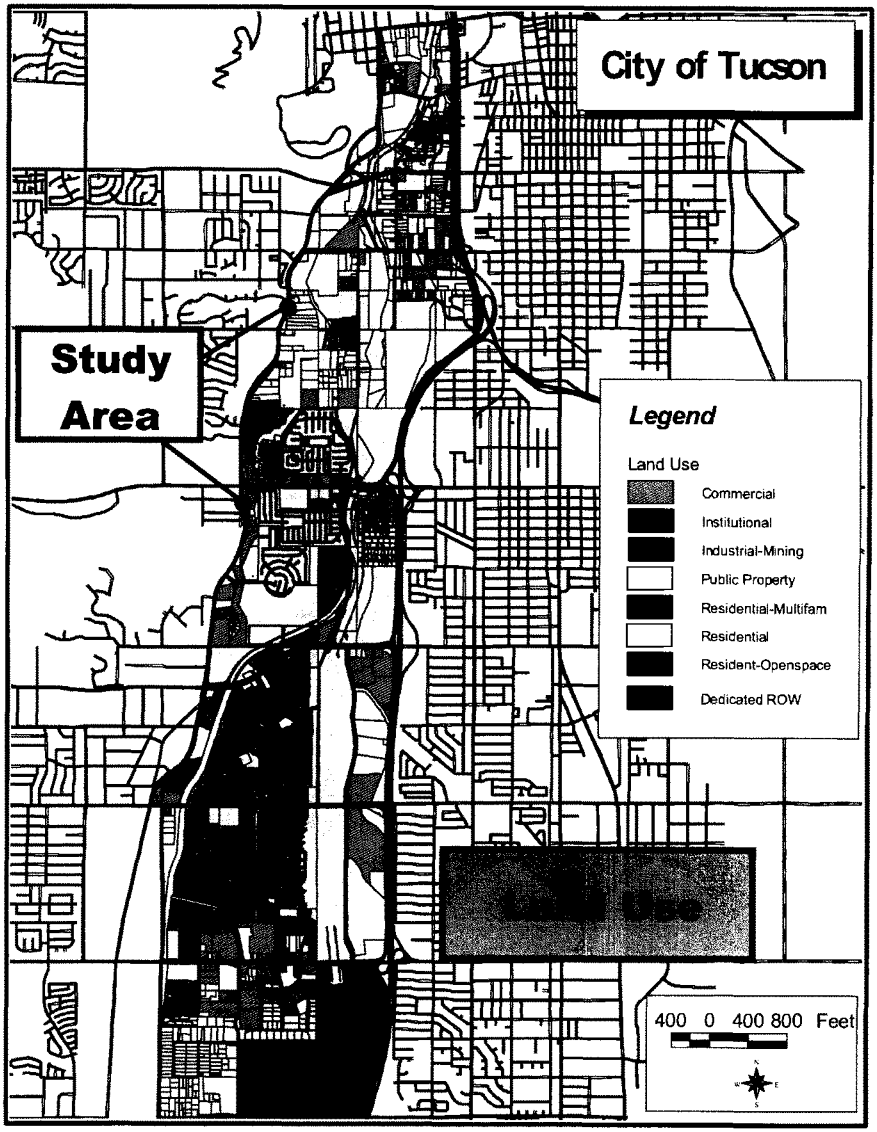
Mining. South of Valencia Road, along both sides of the River, there are approximately 400 acres of land recently used for sand and gravel extraction. This operation is in the process of being terminated. No other mining operations are active within the Study Area at this time.

Landfills. Six closed landfill sites currently owned and managed by the City of Tucson are located along the Santa Cruz River. These landfills were closed prior to Federal, state or local regulations for closure specifications and monitoring of landfill gases. They are:

1. Rio Nuevo South (also known as Congress landfill, located south of Congress Street along the west bank of the Santa Cruz River; approximately 40 acres; operated 1953-60)
2. Nearmont (also identified as part of the Rio Nuevo South landfill, located south of Congress Street, northeast of Rio Nuevo landfill, approximately 10 acres; operated 1960-67)
3. "A" Mountain (located between Mission Lane and 22nd Street; approximately 36 acres; operated 1953-1962)
4. Mission (located north of 22nd Street/Starr Pass Boulevard, west of the Santa Cruz River; approximately 30 acres; operated 1963-1970)
5. 29th Street (located north of Silverlake Road along the west bank of the Santa Cruz River; approximately 50 acres; operated 1963-1967)
6. Ryland (located between 36th and 44th Streets along the east bank of the Santa Cruz; approximately 50 acres; operated 1960-1965).

There have been no known reports of leaking or other hazards from any of these landfills. These landfills have been deliberately excluded from any of the proposed project areas.

Figure 4.1 Land Use



Light Industrial and Commercial. Light industrial development historically arose adjacent to the river, particularly between Ajo Way and 22nd Street, and this area continues to support light industrial uses today. Examples include materials recycling operations, collision repair, materials storage, construction yards, warehousing, etc. Desert Vista Campus of the Pima Community College (PCC) is located just south of Drexel Road and east of the Santa Cruz River and numerous elementary schools are located in the newer developments south of Ajo Way. Other commercial development in this area includes business parks (Honeywell facility immediately north of the PCC campus), and a shopping center just south of Irvington Road. One medical facility in the Study Area, Midvale Family Medical Center, is located just west of the river on Valencia Road.

Residential. Residential development in the Study Area includes recently developed tract home subdivisions, numerous mobile home parks, and semi-rural large-lot single-family residences. The northern portion of the Study Area is nearest to the historic center of Tucson and residential areas in this portion include historic barrios of single-family residences. Further, towards the south of the Study Area, relatively newer tract home subdivisions dominate the landscape, especially between Silverlake and Valencia roads.

Transportation. Seven major east-west arterials and hundreds of surface streets lie within the Study Area; several bridges provide access between lands west of downtown Tucson and points east. Major east-west arterials that cross the river, from south to north, include Valencia Road, Drexel Road, Irvington Road, Ajo Way, Silverlake Road, 22nd Street/Starr Pass Boulevard, and Congress Street. Both Mission Road and I-19/I-10, which form the western and eastern boundaries, respectively, of the Study Area, provide for north-south travel from southwest Tucson towards downtown and northward to Phoenix.

Recreation. The Santa Cruz River Park is a linear park and is the primary recreational facility within the Study Area. Developed and managed jointly by the City of Tucson and Pima County, this interrupted linear park extends within the Study Area from Congress south to Irvington Road and provides a paved trail, rest facilities, informational signage, and occasional public artworks on both sides of the river. River Park users include walkers, joggers, bicyclists, and passive recreationists like birders. Other recreational uses include small neighborhood parks such as Oak Tree Park, Ormsby Park, and Verdugo Park.

Vacant. Vacant lands within the Study Area comprise former agriculture fields, undeveloped lands, abandoned/undeveloped residential lots, and the river corridor and river bottom itself. As the dominant physiographic feature within the Study Area, the Santa Cruz River is characterized as an arroyo with most high flows entirely contained within the main channel. Approximately 3.1 miles of soil cement bank protection has been applied in a discontinuous fashion within the Study Area. Soil cement protection is located on both banks at the Valencia Road Bridge (about 0.4 miles), from Ajo Way to Irvington Road (about 1 mile), and from Silverlake Road to Congress Street (1.7 miles). The remaining approximately 4 miles of the riverbanks within the Study Area are unprotected. The current 100-year floodplain of the Santa Cruz River is narrower than its historic width as it passes through the Study Area, due to the effects of channelization and downcutting of the river. Vacant lands in the Study Area are used by vagrants or homeless persons as overnight or seasonal camp spots.

4.3 Soils

The surficial soil deposits in the Tucson Basin include two soil associations (SCS, 1972). The first is the Grabe-Anthony-Gila association, which consists of level and nearly level to gently sloping soils that are predominantly loam to gravelly-sandy loam. This association is found on floodplains and alluvial fans in the main channel of the river. The second association is the Cave-Rillito-Mohave association, which consists of nearly level to gently rolling soils that are predominantly gravelly loam and gravelly-sandy loam, and are found on low dissected terraces in portions of the banks away from the main channel (SCS, 1972). Historically these were floodplain soils that received silt and nutrients carried by floods and had some accumulation of natural litter and soil organisms. Wind and water, historic farming, trash dumping, and vehicles have resulted in profound disturbance and erosion of former soil profiles. With little to no flood-related deposits for many decades and a paucity of vegetation, organic material in the floodplain soils has been virtually depleted. Because of the absence of seeds and soil nutrients caused by mechanical soil disturbance, combined with packing of soil by machinery, most of the soil is barren or vegetated only by annual shallow-rooted plants.

4.4 Hydrology and Water Resources

4.4.1 Surface Water

No permanent, naturally-occurring surface water resources exist along the Santa Cruz River within the Study Area. The presence of surface water within the subject portion of the drainage is rare and occurs only during and after rainfall events or as a result of human release. The Santa Cruz River channel may carry surface water flows after large precipitation events across the boundary into Pinal County to the north. Surface water flows contribute to groundwater recharge by infiltrating down through the river channel into the aquifer.

At a staff gage (Tucson station) on the Congress Street Bridge, average daily stream flow rates are 17 cfs to 90 cfs in summer (July-October) and 11 cfs to 42 cfs in winter (December-February) and the annual average daily stream flow rate is 24.4 cfs. Maximum monthly stream flow rates are 312 cfs to 682 cfs in summer (July-October) and 202 cfs to 895 cfs in winter (December-February) and the annual maximum stream flow is 112 cfs. An average daily flow of 1 cfs was exceeded during 17% to 43% of the record during the summer season (July-August-September). Average daily flows of 10 cfs have been exceeded from 12% to 30% of the record. Average daily flows of 1 cfs were exceeded in 7% to 14% of the winter record (December through March). Average daily flows of 10 cfs were exceeded in 5% to 8% of the record. During the remaining months, (October-November and April-June) there are zero flows for upwards of 92% of the record.

Data concerning flows at tributary confluences is important because the flows at the end of flood events represent a portion of the potential quantities of storm water that might be harvested to support restoration efforts. There are nineteen notable tributaries joining the mainstem of the Santa Cruz River in the study reach and twelve of them join from the west bank.

Minor ephemeral flows from several tributaries, in addition to ephemeral flows within the Santa Cruz River, provide a source of water that is sufficient to support only minor (less than 5% of the river corridor) patches of riparian habitat. There can be considerable variation in the timing of these flows from the various tributaries and the main river. The 100 feet or more to groundwater, in combination with infrequent surface flows result in the xeric conditions. Engineered techniques for capturing and retention of the infrequent surface water flows could provide additional water for habitat restoration.

Anthropogenic water sources (reclaimed water and treated effluent) could be available to support restoration. Reclaimed water lines cross the northern portion of the Study Area just south of Congress Street and parallel the Study Area to the east as far south as Ajo Way. Extensions of existing lines are planned for the near future within the Study Area. While delivery systems are currently not in place, wastewater treatment plants within several miles of the Study Area represent potential sources of treated effluent that could be used to support restoration.

Wastewater from a sand and gravel extraction and washing operation created a 30-acre pond at the south end of the Study Area. The operation has not been granted permits to expand and is expected to close in the near future (2-5 years). Once commercial operations cease, the effluent to the ponds would be cut off and surface water would disappear.

Because surface water is present only briefly following rainfall events, surface water quality is affected by amount and timing of runoff from the urban area and to a lesser degree by any materials illegally dumped in the river channel. Other factors that may affect surface water quality occasionally are ruptures in sewage pipelines adjacent to the river. No active monitoring of surface water quality is regularly occurring in the Study Area because there is normally no surface water.

4.4.2 Surface Water Rights

Surface water rights are not an issue along this reach of the Santa Cruz River because of the absence of sustained surface flows; those in possession of surface rights are not able to divert water.

4.4.3 Flood Potential

Floods can occur from heavy thunderstorms, but are typically of short duration (lasting up to three hours). Occasionally, longer-term summer storms occur, associated with tropical storms from the Gulf of Mexico or the Pacific Ocean. These storms may provide heavy precipitation for up to 24 hours, causing longer lasting flood events (24 hours or more). The 2-year, 24-hour storm event assumes about 1.8 inches or rainfall in Tucson and the 100-year, 24-hour storm event assumes approximately 4.6 inches.

The 2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-year frequency flood events were modeled for the Santa Cruz River within the Study Area. The existing banks of the Santa Cruz River were determined to contain both the 50- and 100-year flow. The 200- and 500-year flood events would overtop the channel banks. The bridges within the study reach would not be overtopped during the 100-year flood event. However, most of the bridges would likely be overtopped during the 200- and 500-year flood events.

Flood damage reduction opportunities were analyzed and based on the results of environmental, hydrologic/hydraulic, and economic analyses, flood damage reduction as a project purpose could not be justified.

4.4.4 Groundwater

The main groundwater reserve in the Tucson Basin is within the sedimentary rocks and alluvium of a single aquifer (from bottom to top) of the Pantano Formation, the Tinaja Beds, and the Fort Lowell Formation. The Pantano Formation yields small to moderate amounts of water to wells while the Tinaja beds yield small to large amounts of water to wells, frequently in excess of 1,000 gallons per minute. The water table for this main aquifer is within 350 feet of the ground surface throughout most of the Basin. Current well information indicates that depth to groundwater in the wells close to the Santa Cruz River channel generally range from 100 to 200 feet below the ground surface.

City of Tucson Water Department provides potable water to residents and businesses within the Study Area. Potable water supplies for the Tucson area are drawn from 190 groundwater wells that are located within and around the municipality. With the increase in population and industry in Tucson, groundwater pumping intensified in the 1940s and 1950s and has continued since that time. Groundwater levels in Tucson Water's central wellfield have fallen as much as 200 feet since 1940, creating a large cone of depression underlying the city. Typical declines in the central wellfield have been around 3 to 4 feet per year substantially because of the expanding population and increasing demand for water. Future groundwater levels would be affected by the amount and location of groundwater pumping and the introduction of Central Arizona Project (CAP) recharge water. Direct use of CAP water by agriculture, industry and municipal users as well as the direct use and recharge of treated wastewater effluent would also affect groundwater levels.

4.5 Biological Resources

A Biological Evaluation (SWCA, 2003) was completed to characterize the Study Area and identify Federally-listed species known to occur in Pima County, state-listed species identified as Wildlife of Special Concern in Arizona, and species defined as Priority Vulnerable Species (PVS) in the draft Sonoran Desert Conservation Plan (SDCP). PVS are species that Pima County has determined are at risk, or have been extirpated but have potential to be reintroduced within the County. Collectively, all of the species considered in the Biological Evaluation (SWCA, 2003) are termed special status species.

In addition to special status species evaluations, vegetation communities and potential wildlife habitat within the study were delineated using a combination of aerial photography and field visits. Vegetation was classified following the Brown, Lowe, and Pase system (Brown 1980, 1994), the regional standard for vegetation classification.

4.5.1 Vegetation

The Paseo de las Iglesias Study Area supports several distinct vegetation communities: 1) Sonoran Desertscrub, 2) Sonoran Riparian Deciduous Forest and Woodland, 3) Sonoran Deciduous Riparian Scrub, 4) Sonoran Interior Strand, and 5) Cultivated and Cultured Uplands. Figure 4.2 shows the locations of vegetation communities within the Study Area. Acreages of each community in the Study Area are provided in Table 4.1. Less than 20 percent (about 100 acres) of the Study Area is characterized by vegetation that is considered undisturbed or native; the remainder has been disturbed, in most cases for urban use.

Figure 4.2 Existing Vegetation in the Study Area

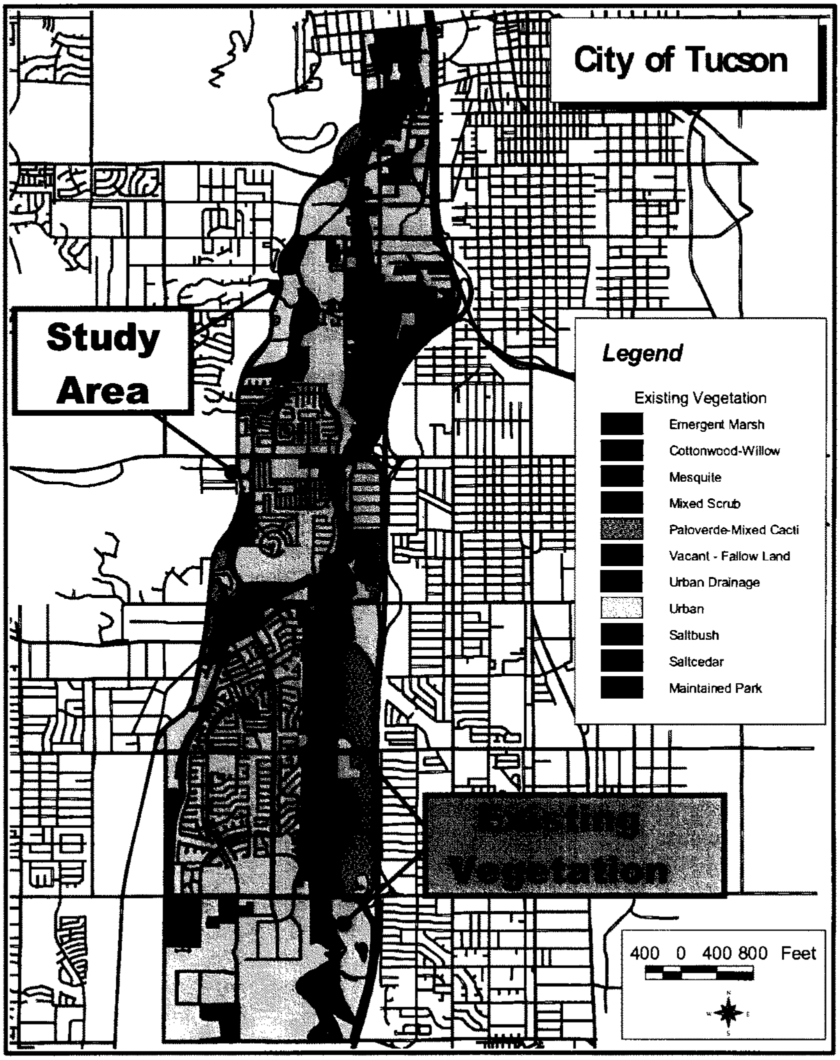


Table 4.1 Acreages of Vegetation Types Within the Paseo de las Iglesias Study Area

Vegetation Classification	Acres in Study Area	Percent of Study Area
Sonoran Desertscrub		
Paloverde-Mixed Cacti	237	4.7
Saltbush	96	1.9
Sonoran Riparian Deciduous Forest and Woodland		
Mesquite	160	3.2
Sonoran Deciduous Riparian Scrub		
Saltcedar Disclimax	87	1.7
Sonoran Interior Strand	261	5.2
Cultivated and Cultured Uplands		
Urban	3,045	60.8
Recreational	86	1.7
Vacant or Fallow lands	934	18.7
Urban Drainage	99	2.0
TOTAL	5,005	100

Vegetation communities in the Study Area are described in detail below.

4.5.1.1 Sonoran Desertscrub

Sonoran Desertscrub is the characteristic upland biome in the region. It is typified by open to dense stands of drought and heat tolerant deciduous trees and shrubs that have small leaves, and often thorns. Vegetation density and diversity is often related to local conditions. Within the Study Area, this biome forms two distinctive vegetation series, which are distributed as isolated outcrops between roads and developed areas: Paloverde-Mixed Cacti and Saltbush. Dominant woody perennial species include creosote bush (*Larrea tridentata*) on gravely soils and fourwing saltbush (*Atriplex canescens*) on silty soils.

4.5.1.2 Sonoran Riparian Deciduous Forest and Woodland

This vegetation community is typically encountered along perennial or intermittent drainage ways and springs, where vegetation is able to tap shallow subsurface water. In the Study Area, only the Mesquite Woodland type is currently present. The Cottonwood-Willow type, which at one time was a common vegetation community along portions of the Study Area, has been eliminated. In addition to mesquite, common plant species in the Mesquite Woodland are catclaw acacia (*Acacia constricta*), blue paloverde (*Parkinsonia florida*), pitseed goosefoot (*Chenopodium berlandieri*), lotebush (*Zizyphus obtusifolia*), fourwing saltbush, and various species of forbs, grasses, and vines.

In the Study Area, mesquite trees in some remaining stands are relatively large, reaching heights between 10 and 20 feet. None, however, approach the 60-foot height of those trees that existed pre-settlement. Furthermore, the existing trees are not regenerating. Despite their comparatively small size, however, the remaining mesquite trees in the Study Area, especially where they occur in dense stands, provide important habitat for wildlife. The best remaining examples of this community are located across Santa Cruz Road from Pima Community College Desert Vista Campus, along the West Branch from Ajo Road to Silverlake Road (Rosen 2001, Mauz 2002), and along portions of Julian Wash between Silverlake Road and 20th Street.

4.5.1.3 Sonoran Deciduous Riparian Scrub

This community is primarily limited to the areas adjacent to washes, but an example is also found within the Santa Cruz River bed. In the Study Area, the Sonoran Deciduous Riparian Scrub Biome is represented by a Saltcedar Disclimax series, which is present primarily in the areas formerly vegetated by Sonoran Riparian Deciduous Forest and Woodland. This vegetation type has limited structural diversity and is dominated by plant species that are adapted to xeric conditions, in particular non-native invasive species such as Athel tamarisk (*Tamarix aphylla*) and saltcedar (*Tamarix ramosissima*) which form open to dense stands. Typically, trees in this series are less than 20 feet tall and are regularly subjected to intensive flood events. Other common species occurring within this vegetation type within the Study Area are Bermudagrass (*Cynodon dactylon*), camphorweed (*Heterotheca subaxillaris*), western tansymustard (*Descurania pinnata*), and Jerusalem thorn (*Parkinsonia aculeata*).

4.5.1.4 Sonoran Interior Strand

This community persists within the Santa Cruz River mainstem and associated wash channels where it is subject to frequent flood events and regular scouring. It includes the existing low-flow channels, because the areas of vegetation change rapidly as a result of flow events. Strand habitats are characterized by scattered patches of vegetation and soils are usually sand and gravel, with small silt deposits and low organic content. Common species in this community include many that are also associated with scrubland communities, such as singlewhorl burrobrush (*Hymenoclea monogyra*) and desert broom (*Baccharis sarothroides*). Also found in this community are annuals, short-lived perennials, and invasive species, such as Adonis blazingstar (*Mentzelia multiflora*), camphorweed, Canadian horseweed (*Conyza canadensis*), common sunflower (*Helianthus annuus*), desert horsepurselane (*Trianthema porulacastrum*), western tansymustard, and buffelgrass (*Pennisetum ciliare*).

4.5.1.5 Cultivated and Cultured Uplands

This broad category encompasses areas where most native vegetation has been removed as a result of past or ongoing human activity. Non-native landscaping plants are in many cases the only component of the vegetation. This category includes residential properties, building sites, landscaped recreation areas, agricultural areas, closed landfills, and other disturbed areas. Based on ecological and aesthetic characteristics, the Cultivated and Cultured Upland community can be subdivided into the following subcategories: Urban Land, Recreational Land, Sonoran Vacant or Fallow Land, and Urban Drainages.

Urban Land (Residential, Commercial, and Industrial).
Much of the land in this category is essentially devoid of native vegetation, or, where vegetation does occur, it is usually sparse and scattered. As a general rule, the current condition of vegetation can be classified along the following continuum (from greatest impact to least impact): industrial, commercial, heavy residential, and light residential (Brown, 1980). Included in Urban classification are horse properties and small agricultural fields around houses. Common plant species include velvet mesquite, burroweed (*Isocoma tenuisecta*), Jerusalem thorn, prickly Russian thistle (*Salsola tragus*), native and nonnative grasses, and numerous ornamentals and cultivars. Included among the ornamentals is a large stand of fan palms located on the west side of the river, between Irvington Road and Ajo Way in a large mobile home park.

Recreational Land.
Recreational lands consist of parks, including the Santa Cruz River Park and two small urban parks. This classification is composed of a wide array of vegetation types, ranging from predominantly nonnative landscaped trees and shrubs to comparatively natural vegetation that is actively maintained. Vegetation structure and density is highly variable. Common plants found on recreational lands include olive (*Olea europaea*), gum (*Eucalyptus* sp.), Goodding's willow (*Salix gooddingii*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), Chinaberrytree (*Melea azederach*), tuna cactus (*Opuntia ficus-indica*), European fan palm (*Chamaerops humilus*), velvet ash (*Fraxinus velutina*), Florida hopbush (*Dodonea viscosa*), velvet mesquite, creosote bush and whitethorn acacia.

Sonoran Vacant or Fallow Land.
Historically, vacant or fallow lands were part of the upper terrace and/or floodplain of the Santa Cruz River, and many of them were used for agricultural production. During the 1950's and 1960's, however, most of these areas were retired from agricultural production. Today, these areas consist of fallow agricultural fields, closed landfills, inactive gravel pits, and other areas that have been recently disturbed but are not currently being used for other purposes. Most of these lands are owned by either the City of Tucson or Pima County. Most woody perennial vegetation has been removed from these lands. The most commonly established plant species are velvet mesquite, Jerusalem thorn, Athel tamarisk, burroweed, and a variety of native and non-native grasses and forbs.

Urban Drainages.
Urban drainages are drainage ways or conveyance channels for urban runoff that are maintained as part of the City's floodwater drainage system. Many of these drainages may originally have been natural washes, but have undergone bank stabilization and channel modification. Others are entirely artificial in origin. They are currently impacted by flooding, channel maintenance activities, transient camps, and wildcat dumping. Urban drainages are now vegetated primarily by non-native species and escaped cultivars, although remnant patches of native vegetation remain. In the Study Area, common plant species include Jerusalem thorn, camphorweed, Bermudagrass, red brome (*Bromus rubens*), mesquite, rough cocklebur, African sumac, and desert broom.

4.5.2 Wetlands

There are no known remaining natural wetlands in the Study Area.

4.5.3 Fish and Wildlife

There is no fish habitat due to the absence of surface water within the Study Area. Wildlife species currently found within the Study Area are typical of those found in remnant Sonoran Desertscrub habitats within an urban environment. No surveys were conducted for bats or small mammals. The common vertebrate wildlife species associated with each of the vegetation communities are discussed below.

Sonoran Desertscrub
No amphibians were observed in this community. Reptiles observed were western whiptail and zebra-tailed lizards, both of which were abundant. Seventeen species of birds were observed. The most common were cactus wren, curve-billed thrasher, Gambel's quail, mourning dove, northern mockingbird, and white-winged dove. Five species of mammals were observed; the most common species were black-tailed jackrabbit, desert cottontail, and round-tailed ground squirrel.

Sonoran Riparian Deciduous Forest and Woodland (Mesquite)
No amphibians were observed in this community. Reptiles observed were desert spiny lizard, tree lizard, and western whiptail. Seventeen species of birds were observed in Mesquite Woodland. The most common were ash-throated flycatcher, Gambel's quail, mourning dove, and white-winged dove. Five species of mammals were observed, but none were particularly abundant or representative of this community.

Sonoran Deciduous Riparian Scrub (Saltcedar Disclimax)
No amphibians were observed in this community. Western whiptails were common; the only other reptile observed was the tree lizard. Eighteen species of birds were observed. The most common were Abert's towhee, mourning dove, and white-winged dove. Six

species of mammals were observed, none of which were abundant or unique to this community.

Sonoran Interior Strand.

The only amphibian species observed outside the West Branch, the Sonoran Desert toad, was reported from this community. In the West Branch, six species of amphibians were present in this community. Western whiptail and zebra-tailed lizards were the only reptiles observed, and they were uncommon. Twenty-five species of birds were observed in this community. Common species were mourning dove, northern rough-winged swallow, rock dove, and white-winged dove. Steeply cut dirt banks provide nesting habitat for the following species: barn owl, common raven, great horned owl, northern rough-winged swallow, and rock dove. Five species of mammals were observed, the most common of which was black-tailed jackrabbit.

Cultivated and Cultured Uplands.

Urban: Residential, Commercial, and Industrial.

Some native wildlife species have adapted to the range of conditions present in this community. Some residents provide water and feeders for birds, which encourages seed eating species and hummingbirds. A much higher diversity of native wildlife occurs in light residential areas, where some native vegetation remains, than in heavy residential, commercial, or industrial areas. No amphibians were observed in the urban area. Three species of lizards were observed, none common. Eleven species of birds were observed in the urban area. The most common of these were great-tailed grackle, house finch, house sparrow, mourning dove, northern mockingbird, rock dove, and white-winged dove. Five species of mammals were observed, but none were uniquely representative of this community.

Recreational Lands.

Because of high variation in vegetation composition, structure, and density, and the occasional availability of water, several animal species utilize the maintained parkland use category, including 32 species of birds observed during field visits. The most common birds were house sparrow, mourning dove, northern mockingbird, western kingbird, white-crowned sparrow, and white-winged dove. At least one burrowing owl was utilizing a nest box located in the Santa Cruz River Park. Four species of reptiles were observed in this community. Four species of mammals were observed; the most common was the round-tailed ground squirrel. None of the bridges that occur in the maintained park appear to be utilized by wildlife for nesting or roosting.

Sonoran Vacant or Fallow Land.

No amphibians were observed in vacant lands. Three species of lizards were observed, with the western whiptail being the most common. Fifteen species of birds were observed, with house sparrow, mourning dove, white-crowned sparrow, and white-winged dove common. The most notable species in this community is the burrowing owl. Five species of mammals were observed, of which black-tailed jackrabbit and round-tailed ground squirrel were most common.

West Branch.
Some of the wildlife species found in the Study Area appear to be limited to mesquite and strand habitat along the West Branch. These include relict populations of reptiles and amphibians that were historically found over a much wider range. The giant spotted whiptail and the Sinaloan narrow-mouthed toad, for example, have not been reported elsewhere along the Santa Cruz River in Tucson in recent years. The West Branch also has the largest number of frogs and toads (six species), and lizards (ten species) observed at any site in Tucson. Several of the 73 bird species found along the West Branch are now considered rare in the Tucson urban area. Rosen (2001) has characterized the West Branch as containing "...all that is left of the original fertile and biologically diverse floodplain and river channel system that was the original reason for Tucson's existence".

4.5.4 Threatened and Endangered Species

There are no species currently listed, proposed, or considered as a candidate for listing under the Federal Endangered Species Act that are likely to occur within the Study Area. In addition, no critical habitat for any Federally listed threatened or endangered species occurs within the Study Area.

It was determined that ten special status species either occur or have the potential to occur within the Study Area. These species are of concern to Federal, state, and local agencies, but are not afforded protection under the Endangered Species Act. They are Tumamoc globeberry, giant spotted whiptail, burrowing owl, Abert's towhee, Bell's vireo, rufous-winged sparrow, western yellow bat, California leaf-nosed bat, pale Townsend's big-eared bat, and Merriam's mouse. Provided below for each species is a brief description of habitat requirements and an evaluation of potential for occurrence in the Study Area.

Tumamoc Globeberry
This species was listed as endangered by the USFWS in 1986, but in 1993 it was removed from the endangered species list because it was found to be more abundant and widespread than previously thought. It is currently listed as Salvage Restricted under the Arizona Native Plant Law, and as a PVS by Pima County. Tumamoc globeberry occupies a wide range of vegetation types from coastal scrub to saline hardpan to creosote desert scrub. The requirements for this species appear to be presence of a nurse plant that provides shade, elevated humidity for seed germination, and support for climbing. No individuals were observed during field reconnaissance of the Study Area. Potential habitat in the Study Area was identified within the mesquite series.

Giant Spotted Whiptail
The giant spotted whiptail is a Species of Concern to the USFWS and a PVS in Pima County. It has no special state status. This lizard inhabits mountain canyons, arroyos, and mesas descending to the lowland desert along permanent or intermittent streams. Giant spotted whiptails were formerly found in the Santa Cruz River floodplain, but recently have been found only along a small portion of the West Branch (Rosen, 2001).

Although not observed outside the West Branch, this species may persist within other small remnant patches of dense cover within the Study Area. In the Study Area, potential giant spotted whiptail habitat was identified within the mesquite series.

Burrowing Owl
The burrowing owl has no special Federal or state status, but is a PVS in Pima County. Burrowing owls inhabit open sites and can adapt well to sites modified by human activities, such as golf courses, agriculture fields, vacant lots, and road embankments. They mainly use burrows excavated by other animals to roost and nest, but also are known to use artificially constructed nest boxes. This species is considered extremely rare in Pima County. A total of nine individual burrowing owls were observed during field reconnaissance within the Study Area, two in the Santa Cruz River Park (Cultivated and Cultured Uplands, Recreational) and seven in vacant lots largely devoid of vegetation (Cultivated and Cultured Uplands, Vacant or Fallow).

Rufous-winged Sparrow
The rufous-winged sparrow has no special Federal or state status, but is a PVS in Pima County. This species requires flat or gently rolling desert grasslands, with scattered trees or shrubs. It was reportedly observed once along the West Branch (Rosen, 2001). However, it was not observed anywhere in the Study Area by SWCA during field reconnaissance, and habitat conditions in the majority of the Study Area are considered marginal for this species; most of the Study Area lacks sufficient low level cover, such as grass, and dense vegetation. Rufous-winged sparrow may occur infrequently in portions of the Project Area that support a mesquite vegetation community.

Abert's's Towhee
Abert's's towhee has no special Federal or state status, but is a PVS in Pima County, where it inhabits low-elevation riparian sites. This bird tends to occur most often in Sonoran riparian deciduous woodlands and riparian scrublands with dense understories. Within the Study Area, Abert's's towhees were observed regularly in a variety of habitats including mesquite, urban drainage, Sonoran interior strand, saltcedar disclimax, and recreational land (maintained park).

Bell's Vireo
Bell's vireo has no special Federal or state status, but is a PVS for Pima County. Bell's vireos generally are found in dense, low, shrubby areas with tamarisk, cottonwood, mesquite, and seepwillow. No Bell's vireos were reported during field reconnaissance for this project, but potential habitat for this species was identified within those portions of the Study Area that contain mesquite habitat, such as the West Branch.

Western Yellow Bat
This species has no Federal status, but is a Wildlife Species of Special Concern in Arizona and a PVS in Pima County. It has been found in riparian deciduous woodlands and in association with fan palms, which it uses as roost sites. In Pima County, western yellow bats are thought to be primarily associated with planted fan palms. Although no species-specific surveys were conducted for this species and no individuals were

observed during field reconnaissance, there is a 6-acre grove of fan palms in the Study Area, which is considered potentially suitable habitat for this species.

California Leaf-nosed Bat

The California leaf-nosed bat is a Species of Concern to USFWS, a Wildlife Species of Special Concern in Arizona, and a PVS in Pima County. In Arizona, the California leaf-nosed bat is known to occur throughout the Sonoran desertscrub biome, where it consumes large flying insects. It roosts primarily in caves and abandoned mines, and populations are known from most, if not all, of the mountain ranges in Pima County. Limited information indicates that it forages primarily along washes. It is possible that individuals may occasionally forage within the Study Area, but there are no suitable roost sites present.

Pale Townsend's Big-eared Bat

This bat is a Species of Concern to USFWS, a Wildlife Species of Special Concern in Arizona, and a PVS in Pima County. Pale Townsend's big-eared bat has been found in a wide variety of habitats from deserts to mountains, but is nowhere common. In Pima County, it roosts in caves and inactive mines, and occasionally in buildings. It is known to occur in Tucson Mountains Park, which is located several miles west of the Study Area. Although there are no suitable roost sites present, it is possible that individuals may occasionally forage within the Study Area.

Merriam's Mouse

The Merriam's mouse has no special Federal or state status, but is a PVS in Pima County. In Arizona, it apparently once inhabited large mesquite forests along rivers throughout Pinal, Pima, and Santa Cruz counties. However, recent information on its status and distribution is lacking in areas where it was formerly found, including the Santa Cruz River at San Xavier where the mesquite bosques were removed in the early part of the twentieth century, and at Wilmot Station southeast of Tucson where it was formerly common. There have been very few records of this species in the past several decades. No species-specific surveys were conducted for this species in the Study Area. Although it is unlikely that this species remains in the Santa Cruz valley, it is possible that a remnant population may persist in remnant mesquite woodland along the West Branch.

Potentially Suitable Habitat in the Study Area

Potentially suitable habitat within the Study Area was quantified for each of the special status species evaluated above (see Table 4.2). The vegetation community supporting the greatest number of special status species is mesquite, the majority of which is located along the West Branch. This vegetation community provides potential habitat for a total of six special status species in the Study Area.

Table 4.2 Approximate Acreage of Potentially Suitable Habitat

Species	Study Area Acres	Vegetation Type(s)
Tumamoc globeberry	160	Mesquite
Giant spotted whiptail	160	Mesquite
Abert's towhee	693	Mesquite, Urban Drainage, Sonoran Interior Strand, Saltcedar Disclimax, and Recreational Land
Bell's vireo	160	Mesquite
Burrowing owl	1,020	Recreational and Vacant or Fallow
Rufous-winged sparrow	160	Mesquite
Western yellow bat	6	Urban (Fan Palms)
California leaf-nosed bat	--	--
Pale Townsend's big-eared bat	--	--
Merriam's mouse	160	Mesquite

4.6 Cultural Resources

The Tucson Basin has been witness to human activity for over 10,000 years. During the Middle Archaic Period, villages along the Santa Cruz River developed approximately 5,000 years ago. Indigenous groups collected wild plants, hunted small animals and cultivated maize. Pottery was introduced to the Tucson Basin approximately 2,000 years ago during the Late Archaic Period. The use of pottery is associated with sedentary, agricultural societies. Settlements (round houses) became larger and there was an increasing dependence on agriculture. There is also an increased focus on storage of foods.

As large scale irrigation agriculture developed in the succeeding Formative period, the pace and complexity of culture change increased dramatically. Early Period subsistence was a mix of hunting agriculture and hunting and gathering. Painted ceramics were introduced approximately 1400 years ago. The succeeding Pioneer Period witnessed the construction of ball courts at large primary villages (O'Mack and Klucas, 2002). The Hohokam culture developed in the Phoenix area around 1300 years ago, spreading to the Tucson Basin during this same period. Decorated pottery, ball courts, and floodplain canal systems are all characteristics of the Hohokam culture. In the following Colonial Period, there was emphasis on large primary villages with an increase of the use of floodplain environments. The prehistoric population of the Tucson Basin was at its highest levels approximately 1,000 years ago during what is called the Sedentary Period. There appears to be a major settlement shift however where several large primary villages were abandoned. According to some researchers, the Hohokam on a regional level collapsed at the end of this period (Ciolek-Torrello, 1999:35). Additionally, the succeeding Classic Period was the time when semi-subterranean, rectangular rooms were favored, platform mounds over ball courts, and burial practices shifted from cremation to inhumation. These changes can be attributed to either the arrival of the Salado culture during this time period or internal cultural evolution.

By the time the explorer Father Kino representing the Spanish crown traveled to the Tucson Basin in 1691, some say the Hohokam disappeared from the area. Environmental stress brought on by a series of droughts and floods may have had catastrophic effects on irrigation-based societies such as the Hohokam. That does not address the fact however that the Tucson Basin was never abandoned. The Spanish encountered several villages in the Tucson basin, the largest at Bac (later San Xavier del Bac). The Spanish called the native inhabitants of Tucson the Sobaipuri. The word is a Hispanicized native term and it's meaning is unclear. The Sobaipuri have since ceased to exist as a distinct cultural group.

As European exploration continued, San Xavier Mission del Bac south of Tucson was founded in 1700, originally as a *visita.* In 1775, an expedition led by Juan Bautista de Anza traveled north through the Study Area generally following the west bank of the Santa Cruz River, camping at Bac on the way. A Spanish presidio, christened San Agustín del Tucson, was established in 1775 in what is currently downtown Tucson to provide protection to a growing number of Spanish settlers. Across the Santa Cruz River within in our Study Area, there was a well-established Sobaipuri settlement. Later in the late 1700s, a church, convento, granary, and gardens were established on top of the village. The Gadsden Purchase of 1853 placed the geographic area encompassing Arizona under United States possession, settling a long dispute with Mexico. Arizona was declared a territory separate from New Mexico in 1863. Fort Lowell was founded in 1873 on the south side of the Rillito River near the confluence of Pantano Wash and Tanque Verde Creek. The Arizona Territory was admitted as the 48th state in the union in 1912.

The Tucson Basin today is the home of the Pascua Yaqui Tribe and the Tohono O'odham Nation. Tohono O'odham means desert or country people.

Statistical Research, Inc. (O'Mack and Klucas, 2002) through the Arizona State Museum performed a literature search and cultural resources overview of the Study Area. This search indicates that less than 50 percent of the Study Area has been surveyed by archeologists (Betancourt, 1978; Courtwright and Wright, 1999; Dutt, 2000; Mabry, 1990; Tompkins, 1996). These surveys recorded 47 archeological sites within the Study Area and are listed in Table 4.3. Site AZ BB:13:15 (Valencia Site) was nominated and listed in the National Register of Historic Places (NRHP) in 1984 (along with AZ BB:13:74) by William Doelle with the Institute of American Research. At least four sites are eligible for the NRHP including AZ AA:16:3 (West Branch Site), AZ AA:16:49 (Dakota Wash Site), AZ BB:13:6 (Clearwater Site, Mission San Agustín del Tucson, Tucson Pressed Brick Company), and AZ BB:13:17 (Julian Wash Site). The Corps determined the Julian Wash Site eligible for the NRHP in 1995 as part of the Tucson Diversion Channel Project. The remainders of recorded sites within the Study Area are undetermined as to NRHP eligibility, unless they have been documented as destroyed in which case they would not be eligible for listing on the National Register. Sites described as destroyed are subject to confirmation via a field check. Many of the sites in the Study Area can be considered potentially eligible. Table 4.3 lists the sites in the Study Area, and all site numbers are recorded in the Arizona State Museum system.

Given the project's association with the Santa Cruz River floodplain, the overall archeological sensitivity and potential are very high. Therefore, avoidance of all cultural resources by project alternatives may not be possible.

Table 4.3 Known Archeological Sites Within the Study Area

SITE	DESCRIPTION	NRHP STATUS
AZ AA:16:3	Hohokam village	Eligible
AZ AA:16:28	Historic Papago houses	Undetermined
AZ AA:16:47	Prehistoric/Historic	Undetermined
AZ AA:16:49	Hohokam village	Eligible
AZ AA:16:60	Prehistoric/Historic	Undetermined
AZ AA:16:61	Prehistoric/Historic ranch	Undetermined
AZ AA:16:62	Historic ranch/farm	Undetermined
AZ AA:16:68	Historic residence	Undetermined
AZ BB:13:6	Prehist. Village/hist. Mission	Eligible
AZ BB:13:15	Prehistoric village	Listed 1984
AZ BB:13:17	Hohokam village	Eligible
AZ BB:13:19	Prehistoric/Historic	Undetermined
AZ BB:13:20	Prehistoric/Historic	Undetermined
AZ BB:13:21	Prehistoric habitation	Destroyed?
AZ BB:13:22	Prehistoric habitation	Undetermined
AZ BB:13:55	Prehistoric/Historic	Undetermined
AZ BB:13:56	Prehistoric/Historic	Undetermined
AZ BB:13:89	Historic residence	Undetermined
AZ BB:13:90	Prehist. Burial/Hist. Canal	Undetermined (disturbed)
AZ BB:13:91	Prehist. Habitation/Historic	Undetermined
AZ BB:13:92	Prehistoric habitation	Undetermined
AZ BB:13:93	Prehistoric habitation	Undetermined
AZ BB:13:94	Prehistoric/Historic	Undetermined
AZ BB:13:95	Prehistoric/Historic	Undetermined
AZ BB:13:96	Prehistoric/Historic irrigation	Undetermined
AZ BB:13:97	Prehistoric/Historic	Undetermined
AZ BB:13:99	Prehistoric	Undetermined
AZ BB:13:100	Prehistoric/Historic	Undetermined
AZ BB:13:101	Prehistoric	Undetermined
AZ BB:13:103	Prehistoric habitation	Undetermined
AZ BB:13:104	Prehistoric habitation	Undetermined
AZ BB:13:105	Prehistoric/Historic	Undetermined
AZ BB:13:106	Prehistoric	Undetermined
AZ BB:13:107	Prehistoric	Undetermined
AZ BB:13:108	Prehistoric	Undetermined
AZ BB:13:109	Historic irrigation	Undetermined
AZ BB:13:111	Prehistoric/Historic mill	Undetermined
AZ BB:13:129	Prehistoric/Historic	Undetermined
AZ BB:13:136	Prehistoric/Historic	Undetermined
AZ BB:13:142	Historic pumping plant	Destroyed?
AZ BB:13:145	Prehistoric	Undetermined
AZ BB:13:223	Prehistoric habitation	Undetermined
AZ BB:13:323	Prehist. habitation/Hist. farm	Undetermined
AZ BB:13:402	Prehistoric/Historic	Undetermined
AZ BB:13:481	Historic canal system	Undetermined
AZ BB:13:539	Historic irrigation pipe	Undetermined
AZ BB:13:630	Historic Papago	Undetermined

4.7 Aesthetics

The Santa Cruz River valley is relatively flat and ranges from 2,000 to 3,000 feet above mean sea level. It is surrounded by several mountain ranges greater than 8,000 feet in elevation. The smaller of these mountain ranges that contribute to the unique visual quality of the valley and the Study Area include the Tucson Mountains to the west, Silverbell Mountains to the northwest, the Tortolita Mountains to the north, and the Sierrita Mountains to the southwest. The larger mountain ranges that ring the Tucson Basin and provide a backdrop to the Study Area are the Santa Catalinas, Rincons, Tanque Verdes, and Santa Ritas. A small volcanic peak, called Sentinel Peak or "A" Mountain, is immediately adjacent to the Study Area on the west between Congress and Starr Pass Blvd. (The alternate name refers to a large letter "A" painted on rock at the top of the peak by University of Arizona students.) The Sentinel Peak Park (owned by the City of Tucson) is a popular viewpoint overlooking the valley (Figure 4.2).

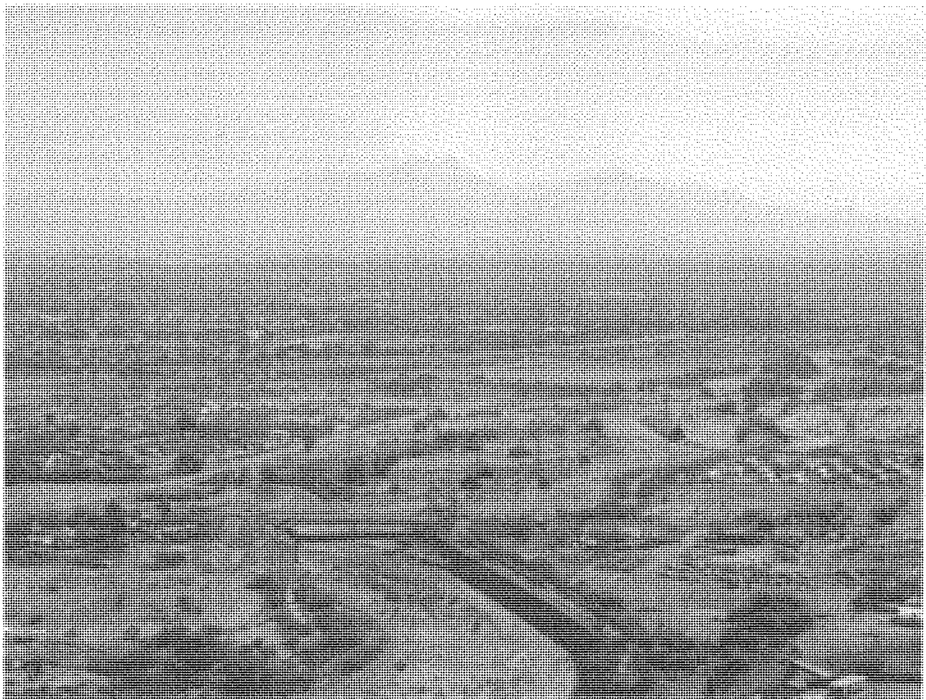


Figure 4.2 View of The Santa Cruz River Valley, Looking South from Sentinel Peak.

Within the natural landscape, the City of Tucson has developed primarily on valley fill land. Tucson is a sprawling, low-density metropolitan area that straddles the river for many miles as it travels northward. The majority of the urban area is located east of the Santa Cruz River channel in the Tucson Basin. Cityscapes visible from the Study Area include a wide range of building styles and sizes, from elevated interstate freeway and 20-story tall office buildings to single-family homes and mobile home parks.

The river itself is a highly disturbed, deeply entrenched ephemeral riverbed. Approximately half of the river's reach in the Study Area (see Figure 4.3) is artificially reinforced banks consisting primarily of soil cement armored sides; these soil cemented reaches create the impression of a relatively narrow ditch. Where there is soil cement, overbank areas have been developed into dual-purpose pedestrian/bicycle paths and landscaped areas consisting of a mixture of native and non-native trees and shrubs and dense patches of invasive non-native grasses and weeds (Figure 4.3). This is the Santa Cruz River Park, portions of which are managed by the City of Tucson, and portions by Pima County. The park provides dramatic views of the urban landscape and surrounding mountains and views of the Project Area. Access to the riverbed is available from ramps and parking lots along the banks within the river park boundaries.

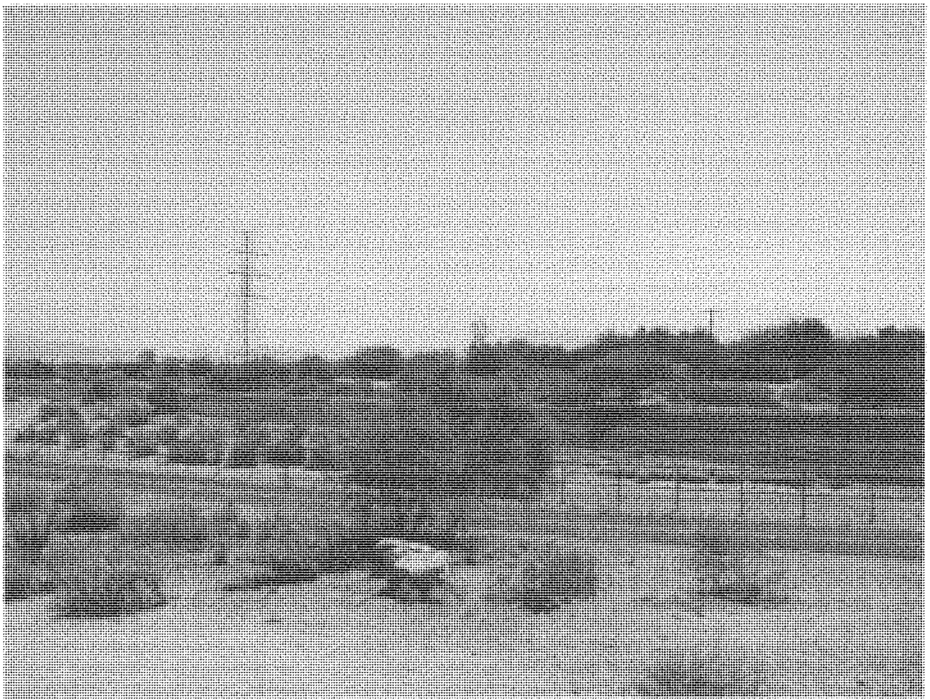


Figure 4.3 View from west bank, within Santa Cruz River Park, looking east. Note cement banks, railings, and landscaping.

Outside the developed river park, the overbank area consists primarily of abandoned agricultural land or the remains of houses carried away by floods or intentionally demolished. (Figures 4.4, 4.5, and 4.6). Banks are steep and eroding. Numerous dirt roads are present. Piles of refuse dumped illegally are scattered throughout the vacant lots and dumped into the riverbed. Through the entire Study Area, all-terrain vehicle enthusiasts and equestrians frequently use the Main Branch channel (Figure 4.7). Under many of the large Athol tamarisk trees are small homeless camps. Many camps continue to be actively used and the accumulated debris of such camps punctuates the otherwise sparsely vegetated landscape of many of the vacant lots. Many constructed features such as bridges, sound walls, and power poles in the Study Area have been sprayed with graffiti, eliciting a sense of urban decay in pockets of the Study Area.

Figure 4.4 View Across River Bottom, Looking East. Note Cut Bank, Erosion, Buildings, Debris, and Tracks.

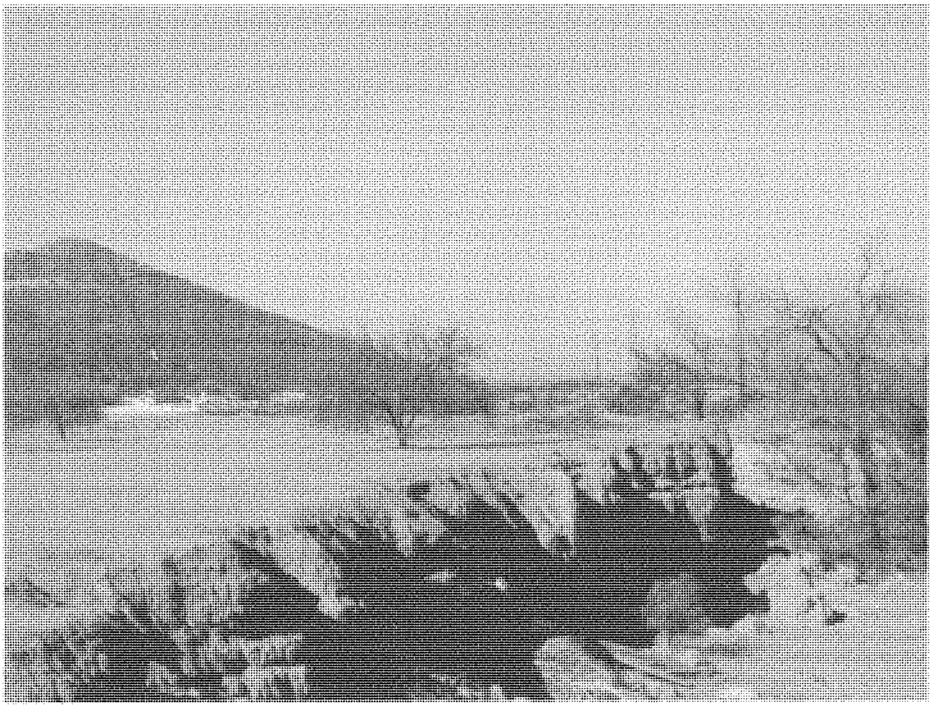


Figure 4.5 View Toward North, Showing West Bank of Santa Cruz River, Sentinel Peak in Left Background. Note Condition of Overbank Vegetation, Cut Bank, And Debris.

Figure 4.6 View From East Bank, Looking West.

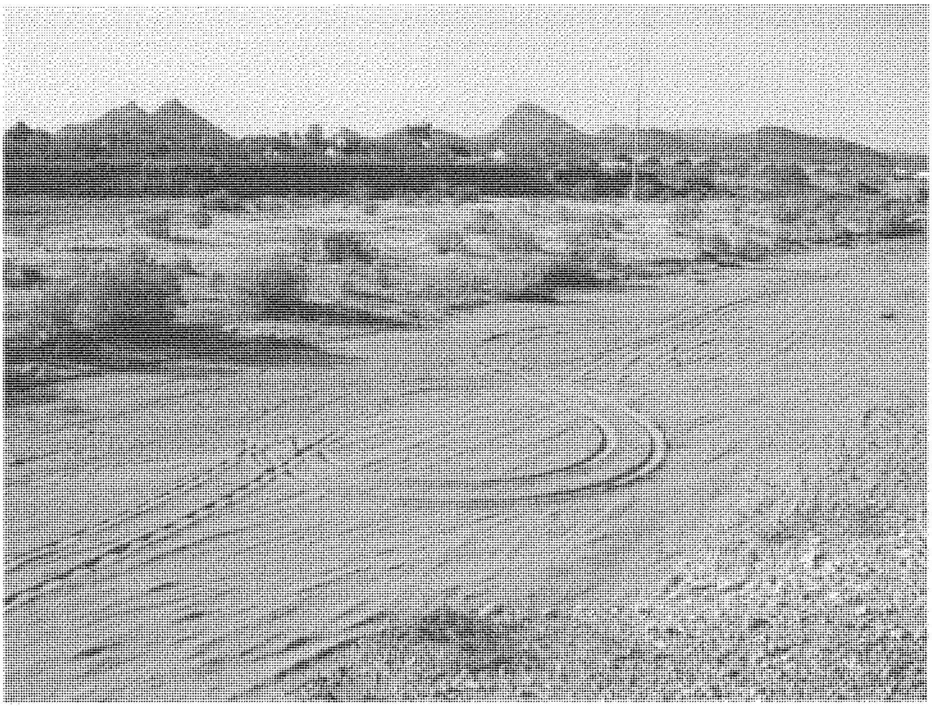


Figure 4.7 View From East Bank, Looking West. Note Vehicle Tracks and Eroding Banks.

The West Branch, along much of its course within the Study Area, is lined with mesquite and other trees. It is the best remaining example of nearly natural conditions along the river, but it, too, has been severely impacted by human activities. Banks are eroding, and the river bottom contains discarded debris ranging from paper to concrete chunks. Most of the West Branch passes through a developed urban area of single-family residences and mobile homes. Part of the area between Ajo and Silverlake Roads retains a semblance of rural character, with livestock and large lots around single-family houses. The northern portion of the West Branch channel is highly altered and portions were filled in the 1960s to create part of Mission Road. The landscape at the confluence of the West Branch and main stem of the river is visually dominated by the cement-lined wash and the multi-storied Pima County jail.

4.8 Climate

The Study Area is located in a region of the southwestern United States that is characterized as semiarid and is typified by long, hot summers and short, mild winters. The coldest month is January, with an average temperature of 51.7 degrees Fahrenheit, and the warmest month is July, with an average temperature of 86.5 degrees Fahrenheit.

Temperatures of 100 degrees Fahrenheit or higher occur about 40 days per year, and temperatures below freezing occur an average of 16 days per year. Average annual precipitation is 12.17 inches, with the three wettest months being July (2.07 inches monthly average), August (2.30 inches monthly average) and September (1.45 inches monthly average). Rainfall has a bimodal distribution during the year, with peaks during summer monsoons, and secondarily during winter storms. It is not unusual for no rain to fall in May and June. Currently, the region is experiencing drought, with primary physical effects on water supplies, streams, groundwater, reservoirs, and native vegetation.

4.9 Air Quality

The EPA Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQS) for six principal pollutants, called "criteria" pollutants. They include ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), suspended particulate matter (PM_{10} and $PM_{2.5}$), and lead (Pb). Federal, state, and regional agencies have established standards and regulations for air quality. The NAAQS for criteria pollutants are not to be exceeded more than once per year with two exceptions. In the case of ozone, PM_{10}, and $PM_{2.5}$, compliance is determined by the number of days on which the standard is exceeded. The number of exceedance days permitted each year, based on a 3-year running average, is one.

Tucson and Pima County are attainment areas for all criteria pollutants and have not exceeded National Ambient Air Quality Standards for any of these pollutants except PM_{10} and $PM_{2.5}$ in the past 19 years (Pima Association of Governments, 2003). Pima County has occasionally exceeded the primary standard for PM_{10}, due to naturally-occurring wind storms combined with an extended period of low rainfall and/or construction activity. Exceedances occurred five times between July 1, 2002 and June 30, 2003 (Pima County Department of Environmental Quality, 2003) and four times in 1999 (Davis, 2002). The primary sources of PM_{10} in the general Tucson area include vehicle traffic, vehicle exhaust, earthmoving, and agricultural activities. Particulate matter that is naturally occurring within the desert accounts for approximately one-third of the urban PM_{10} concentration. Pima County also exceeded the primary standard for $PM_{2.5}$ on two days between July 1, 2002 and June 30, 2003 (Pima County Department of Environmental Quality, 2003). $PM_{2.5}$ originates primarily from vehicle exhaust but can also form in the atmosphere from chemical reactions of pollutant gases.

The Pima County Department of Environmental Quality (PCDEQ) currently monitors PM_{10} at nine locations and $PM_{2.5}$ at six locations, none of which are within the Study Area.

The Study Area is located within the Tucson Air Planning Area (TAPA), which primarily covers the Tucson metropolitan area. Within the TAPA, the PCDEQ monitors air quality in eastern Pima County, where 95 percent of the county's population resides.

The Study Area, with an abundance of vacant, disturbed, unvegetated or sparsely vegetated lands, is subject to frequent, localized reduction in air quality and visibility from air-borne dust. Seasonal storm events also contribute to these localized episodes. The routine automobile and truck traffic within and adjacent to the Study Area contribute to dust and emissions but would not be expected to differ substantively from other areas of metropolitan Tucson. The air quality of the Study Area is considered representative of the greater Tucson metropolitan area.

4.10 Noise

Noise is defined as unwanted sound that interferes with normal activities or otherwise diminishes the quality of the environment. It can be intermittent or continuous, steady or impulsive, stationary or transient. Stationary noise sources are normally related to specific land uses and activities, e.g., industrial plants or mining operations. Transient sources move through the environment, either along established paths (e.g., highways, or aircraft operating from an airport), or randomly. A noise environment consists of a base of steady "background" or ambient noise that is the sum of many distant and individually indistinguishable noise sources. Superimposed on this background noise is the sound from individual local sources. These sources can vary from an occasional aircraft overflight to virtually continuous noise from traffic on a nearby street.

For perspective, the noise from occasional commercial aircraft crossing at high altitudes is indistinguishable from the natural background noise of an urban setting. Noise ranging from about 10 dBA (A-weighted sound level measured in decibels) for the rustling of leaves to as much as 115 dBA (the upper limit for unprotected hearing exposure established by the Occupational Safety and Health Administration) are common in areas where there are sources of industrial operations, construction activities, and vehicular traffic.

The U.S. Federal Transit Administration (USFTA) has established noise impact criteria founded on well-documented research on community reaction to noise based on change in noise exposure using a sliding scale (USFTA, 1995). The USFTA Noise Impact Criteria groups noise sensitive land uses into the following three categories:

- Category 1: Buildings or parks where quiet is an essential element of their purpose (e.g., war memorial park or similar contemplative-type area),
- Category 2: Residences and buildings where people normally sleep (e.g., residences, hospitals, and hotels with high nighttime sensitivity), and
- Category 3: Institutional buildings with primarily daytime and evening use (e.g., schools, libraries, and churches).

Properties adjacent to the Project Area do not include any Category 1 properties, but there are Category 2 properties and Category 3 properties within the Study Area.

No noise measurements were taken in the Study Area; instead, a qualitative characterization of the noise conditions of the Study Area is provided. Ambient noise levels within the Study Area would be expected to range from quiet (30+ dBA) to pain threshold (90+ dBA). Existing noise sources include highway traffic from nearby Interstates 10 and 19, traffic on urban streets with bridges crossing the river, distant railroads, air traffic from the Tucson International Airport and Davis-Monthan Air Force Base, and industrial activities including reconstruction of the I-10/I-19 interchange (temporary) and sand and gravel mining operations (soon to cease). High noise levels occur sporadically with the passage of aircraft and/or large trucks.

Noise levels immediately adjacent to the six bridge crossings in the Study Area can be very high, reaching the pain threshold (90-100 decibels) when extremely loud or large vehicles pass. As distance from these bridges increases, traffic noise levels attenuate, but none of the crossings are free of vehicle noise, particularly during daylight hours.

In contrast to the high altitude overflights mentioned above, low altitude aircraft overflights are noticeable "noise events" that can produce brief but moderately loud to pain threshold levels of noise. The Study Area is outside the "Territory in the Vicinity of a Military Airport" (Arizona Department of Commerce, 2003) and also outside the area of "Significant Levels of Noise Exposure" for Tucson International Airport (Tucson Airport Authority, 2003). These specific designations are based on the day-night average sound level being above the Federal standard defining significant levels of noise exposure, a minimum of 65 decibels. Davis-Monthan Air Force Base averages more than 200 takeoffs, landing, and pattern flights every day (Associated Press, 2002). Depending on weather conditions and Air Force needs, none to all of the base flights may pass over the Study Area on any given day.

Motor vehicles are prohibited from using the riverbed itself and the Santa Cruz River park trails, which are located along the top of the banks. However, unauthorized off-road vehicle use does occur, as evidenced by numerous tracks throughout the Study Area. Infrequently, maintenance vehicles are used within the developed parks. These sources of noise are intermittent and irregular and therefore should not be considered as ambient noise sources within the Study Area.

Secondary noise sources include sports, concert, and other activities that are event-related and, therefore, typically of short duration. There are no sports or concert facilities currently within the Study Area. An annual nighttime fireworks display from Sentinel Peak on July 4 is one event-related, nearby noise source but due to its brevity and associated social meaning, is unlikely to generate annoying or unsafe noise levels for most human receptors in the Study Area. Another event that generates both additional traffic and noise in the Study Area is the semi-annual Tucson Gem and Mineral Show, for which hundreds of vendors set up booths and tents along the I-10 frontage road from 22nd to Congress Streets and on vacant lands south of Congress along the river for about 2- to 3-week periods in February and September. Other recreational activities such as bird watching and recreational walking and bicycling do not produce appreciable noise.

4.11 Socioeconomics

Employment and Income

The dominant industries in Tucson are: educational, health and social services (23.2%); retail trade (12.5%); arts, entertainment, recreation, accommodation and food services (11.4%); and, professional, scientific, management, administrative, and waste management services (10.8%). A summary of industry employment for 1990 and 2000 in the Study Area, county and state is provided in Table 4.4; some industries have been grouped for presentation purposes. In Tucson, farming, mining and wholesale/retail trade continued to decline during the 1990s, as in much of the United States. The construction industry experienced a dramatic increase in employment in the 1990s, related to the influx of new residents and new businesses to the region. The increase in population also led to increased employment in transportation, communication, utilities, and information sectors and the services industry.

According to the 2000 Census, the rate of unemployment in Tucson was 3.9 percent at that time. The City of Tucson Planning Department reports that the civilian labor force was approximately 411,800 and total employment was 394,200 as of December, 2002. Therefore, the unemployment rate was 4.3 percent, which is slightly higher than Pima County (4.2%) and lower than both Arizona (5.6%) and the United States (6.0%) for 2002. The 1999 per capita income for Tucson was $16,322, or 76 percent of the per capita income for the United States ($21,587). Approximately 18.4 percent of the population of Tucson was living below the poverty threshold (income of $17,029 for a family of four) in 1999.

Approximately 6,000 military and 1,700 civilian employees work at Davis-Monthan Air Force Base located within the city limits of Tucson, and nearly 13,000 military retirees reside in the Tucson area. Davis-Monthan is a key Air Combat Command installation that was dedicated in 1927.

Construction of housing units has been increasing over the last decade. To accommodate population expansion in the area, 50,301 housing units were built over the previous nine years. A total of about 348,508 housing units were constructed in Pima County before 1999. This figure is up from 298,207 housing units built before 1990.

In fact, the 1999 American Community Survey Profile for Pima County, Arizona, indicated that about 21 percent of the housing stock has been constructed in the past ten years. Most of the newer homes in master planned communities are reasonably priced compared to other metropolitan areas. The average cost of a new single family home is about $109,102, a primary factor making the overall cost of living in Pima County among the lowest of major U.S. metropolitan areas.

Table 4.4 Industry Employment, Census 2000

	City of Tucson (% of Total)	City of Tucson % Change Since 1990	Pima County (% of Total)	Arizona (% of Total)
All-Industry Total	216,006 (100)	20.2%	370,768 (100)	2,233,004 (100)
Farming	525 (0.2)	-80.7%	1,299 (0.4)	21,930 (1.0)
Mining	726 (0.3)	-60.2%	1,893 (0.5)	10,746 (0.5)
Construction	17,337 (8.0)	63.8%	29,831 (8.0)	193,464 (8.7)
Manufacturing	18,592 (8.6)	9.0%	35,214 (9.5)	228,590 (10.2)
Transportation, Communication, Utilities, Information	14,992 (6.9)	56.1%	26,370 (7.1)	173,763 (7.8)
Wholesale & Retail Trade	31,933 (14.8)	-28.5%	53,572 (14.4)	347,305 (15.6)
Financial, Insurance & Real Estate	11,338 (5.2)	14.6%	21,094 (5.7)	175,311 (7.9)
Services	120,563 (55.8)	44.7%	201,495 (54.3)	1,081,895 (48.5)

Education

The Tucson Unified School District is divided into five administration regions: Northeast, Southeast, Northwest, Southwest and Central Services. There are 11 high schools, 20 middle schools, 72 elementary schools, and 13 special needs programs within the District. As of January 2003, there were 60,816 students enrolled in the school district. Approximately 80 percent of the population graduated from high school, and almost 30 percent have received a bachelor's degree or higher. English is the only language spoken in 67-percent of the homes, while Spanish is the primary language in 28 percent of homes.

The 357-acre University of Arizona is located in Tucson and recorded a Fall 2002 enrollment of 36,847 students, of which 28,278 (77%) are undergraduates. There are 325 degreed fields available, and the university employs approximately 13,800 persons. In 2002, 37-percent of the freshmen class came from high schools outside Arizona. Pima Community College (PCC) is also located in Tucson. In FY 2000/2001, PCC had an annual enrollment of 81,943 and conferred over 2,500 degrees in May 2001. PCC operates 6 campuses throughout the city, as well as 5 community learning centers and approximately one-quarter of the enrolled students attend full-time.

4.12 Demographics

The 2000 Census (U.S. Bureau of the Census, 2000) reports a Pima County population of 843,746 persons, representing a population increase of 26.5 percent since 1990 (Table 4.5 below). Pima County ranked 27th in the nation for greatest absolute population change in the 1990s. The 2000 population of the City of Tucson was 486,699 persons and the city's population increased 20.1 percent during the 1990s. The rate of population growth in Arizona (40%), Pima County, and Tucson during the 1990s far exceeded the nationwide growth rate of 13.2 percent (City of Tucson Planning Department, 2002).

Due to the rapid population growth and the rapidly expanding land area within the City of Tucson, the City Planning Department provides more current information on their web site regarding population trends (City of Tucson Planning Department, 2003). As of February 2003, Tucson covers 226.1 square miles and the population has increased to an estimated 512,671 persons (+5.3% since 2000). The population density is estimated to be 2,267 persons per square mile. In spite of the rapid population growth, population density has decreased since 1990 (2,594 persons per square mile) because the city's land area increased by 45 percent, from 156.3 square miles to 226.1 square miles. Much of the Study Area has experienced relatively rapid population growth since 1990.

Table 4.5 Population Changes

	Census Population		Population Projections			% Change 1990-2000	% Change 2000-2050
Community	**1990**	**2000**	**2020**	**2040**	**2050**		
City of Tucson	405,390	486,699	698,671	876,906	953,455	20.1%	95.9%
Pima County	666,880	843,746	1,222,837	1,649,229	1,824,271	26.5%	116.2%
Arizona	3,665,228	5,130,632	7,363,625	9,863,625	11,170,975	40.0%	117.7%
United States	248,709,873	281,421,906	324,927,000	377,350,000	403,687,000	13.2%	43.4%

Source: Tucson and Pima County projections provided by Tucson Planning Dept., Continual Annexation Scenario. Arizona projections provided by Southeastern Arizona Governments Organization (http://www.seago.org/). U.S. projections from U.S. Census Bureau.

The populations of Tucson, Pima County and Arizona are projected to continue their rapid rate of growth through the first half of the 21st century. Population is predicted to more than double by 2050 in the county and state, while the continued geographic expansion of Tucson's city limits could lead to the city's population nearly doubling by 2050.

According to the Tucson Planning Department, the ethnic mix of residents in 2000 was 54.2 percent Caucasian, 35.7 percent Hispanic, 4.1 percent African American, 1.6 percent

American Indian and 2.4 percent Asian. Due to Tucson's proximity to Mexico, the city receives its largest number of Hispanic immigrants from that country. The city's Hispanic proportion will probably continue to increase in the years to come, due to continued immigration and the presence of larger, younger families in the group. The long-term ratio of in- to out-migration in Tucson varies from 4:3 to 3:2. During the period from 1999 to 2000, 53,697 people moved into the Tucson area, and 41,964 moved out.

The median age of Tucson's population was 32.8 years in 1990 (slightly below the national average), and 35.7 years in 2000. The slow rise of the median age is due to the aging of the Baby Boomers, not to any distinct influx of seniors.

4.13 Transportation

The Study Area is approximately 120 miles from the state capitol at Phoenix, Arizona, and 260 miles from Flagstaff, Arizona in the north-central portion of the state. Las Vegas, Nevada is slightly more than 400 miles northwest of Tucson. Interstate Highway 10 services Tucson from the east and west, while Interstate 19 brings travelers to and from Nogales, Mexico, just below the international border 70 miles to the south. North of Tucson, State Highways 77 and 79 are the main transportation routes.

Thirteen airlines provide commercial service to Tucson International Airport (TIA), with an average of 69 daily flights to major destinations on both coasts and throughout the Midwest. Over 3.5 million passengers flew into or out of TIA in 2002. The nearby Phoenix Sky Harbor International Airport in Phoenix accommodated over 35.5 million passengers in 2002. Phoenix Sky Harbor was the sixth busiest airport in the United States in 2001.

Amtrak provides passenger rail service to Tucson via the Sunset Limited (traveling to/from Orlando, San Antonio, and Los Angeles). The Southwest Rail Corridor is the cargo rail link that connects the major cities of Southern Arizona and California. To the west, it connects with California's growing rail corridors and the Pacific Rim ports. To the east, it connects with New Mexico, Texas, Northern Mexico and points East. The center segment of the Corridor, namely the "Phoenix West Line" between Yuma and Phoenix, is currently inactive and is scheduled for removal by the Union Pacific Railroad. Stakeholders have created the Southwest Rail Corridor Coalition to ensure that the Southwest Rail Corridor becomes an option for enhancing mobility between Arizona and Southern California.

The Arizona Department of Transportation maintains a record of average daily traffic counts on their internet page: www.dot.co.pima.az.us/trafeng/trafcnt/. The most current volumes shown are January 2003 average daily traffic. Average Daily Traffic data for each of these bridge crossings are shown in Table 4.6.

Table 4.6 Average Daily Traffic (ADT) Counts for Six Bridges in the Study Area.

Bridge	2002 ADT (thousands)
Congress Street	17.2
22nd Street/Starr Pass Boulevard	21.7
Silverlake Boulevard	12.0
Ajo Way	34.9
Irvington Road	37.8
Valencia Road	32.3

Source: Pima Association of Governments, Historic Traffic Data, 2002

4.14 Recreation Resources

A survey of local parks shows substantial existing recreation in the area. Two of those parks, the Santa Cruz and the Rillito River Parks represent models for planned future park expansions of the Santa Cruz River along Paseo de las Iglesias and future development of a river park along the New West Branch of the Santa Cruz River. The Santa Cruz River Park is constructed within and adjacent to the 100-year floodplain. Along with the potential future development of River Parks within the Study Area, the City of Tucson master plan for the Rio Nuevo District includes creation of recreation areas and parks along the Santa Cruz River in the northern portion of the Study Area. Future river parks are also planned for Tanque Verde Creek and Pantano Wash. The Santa Cruz, Rillito, Tanque Verde Creek, and Pantano Wash river parks are envisioned function as one large unified trail system. In the 1997 Bond Election, funding was approved for the Santa Cruz River Community Park (a sports field complex) along the east bank of the Santa Cruz River, north of Ajo Way.

Many factors contribute to make the proposed riparian habitat areas along the Paseo de las Iglesias and New West Branch Study Areas attractive in terms of their potential to meet unmet demand for passive recreation through combination with adjacent facilities. Those factors include:

1. *Recreation Experience*-- Proposed general recreation activities for the Study Area include trails for hiking, biking, and jogging. Among the activities identified, most have unmet demand.

2. *Availability of Opportunity*-- The proposed facilities along the Paseo de las Iglesias and New West Branch would provide opportunity for many urban individuals to recreate close to their homes, work, and downtown

3. *Carrying Capacity*-- As previously discussed, Pima County has experienced rapid population growth. Pima County's population was 843,746 in year 2000, and is expected to reach 1,518,000 by year 2025—a difference of 674,254 over 25 years.

With this increase in population comes an increased demand for recreational facilities.

4. *Accessibility*-- According to 43% of the Arizona Trails 2000 survey respondents, loss of access to trails is one of the top three most important issues facing trail users today.

5. *Environmental*-- There are several recreation areas located in the Study Area. Within these parks, there are no thriving riparian areas.

Recreation demand in the Study Area is expected to grow steadily in the future due to regional population growth and increased tourism.

4.15 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Population and Low-Income Populations* (Executive Order, 1994), directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority population and low-income populations. When conducting NEPA evaluations, the Corps incorporates environmental justice considerations into both the technical analyses and the public involvement in accordance with EPA and Council on Environmental Quality guidance (CEQ, 1997).

The CEQ guidance defines "minority" as individual(s) who are members of the following population groups: American Indian or Alaskan native, Asian or Pacific Islander, Black, not of Hispanic origin, and Hispanic (CEQ, 1997). The Council defines these groups as minority populations when either the minority population of the affected area exceeds 50 percent or the percentage of minority population in the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis. According to the Census 2000 Fact Sheets for Tucson, Arizona, and Pima County (U.S. Bureau of the Census, 2004), the minority population in each of those municipalities is 43.9 percent and 36.9 percent respectively.

Low-income populations are identified using statistical poverty thresholds from the Bureau of the Census Current Population Reports, Series P-60 on Income and Poverty (U. S. Bureau of the Census, 2000). In identifying low income populations, a community may be considered either as a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect. The threshold for the 2000 census was an income of $17,761 for a family of four (U.S. Bureau of the Census, 2000a). This threshold is a weighted average based on family size and ages of the family members.

Based on the 2000 Census, Tucson has approximately 13.7 percent of families below the poverty level (U.S. Bureau of the Census, 2004) compared to a national average of 9.2 percent and Pima County with 10.5 percent.

4.16 Hazardous, Toxic, and Radioactive Waste

A preliminary HTRW investigation was conducted within the Paseo de las Iglesias Study Area (Tetra Tech, 2002). The objective of the Phase I Environmental Site Assessment (ESA) was to assess the area for the presence or likely presence of hazardous materials or petroleum products under conditions that indicate an existing release, a past release, or material threat of a future release. This would include a release of any hazardous substances or petroleum products into structures on the property, or into the ground, groundwater, or surface water of the Study Area. The evaluation is not intended to include *de minimus* conditions that generally do not present risks of harm to public health or the environment and that generally would not be the subject of enforcement actions if brought to the attention of appropriate regulating agencies. The Phase I ESA did not include a sample collection for the presence of asbestos-containing materials (ACM), radon and all other radioactive substances, lead-based paint, non-hazardous wastes and materials, or biological or medical wastes. The assessment also did not include interviews with local residents or occupants of the many business and government facilities within the Study Area.

Information obtained during completion of a Phase I ESA indicates that the site was used primarily for agriculture through the 1960's at which time development began to encroach upon the riverbanks primarily in the form of residential areas. There is some commercial development within the project boundaries such as gas stations, government operations (county offices and motor fleet maintenance), as well as bus and truck maintenance. Additionally, there is substantial gravel mining at the south end of the Study Area.

Applicable Federal and state environmental regulatory databases were reviewed and the search identified thirty-three sites or facilities within the Study Area that have been registered, investigated, or otherwise documented by various environmental regulatory, emergency response, or enforcement agencies (Tetra Tech, 2002). These areas are listed in Appendix G, Phase I Site Assessment of the Main Report.

The Study Area has a history of landfills that were closed with no known valid documentation of the contents. Several closed City of Tucson landfill sites are located along the Santa Cruz River within the Study Area. These landfills were closed prior to Federal, state or local regulations for closure specifications and monitoring of landfill gases.

They include:

a. Rio Nuevo South (located south of Congress Street along the west bank of the Santa Cruz River, approximately 40 acres and operated 1953-1960),

b. Nearmont (also identified as part of the Rio Nuevo South landfill, located south of Congress Street, northeast of Rio Nuevo landfill; approximately 10 acres; operated 1960-67)

c. "A" Mountain (located between Mission Lane and 22nd Street; approximately 36 acres and operated 1953-1962),

d. Mission (located north of 22nd Street/Starr Pass Boulevard, west of the Santa Cruz River; approximately 30 acres and operated 1963-1970),

e. 29th Street (located north of Silverlake Road along the west bank of the Santa Cruz River; approximately 50 acres and operated 1963-1967), and

f. Ryland (located between 36th and 44th Streets along the east bank of the Santa Cruz River; approximately 50 acres and operated 1960-1965).

In addition to these closed landfills, illegal dumping occurs regularly along the Santa Cruz riverbanks and in the channel of the river. Debris is scattered throughout most of the length of the river corridor within the Study Area. Based on the wide distribution and the contents of the debris piles (e.g., papers, boxes, food and beverage containers, scrap wood and metal, household trash, furniture, appliances), it does not appear that the river bottom has been the site of prolonged commercial or industrial waste disposal activities. The Site Reconnaissance did not reveal evidence of any HTRW concerns.

5 Environmental Consequences

The CEQ NEPA-implementing regulations describe the process of determining the significance of environmental effects by the consideration of two factors: context and intensity (40 CFR 1508.27). Context means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality; significance varies with the setting of the proposed action. In the case of a site-specific action, significance would usually depend upon the effects in the locale or region, rather than in the world as a whole. Both short- and long-term effects are relevant and should be considered in determining the context of the effects. Intensity refers to the severity of the effect and must consider a large number of factors in quantifying the potential significance of the proposal. The assessment needs to consider:

- Whether the effects are beneficial or adverse,
- The degree to which the action may affect public health and safety,
- The unique characteristics of the project setting,
- The degree of scientific controversy (if any) regarding the potential effects,
- The degree to which the action could be precedent setting,
- Whether the action is related to other actions with individually insignificant but cumulatively significant effects,
- Whether the proposed action could affect unique historic resources, protected species, or
- If implementation could threaten to exceed Federal, state, or local environmental protection laws.

Section 5 describes the potential effects from project-related activities on the physical resources, biological resources, HTRW, cultural resources, recreational resources, aesthetic resources, flood protection and public safety, socioeconomics, noise, environmental justice, and the cumulative effects of implementing the proposed action and/or alternatives. The estimated effects are quantified where possible and otherwise described qualitatively within a range of no impact to either potentially adverse or potentially beneficial. The significance of each change in impact is also described based on the magnitude of change resulting from the proposed action and the importance of the resource. To ensure that small potential effects are not over-analyzed, potential impacts have been assessed at a level of detail commensurate with the potential significance.

As stated in Section 3.1, the alternative formulation analysis examined a range of water quantity delivery alternatives and land was presumed to be available only within the Study Area and only in undeveloped parcels within and contiguous with the river channel. A fixed potential project implementation area (identified as the *Project Area*) was therefore identified and used as the implementation "footprint" for all water application and planting variations. This approach did not limit restoration alternatives but defined the most rational location for project implementation.

To avoid dilution of the consequences and benefits from the action alternatives, the environmental consequences and ecological benefits associated with the action alternatives are primarily quantified in the context of the Project Area. Where addressing potential effects outside the Project Area (e.g., air quality, traffic), discussion of the effects perforce addresses the entire Study Area and beyond.

5.1 Geomorphic and Geological Setting

5.1.1 No Action

In the absence of Federal action, there would be no changes to the ongoing geomorphic processes at work in the Santa Cruz River.

5.1.2 Alternative 2A

Implementing any of the action Alternatives would result in minor, re-grading to steep sided riverbanks at locations within the Project Area, but would not demonstrably alter the geomorphic patterns of the Santa Cruz River. There would be no effects to the geology.

5.1.3 Alternative 3E

The effects would be the same as with Alternative 2A.

5.1.4 Alternative 4F

The effects would be the same as with Alternative 2A.

5.2 Land Use

5.2.1 No Action

The No Action alternative would not result in any direct land use changes, because no project would be constructed. With No Federal Action, it is reasonable to expect that ongoing changes in land use within the Project Area would continue. Expansion of commercial, light-industrial, and residential land uses into currently vacant land would be expected. Predictions of the extent of change are highly speculative, but the continued increase in Tucson's population places ever-increasing demands for vacant land within the Santa Cruz corridor.

Extensive application of soil cement to the Santa Cruz riverbanks downstream of the Paseo de las Iglesias has permitted land development to take place. It would be reasonable to predict that the municipal pressures on land use would continue to result in soil cement application eventually hardening the riverbanks throughout the Project Area. Assuming the river banks were hardened throughout the Project Area within the next 50 years, the majority of vacant land within the Project Area could be utilized for commercial, light-industrial, or residential use and would no longer be available for restoration.

The City of Tucson has established development setbacks for unprotected reaches of riparian corridor. Where the river course is straight or the inside of a bend, the setback is 490 feet, where it is the outside of bend; the setback is 1,220 feet (City of Tucson Planning Department, 1998). Once hardened, those areas can be developed to within 50 feet of the river channel where the channel contains the 100-yr flow and the bank protection has 100-yr toe down.

5.2.2 Alternative 2A

For each action alternative, the primary factor affecting land use change involves the bank stabilization throughout nearly nine miles of riverbank within the Project Area. Once the bank stabilization has been completed, land use changes can be made adjacent to the Project Area that currently cannot take place because of mandatory setbacks from unprotected riverbank within the City of Tucson floodplain regulations. With the completion of the project, those areas currently within that setback, but outside the Project Area would become eligible for commercial, light-industrial, or residential use. This would likely result in land-use changes occurring more quickly than under No Action, but either of the action alternatives would have the Project Area preserved as habitat where none would likely occur under the No Action alternative.

Recent Federal regulations (14 CFR 139.337, Wildlife Hazard Management) establish compatible land use practices on or near airports. This regulation is an effort to consider and minimize or eliminate land use practices that attract or sustain hazardous wildlife populations on or near airports thus minimizing the potential for wildlife-aircraft collisions. Wildlife attractants within 5,000 feet of an airport that serves piston powered aircraft or 10,000 feet of an airport that serves turbine-powered aircraft (including turbo-props) are considered non-compatible. Interagency coordination on this issue with the U.S. Department of Agriculture, Wildlife Services is ongoing.

5.2.3 Alternative 3E

The effects would be the same as with Alternative 2A.

5.2.4 Alternative 4F

The effects would be the same as with Alternative 2A.

5.3 Soils

5.3.1 No Action

Under the No Action alternative, continued erosion and deterioration of soils is expected to occur. Soil that is currently barren of vegetation would continue to be easily eroded by wind and water. Collapse of existing riverbanks that have not been armored may result in erosional loss of overbank soil. Continued off road vehicle use and trash dumping are likely to occur in areas that remain undeveloped. The impacts of these activities include soil compaction, soil disruption, and destruction of vegetation cover. Areas that become developed would lose soil as a result of increases in artificial surfaces. An increase in impermeable surfaces associated with developed areas would result in intense localized runoff and soil loss.

5.3.1 Alternative 2A

All of the area utilized by each of the alternatives would be exposed to some level of disturbance and restoration activity. While grading and excessive soil manipulation would be avoided in remnant natural communities, most areas would require moderate to profound disturbance of the existing surface. These manipulations would include soil scarification, incorporation of nutrients and organic matter, mulching, ground patterning, water harvesting techniques for non-irrigated restoration, the placement of natural wind and sun-shading features and slope stabilization. Weed control and direct seeding of native species mixes would be applied for all lands included in the alternatives. The long-term result of the alternative would be to increase the ability of soils to support healthy native vegetation and resist erosion.

5.3.2 Alternative 3E

The effects would be the same as with Alternative 2A.

5.3.3 Alternative 4F

The entire area utilized to implement Alternative 4F would be temporarily disturbed by soil restoration activities. Grading and excessive soil manipulation would be avoided in remnant natural communities, but most areas would require moderate to profound disturbance of the existing surface soils to improve them. Changes include soil scarification, incorporation of nutrients and organic matter, mulching, ground patterning, water harvesting techniques for non-irrigated restoration, the placement of natural wind and sun-shading features and slope stabilization. The long-term result of the soil modifications would be a permanent increase the ability of soils to support healthy native vegetation and resist erosion.

5.4 Hydrology and Water Resources

5.4.1 Surface Water Hydrology

5.4.1.1 No Action

The No Action alternative would not result in any direct surface water hydrology changes because the project would not be constructed. Currently, there are no local permanent naturally occurring water resources existing along the Santa Cruz River in the Study Area. Surface water is rare and occurs only following rainfall events or release of water from human activity.

5.4.1.2 Alternative 2A

Surface water hydrology would not change significantly from the existing conditions to the proposed xeroriparian efforts as described in Alternative 2A. Water harvesting basins would be constructed at specific locations within the Project Area, and would be designed to limit the infiltration of naturally occurring surface water flows. Landscaping techniques would be proposed to concentrate surface runoff from the historic floodplain areas for use in vegetative uptake.

Water harvesting basins would retain water near-surface and would be constructed at tributary confluence locations and upstream of the grade control structures located in the main channel of the Santa Cruz River. With the construction of these basins, the rate of infiltration would be lessened around the footprint of each basin. In lessening the rate of infiltration, surface water hydrology would be increased, with more water available for continued surface flow. The impact of this action for Alternative 2A, however, would be negligible when considering the total footprint size of the water harvesting basins (approximately 19 acres) in relation to the size of the entire project watershed (over 2,200 square miles) and the surficial flows within the Paseo reach. Based on this comparison, the water harvesting basins would not contribute any measurable flow during surface water discharges within the project. The reach of the Santa Cruz immediately downstream is an engineered channel with soil cement through the entire reach. As such, changes to the surface water hydrology would not have downstream effects.

Landscape excavation on the historic floodplain would conversely decrease the surface water hydrology as surface runoff would be directed toward depressional areas for near-surface infiltration and vegetative uptake. Under existing conditions, surface water flows directly over the hard-packed ground and into the Santa Cruz main channel as storm flow. Approximately 3.5 percent of the 1,350 acres in the active Project Area would be altered in an attempt to promote infiltration for ecosystem restoration.

5.4.1.3 Alternative 3E

There would be no measurable change to the surface water hydrology in the Santa Cruz mainstem because of the small Project Area relative to the overall watershed size. Local effects to surface water hydrology within the Project Area would include a reduction in overland flow and an increase in water retention because of the establishment and maintenance of vegetation.

5.4.1.4 Alternative 4F

Change to the surface water hydrology would occur because periodic flow would be introduced from water main pipes positioned along the main channel thus restoring a modest intermittent flow within the channel. By introducing surface water into the channel, there would be intermittent, albeit artificial, flow as opposed to the episodic storm water or flood flows now characteristic of the Santa Cruz River. This small quantity of water reintroduced to the main channel would not alter the surface water hydrology in any significant way.

5.4.2 Surface Water Quality

5.4.2.1 No Action

The No Action alternative would not result in any direct surface water quality changes, since the project would not be constructed. Because surface water is present only briefly following precipitation events, surface water quality is affected by amount and timing of runoff from the urban areas and to a lesser degree by any materials illegally dumped within the river channel. Other factors that may affect surface water quality occasionally are ruptures in sewage pipelines adjacent to the river or surficial spills within industrial areas that could enter the stormwater runoff. No active monitoring of surface water quality is regularly occurring in the Study Area because there is normally no surface water.

5.4.2.2 Alternative 2A

The water quality of surface water flow in the main channel would not be affected by the local modifications for any of the restoration alternatives. The surface water quality of runoff in the mainstem Santa Cruz River is dictated by landscape-level factors that could not be changed on the small-scale restoration. Local changes to the overland flows and the tributary washes could be realized. As part of this alternative, efforts would be made to stabilize eroding banks, and to identify and remove illegally dumped materials. In addition, new habitat would be created to support vegetation development, which enhances water quality through natural process filtration.

5.4.2.3 Alternative 3E

The effects to surface water quality for implementing Alternative 3E would be substantially the same as 2A.

5.4.2.4 Alternative 4F

The water quality of any surface water discharges within the channel could be slightly improved with this alternative. Similar to Alternative 2A, efforts would be made to stabilize eroding banks, identify and remove illegally dumped materials, and create habitat to support plant growth, which enhances water quality through natural process filtration. All of these efforts would improve the water quality of naturally occurring surface flows within the Project Area.

A secondary feature of this alternative that may affect water quality is the introduction of reclaimed water for periodic discharge in the channel to create intermittent flow conditions. The reclaimed water could be taken from local wastewater treatment facilities that treat the effluent to secondary treatment levels. Wastewater treated to secondary levels has been treated to remove most suspended solids but still may contain colloidal solids and some nutrients. Secondary treated water is not deemed safe enough for human consumption but suitable for certain types of agricultural practices. In the case of Alternative 4F, the water quality of the introduced reclaimed water would be improved as the water proceeded through the project because of the filtering processes and nutrient uptake associated with establishment of native vegetation.

Secondary treated water is unlikely to be consistently of high enough quality to reliably support the reintroduction of fish species into the mainstem Santa Cruz River.

5.4.3 Surface Water Rights

5.4.3.1 No Action

The No Action alternative would not result in any direct surface water rights changes. The hydrologic factors existing in the Project Area are incorporated into an already fully adjudicated watershed. Any actions resulting from this project would not change existing water rights.

5.4.3.2 Alternative 2A

Similar to the No Action Alternative, the xeroriparian alternative does not include any proposed management change or construction methods that would change the existing water rights. The hydrologic factors existing in the Project Area are incorporated into an already fully adjudicated watershed.

5.4.3.3 Alternative 3E

The effects to surface water rights from implementing Alternative 3E would be the same as 2A.

5.4.3.4 Alternative 4F

The Pima County Department of Transportation and Flood Control is the primary sponsor for the project and would be responsible for bringing intermittent flow back into the channel, as part of this alternative. As such, the added discharges would be owned and managed by Pima County for the intended purpose of ecosystem restoration improvements.

The hydrologic factors existing in the Project Area before construction of this alternative are incorporated into an already fully adjudicated watershed. Any actions resulting from this project would not change existing water rights.

5.4.4 Flood Potential

5.4.4.1 No Action

In the absence of Federal action, there would be a naturally-occuring increase in the flood potential risk along the channel due to the continued desiccation and instability of steep channel banks that are highly susceptible to erosional forces. As the river channel continues to exhibit unstable conditions, significant bank failure would continue to result in flow blockages that would induce backwater effects resulting in the potential for flooding. If soil cement is used comprehensively throughout this reach, flooding would not be predicted to increase over the life of the project. Absent stabilizing existing channels, the potential for flooding would be predicted to increase over time.

5.4.4.2 Alternative 2A

One of the main aspects of this alternative is to augment ecosystem function by increasing vegetative cover and promoting habitat renewal. Vegetative cover would be established in areas that are currently devoid of vegetation and are therefore neither productive for habitat nor increasing channel stability. Channel stability can be increased through the establishment of vegetation and the creation of a subsurface rooted matrix that provides the highest level of soil stabilization. Higher levels of soil stabilization would decrease the risk of bank failure and therefore provide a factor of safety against flooding.

The construction aspects of this alternative include the re-grading of overly-steep banks to gentle slopes that are more suitable for the establishment and proliferation of vegetation. The reaches of steep natural banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. Typically, banks would be re-constructed at a 5-foot horizontal to 1-foot vertical grade and planted. This construction would increase the conveyance area of the channel and therefore allow larger volumes of water to pass at the same water surface elevation, thereby diminishing the potential for flooding.

Although the conveyance of the channel is increased through re-graded banks, the establishment of vegetation on these banks to increase habitat and soil stability, would also cause a rise in the flood water surface elevation due to greater roughness of the channel lining. Whereas riparian flow is hindered over dense, rough vegetation, it is facilitated over clear, smooth areas devoid of vegetation obstructions. The tradeoff between stable channels and increased vegetative output would be balanced at the more detailed design to ensure that the project would not create conditions that would increase the potential for flooding.

5.4.4.3 Alternative 3E

Similar to Alternative 2A, the mesoriparian alternative would exhibit a tradeoff between stable channels and increased vegetative output, but flood surface elevations would not be increased.

5.4.4.4 Alternative 4F

Similar to Alternative 2A, the hydroriparian alternative would exhibit a tradeoff between stable channels and increased vegetative output. Stream channel re-grading in this alternative would be similar to that described in Alternative 2A for the purposes of habitat creation and riverbank stabilization. The main difference, however, is that the density of vegetation would be greater under intermittent flow conditions than xeroriparian conditions. The increase in vegetative cover would create a higher roughness coefficient, which would decrease the conveyance of flood discharges and promote higher water surface elevations at flood stages. Detailed design would ensure that the project would not create conditions that would increase the potential for flooding.

5.4.5 Groundwater Hydrology

5.4.5.1 No Action

The No Action alternative would not create any changes to groundwater hydrology.

5.4.5.2 Alternative 2A

Construction aspects of this alternative include the construction of water harvesting basins and landscape excavation to retain surface runoff. The water harvesting basins would be located at grade control structures in the channel and at tributary confluences along the channel terraces. The basins would serve to retain infiltrated water for vegetation uptake, and therefore decrease the amount of water that reaches the regional aquifer. The volume of water that would be potentially retained would be insignificant when compared to the volume of water that flows through the hydrologic system. Proposed water harvesting basins within the main channel would consist of 12 structures with a total surface area of 19 acres. This area would serve to retain surface runoff in the near sub-surface for vegetation uptake coming from a watershed that has an area greater than 2,200 square miles. Therefore, the changes to the groundwater hydrology would be insignificant for the proposed water harvesting basins.

Changes to groundwater hydrology on the historic floodplain areas of the project would be more pronounced for the proposed landscape excavation of this xeroriparian alternative. Approximately 80 percent of the 1,350 acres in the active Project Area would be altered in an attempt to promote infiltration for vegetative uptake. Much of this landscape excavation includes the construction of depressional areas that would serve to collect surface runoff before the flow is allowed to enter into the Santa Cruz main channel. Other areas would be landscaped to direct surface runoff toward landscape features that are designed for near-surface infiltration and vegetative uptake. The change in groundwater hydrology would be to promote an increase in infiltration in localized areas on the historic floodplain.

5.4.5.3 Alternative 3E

With the introduction of irrigation water and soil treatment throughout the Project Area, the groundwater hydrology would be expected to receive an immeasurably small increased infiltration in the historic floodplain, terraces, and active channel areas. The expected long-term effect on regional groundwater hydrology would be an indiscernible decrease in the current trend of lowering for regional groundwater levels.

5.4.5.4 Alternative 4F

With the introduction of periodic flow for a hydroriparian regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. Groundwater recharge would occur on a periodic basis with intermittent flow in the channel and irrigation on the historic floodplain areas. The expected long-term effect on groundwater hydrology would be an indiscernible decrease in the current rate of lowering for regional groundwater levels.

5.4.6 Groundwater Quality

5.4.6.1 No Action

The No Action alternative would not result in any direct groundwater quality changes.

5.4.6.2 Alternative 2A

With the proposed construction of water harvesting basins and landscape excavation, the amount of surface water that infiltrates would increase very slightly within the Project Area . This additional groundwater recharge would occur through porous media at the constructed sites and would continue the downward percolation into the regional aquifer under normal processes. Although the irrigation water could originate as urban runoff, the cleansing effect of infiltration through overburden material would result no changes to local groundwater quality.

5.4.6.3 Alternative 3E

Groundwater recharge would increase very slightly within the Project Area due to the irrigation and soil treatment throughout the Project Area. Although the irrigation water could originate as secondary treatment water, the cleansing effect of infiltration through overburden material would result no changes to local groundwater quality.

5.4.6.4 Alternative 4F

Similar to Alternative 2A and 3E, groundwater recharge would increase throughout the Project Area due to soil treatment and dry land restoration. However, the proposed intermittent flow in the channel and irrigation on the historic floodplain under this alternative distinguishes it from the others. Although the periodic flow would originate as secondary treatment water, the cleansing effect of infiltration through overburden material would result in no changes to local groundwater quality.

Some areas on the historic floodplain would be irrigated for the establishment and proliferation of vegetation for ecosystem restoration. Areas chosen for irrigation would be isolated from any existing landfills in order to prevent the potential for leachate production that could deteriorate water quality.

5.4.7 Groundwater Rights

5.4.7.1 No Action

The No Action alternative would not result in any direct groundwater rights changes.

5.4.7.2 Alternative 2A

Similar to the No Action Alternative, the xeroriparian alternative does not include any proposed management change or construction method that would change the existing groundwater rights. The hydrologic factors proposed for the Project Area are incorporated into an already fully adjudicated aquifer.

5.4.7.3 Alternative 3E

Similar to the No Action and other action Alternatives, this alternative does not include any proposed management change or construction method that would change the existing groundwater rights. The hydrologic factors proposed for the Project Area are incorporated into an already fully adjudicated aquifer.

5.4.7.4 Alternative 4F

Similar to the No Action and other action Alternatives, this alternative does not include any proposed management change or construction method that would change the existing groundwater rights. The hydrologic factors proposed for the Project Area are incorporated into an already fully adjudicated aquifer.

5.4.8 Groundwater Sources and Water Budget

5.4.8.1 No Action

With the No Action alternative, there would be no new source of groundwater, as none would be used. There would be no burden on existing groundwater sources or water budget.

5.4.8.2 Alternative 2A

Construction aspects of this alternative include the construction of water harvesting basins and landscape excavation to retain surface runoff. The volume of water that would be retained by the water harvesting basins and introduced as groundwater recharge would be insignificant when compared to the volume of groundwater recharge that currently infiltrates through the hydrologic system. Conversely, landscape excavation techniques would increase the volume of groundwater recharge in the active Project Area. As stated earlier, approximately 80 percent of the total acreage in the historic floodplain would be altered to promote groundwater recharge and therefore increase the groundwater source and groundwater budget.

5.4.8.3 Alternative 3E

With the introduction of irrigation watering under this regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. The relatively small amount of water involved, relative to the regional groundwater aquifer, would predict that regional groundwater sources and groundwater budgets would be unchanged under this alternative.

5.4.8.4 Alternative 4F

With the introduction of periodic flow for a hydroriparian regime, changes to the groundwater hydrology would be expected with increased infiltration in both the historic floodplain and channel regions of the active Project Area. Groundwater recharge would occur on a periodic basis with intermittent flow in the channel and irrigation on the historic floodplain areas. The relatively small amount of water involved, relative to the regional groundwater aquifer, would predict that regional groundwater sources and groundwater budgets would be unchanged with this alternative.

5.5 Biological Resources

5.5.1 Vegetation

Vegetation within the approximately 5000-acre Study Area is expected to change as time passes. Figure 5.1 shows the present BLP (Brown, Lowe and Pase) Vegetation Classification (Brown, et al. 1980) within the Study Area and in the project implementation area. Under the No-action Alternative, changes would occur randomly from continued urban development pressures along the Santa Cruz riparian corridor. The predicted result for the No-action Alternative is the continuation urbanization pressures resulting in full development of a constructed environment from the present developed limits, up to a fully hardened (soil cemented) main stem channel. The result is expected to entail total elimination of most other vegetation and land use classifications, except "Urban Drainage". The implementation of either Alternative 2A, 3E or 4F would alter approximately 1,125 acres of the existing vegetation classes in a predictable manner, and with both short term and long term effects within a specifically delineated project implementation area. The remaining approximately 3,750-acre area outside the project implementation area for either action alternative is presently composed of about 70% urbanized classes. The remaining 30% of this area would likely continue toward urbanization and use as urban drainage corridors, ultimately eliminating other vegetation classifications.

Table 5.1 compares changes in vegetation class areal coverage expected for existing vegetation classes, with each vegetation class expected to be present within the study area 50 years after project construction, or for the same time period following a no-action decision. Areal comparison is based on use of GIS-generated acreage from the original vegetation mapping prepared by Pima County (SDCP 1999), based on the BLP vegetation classification system, to support environmental documentation in the Without Project Conditions document (LA District, 2001), with future plant community classes from the restoration-area mapping prepared for plan formulation. Assumptions for planting density by species, from the mapping prepared for plan formulation and selection of alternatives, are used to define comparable BLP classification plant community polygons. A restoration community planted as "mixed scrub with 50% mesquite" was assumed to be a "Mesquite" community type under the BLP Sonoran Riparian Deciduous Forest and Woodland. Restoration communities planted with 20% and 30% mesquite are here assumed to be the BLP "Mixed Riparian Scrub" type. Emergent Marsh is assumed to be Sonoran Interior Marshland. "Riparian grasses" is assumed to be "Sacaton Grass Scrub".

Figure 5.1. Existing BLP Vegetation Classifications in the Study Area.

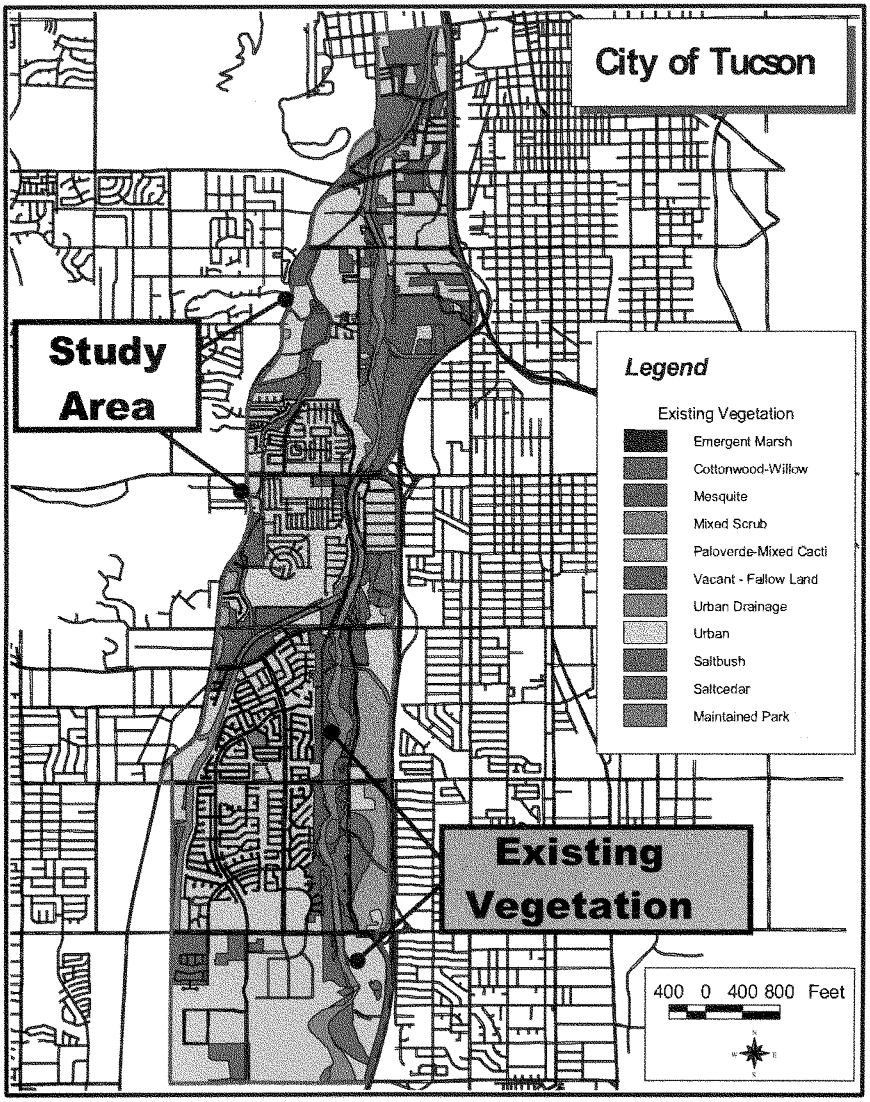


Table 5.1 Maximum Benefit Condition Vegetation Classes

Vegetation Classification	Existing Acres in Study Area	No Action	2A	3E	4F
Sonoran Desertscrub					
Paloverde Mixed Cacti	237	0	0	0	0
Saltbush	96	0	0	0	0
Sonoran Riparian Deciduous Forest and Woodland					
Mesquite	160	0	241	718	976
Cottonwood-Willow	0	0	0	18	68
Sonoran Deciduous Riparian Scrub					
Saltcedar Disclimax	87	0	0	0	0
Sonoran Interior Strand					
Mixed Scrub	261	0	880	356	0
Sacaton Grass Scrub	0	0	0	0	126
Marshland	0		6	6	59
Flowing Water	0	0	0	0	19
Cultivated and Cultured Uplands					
Urban	3045	4,487	3,663	3,620	3,547
Recreational (Park land)	86	90	90	90	90
Vacant or Fallow	934	0	0	0	0
Urban Drainage	99	428	125	180	120
Total	5,005	5,005	5,005	5,005	5,005

5.5.1.1 No Action

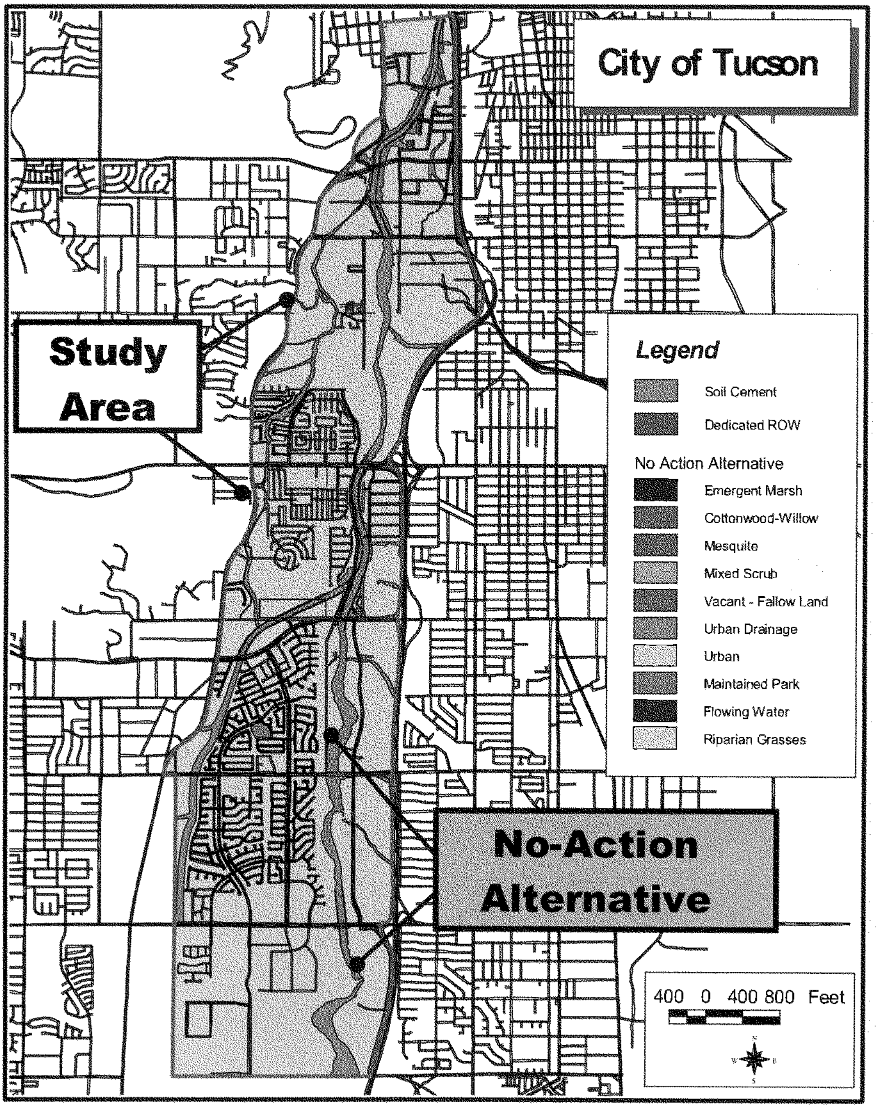
Under the No Action alternative, native biotic communities along the Paseo de Las Iglesias reach of the Santa Cruz River would not be restored. Native plant species diversity would decrease. Species that are regionally rare and sensitive to human impacts would sharply decline in abundance, or be eliminated. After 50 years or less, the study area probably would have lost all vestiges of the historically dominant vegetation communities. The Mesquite community would continue to degrade as a result of insufficient water to support sustained growth, lack of a flood regime to foster establishment of seedlings, and woodcutting of remaining trees. Some of the Mesquite community would be replaced by soil cement for flood control, and the remainder would likely be converted to urban uses. The Sonoran Desertscrub community would continue to deteriorate as a result of human impacts, including residential and commercial development of the overbank areas as well as impacts by off-road vehicles, equestrians, and fire.

The Sonoran Interior Strand community would deteriorate as a result of increased erosion and disturbance by human activities, and by increased flood velocity and frequency resulting from the increase in impermeable surfaces associated with adjacent development and bank protection. In all communities, increased disturbance would favor non-native versus native plant species. Table 5.2 summarizes these assumptions, presenting the vegetation classes likely to exist at the end of the period of analysis. Figure 5.2 depicts the future No-action configuration of the Study Area.

Table 5.2 No-Action Alternative Summary

Vegetation Type	**Area (Acres)**
Maintained Park Total	90.5
Urban Drainage Total	428.2
Urban Total	4486.7
Grand Total	**5005.3**

Figure 5.2. Study Area Vegetation Classifications Under the No-Action Alternative



5.5.1.2 Alternative 2A

This alternative would result in the restoration or rehabilitation of 1,125 acres of vegetation, including 867 acres of Sonoran Interior Strand, 252 acres of Mesquite and six acres of Emergent Marsh within five created basins. The marsh would be created in the existing Sonoran Interior Strand community of the existing channel bottom by modifying existing grade-break structures. The marsh would not depend on irrigation, but on the capture of rainfall runoff. It would be dependent upon occasional maintenance following floods. All 160 acres of the existing Mesquite community would be retained, and 92 acres of new Mesquite would be planted, bringing the total Mesquite community to 252 acres.

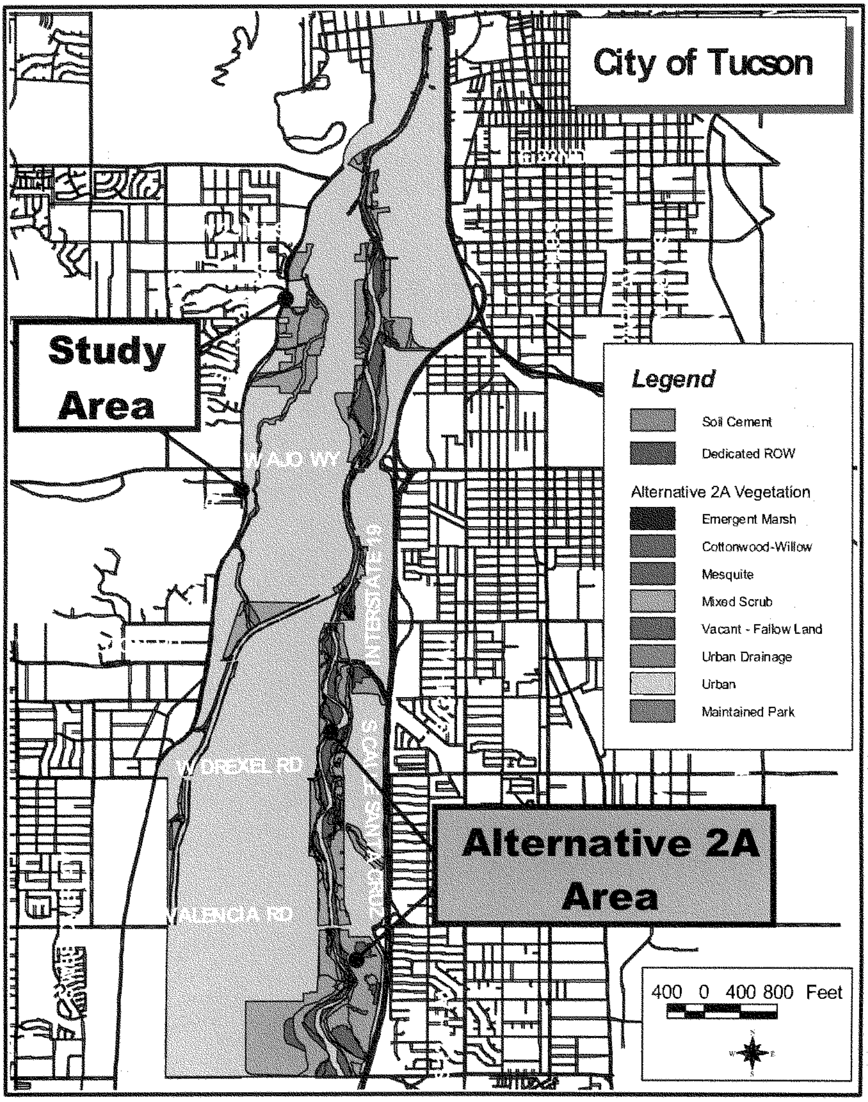
The new Mesquite community would be created on land that is currently Urban Drainage and Vacant or Fallow land. Survival, growth, and recruitment of mesquites and other component species of this community would be improved by the irrigation for establishment and when needed in drought emergencies. Water harvesting methods would be utilized to enhance collection and infiltration of rainfall. Sonoran Interior Strand would be preserved and improved by reduction of erosion, water harvesting, inter-planting with additional native species characteristic of this community, and exclusion of off-road vehicles. The new Sonoran Interior Strand Mixed Scrub community would be created from existing Vacant or Fallow land, Sonoran Desertscrub and Saltcedar Disclimax. Table 5.3 lists the vegetation types created in the Alternative 2A plan; figure 5.3 depicts the future configuration of the Study Area under Alternative 2A.

Under this alternative, all of the native plant communities would be retained and improved or established in a pattern that differs somewhat from the historic pattern, but is sustainable with minimal maintenance and without addition of water except to establish plantings and sustain vegetation during extreme drought conditions. In each community, a mixture of native plant species would be planted that would increase vegetation diversity beyond baseline conditions to more closely replicate the diversity characteristic of healthy natural communities. Prescribed operation and maintenance activities include periodic removal of invasive plants.

Table 5.3 Alternative 2A Restoration Summary

Vegetation Type	Area (Acres)
Mesquite Total	252
Mixed Scrub Total	867
Marshland Total	6.0
Grand Total	**1125**

Figure 5.3 Study Area Vegetation Classifications Under Alternative 2A



5.5.1.3 Alternative 3E

This alternative would result in the restoration or rehabilitation of approximately 1,098 acres of riparian habitat. Table 5.4 summarizes vegetation classification by area in acres. Table 5.1 shows the changes from existing vegetation classifications

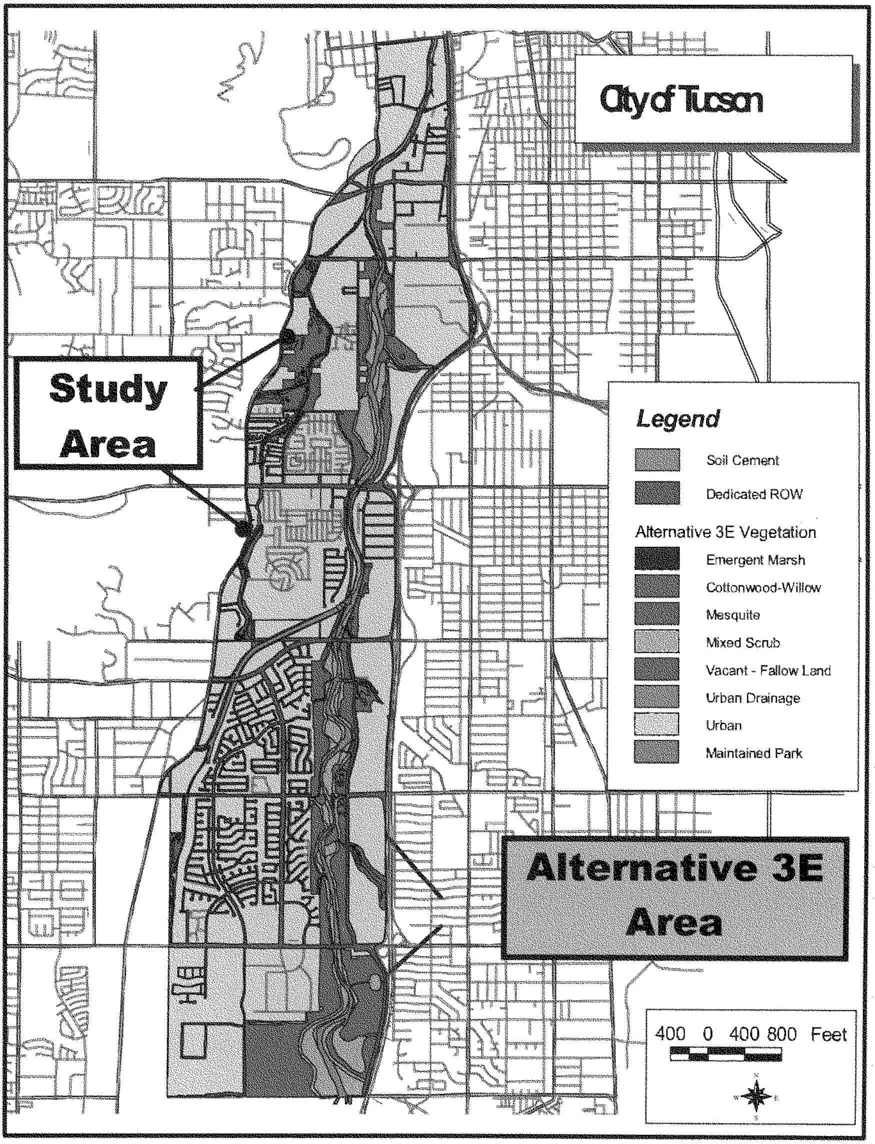
Table 5.4 3E Alternative Restoration Summary

Vegetation Type	Area (Acres)
Cottonwood-Willow Total	18
Marshland Total	6
Mesquite Total	718
Mixed Scrub Total	356
Grand Total	1,098

Approximately 18 acres of Cottonwood-willow community, planted in 8 off-channel basins and six acres of Sonoran Desert Strand Marsh, planted in 5 grade control basins, would be restored. The Cottonwood-willow and Emergent Marsh communities would depend on intermittent supplementary irrigation using secondarily-treated wastewater. A total of 65 acres of the existing Mesquite community would be retained and supplemented with in-fill plantings. An additional 653 acres of Mesquite would be planted on channel terraces, natural and regraded slopes and in the historic floodplain, bringing the total Mesquite community to about 718 acres. Survival rate and recruitment rate of mesquites and other component species of this community would be increased by the provision of water beyond the natural background supply. Trees would grow to larger stature because sufficient water would be provided by irrigation and water harvesting.

Sonoran Interior Strand (356 acres), composed of mesoriparian mixed shrubs, would be created on first terraces (above the active channel but below the approximate 2-year flood elevation). Under this alternative all of the native plant communities would be retained within the Project Area, established in a pattern that differs somewhat from the historic pattern, but is sustainable with maintenance and water application. In each community, mixtures of native plant species would be planted to increase vegetation diversity beyond baseline conditions, to more closely replicate the diversity characteristic of natural communities. Prescribed operation and maintenance activities include periodic removal of invasive plants. Figure 5.4 depicts the future vegetation of the Study Area with Alternative 3E implemented.

Figure 5.4 Alternative 3E Vegetation Community Projection



5.5.1.4 Alternative 4F

This alternative would result in the restoration or rehabilitation of approximately 1,249 acres of riparian habitat. Table 5.5 summarizes vegetation classification by area in acres. Table 5.1 shows the changes from existing vegetation classifications.

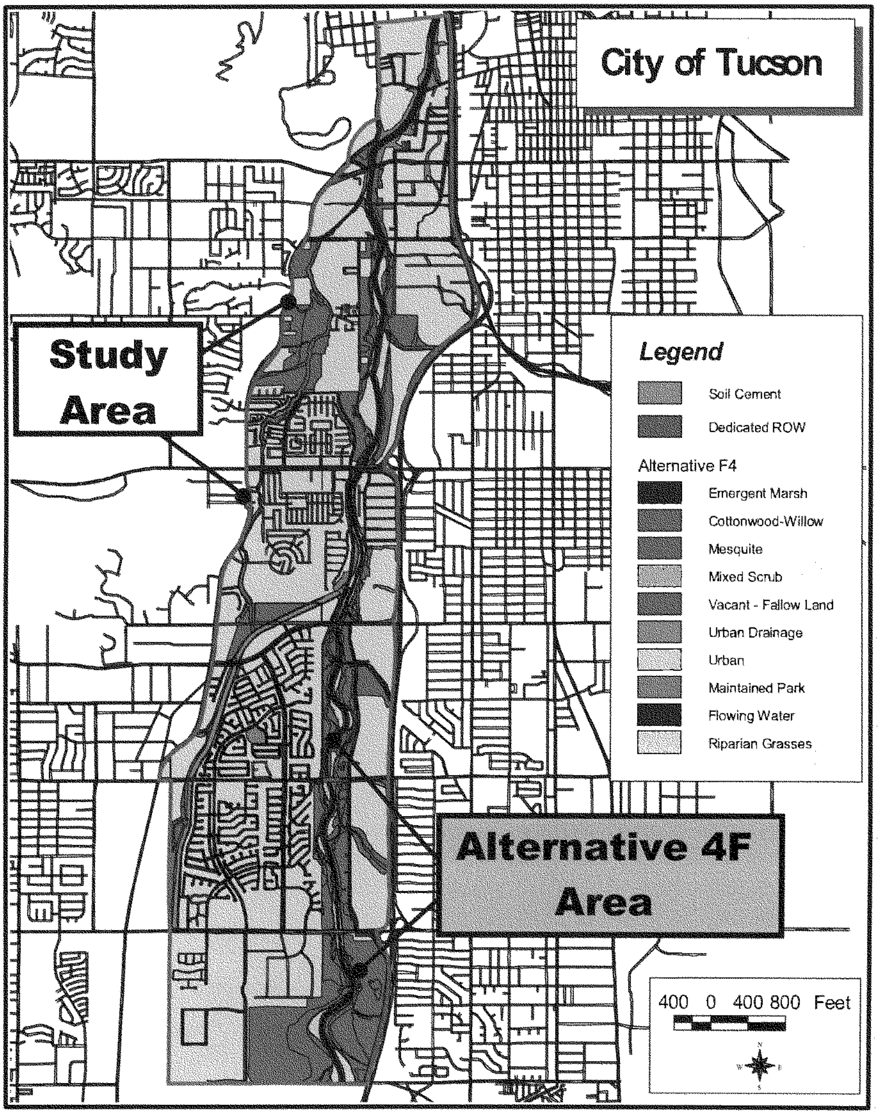
Approximately 79 acres of Cottonwood-willow community, planted in a corridor and 59 acres of Sonoran Desert Strand Marsh would be restored along the low-flow channel and within 11 created basins. It is possible that additional marsh vegetation would develop incidental to the application of surface water for the creation of the Cottonwood-willow community. The Cottonwood-willow and Emergent Marsh communities would depend on intermittent discharge of secondarily-treated wastewater. A total of 160 acres of the existing Mesquite community would be retained and supplemented with in-fill plantings. Plantings of mesquite and mixed scrub would be interspersed throughout the project area with the resulting dominant cover in those areas considered here as mesquite. This yields an additional 806 acres of Mesquite that would be planted on channel terraces and the historic floodplain, bringing the total Mesquite community to about 966 acres. Survival rate and recruitment rate of mesquites and other component species of this community would be increased by the provision of water beyond the natural background supply. Trees would grow to larger stature because irrigation and water harvesting would provide sufficient water.

Sonoran Interior Strand (126 acres), created to be dominantly riparian grasses to minimize flood retardance, would be created by reduction of erosion, water harvesting, planting with additional native species characteristic of this community, and exclusion of other causes of disturbance (such as off-road vehicles). Under this alternative, all of the native plant communities would be retained within the Project Area, established in a pattern that differs somewhat from the historic pattern, but is sustainable with maintenance and liberal water application. In each community, mixtures of native plant species would be planted to increase vegetation diversity beyond baseline conditions, to more closely replicate the diversity characteristic of healthy natural communities. Prescribed operation and maintenance activities include periodic removal of invasive plants. Figure 5.5 depicts the future vegetation of the Study Area with Alternative 4F implemented.

Table 5.5 4F Alternative Restoration Summary

Vegetation Type	Area (Acres)
Cottonwood-Willow Total	79
Marshland Total	59
Flowing Water Total	19
Mesquite Total	966
Sacaton Grass Scrub Total	126
Grand Total	1249

Figure 5.5 Alternative 4F Vegetation Community Projection



5.5.2 Wetlands

5.5.2.1 No Action

There are no known remaining natural wetlands in the Study Area. No new wetlands would be expected to develop under this scenario.

5.5.2.2 Alternative 2A

This alternative would result in the creation of six acres of emergent marsh at basins on the upstream side of five existing grade structures, replacing some of the wetlands that have been lost from the Study Area due to historic human activities. Habitat that is regionally declining would be restored.

5.5.2.3 Alternative 3E

This alternative would result in the creation of six acres of emergent marsh at basins on the upstream side of five existing grade structures. Approximately 18 acres of Cottonwood-willow forested wetlands would be created within eight created basins.

5.5.2.4 Alternative 4F

This alternative would result in the creation of 59 acres of emergent marsh in depressional areas on each side of the low flow channel and within 11 created basins. Approximately 68 acres of Cottonwood-willow forested wetlands would be created adjacent to the intermittent channel. This alternative would contribute substantially to the replacement of wetlands that have been lost from the Study Area due to historic human activities. Wetland habitat that is regionally declining would be restored.

5.5.3 Fish and Wildlife

5.5.3.1 No Action

The No Action alternative would likely result in the continued deterioration and ultimate loss of the remaining native wildlife habitat in the Study Area. Most of the species currently present in the Project Area are capable of survival in the presence of urbanization, and it is unlikely that the No Action alternative would result in the complete local extirpation of any of these species. The No Action alternative would result in the continued loss of the remaining wildlife habitat, particularly the mesquite community, which is regionally declining. The No Action Alternative would probably result in local loss of some species that are regionally rare, endemic, or otherwise sensitive, such as the suite of amphibians and reptiles currently found along the West Branch, and birds characteristic of the Mesquite community, such as Abert's towhee and Bell's vireo.

5.5.3.2 Alternative 2A

Alternative 2A would result in an increase in wildlife habitat and species diversity in the Study Area. Habitats that existed at baseline as small isolated blocks would be increased in size, reducing the adverse effects of habitat fragmentation. Habitat restored from existing habitat would not decrease existing populations because the existing habitat is such poor quality.

Under this alternative, three species (black-tailed jackrabbit, desert cottontail, and round-tailed ground squirrel) would likely increase greatly in abundance. Other species currently known to occur in small numbers in the Study Area would potentially increase in abundance somewhat. Additional habitat would be created for them, and existing habitat would be protected from further degradation. Some species would colonize the newly created emergent marsh under this alternative.

The riverbank protection with soil cement may negatively affect habitat suitable for burrowing owl under each of the action alternatives alternative due to the re-grading of the currently steep eroded riverbanks. Ultimately, stabilization of these banks may provide greater protection for nest sites as the erodability of the unprotected banks leads to destruction of nest sites during floods.

The creation of habitat may also provide habitat suitable for mosquitoes in the emergent marsh community. This should be addressed in the final planning and operational phases of this alternative, if it is selected.

5.5.3.3 Alternative 3E

The effects to wildlife from implementing Alternative 3E would be similar to 2A, but would favor those species highly dependent on mesquite habitat.

5.5.3.4 Alternative 4F

This alternative would have the greatest potential benefits to the greatest number of wildlife species in the Study Area, especially to species that are regionally rare or declining. Under this alternative, habitats that are regionally rare and declining would be created, improved, and/or protected. Habitats that existed at baseline as small isolated blocks would become contiguous with larger blocks, reducing the adverse effects of habitat fragmentation. New habitats would be created that would provide for many species of native fish and wildlife. Opportunities for the reintroduction of species that have been extirpated would be provided.

Under this alternative, substantially more habitat suitable for mosquito breeding would be created than under the other alternatives because of the creation of intermittent surface water flows in the channel.

5.5.4 Threatened and Endangered Species

No Federally listed threatened or endangered species are likely to occur in the Study Area under current conditions and no critical habitat for any listed species is present within the Study Area. Therefore, none of the alternatives considered would adversely affect listed species or critical habitat. Detailed information is included in Appendix 14.2.

5.5.4.1 No Action

The No Action Alternative would not contribute to a need to list any species as threatened or endangered. Also, the No Action Alternative would not create or conserve habitat that is potentially suitable for threatened or endangered species.

5.5.4.2 Alternative 2A

Implementation would not result in an increase of habitat or critical resources that could be used by Federally-listed species or species proposed or candidates for listing. However, this alternative would result in the restoration of regionally rare habitats for species that are of concern to Federal, state and local agencies.

5.5.4.3 Alternative 3E

The effects of implementing Alternative 3E would be very similar to Alternative 2A with respect to the effects to protected species.

5.5.4.4 Alternative 4F

This alternative would result in the creation of more emergent marsh and cottonwood-willow vegetation that could be used by several species that are of concern to Federal and state agencies, and are regionally rare, endemic, or otherwise sensitive. The creation of an open channel intermittent flow and more acres of emergent marsh and cottonwood willow may benefit more species of concern under this alternative than under Alternative 2A or 3E.

5.6 Cultural Resources

5.6.1 No Action

There would be no earth-moving activities or construction under the No Action alternative, and thus no known or previously undiscovered cultural resources would be affected during construction of restoration alternatives. However, the existing highly erosive processes would continue throughout the Project Area, eroding and potentially destroying undiscovered sites.

5.6.2 Alternative 2A

In accordance with 36 CFR 800, regulations implementing Section 106 of the National Historic Preservation Act, identification and evaluation studies would be coordinated with the Arizona State Historic Preservation Office (SHPO), Pima County and interested Native American Indian tribes. Given the project's association with the Santa Cruz River floodplain, the overall archeological sensitivity and potential are very high and the floodplain may contain buried resources. Therefore, complete avoidance of all cultural resources by project alternatives may be unsuccessful. Implementation of either of the restoration alternatives would have potentially adverse effects on resources potentially eligible for listing in the National Register of Historic Places (NRHP).

When carrying out any action alternative, the Corps would implement the following commitments:

- Qualified archeologists would perform a survey of previously un-surveyed areas within the area to be disturbed.

- Subsurface exploration to determine the presence/absence of buried cultural deposits may also be necessary.

- If cultural resources cannot be avoided, they would be evaluated regarding eligibility for listing in the NRHP.

- Identification, evaluation, and mitigation studies would be coordinated with Pima County and interested Native American Indian Tribes.

- All NRHP sites that would be impacted by project construction would be mitigated.

After the required surveys and evaluation efforts have been implemented, and after consideration of buried prehistoric resources within the floodplain terraces, a determination of effect would be made in consultation with Native American Indian tribes and Pima County. The Corps' determinations of resource eligibility and project effect would be coordinated with the SHPO. If National Register listed or eligible properties would be adversely affected by the project, a Memorandum of Agreement, to include monitoring during construction, would be negotiated with the SHPO, Pima County, and interested tribes and an archeological site treatment plan would be developed in consultation with the SHPO, Pima County, and interested tribes.

5.6.3 Alternative 3E

There are no differences between Alternatives 2A, 3E, and 4F with regard to cultural resources as the Project Area utilized and disturbed would be within the same footprint.

5.6.4 Alternative 4F

There are no differences between Alternatives 2A, 3E, and 4F with regard to cultural resources as the Project Area utilized and disturbed would be within the same footprint.

5.7 Aesthetics

5.7.1 No Action

Declines in aesthetic qualities are inextricably linked to declines in natural landscape components. The No Action Alternative would likely result in the continued decline in habitat within the Study Area in coming decades, resulting in a concomitant urbanization of the landscape and a decline in visual resource quality.

The No Action alternative would result in an increasingly urbanized viewshed as the increasing population of Tucson expands into more vacant land or natural areas. Views from Sentinel Peak Park, the existing Santa Cruz River Park, and within the Study Area would be dominated by man-made structures. If other restoration projects currently in planning stages downstream from the north end of the Study Area are completed, the increased urbanization of the Paseo de las Iglesias area would contrast.

5.7.2 Alternative 2A

This alternative would improve aesthetic values within the Study Area by restoring natural landscape components. Erosion would be decreased and the severity of the landscape due to the highly erosive effects of the Santa Cruz River would be diminished. Areas of restored vegetation would replace areas currently vacant or of primarily exotic species. Through an active operations and maintenance program, as well as an expanded community awareness of the project a decrease in the extent of garbage dumping would be predicted.

Views from Sentinel Peak Park, the Santa Cruz River Park, and within the Study Area would be improved by replacing barren eroded ground with native vegetation within the Project Area. This alternative does not conflict aesthetically with current or likely regulations or plans for the area, or result in adverse visual contrast with adjacent scenery and land uses currently present or proposed. It would not result in the adverse modification of the existing viewshed, or obstruct or substantially alter the visual character of any designated public viewpoints.

5.7.3 Alternative 3E

This alternative differs from Alternative 2A and 4F with regard to aesthetics in that it would represent a less verdant restoration than 4F, but would provide a greater expanse of mesquite habitat than 2A. As with Alternative 2A, Alternative 3E represents a substantial visual improvement within the Project Area.

5.7.4 Alternative 4F

This alternative differs from Alternative 2A with regard to aesthetics only in that it would result in free-flowing surface water with the associated greener vegetation adjacent to the narrow strip of surface flows. Similar conditions exist downstream of the Paseo de las Iglesias currently, and would likely be substantially the same. Habitat along the terraces and in the historic floodplain would be substantially the same from a visual standpoint.

5.8 Climate

5.8.1 No Action

In the absence of Federal action, there would be no change to the climate of Tucson or within the Project or Study Area.

5.8.2 Alternative 2A

Implementing any of the action Alternatives would result in no effects to the climate.

5.8.3 Alternative 3E

Implementing any of the action Alternatives would result in no effects to the climate.

5.8.4 Alternative 4F

Implementing any of the action Alternatives would result in no effects to the climate.

5.9 Air Quality

5.9.1 No Action

Under the No Action Alternative, there would be no direct project-related impacts to air quality. The Study Area would continue to experience localized episodes of reduced air quality and visibility from air-borne dust. Dust would likely increase as existing vegetation dies and bare ground continues to erode, until or unless bare ground is stabilized by development. The potential for increases in particulate matter resulting from future loss of native vegetation and increased development activity may result in more frequent PM_{10} exceedances. Increased urbanization of land within the Project Area would likely result in increased vehicular emissions, but there are no data available to suggest that any criteria pollutant standards would be exceeded.

5.9.2 Alternative 2A

Under this alternative, restoration of native vegetation would help stabilize soil and improve air quality. Common pollutants that can be removed by vegetation include particulate matter, nitrogen oxides (NO_X), sulfur oxides (SO_X), and ground-level ozone (USEPA, 2005).

Leaf surfaces collect dust and other particulates until they are washed to the ground by rain or spray irrigation. Dust counts can be reduced by 75 percent downwind of urban plantings, and fumes and bad odors can be intercepted by trees or masked by the more-pleasing smells of the trees or shrubs (Virginia Cooperative Extension, 2005). This would be expected to result in less frequent and severe localized episodes of reduced air quality and visibility from air-borne dust.

Vegetation also removes gaseous pollutants, such as NO_X and SO_X, by absorbing them through leaf surfaces. Once inside the leaf, gaseous pollutants diffuse and may react with inner-leaf surfaces (USEPA, 2005). When widely planted throughout a community, trees can also cool the air and slow the temperature-dependent reaction that forms ground-level ozone pollution (USEPA, 2005).

The recreational facilities included with Alternative 2A would also improve air quality in a less direct way. This alternative would provide continuous shared-use bike paths along the Santa Cruz River from Los Reales Road north to Congress Street. Shared-use facilities can also be utilized by pedestrians and horses, but allow cyclists to travel while completely separated from automobile traffic. Residents living along the project may find it preferable to travel to workplaces in downtown Tucson by bicycle rather than automobile, thus reducing vehicular emissions. Completion of the Rio Nuevo downtown redevelopment project and linking of the Paseo de las Iglesias project with additional shared-use bike paths would encourage additional use by cyclists in the future.

Air quality would improve over current conditions. Potential adverse impacts to air quality include short-term, construction-related effects such as emissions from construction vehicles and dust from construction activities during project implementation. Use of Best Management Practices would reduce these impacts. This alternative would not contribute to new violations of Federal, state or local air quality standards.

5.9.3 Alternative 3E

Implementing Alternative 3E would result in no different effects than those described under Alternative 2A.

5.9.4 Alternative 4F

The effects of this alternative on air quality with regard to dust are similar to those of Alternative 2A. However this alternative would likely have additional negative effects on local air quality as a result of the smell typically emanating from secondary treated water sources. This water, while meeting water quality requirements, would typically be expected to off-gas sulfur dioxide resulting in an easily detected "rotten egg" smell in proximity to the water.

5.10 Noise

5.10.1 No Action

Under the No Action Alternative, ambient noise levels within the Study Area would likely increase slightly over time as a result of increased vehicular traffic within the Study Area resulting from future urban development.

5.10.2 Alternative 2A

Under Alternative 2A, ambient noise levels within the Project Area would increase for a short duration as a result of the construction-related noise from implementing the restoration. However, once completed, ambient noise levels would likely not increase as much as they would under the No Action Alternative because urbanization of the area would not be as great. This alternative would likely not contribute directly to sources of noise within or outside the Project Area. Increased density of vegetation would likely result in some localized attenuation of noise from outside the Project Area.

5.10.3 Alternative 3E

The noise-related consequences of implementing Alternative 3E would be comparable to the effects from implementing Alternative 2A or 4F.

5.10.4 Alternative 4F

The noise-related consequences of implementing Alternative 4F would be comparable to the effects from implementing Alternative 2A or 3E.

5.11 Socioeconomics

5.11.1 No Action

In the absence of implementing any action alternative, the existing socioeconomic conditions would continue to prevail. The nature and extent of the proposed action precludes it from having the potential to demonstrably affect local or regional socioeconomics.

5.11.2 Alternative 2A

None of the alternatives is forecast to have any quantifiable long-term effects on employment, cause long-term economic growth, or lead to public health and safety concerns when compared to the no action alternative. When compared to the no action alternative, implementation of any of the restoration alternatives would have a temporary increase in the economy by the expenditure of money to construct the project and may encourage tourism related to bird watching and enjoyment of the environment on a long term basis.

5.11.3 Alternative 3E

None of the action alternatives are predicted to have any permanent effects on socioeconomics.

5.11.4 Alternative 4F

None of the action alternatives are predicted to have any permanent effects on socioeconomics.

5.12 Demographics

5.12.1 No Action

If no Federal action were conducted within the Paseo de las Iglesias, there would be no predicted change from the existing conditions of continued increase in the local and Pima county population.

5.12.2 Alternative 2A

Implementation of Alternative 2A is not expected to result in any quantifiable long-term effects on local or regional population.

5.12.3 Alternative 3E

Implementation of Alternative 3E is not expected to result in any quantifiable long-term effects on local or regional population.

5.12.4 Alternative 4F

Implementation of Alternative 4F is not expected to result in any quantifiable long-term effects on local or regional population. The growth associated with Pima County and Tucson would not be affected measurably by any of the restoration alternatives.

5.13 Transportation

5.13.1 No Action

Under the No Action Alternative, increased traffic from urbanization of vacant land within the Study Area is expected to occur. With increased urbanization, there is also likely to be an increase in the number of roads and parking places within the Study Area. The magnitude of these increases cannot be predicted accurately because it is dependent upon factors that are beyond the scope of this analysis.

5.13.2 Alternative 2A

Under this alternative, less vacant land within the Study Area would be available for development than under the No Action Alternative. Therefore, it is likely that local traffic would not increase as much under this alternative as under the No Action Alternative.

It is possible that there would be a slight increase in local traffic and parking needs created by the increased recreational opportunities presented by the restored habitat. Increased recreational use is not anticipated to contribute to traffic congestion or parking problems in the area, because recreational use is expected to be passive and not localized.

This alternative includes no construction of additional roads and no road closures. Currently used off-road vehicle trails, which are illegal under City of Tucson and Pima County ordinances, would be closed. Short-term disruption of local traffic during construction is likely to be minimal because access to the Project Area is readily available and construction of the restored habitat would not involve substantial importing of construction materials. No discernable increases in traffic delays or temporary or permanent deterioration of the roadway surfaces during project-related construction activities is predicted to occur. There would be no interference with local emergency-response or emergency-evacuation plans.

5.13.3 Alternative 3E

There are no anticipated differences between Alternatives 2A, 3E, and 4F with respect to the anticipated effects on traffic.

5.13.4 Alternative 4F

There are no anticipated differences between Alternatives 2A, 3E, and 4F with respect to the anticipated effects on traffic.

5.14 Recreation Resources

5.14.1 No Action

Under the No Action Alternative, no new areas would be designated for recreation and large areas of the Project Area could continue to be used by equestrian and hikers/joggers. The areas used for recreation are primarily within the Santa Cruz channel and lower terraces and not within the historic floodplain. If no restoration occurs, soil cementation is predicted for the entire reach over the next 50 years and would likely result in improved pedestrian access via jogging trails at the upper edge of the soil cement, but greatly decreased opportunities for hiking and equestrian recreation within the active river channel and terraced floodplain because access would be severely limited by the grade of the cemented slopes. Additionally, the area would likely become less popular for off-road vehicle (ATV's and 4 x 4) use because of the same accessibility issue.

5.14.2 Alternative 2A

Under this alternative, recreational resources are expected to improve as vegetation restoration makes the area more attractive to pedestrians and equestrians. Recreational opportunities for wildlife observation are expected to increase with the increase in quality and diversity of wildlife habitat.

Unless trails are incorporated into the final design of water harvesting basins and grade control structures, these structures could become impediments to equestrian and pedestrian traffic. In that event, either such traffic would be reduced or unplanned trails would be developed. This alternative is expected to reduce off-road vehicle activity by creating obstacles to vehicle access and vegetated land that would be less attractive to vehicle users. Increased use of the area by the public may also decrease illegal vehicle use by resulting in the greater presence of law enforcement.

5.14.3 Alternative 3E

Under this alternative, the same conditions described under Alternative 2A would prevail. If currently extirpated native wildlife return or are returned to the area, it is likely that recreational use by wildlife observers would increase as well.

5.14.4 Alternative 4F

Under this alternative, the same conditions described under Alternative 2A would prevail, but wildlife observation opportunities are expected to be significantly greater because a greater variety of habitats would be available to attract more diverse wildlife, especially birds. If currently extirpated native wildlife return or are returned to the area, it is likely that recreational use by wildlife observers would increase greatly.

5.15 Environmental Justice

5.15.1 No Action

Implementing the no action alternative would result in no changes to existing conditions within the Study Area.

5.15.2 Alternative 2A

In order to have potential environmental justice impacts, a proposal must have potential for disproportionately high and adverse human health or environmental effects on low-income populations, minority populations, or Indian Tribes. This action has been evaluated for potential disproportionately high environmental effects on minority and low-income populations. The evaluation concluded that the nature of the proposed action could not create high human health or environmental impact on any human population, including minority and low-income populations.

Implementing Alternative 2A would not result in any change to environmental resources that individuals involved in subsistence fishing or hunting utilize, nor involve the release of hazardous, toxic, or radioactive materials to which minority or low-income populations could be exposed. As such, the nature of the alternative being considered precludes the potential to create disproportionately high and adverse human health or environmental effects on low-income populations, minority populations, or Indian Tribes.

5.15.3 Alternative 3E

The effects to environmental justice issues associated with implementing Alternative 3E would be the same as Alternative 2A or 4F.

5.15.4 Alternative 4F

The effects to environmental justice issues associated with implementing Alternative 4F would be the same as Alternative 2A or 3E.

5.16 Hazardous, Toxic, and Radioactive Waste

5.16.1 No Action

Under the no action alternative, there would be no change over the existing conditions. Eventual soil cementing of the river channel throughout the Study Area could potentially decrease the risk of spreading contaminants from adjacent landfills during flood conditions.

5.16.2 Alternative 2A

In order to establish the sites within the Project Area suitable for implementing restoration, many variables were considered, including the locations of known HTRW sites. The Phase I assessment indicated the locations of landfills and other HTRW concerns within the Study Area and the identification of sites suitable for ecosystem restoration were identified based on avoiding the known landfill locations. Implementation of this alternative is not expected to result in contact with any HTRW materials.

In the event of an unplanned discovery of HTRW materials during construction, work would be stopped and appropriate notification and coordination with appropriate regulatory authorities would be completed. Investigations would be conducted to characterize the nature and extent of the contamination and establish appropriate resolution.

5.16.3 Alternative 3E

The effect of implementing Alternative 3E on HTRW issues associated would be the same as Alternative 2A or 4F.

5.16.4 Alternative 4F

The effect of implementing Alternative 4F on HTRW issues associated would be the same as Alternative 2A or 3E.

6 Cumulative Effects

Cumulative effects result "from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time" (40 CFR 1508.7). These actions include on- or off-site projects conducted by government agencies, businesses, or individuals that are within the spatial and temporal boundaries of the actions considered in this EIS.

The cumulative effects of the ecosystem restoration projects, in part, depend on what other projects in proximity are actually completed and the timing of their construction. Negative effects associated with implementation of the Preferred Alternative that could contribute cumulatively with the effects of other projects include minor and temporary increases in traffic, noise, vehicle emissions, and fugitive dust during the construction period. Because the Project Area is in an air quality attainment area, detailed air quality assessment was not required and cumulative effects would be minimal. Through implementing careful construction practices, no significant cumulative effects would be predicted.

The positive cumulative effects of the Paseo de las Iglesias ecosystem restoration include benefits from other ecosystem restoration feasibility studies and/or construction projects the Corps of Engineers is performing in the Tucson area in eastern Pima County. These projects are identified in the Santa Cruz River Watershed Study (USACE, 2001) including: El Rio Antiguo, Tres Rios del Norte, Paseo de las Iglesias, and El Rio Medio. The El Rio Medio (translated "the middle") project would be developed between Tres Rios del Norte and Paseo de las Iglesias all within the mainstem of the Santa Cruz River.

Each of these Study Areas was delineated to address distinctly different physical characteristics for each of the studies. Paseo de las Iglesias was delineated because it has a significant lack of water sources, but a great deal of spatial opportunity for restoration; El Rio Medio has a similar dearth of water availability but is entirely confined within soil cement banks and has more urban encroachment; and Tres Rios del Norte has numerous spatial opportunities and high water availability (because of a pre-existing effluent discharge). These important spatial and water availability differences provide different restoration opportunities and constraints and dictated evaluating each of these sites separately. The cumulative benefit of restoring riparian corridor over such a large distance would not be realized until each of these projects has constructed and fully functioning ecosystems, but would eventually contribute importantly to reaching local and regional habitat restoration and species diversity goals.

6.1 Past, Present, and Reasonably Foreseeable Future Actions

The Corps of Engineers Santa Cruz River Watershed Study (USACE, 2001) identified ecosystem restoration projects to be developed including: El Rio Antiguo, Tres Rios del Norte, Paseo de las Iglesias, and El Rio Medio. The City of Tucson is also examining alternatives for an urban riverside park and habitat restoration called Rio Nuevo immediately downstream of the Paseo de las Iglesias project. When the restored habitat of the Paseo de las Iglesias reach is examined in the context of the other habitat restoration activities within the Santa Cruz watershed, this habitat contributes to restoring the connectivity of the riparian corridors in the desert southwest.

7 Summary of Environmental Effects

7.1 Unavoidable Environmental Impacts

Unavoidable adverse environmental effects from any of the action alternatives would include a minor temporary increase in noise, fugitive dust, and local vehicle traffic during construction.

7.2 Short Term Use and Long Term Productivity of the Environment

Implementation of any of the action alternatives would require the short-term construction-related use of the environment within an extensively disturbed low-value habitat. Disturbance to the environment would be of short duration and would be offset by the increase in productivity from the habitat restoration, recreation, and aesthetic, enhancements to the Paseo de las Iglesias reach. The long-term productivity of the environment would be increased by the restoration of this locally important and regionally rare riparian habitat.

7.3 Irreversible and Irretrievable Commitment of Resources

Implementing any of the action alternatives would irretrievably commit resources including construction materials, fuel used by construction equipment, water for irrigation, and the plants/seedlings used to establish the habitat.

The aspects of the restoration plan represent relatively minor changes to the landscape and would be reversible if necessary; selection of any of the action alternatives does not represent an irreversible commitment of resources.

7.4 Compliance with Environmental Laws and Regulations

As part of the National Environmental Policy Act (NEPA) process, the applicable environmental laws, statutes, and executive orders were reviewed relative to the proposed project.

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements

Federal Statutes	Level of Compliance[1]	Declaration
Anadromous Fish Conservation Act	N/A	N/A
Archeological and Historic Preservation Act	Ongoing	As detailed in Section 5.6.2, commitments have been made to accomplish required field studies, consultation and determinations of resource eligibility and project effects. Ongoing compliance would continue as these activities are completed.
Clean Air Act	Full	Tucson and Pima County are attainment areas for all criteria pollutants. The project would comply with the Act.
Clean Water Act	Full[2]	An evaluation of potential effects by each restoration alternative on water quality has been included as the 404(b)(1) Compliance Evaluation (Appendix 14.3). This project would conform to this provision of the Clean Water Act.
Coastal Barrier Resources Act	N/A	N/A
Coastal Zone Management Act	N/A	N/A
Comprehensive Environmental Response, Compensation, and Liability Act	Full	No locations of hazardous materials, as described by CERCLA, occur within the project area. While some hazardous materials exist in the surrounding area, none exist in the area affected by the project. The project would be in compliance with this act.
Endangered Species Act	Full	No Federally protected species occur within the project area; project would comply with the Act.
Estuary Protection Act	N/A	N/A
Farmlands Protection Policy Act	N/A	The project would not affect prime or unique farmlands.

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements (cont)

Federal Statutes	Level of Compliance[1]	Declaration
Fish and Wildlife Coordination Act	Full	A Planning Aid letter and Final Coordination Act Report have been received. These letters indicate compliance with the act.
Land and Water Conservation Fund Act	N/A	No lands involved in the proposed project were acquired or developed with LWCFA funds.
Magnuson-Stevens Act	N/A	Fishery protection not relevant.
Marine Mammal Protection Act	N/A	N/A
National Historic Preservation Act	Full	As detailed in Section 5.6.2, commitments have been made to accomplish required field studies, consultation and determinations of resource eligibility and project effects. Ongoing compliance would continue as these activities are completed.
National Environmental Policy Act	Ongoing	EIS conforms in form and substance
Resource Conservation and Recovery Act	Full	No locations of hazardous materials, as described by RCRA, occur within the project area. While some hazardous materials exist in the surrounding area, none exist in the area affected by the project. The project would be in compliance with this act.
Wild and Scenic Rivers Act	N/A	This segment of the Santa Cruz River is not a component of the National Wild and Scenic Rivers system nor is it listed on the Nationwide Rivers Inventory.
Executive Orders, Memoranda, etc.		
Migratory Bird (E.O. 13186)	Full	Requires that agencies take reasonable steps that include restoring and enhancing habitat, and incorporating migratory bird conservation into agency plans and their planning processes. The project would create unique habitat for riparian species, including birds.
Protection and Enhancement of Environmental Quality (E.O. 11514)	Full	EO directing agency implementation of the National Environmental Policy Act

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements (cont)

Federal Statutes	Level of Compliance[1]	Declaration
Protection and Enhancement of Cultural Environment (E.O. 11593)	Full	EO directing agency compliance with historic preservation law.
Floodplain Management (E.O. 11988)	Full	The project would augment natural floodplain processes, rather than suppress them further. The project would be in compliance with the order.
Protection of Wetlands (E.O. 11990)	Full	No wetlands currently exist in the project area. Project measures would create wetland areas. The project would be in compliance with the order.
Prime and Unique Farmlands (CEQ Memorandum, 11 Aug. 1980)	N/A	The project would not affect prime or unique farmlands.
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)	Full	This action has been evaluated for potential disproportionately high environmental effects on minority and low-income populations. The evaluation concluded that the nature of the proposed action could not create high human health or environmental impact on any human population, including minority and low-income populations. See Section 5.15.
Invasive Species (E.O. 13112)	Full	The project would require periodic removal deciduous saltcedar, an acknowledged invasive species. The project would be in compliance with the order.
Protection of Children from Health Risks & Safety Risks (E. O. 13045)	Full	No aspect of the project would expose children to materials having an adverse effect on their health. Areas where potential fall hazards exist (construction staging areas) would be provided with perimeter fencing and/or signed as appropriate to deter unauthorized access especially to ensure children's safety.

[1] Level of Compliance:
Full Compliance (Full): Having met all requirements of the statute, E.O., or other environmental requirements.
Ongoing Compliance (Ongoing): Compliance requires continuing actions through later stages of project.
Non-Compliance (NC): Violation of a requirement of the statute, E.O., or other environmental requirement.
Not Applicable (N/A): No requirements for the statute, E.O., or other environmental requirement.

[2] Section 404(r) of the Clean Water Act exempts Federal projects from the requirement to obtain State 401 Water Quality Certification, if they meet specific criteria. The Corps believes that this project would meet the criteria for 404(r) exemption in that it is (1) a Federal construction project that (2) requires Congressionally authorized funds and (3) for which an EIS and a Section 404(b)(1) evaluation have been prepared.

8 Public Involvement

8.1 Scoping Process

In April 2001, the USACE published a Notice of Intent (NOI) for the Paseo de las Iglesias Ecosystem Restoration EIS in the *Federal Register* (April 6, 2001, Volume 66, Number 67) in compliance with 40 CFR 1508.22. As recommended in 40 CFR 1501.7(b), public scoping meetings also were held for the project. The meetings were held on March 30 and 31, 2001 at 450 W. Paseo Redondo in Tucson. An all day meeting was conducted on March 31 between 8:00 a.m. and 3:00 p.m. Guided site visits were available on April 1, 2001 for all who expressed interest.

The USACE and the Pima County Flood Control District (the project's non-Federal sponsor) implemented a public involvement program to obtain input from various groups, organizations, or individuals that represent business, homeowner, educational, environmental, government, neighborhood, and community interests. The program established a mailing list of interested parties. The mailing list was used for the distribution of invitations to public meetings and dissemination of project documents. Announcements for public meetings were also made in local newspapers, including date, time, place, and subject matter.

8.2 Major Issues Identified For Analysis During Scoping

Public comments received during the public scoping meeting, have been incorporated into the plan formulation, feasibility, and evaluation process associated with this flood control project. The key issues that were raised during the public scoping process are summarized below.

Process: Many people expressed concern about what process should take place to address the Santa Cruz River. Attendees at the scoping meeting advocated bringing together a diverse group of people (government officials, scientists, citizens, nonprofits, and schools) to address the technical, ecological, political, community, and business issues affecting river restoration.

River Channel and Banks: People expressed a desire to have the river channel restored to a more natural pattern. Specifically, the public advocated removing soil cement banks completely where possible and re-evaluating their use. Other comments addressed allowing a more natural meandering pattern and establishing terraces along the banks vegetated with native plants.

Natural Habitat Restoration: Most respondents expressed a desire to see a restoration of natural habitats along the river. Clean ups and native vegetation plantings were suggested and the need to control invasive plants was noted. People indicated a desire to see vegetation supported by rain, flood, and/or reclaimed water. No one source of water was favored.

River Flow and Water: Comments regarding the use and presence of water in the river varied. Some called for the addition of water in some form (e.g., effluent, Central Arizona Project water and reclaimed water) while others recognized the potential problems in committing substantial volumes of water to restoration. Creation of standing water would have the undesirable consequence of breeding of mosquitoes.

Recreation: People expressed a strong desire to have recreation integrated with restoration. Specific recreation requirements identified included trails, interpretive signage and picnic/resting spots.

Rio Nuevo and Redevelopment: With regard to redevelopment plans and the Rio Nuevo project, people raised concerns about how restoration might be integrated with re-development.

8.3 Coordination

A Draft Feasibility Report and EIS were circulated for public review and comment. The 45-day review period was initiated by publication of a Notice of Availability (NOA) for the initial Draft EIS in the Federal Register on October 8, 2004, in compliance with 40 C.F.R. 1508.22. A public hearing to discuss and receive comments on the Draft EIS was held at the Desert Vista Campus of Pima Community College in Tucson, Arizona on the evening of October 26, 2004. 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 14.5 of the Final EIS.

9 List of Preparers

Name	Affiliation	Expertise/Experience	Role
William Bissel, P.E.	David Miller & Assoc.	Engineering/15 years	Alternative/ Consequences
Michael Fink	USACE	Landscape Ecologist/25 years	Technical Review
Kim Gavigan P.E.	USACE	Engineering, Planning/15 years	Alternatives Analysis, Purpose and Need
Keith Harrington, PhD	David Miller & Assoc.	Economics/15 years	Scoio-Economics
John Killeen, RPA	USACE	Archaeologist/20 years	Technical Review
Kenneth Kingsley, PhD	SWCA	Ecologist/30 years	Affected Environment, Consequences
Eldon Kraft	David Miller & Assoc.	Planning/20 years	Alternatives Analysis
Sarah Laughlin	USACE	Biologist/5 years	Technical Review
Tina Lee	SWCA	Impact Assessment/ 20 years	Technical Review
Michael McGarry	David Miller & Assoc.	Impact Assessment/14 years	Principal Author, Lead Analyst
Robert Wiley, RLA	David Miller & Assoc.	Landscape Architect, Ecologist/30 years	Affected Environment, Alternatives Analysis Consequences

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12 Organizational Conflict of Interest Statement

NEPA FINANCIAL DISCLOSURE STATEMENT FOR PREPARATION OF U.S. ARMY CORPS OF ENGINEERS ENVIRONMENTAL IMPACT STATEMTENTS

Council on Environmental Quality Regulations at 40 CFR 1506.5 (c), which have been adopted by the U.S. Army Corps of Engineers (ER 200-2-2), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial interest or other interest in the outcome of the project. The term "financial or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance, Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 Federal Register 18,026 - 18,038, Questions 17a and 17b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)," 46 Federal Register 18,031.

In accordance with these requirements, the undersigned hereby certifies that the company and any of its proposed subcontractors have no financial or other interest in the outcome of the above named project.

31 August 2005
Date

Signed:

David J. Miller
Name

President
Title

David Miller & Associates, Inc.
Company

13 Distribution List

Agencies, local governmental entities, organizations, and persons listed below with inherent interest in the restoration alternatives evaluated in this EIS will receive copies. Some recipients will receive printed copies; most will receive a compact disc holding the EIS in electronic form as a continuous and interlinked Adobe Acrobat® file.

FEDERAL

U.S. Environmental Protection Agency
Office of Federal Activities
EIS Filing Section
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Tucson, AZ 85701-1207

Pima County Wastewater
201 N. Stone 8th Floor
Tucson, AZ 85701

Pima County Department of Environmental
Quality
ATTN: Ms. Ursula Kramer, Manager
130 W. Congress Street, 3rd Floor
Tucson, AZ 85701

CITY OF TUCSON

City Manager
ATTN: Benny Young
PO Box 27210
Tucson, AZ 85726-7210

Tucson Water
ATTN: Linda Smith
P.O. Box 27210
Tucson, AZ 85726

ORGANIZATIONS

Arizona Native Plant Society
Southern Arizona/Tucson Chapter
P.O. Box 40685
Tucson, Arizona 85717-0685

Judy Edison
Tucson Audubon Society
300 E. University Blvd.
Tucson, Arizona 85705

Dr. Rick Brusca
Arizona-Sonora Desert Museum
2021 N. Kinney Road
Tucson, Arizona 85743-8918

Friends of the Santa Cruz River
PO Box 4275
Tubac, AZ 85646

Mr. Staffan Schoor
Pima County Association of Governments
177 N. Church Ave., Ste 405
Tucson, AZ 85701

Charles Matthewson
Environmental Planning Director
Pima County Ass. of Governments
177 N. Church #405
Tucson, AZ 85701

Tucson Clean & Beautiful
P.O. Box 27210
Tucson, AZ 85726-7210

Pima Trails
P.O. Box 35007
Tucson, AZ 85740

Diana Hadley
C/O Santa Cruz River Alliance
Arizona State Museum
University of Arizona
Tucson, Arizona 85721

The Nature Conservancy
Tucson Conservation Center
1510 E. Fort Lowell Road
Tucson, Arizona 85719

Sonoran Institute
ATTN: Amy McCoy
Project Manager, Southeast Arizona Program
7650 E. Broadway Blvd., Ste. 203
Tucson, AZ 85710

LIBRARIES

University of Arizona Library
Room A349
Tucson, Arizona 85721

Pima County Community College Library
2202 W. Anklam Rd.
Tucson, Arizona 85709-0001

Tucson-Pima County Public Library System:

Ms. Kathy Scott, recipient for all
Joel D. Valdez Main Branch Library
101 N. Stone Avenue
Tucson, Arizona 85701

Valencia Branch Library
202 W. Valencia Road
Tucson, Arizona 85706

Dusenberry-River Center Branch Library
4350 E. River Road
Tucson, Arizona 85750

Nanini Branch Library
7300 N. Shannon Road
Tucson, Arizona 85741

Columbus Park Branch Library
4350 E. 22nd Street
Tucson, Arizona 85711

Woods Memorial Branch Library
3455 N. 1st Avenue
Tucson, Arizona 85719

Himmel Park Branch Library
1035 N. Treat Avenue
Tucson, Arizona 85716

Kirk-Bear Canyon Branch Library
8959 E. Tanque Verde
Tucson, Arizona 85749

Wilmot Branch Library
530 Wilmot Road
Tucson, Arizona 85711

Southwest Branch Library
6855 South Mark Road
Tucson, Arizona 85746

14 Appendices

14.1 Fish and Wildlife Coordination Act Correspondence

United States Department of the Interior
U.S. Fish and Wildlife Service
Arizona Ecological Services Field Office
2321 West Royal Palm Road, Suite 103
Phoenix, Arizona 85021-4951
Telephone: (602) 242-0210 Fax: (602) 242-2513

In Reply Refer to:

AESO/FA February , 2003

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 (PAL) presents the Fish and Wildlife Service's preliminary evaluation of potential environmental effects and habitat benefits associated with the U.S. Army Corps of Engineers (COE) Paseo de las Iglesias 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 our report under Section 2(B) of the FWCA. This PAL is based on coordination with the Arizona Game and Fish Department, literature research, file reviews, and information provided by the COE. A more detailed evaluation of the hydrogeomorphic functional analysis, existing conditions, and future with and without project scenarios will be incorporated into the 2(B) report.

PROJECT DESCRIPTION

The Paseo de las Iglesias study area is located along a 7-mile stretch of the Santa Cruz River from Los Reales Road to Congress Street in metropolitan Tucson, Pima County, Arizona. Under authority of House Resolution 2425 of 1994, the Flood Control Act of 1938, and the Energy and Water Development Appropriation Act of 2001, the Corps is authorized to conduct feasibility studies for flood protection and environmental restoration in the State of Arizona in cooperation with a local non-Federal sponsor. The local sponsor for the project would be the Pima County Flood Control District.

Planning objectives of the project are to

restore wetland and riparian vegetative communities within the river and over-bank corridor to a more natural state;
increase the acreage of riparian habitat;
minimize disturbance-type impacts to restored riparian habitat;
minimize potential for sediment, organic matter, and debris accumulation in restored riparian habitat that may induce flood damage;

increase habitat diversity by providing a mix of habitats within the river corridor including the riparian fringe; and
provide incidental flood damage reduction in specified areas.

EXISTING BIOLOGICAL RESOURCES

Vegetation within the Paseo de las Iglesia study area is sparse and includes species such as paloverde (*Cercidium* sp.), mesquite (*Prosopis* sp.), creosote bush (*Larrea tridentata*), desert broom (*Baccharis sarothroides*), and salt cedar (*Tamarix* sp.). A wastewater treatment plant near Roger and Ina Roads discharges effluent into the Santa Cruz River. Vegetation along the wetted portions of the river is vigorous and dense.

Native wildlife species in the project area likely include coyote (*Canis latrans*), kangaroo rats (*Dipodomys* spp.), black-tailed jackrabbit (*Lepus californicus*), cottontail (*Sylvilagus audubonii*), pocket mice (*Perognathus* spp.), ground squirrels (*Ammospermophilus* spp.), black-chinned sparrow (*Amphispiza bilineta*), roadrunner (*Geococcyx californianus*), Gambel's quail (*Lophortyx gambelii*), curve-billed thrasher (*Toxostoma curvirostre*), common raven (*Corvus corax*), mourning dove (*Zenaida macroura*), whiptails (*Cnemidophorus* spp.), rattlesnakes (*Crotalus* spp.), horned lizards (*Phrynosoma* spp.), and lizards (*Urosaurus* spp.). We are unaware of the occurrence any federally threatened or endangered species within the project area.

ALTERNATIVES

Specific planning alternatives are not developed. However, alternatives would be representative of the identified planning objectives and developed in coordination with the local sponsor and appropriate resource agencies.

WITHOUT PROJECT PROJECTION

In the absence of active restoration efforts, it is unlikely that biotic communities within this portion of the Santa Cruz River would improve beyond current conditions. The opportunity to restore water and vegetation may not be realized.

WITH PROJECT PROJECTION

Implementation of the proposed project could enhance and restore river flow, native vegetation communities, and wildlife habitats along the Santa Cruz River. The specific nature and configuration of a water source and native vegetation needs to be determined. The opportunity exists to provide habitat for a diversity of native wildlife species.

DISCUSSION

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.

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 on 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.

PRELIMINARY RECOMMENDATIONS

1) Focus significant attention on identifying and, if necessary, securing a permanent and adequate source of water to support the desired biotic communities.

2) 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.

We appreciate the opportunity to provide planning assistance for this 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,

Steven L. Spangle
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ARD-ES)
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Study Manager, Planning Branch, Army Corps of Engineers, Phoenix, AZ

W:\Mike Martinez\Pasco-pal.wpd:cgg

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In Reply Refer to:

AESO/FA

June 15, 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:

This report presents the Fish and Wildlife Service (FWS) evaluation of the U.S. Army Corps of Engineers (Corps) Paseo de las Iglesias Ecosystem Restoration Project and is provided pursuant to Section 2(B) of the Fish and Wildlife Coordination Act (48 stat. 401, as amended; 16 U.S.C. 661 et seq.) (FWCA). This report is based on coordination with the Arizona Game and Fish Department (AGFD), local sponsors, literature research, file reviews, and information provided by the Corps including their Draft Environmental Impact Statement (June 2004) (DEIS).

PROJECT DESCRIPTION

The Paseo de las Iglesias study area is located along a 7-mile stretch of the Santa Cruz River from Los Reales Road to Congress Street in metropolitan Tucson, Pima County, Arizona. Under authority of House Resolution 2425 of 1994, the Flood Control Act of 1938, and the Energy and Water Development Appropriation Act of 2001, the Corps is authorized to conduct feasibility studies for flood protection and environmental restoration in the State of Arizona in cooperation with a local non-Federal sponsor. The local sponsor for the project would be the Pima County Flood Control District.

Planning objectives are listed below and provide a framework for the development of project alternatives.

- Increase the acreage of functional riparian and floodplain habitat within the Study Area.
- Increase wildlife habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe, and historic floodplain.
- Provide passive recreation opportunities.

- Provide incidental benefits of flood damage reduction, reduced bank erosion and sedimentation, and improved surface water quality consistent with ecosystem restoration goals.
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

EXISTING BIOLOGICAL RESOURCES

The DEIS describes several distinct vegetation communities within the Paseo de las Iglesias study area including Sonoran desertscrub, Sonoran riparian deciduous forest and woodland, Sonoran deciduous riparian scrub, Sonoran interior strand, and cultivated and cultured uplands. Less than 20 percent (about 100 acres) of the study area is characterized by vegetation considered undisturbed or native.

Sonoran desertscrub is typified by drought tolerant deciduous trees and shrubs with small leaves and thorns. Vegetation density and diversity is related to local conditions. This biome forms two distinctive vegetation series within the study area. The Paloverde-Mixed Cacti series occupies 237 acres and the saltbush series occupies 96 acres. Dominant woody perennial species include creosote bush (*Larrea tridentata*) on gravely soils and fourwing saltbush (*Atriplex canescens*) on silty soils.

Sonoran riparian deciduous forest and woodland is typically encounterd along perennial or intermittent drainages with shallow subsurface water. The study area contains about 160 acres of mesquite woodland series. Common plant species include mesquite (*Prosopsis* sp.), catclaw acacia (*Acacia constricta*), blue paloverde (*Parkinsonia florida*), pitseed goosefoot (*Chenopodium berlandieri*), lotebush (*Zizyphus obtusifolia*), and fourwing saltbush. The cottonwood-willow series, which was once common along the Santa Cruz River, has been eliminated.

Sonoran deciduous riparian scrub is primarily limited to areas adjacent to washes. This biome is represented by 87 acres of saltcedar disclimax series in the study area. This vegetation type is dominated by plant species that are adapted to xeric conditions, in particular non-native invasive species such as Athel tamarisk (*Tamarix aphylla*) and saltcedar (*T. ramosissima*). Other common species occurring within this vegetation type are Bermuda grass (*Cynodon dactylon*), camphorweed (*Heterotheca subaxillaris*), western tansymustard (*Descurania pinnata*), and Jerusalem thorn (*Parkinsonia aculeata*).

Sonoran interior strand persists within the Santa Cruz River mainstem and associated wash channels where it is subject to frequent flood events and regular scouring. About 261 acres occur within the project area, mainly along existing low-flow channels and is characterized by scattered patches of vegetation on sand and gravel with small silt deposits and low organic content. Common species include many associated with scrubland communities such as singlewhorl burrobrush (*Hymenoclea monogyra*) and desert broom (*Baccharis sarothroides*). Also found in this community are annuals, short-lived perennials, and invasive species such as Adonis blazingstar (*Mentzelia multiflora*), camphorweed, Canadian horseweed (*Conyza canadensis*), common sunflower (*Helianthus annuus*), desert horsepurselane (*Trianthema portulacastrum*), western tansymustard, and buffelgrass (*Pennisetum ciliare*).

Cultivated and cultured uplands encompass areas where most native vegetation has been removed as a result of past or ongoing human activity. Non-native landscaping plants are in many cases the only component of the vegetation. This category includes residential properties, building sites, landscaped recreation areas, agricultural areas, closed landfills, and other disturbed areas. Within the study this category includes 3,045 acres of urban land, 86 acres of recreational land, 934 acres of vacant or fallow land, and 99 acres of urban drainages. Common plant species include velvet mesquite, burroweed (*Isocoma tenuisecta*), Jerusalem thorn, prickly Russian thistle (*Salsola tragus*), olive (*Olea europaea*), gum (*Eucalyptus* sp.), Goodding's willow (*Salix gooddingii*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), Chinaberrytree (*Melea azederach*), tuna cactus (*Opuntia ficus-indica*), European fan palm (*Chamaerops humilus*), velvet ash (*Fraxinus velutina*), Florida hopbush (*Dodonea viscosa*), creosote bush, whitethorn acacia, red brome (*Bromus rubens*), various native and nonnative grasses, and numerous ornamentals and cultivars.

These vegetation communities provide habitat for a variety of native wildlife species. Wildlife in the project area include species such as coyote (*Canis latrans*), kangaroo rats (*Dipodomys* spp.), black-tailed jackrabbit (*Lepus californicus*), cottontail (*Sylvilagus audubonii*), pocket mice (*Perognathus* spp.), ground squirrels (*Ammospermophilus* spp.), black-chinned sparrow (*Amphispiza bilineta*), roadrunner (*Geococcyx californianus*), Gambel's quail (*Lophortyx gambelii*), curve-billed thrasher (*Toxostoma curvirostre*), common raven (*Corvus corax*), mourning dove (*Zenaida macroura*), whiptails (*Cnemidophorus* spp.), rattlesnakes (*Crotalus* spp.), horned lizards (*Phrynosoma* spp.), and lizards (*Urosaurus* spp.).

We are unaware of threatened or endangered species listed under the Endangered Species Act within the project area. Based on habitat evaluations, the Draft EIS concludes that no listed, proposed, or candidate species are likely to occur within the study area because vegetation structure does not meet habitat-suitability criteria.

ALTERNATIVES

A number of measures were developed and originally identified in the Reconnaissance Phase. Additional measures were added based on results of public involvement and other studies in the region. The initial conceptual alternatives presented in the Draft Feasibility Report were expanded into an array of 14 alternatives that were subjected to detailed analysis. A final array of alternatives was produced consisting of alternatives 2A, 4F, 3E, and no action.

Paseo de las Iglesias

Alternative 2A

This alternative would use basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading, a low flow diversion, and construction of subsurface water harvesting basins. These measures would allow creation of new vegetation as well as enhancement of existing vegetation. The alternative would require irrigation for establishment of vegetation and periodic irrigation during periods of prolonged drought.

The channel features for this alternative would consist of two measures; construction of water harvesting basins on the upstream side of five existing grade structures and construction of a low flow diversion to direct water from the New West Branch (NWB) back into the Old West Branch (OWB) on the Santa Cruz River. The water harvesting basin features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to minimize effects on flood flows.

The low flow diversion would be constructed by placing a diversion structure in the New West Branch channel to pond low flows and placing a conduit through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The tributary water harvesting basins discussed above would be constructed, however, they would be increased in size. The off-channel areas would be created in the floodplain to concentrate local runoff.

This alternative would restore or enhance 1,125 acres of habitat. It would include 867 acres of xeroriparian shrub with 252 acres of mesquite and 6 acres of emergent marsh. Project features would be subject to damage by flood flow and periods of inundation, resulting in the need for periodic maintenance to insure successful habitat restoration. Operation and maintenance costs would include periodic channel clearance, control of invasive plant species, and irrigation system maintenance. Operation and maintenance would also include periodic replanting of large habitat areas eliminated by flood flow erosion.

Alternative 3E (Preferred Alternative)

Mesquite bosque creation would be the dominant feature of Alternative 3E. Alternative 3E would provide a nearly uniform mesoriparian hydrologic regime (through various means of supplemental irrigation) to all geomorphic positions in the floodplain above the low flow channel. This alternative would create approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub, 18 acres of cottonwood-willow, and almost six acres of emergent marsh.

This alternative would maintain the low flow channel in an unplanted condition similar to the without-project condition. Lower channel terraces (those vegetated areas above the low flow channel but below the 2-year recurrence interval flow event) would be planted with a mixed shrub-scrub community, suitable for a mesoriparian regime, with supplemental water delivered by bank-mounted sprinklers. Upper channel terraces (those above the 2-year storm), natural and regraded banks and the historical floodplain would be planted to mixed riparian communities. Mesoriparian shrub would compose more than 50 percent of the planted community and irrigated to provide a mesoriparian hydrologic regime.

Water harvesting basins would be constructed in the channel at the confluence of tributaries with the main Santa Cruz channel at eight locations. These basins would support cottonwood-willow and emergent marsh vegetation with cottonwood-willow composing more than 50 percent of the community. Adequate water would be supplied through the maintenance of a hydroriparian hydrologic regime using supplemental discharges from buried irrigation pipes. Similarly, five grade control basins would be created in the Santa Cruz main channel using reinforced or newly constructed at-grade barriers to detain channel runoff. These basins, approximately one-acre in area each, would support emergent marsh vegetation.

Both the tributary basins and grade control basins are harvesting-basin features involving excavation in channel bottoms. Excavation would be to a depth of approximately four feet, with bottoms mechanically compacted to impede exfiltration. The excavated void would be filled with layers of appropriately sized boulders, cobbles, and gravel to create inter-particle interstices for water storage. This material would be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of pipe flood or subsurface drip irrigation to distribute water at specific locations.

Approximately 56,000 linear feet of overly-steep, highly eroded banks would be regraded to an approximate maximum of 5:1 horizontal to vertical ratio slopes and planted to improve channel stability. The graded reaches would be created by excavating historic floodplain, rather than be filling into the active channel. This would provide an ancillary effect of increased in-channel flood storage capacity. Approximately 3,700 linear feet of unstable, eroding slopes would be stabilized using conventional soil cement slope protection along selected reaches for which there would be insufficient distance from the active channel to the Project Area boundary to create a stable graded and vegetated slope.

For as long as the project would remain authorized, the non-Federal sponsor must provide sufficient water for construction, operation, and maintenance of the project.

Alternative 4F

This alternative would establish a low flow channel with intermittent flow, graded vegetated banks, soil amendment, surface grading, and construction of subsurface water-harvesting basins.

Implementation of these measures would allow creation of new vegetation as well as enhancement of existing cottonwood-willow, mesquite, scrub/shrub, and marsh. These planted areas would be irrigated.

Alternative 4F would have hydroriparian communities in the active channel. Implementation of this alternative would involve constructing a low flow channel that would convey intermittent flows through the entire length of the Santa Cruz River within the project boundaries. The existing low flow channel would require grading to create a new low flow channel averaging six feet in width and one-half foot in depth. The soil comprising the bed of the new low flow channel would be amended to accelerate formation of a near-surface water harvesting basin below the streambed. This feature would help direct infiltration losses from the intermittent flow laterally toward restored habitat areas to be created on either side of the channel.

Grading would also create depressional areas on each side of the low flow channel approximately ten feet in width where soil saturation conditions resulting from lateral percolation would support emergent marsh communities. A low terrace (first bench) varying in width from ten to twenty feet would be constructed adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.

Because of the conveyance impacts that would result from such a feature, hydroriparian terrace features are limited to the upper level terraces. This would include construction and planting of water harvesting basins at the confluences of 11 tributaries and permanent irrigation systems for all planted areas including the water harvesting basins. The water harvesting basin features would involve excavating in the area where tributaries would enter the terraces. Excavation would be to a depth of approximately four feet; and a liner membrane would be placed on prepared substrate. The excavated, membrane-covered void would be filled with layers of appropriately sized cobble and gravel to create large inter-particle interstices for water storage. This material would be covered with granular fill of decreasing particle diameter. Permanent irrigation would combine construction of feeder pipelines to move water through the Project Area with use of gated pipe flood or subsurface drip irrigation to distribute water at specific locations. In some cases, such as the tributary water harvesting basins, a simple outflow would be sufficient.

The reaches of steep natural banks would be modified by cutting back into the historic floodplain to create gentler and more stable slopes. The method of stabilization would be based on the distance to the Project Area boundary and a maximum slope gradient. Typically, banks would be re-constructed at a 5 foot horizontal to 1-foot vertical grade and revegetated. A different treatment would be used in areas where there is not enough land to create a 5:1 slope, but sufficient distance to the Project Area boundary exists to create slopes between 5:1 and 2:1. In those situations, the banks would be constructed as the minimum slope that can be accommodated and hardened as necessary to prevent further erosion and collapse. In areas where insufficient distance exists to accommodate 2:1 slopes, placement of rip rap or soil cement may be necessary for bank protection. Such engineering solutions would be designed on a case-by-case basis. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it would reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to washout.

This plan would produce 1,227 restored or enhanced acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow, and 59 acres of emergent marsh. For as long as the project would be authorized, the non-Federal sponsor must provide sufficient water for construction, operation, and maintenance of the project.

No Action

The Corps and local sponsor would not cooperatively implement restoration measures within the study area.

WITH PROJECT PROJECTION

Implementation of any one of the proposed alternatives would enhance and restore river flow, native vegetation communities, and wildlife habitat. The opportunity exists to provide habitat for a diversity of native wildlife species. The relative environmental output for each alternative was determined through the application of a model developed consistent with the Hydrogeomorphic (HGM) Approach to Wetland Assessment. The model was developed by an interagency team consisting of the Corps, Pima County Flood Control District, FWS, and AGFD. Environmental outputs are quantified and expressed as Functional Capacity Units (FCUs). A complete description of the HGM model and its development is described in the DEIS.

Alternative 2A

This alternative would produce a net gain of 402 average annual FCUs at a cost of $10,772 per unit. As described above, this plan would restore xeroriparian shrub, mesquite, and emergent marsh vegetation communities.

Alternative 3E

This alternative would produce a net gain of 454 average annual FCUs at a cost of $12,598 per unit. As described above, this alternative would restore mesquite, mesoriparian shrub-scrub, cottonwood-willow, and emergent marsh vegetation communities.

Alternative 4F

The plan would produce 519 average annual FCUs at a cost of $13,473 per unit. As described above, this alternative would restore cottonwood-willow, mesquite, scrub/shrub, and marsh vegetation communities.

WITHOUT PROJECT PROJECTION

In the absence of active restoration efforts, it is unlikely that biotic communities within this portion of the Santa Cruz River would improve beyond current conditions. The remaining vestiges of riparian and floodplain fringe habitat would likely disappear. Fragmented enclaves of native species would likely vanish, lowering abundance and diversity of native wildlife in the area. In addition, unstable river geomorphology would continue to prevail the Study Area.

DISCUSSION

We are pleased to participate in a project aimed at restoring native vegetation communities, particularly valuable riparian environments. The Paseo project represents a tremendous opportunity to restore native biotic communities within the project area and an opportunity to enhance existing biota on the Santa Cruz River system. We believe the most important aspect of 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, we support efforts focused on securing a permanent and sufficient source of water through water harvesting, stormwater retention, and use of effluent and/or groundwater for supplemental irrigation.

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 on for seed bed formation, seed dispersal, germination, seedling establishment, 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. Based on our review of the DEIS, these issues are already prominent considerations under evaluation.

The proposed project could eventually result in the establishment of habitats suitable for species listed as threatened and endangered or those that are candidates for listing. We encourage the local non-Federal sponsors to explore opportunities to develop Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans as appropriate to address future activities that may affect listed species. Such an effort would greatly facilitate operation and maintenance while providing conservation benefits to listed species. Based on the current condition of habitat and the nature of the project, a Safe Harbor Agreement may be the most appropriate.

Finally, in regard to the HGM model, though we support the process and outputs generated for this project, we encourage the Corps to work with the FWS and AGFD to evaluate opportunities to simplify the HGM methodology for future projects within Arizona.

RECOMMENDATIONS

1) Focus significant attention on identifying and, if necessary, securing a permanent and adequate source of water to support the desired biotic communities.

2) 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.

3) Encourage the local non-Federal sponsors to work with the FWS to evaluate the need for Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans.

4) Work with the FWS and AGFD on a programmatic basis to simplify the HGM methodology for future restoration within the state of Arizona.

We appreciate the opportunity to provide planning recommendations 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
Study Manager, Planning Branch, Army Corps of Engineers, Phoenix, AZ

W:\Mike Martinez\Paseo-rep.doc:cgg

14.2 Biological Evaluation

BIOLOGICAL EVALUATION

PASEO DE LAS IGLESIAS, SANTA CRUZ RIVER, ARIZONA

Prepared for

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT

Los Angeles District - Planning Section C

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Phoenix, AZ 85012-1939

and

PIMA COUNTY FLOOD CONTROL DISTRICT

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Tucson, Arizona 85701

Prepared by

SWCA ENVIRONMENTAL CONSULTANTS

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FEBRUARY 21, 2003

Executive Summary

The U.S. Army Corps of Engineers, Los Angeles District Planning Division, in cooperation with the Pima County (Arizona) Flood Control District, is studying an environmental restoration project called Paseo de las Iglesias along a seven-mile reach of the Santa Cruz River and adjacent lands within the City of Tucson and Pima County, Arizona. The study area is bounded on the north by Congress Street, on the south by Los Reales Road, on the east by Interstate Highway 10 and 19, and on the west by Mission Road, and totals approximately 5,005 acres. Within the study area are lands that are vacant and potentially available for restoration, comprising a total of approximately 1,200 acres depending upon alternative selected, hereinafter termed the project area.

The purpose of the project is to reduce recent and historic flood damage through environmental protection and restoration of natural, native riparian communities along the Santa Cruz River mainstem, related tributary washes, and vacant lands within the project area, while protecting against deterioration of natural and cultural resources. Incidental to this would be improvement of soil stability, reduction of erosion and lateral migration of the river, lessened potential water contamination from buried wastes, aesthetic improvements, and reduction of air pollution by dust through stabilization of soils.

Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, requires that Federal agencies ensure that their actions do not jeopardize listed or proposed species or designated or proposed critical habitats. This Biological Evaluation (BE) reviews the potential impacts of the proposed project to species that are currently listed or proposed for listing as threatened or endangered species by the U.S. Fish and Wildlife Service (USFWS). In addition, this BE considers the potential impacts of the project to species not afforded protection under the ESA but which are of concern to the USFWS, the Arizona Game and Fish Department, and Pima County. After reviewing the existing conditions in project area and the available information on the species discussed in this BE, it is the opinion of SWCA that formal Section 7 consultation with the USFWS is not necessary for this project.[1] Provided below are statements supporting this conclusion.

- No species currently listed, proposed, or a candidate for listing as threatened or endangered under the ESA is likely to occur within the project area. Also, there is no Critical Habitat for any such species within the project area.

- No adverse impacts (e.g., significant population reduction) to the species considered of special interest to Federal, state, and local agencies are likely to occur as a result of the proposed project. It is likely that some species of special interest would benefit from the creation of new habitat and improvement of existing habitat in the project area.

[1] U.S Fish and Wildlife Service. 1998. Final ESA Section 7 Consultation Handbook. P. 3-10: "A biological assessment is required if listed species or critical habitat may be present in the action area."

Introduction

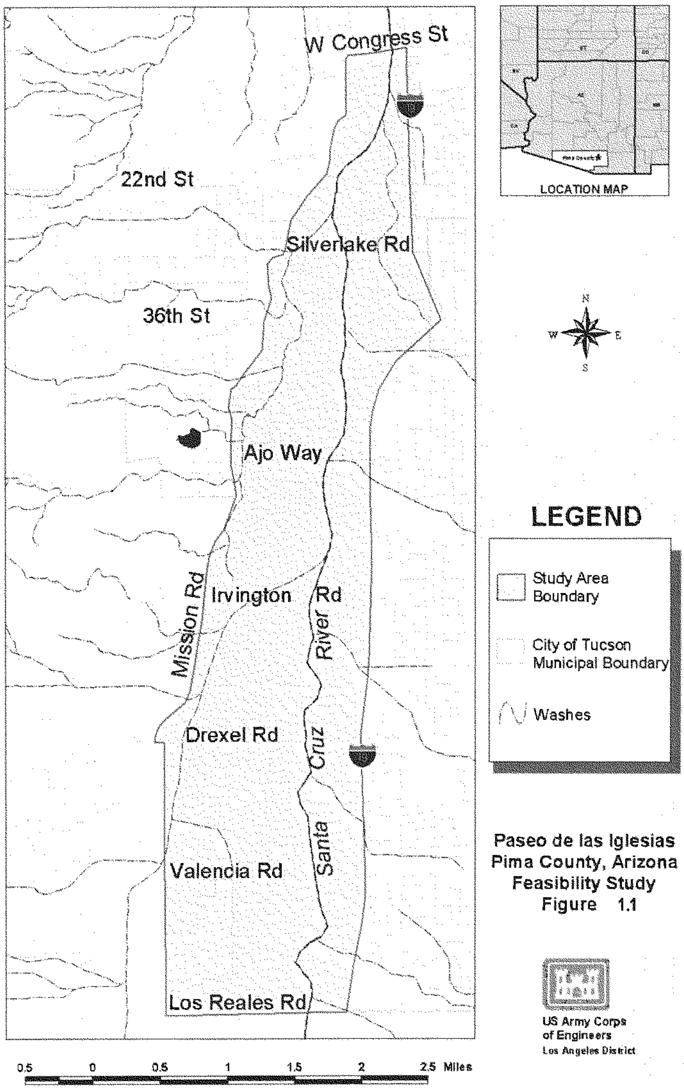
In 2001, Pima County entered into an agreement with the U.S. Army Corps of Engineers (USACE) to conduct a feasibility study for the Santa Cruz River, Paseo de las Iglesias, Arizona Project. The Pima County Department of Transportation and Flood Control District (PCFCD) is the non-Federal sponsor of the proposed project. Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, requires that Federal agencies ensure that their actions do not jeopardize listed or proposed species or adversely modify designated or proposed critical habitats. This Biological Evaluation (BE) reviews the potential impacts of the proposed project to species that are currently listed or proposed for listing as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS). In addition, this BE considers the potential impacts of the project to species not afforded protection under the ESA but which are of concern to the USFWS, the Arizona Game and Fish Department, and Pima County.

Study Area Description

The study area for this BE is a seven-mile reach of the Santa Cruz River and adjacent lands, totaling approximately 5,005 acres, in the Tucson Valley in south-central Arizona. More specifically, the study area consists of the Santa Cruz River Valley between Los Reales Road and Congress Street. Interstate Highways 10 and 19 define the eastern boundary of the study area and Mission Road the western boundary. These project area is located within portions of Sections 14, 22, 23, 26, 27, 34 and 35 of Township 14 South, Range 13 East, and Sections 2, 3, 10, 11, 14, and 15 of Township 15 South, Range 13 East (Figure 1). Within the study area, a project area has been defined to encompass currently vacant lands totally approximately 1,200 acres. These lands are potentially available for restoration, and are collectively termed the Paseo de la Iglesias project (PDLIP) area (Figure 1). The principal land ownerin the area is the City of Tucson.

The study area is located within the Tucson Basin in the Sonoran Desert subprovince of the Basin and Range physiographic province. Elevation in the study area ranges from approximately 2,500 feet above sea level at the southern end to approximately 2,340 feet at the northern, downstream end. The study area consists primarily of developed urban and vacant lands on both sides of a frequently disturbed, deeply entrenched, ephemeral riverbed. Urban development and intensive alteration of natural landscapes have effectively isolated the river channel from natural communities. Historically, all but a few isolated sites within the floodplain were cultivated farmland. In addition to agricultural fields, disturbances include channel bank erosion, adjacent urban development, landfills, off-road vehicle use, equestrian use, soil stabilization structures, wildcat dumping, and transient camps. There are no longer any aquatic or broad-leaf riparian communities present in the study area. Mesquite (*Prosopis velutina*) woodlands are currently represented by diminished, isolated pockets. Non-native plant species, including saltcedar (*Tamarix ramosissima*) and Athel tamarisk (*Tamarix aphylla*), have replaced most of the native cottonwood and willow riparian communities.

Figure 1. Location of the Paseo de las Iglesias Project study area and project area.



Project Description

The proposed action is the restoration of a reach of the Santa Cruz River and adjacent lands to achieve natural habitats and associated functions and values, and potential incidental flood protection benefits. Because the National Environmental Policy Act (NEPA) requires that agencies integrate the NEPA process into their activities at the earliest possible time, this BE was initiated during the early project planning stages. Thus, a final design has not yet been selected, and conceptual designs described herein are based on preliminary information that would be refined during the planning process. Modifications in the design are likely as the study progresses based on detailed engineering, cost evaluations, and environmental considerations, but the fundamental features identified at this stage of the project and the footprint for their construction should remain essentially the same.

The proposed project entails:

- Restoration of native vegetation on severely degraded or denuded lands by planting native trees, shrubs, grasses, and forbs; providing irrigation; and monitoring during the vegetation establishment period (approximately two to five years).

- Stabilization of eroding unprotected river banks by a combination of grading to create gradually sloping banks, planting with native vegetation, and bank protection with soil cement where other methods are impractical.

- Restoration, improvement, or creation of wildlife habitats in riparian areas that have suffered loss or degradation of natural conditions within the project area.

METHODS

SWCA Environmental Consultants (SWCA) was contracted by David Miller and Associates, Inc. (DMA) to complete a Biological Evaluation (BE) for the study area and proposed alternatives as part of the preliminary draft feasibility report of the USACE project planning process. During the development of the without-project conditions report, SWCA served as a subcontractor to TetraTech, Inc., and prepared a Biological Resources Report. Field observations that were conducted during the development of the without-project conditions are incorporated into this BE. SWCA scientists conducted multiple field reconnaissance visits to the study area between 14 June 2001 and 22 January 2003 to collect information on current conditions of vegetation and wildlife resources and evaluate project area characteristics, including topography, geologic features, and soils. Site photographs were taken to document habitat types and site conditions, and lists were recorded of all plant and animal species identified in the study area.

As standard practice in the preparation of BEs, and to assist project proponents in compliance with the Endangered Species Act and Fish and Wildlife Coordination Act, SWCA contacted the U.S. Fish and Wildlife Service (USFWS) and Arizona Game and Fish Department (AGFD) to request their input regarding specific concerns and records of occurrence of special status species in the project area. Typically, USFWS responds with a form letter directing the inquirer to obtain from the USFWS website a list of species for the county in question, and AGFD responds with information from the Heritage Data Management System (HDMS) listing species records from a three-mile radius of the study area. Coordination letters and agency responses are included in Appendix 14.1.

A qualified SWCA biologist (Dr. Kenneth J. Kingsley) reviewed the Pima County list of threatened and endangered available from the USFWS, the list provided by AGFD, and the Pima County Priority Vulnerable Species list in order to evaluate the likelihood of occurrence of each species within the study area. He also personally examined, by pedestrian survey, the entire reach of the Santa Cruz River within the study area, including the West Branch, and all vacant land that could be accessed without trespassing. Maps included in a technical report produced for the Sonoran Desert Conservation Plan (SDCP), which is being developed by Pima County (RECON, 2001), were used to assist in the determination of the probability of occurrence for PVS within the project area. These maps provide the results of GIS habitat modeling of potential habitat, known locations, and expert-defined priority conservation areas.

Vegetation was classified according to Brown (1980, 1994) and Harris et al. (1982). Plant nomenclature in this report is generally based upon the U.S. Department of Agriculture National Resource Conservation Service Plants Database (http://plants.usda.gov/). A combination of aerial photogrametry and field reconnaissance was used to delineate vegetation communities. Vegetation community size was calculated using Arcview 3.2.

Results

Current Project Area Conditions

The study area currently supports six distinct vegetation communities, which are described below. These communities are listed in Table 1 and their locations illustrated in Figure 2. Urban lands, which are a subset of Cultivated and Cultured Uplands, make up the largest percentage of the study area (60.8%) and are characterized by residential, commercial, and industrial uses. Sonoran Vacant or Fallow Lands, another subset of Cultivated and Cultured Uplands, are second in importance (17.6%). Less than 20 percent of the study area is uncultivated/uncultured habitat. Table 1 provides a summary of the amount of each vegetation type in the study area, and Figure 2 illustrates the arrangement of these vegetation types within the study area in December 2002.

Within the study area, approximately 1,200 acres of vacant land were selected as the project area. Since the ultimate size of the project area depends on the alternative selected, the entire study area is considered in this document. Potential project area land includes Sonoran Vacant and

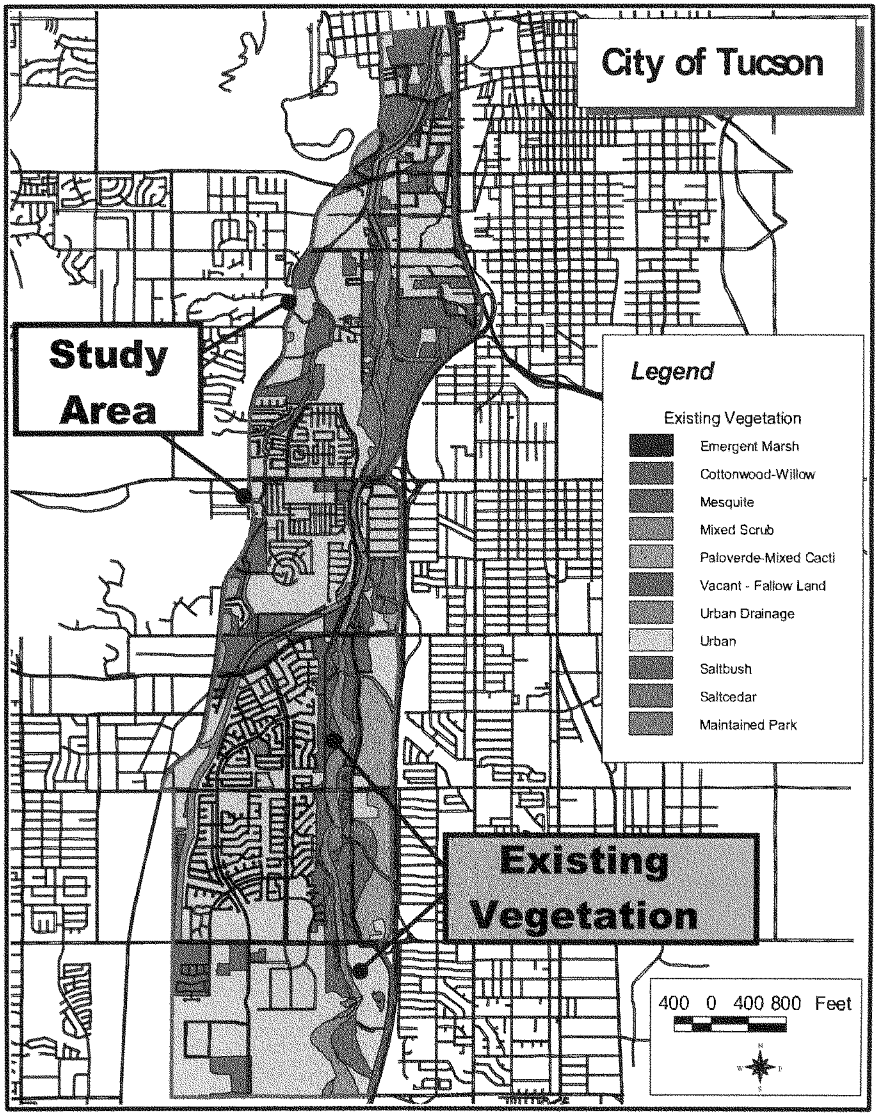
Fallow Lands, Sonoran Interior Strand, urban drainage, Sonoran Deciduous Riparian Scrub (Saltcedar Disclimax), and Sonoran Riparian Deciduous Forest and Woodlands (Mesquite Series). Potential project area lands were selected on the basis of availability, existing disturbance, proximity to the Santa Cruz River, and absence of permanent structures.

Table 1. Vegetation Communities in the Paseo de las Iglesias Study Area, December 2002

BLP* Code	Vegetation Classification to Series Level	Acres in Study Area	% of Study Area
154.1 Sonoran Desertscrub Biome			
154.12	Paloverde-Mixed Cacti Series	237	4.7
154.17	Saltbush Series	96	1.9
224.5 Sonoran Riparian Deciduous Forest and Woodlands Biome			
224.52	Mesquite Series (includes 234.71 Mixed Scrub Series of Sonoran Deciduous Riparian Scrub Biome)	160	3.2
234.7 Sonoran Deciduous Riparian Scrub Biome			
234.72	Saltcedar Disclimax Series	87	1.7
254.7 Sonoran Interior Strand Biome			
254.71	Mixed Shrub Series	261	5.2
300 Cultivated and Cultured Uplands			
314.1	Urban: Residential, commercial, and industrial	3045	60.8
314.15	Recreational (=maintained park)	86	1.7
364.1	Sonoran Vacant or Fallow lands	934	18.7
400 Cultivated and Cultured			
414.12	Urban Drainage	99	2.0
Total Study Area		5005	100

* Brown 1980, 1994

Figure 2. Mapped Vegetation Communities Within the PDLI Study Area.



Sonoran Desertscrub

Sonoran Desertscrub is the characteristic upland biome of the study region, and represents 6.6 percent of the study area. This biome is typified by open to dense stands of drought and heat tolerant deciduous trees and shrubs that have small leaves and often have thorns. Vegetation density and diversity is often related to local edaphic conditions. Within the study area, the characteristic vegetation is dominated either by creosote bush (*Larrea tridentata*) on gravely soils or fourwing saltbush (*Atriplex canescens*) on silty soils. This biome forms two distinctive vegetation series in the study area: the Paloverde-Mixed Cacti Series (in this case, primarily creosote bush), which represents approximately 4.7 percent of the study area, and the Saltbush Series, which comprises approximately 1.9 percent of the study area. Within the study area, this community is distributed as isolated outcrops between roads and developed areas, which eliminates habitat connectivity and usefulness for species that have difficulty dispersing across such barriers. Due to the high fragmentation and repeated alterations of these habitats, each series is highly variable in terms of the individual species that are dominant within any given area. Along drainages, vegetation usually forms more-or-less continuous corridors, consisting of velvet mesquite, blue paloverde (*Parkinsonia florida*), and catclaw acacia (*Acacia greggii*). Water is seldom present in drainages, except briefly following rain. These drainages usually have braided channels that can be substantially rearranged with surface flow events. Within the study area, most of the drainages have been highly modified by human activities.

Sonoran Riparian Deciduous Forest and Woodland

This riparian community is typically encountered along perennial or seasonally intermittent drainageways and springs, where the trees are able to tap shallow subsurface water. If trees are typically greater than 30 ft (10 meters) tall, the biome is considered Forest; when they are less than 30 ft tall, it is considered Woodland. In the study area, two major community types were originally present: Cottonwood-willow (*Populus fremontii-Salix gooddingii*) and Mesquite. The natural cottonwood-willow community was entirely eliminated many decades ago. A few small cottonwood patches remain, several no more than one isolated tree in size, depend on unusual groundwater conditions. Two larger patches entirely dependent on anthropogenic water from a gravel washing operation were present at the south end of the study area. However, these patches were eliminated when the operation was recently closed.

Mesquite-dominated communities were formerly adjacent to cottonwood-willow forests but farther from the general stream course. Historically these were generally restricted to perennial or near perennial streams and springs at elevations below about 3,600 ft (1100 m), and surrounded by Sonoran Desertscrub communities. In the study area, some mesquite remains as structurally diverse stands of velvet mesquite that range from open to dense. Some of these trees are relatively large, but do not reach the stature of the forests that existed pre-settlement. They are not regenerating because the water table has dropped beyond the level necessary to sustain growth of young trees to large stature, or to sustain large old trees. Currently, approximately 160 acres of mesquite (3.2 percent of the study area) remain. The best remaining examples of this community consist of a small patch across Santa Cruz Road from Pima Community College Desert Vista Campus, the West Branch from Ajo Road to Silverlake Road (Rosen, 2001), and portions of Julian Wash between Silverlake Road and 20th Street. Other drainages within the study area have largely been denuded of mesquite, or mesquite have been so reduced in number that the area no longer resembles the original mesquite community. Other plant species commonly present in this series include catclaw acacia and blue paloverde, pitseed goosefoot (*Chenopodium berlanderi*), lotebush (*Zizyphus obtusifolia*), and fourwing saltbush and various species of forbs, grasses, and vines.

Sonoran Deciduous Riparian Scrub

Currently, this community type is limited to the natural communities adjacent to washes, and a depauperate, early seral community within the river bottom that is maintained by infrequent flooding and limited water availability. In the study area, the naturally occurring xeroriparian portions of this community are included in the Mesquite Series description above because they include the same species and are intergraded with the Mesquite Forest and Woodland that once was present in the study area.

The other series within the Sonoran Deciduous Riparian Scrub Biome is the Saltcedar Disclimax Series of the river bottom and benches between banks. This community has limited structural diversity and is dominated by plant species that are adapted to xeric conditions including several non-native invasive species. Athel tamarisk and saltcedar dominate this series and form open to dense stands. Other species present include Bermudagrass (*Cynodon dactylon*), camphorweed (*Heterotheca subaxillaris*), western tansymustard (*Descurania pinnata*), and Jerusalem thorn (*Parkinsonia aculeata*). This series has largely filled the area formerly vegetated by Sonoran Riparian Deciduous Forest and Woodland. Typically, trees in this community are less than 20 feet tall and are regularly subjected to intensive flood events. If more water was consistently available, and flooding was less severe, this community would most likely succeed to a forest or woodland community. This community represents approximately 1.7 percent of the study area. This community is impacted by transient camps, which are established in the shelter and shade of the stands of vegetation. This use may disturb wildlife and has resulted in wildfires.

Sonoran Interior Strand

This community is found within river and wash channels that are subject to seasonal flooding and scouring. Strand habitats typically include sparsely distributed clusters of vegetation that are separated by areas devoid of vegetation. Vegetation is primarily a mixture of shrubs, and this community is also classified as mixed shrub. Soils are typically sand and gravel, with small silt deposits and very low organic content. Common species in this community include many that are also associated with scrubland communities, such as singlewhorl burrobrush (*Hymenoclea monogyra*), desert broom (*Baccharis sarothroides*), and several others. Many of the species that make up the vegetative community are annuals, short-lived perennials, and invasive species, such as Adonis blazingstar (*Mentzelia multiflora*), camphorweed, Canadian horseweed (*Conyza* *canadensis*), common sunflower (*Helianthus annuus*), desert horsepurselane (*Trianthema porulacastrum*), western tansymustard, and buffelgrass (*Pennisetum ciliare*). All of these are characterized by rapid growth, prolific seed production, and short life spans. This community comprises about 5.2 percent of the study area. It is subject to frequent disturbance by flood events, as well as by vehicle and horse traffic.

Cultivated and Cultured Uplands

This community is a broad category that is characterized by recent or active human presence in which most of the native vegetation has been removed or subjugated. Non-native landscaping plants are an important, if not the sole, component of the vegetation. This category includes human dwellings, buildings, landscaped recreation areas, agricultural areas, and similar anthropogenic features. Based on ecological and aesthetic characteristics, this general community can be divided into several different subdivisions that are equivalent to the series levels mapped by Brown, Lowe and Pase (Brown 1980). The following series of cultivated and cultured upland community types are present in the study area.

Recreational Lands (i.e., Maintained Park)

A wide array of vegetation types composes this classification. Both structural diversity and density are highly varied. These areas range from predominantly nonnative landscaped trees and shrubs in park-like atmospheres to virtually natural settings that are actively maintained. Common plants include olive (*Olea europaea*), gum (*Eucalyptus* sp.), Goodding's willow, netleaf hackberry (*Celtis laevigata* var. *reticulata*), Chinaberrytree (*Melea azederach*), sand dropseed (*Sporobolus cryptandrus*), tuna cactus (*Opuntia ficus-indica*), desert marigold (*Baileya multiradiata*), European fan palm (*Chamaerops humilus*), velvet ash (*Fraxinus velutina*), Florida hopbush (*Dodonea viscosa*), wild oat (*Avena fatua*), goldenhills (*Encelia farinosa*), velvet mesquite, creosote bush and whitethorn acacia (*Acacia constricta*). Buffelgrass, fountain grass (*Pennisetum setaceum*), and Bermudagrass have invaded portions of the maintained park. Because of high variation in vegetation composition, structure, and density, and the occasional availability of water, several animal species utilize the maintained park. Thirty-two species of birds were observed. None of the bridges that occur in the maintained park were observed to be utilized by wildlife. At least one burrowing owl was utilizing a nest box, which is in the Santa Cruz River Park. Recreational lands comprise approximately 1.7 percent of the study area. This includes portions of the Santa Cruz River Park within the study area, and two small urban parks. Invasive non-native plants are increasing along walkways and in irrigation wells. Most of the recently planted trees are native mesquites or cottonwoods, although some of the mesquites appear to be non-native or hybrids. These lands are very heavily utilized by people, and as such harbor only those wildlife species that have high tolerance for people.

Urban: Residential, Commercial, and Industrial

These lands are actively occupied and/or currently used properties in which the vegetation is largely the result of ongoing human activities. They have been divided along a gradient that generally follows degree of impact to vegetation and wildlife into the following categories: industrial, commercial, heavy residential, and light residential (Brown 1980), but these categories are not separated in this document. Horse properties and small agricultural fields around houses are included in this classification. Much of this land has been developed into buildings, homes, horse properties, and parking lots and is essentially devoid of native vegetation. Where vegetation does occur, it is usually sparse and locally disjunct. Impervious materials make up a large proportion of the land cover. Common species include velvet mesquite, burroweed (*Isocoma tenuisecta*), Jerusalem thorn, prickly Russian thistle (*Salsola tragus*), native and nonnative grasses and numerous ornamentals and cultivars. A large stand of fan palms of an undetermined species is present at one trailer park, and may provide roosting habitat for western yellow bats, which are a Priority Vulnerable Species in Pima County. Some native wildlife species have adapted to the range of conditions present in this community. Some people provide water and feeders for birds, which encourages seed feeding species and hummingbirds. Much higher diversity of native wildlife occurs in light residential areas where some native vegetation has been left in place, than in heavy residential, commercial, or industrial areas. Introduced rock doves and house sparrows are present, as well as domestic chickens, ducks, peacocks, horses, cattle, dogs, and cats. This series comprises approximately 60.8 percent of the study area. Conditions with regard to wildlife and native plant species are extremely variable within this community, but there is a general loss of habitat and native species.

Sonoran Vacant or Fallow Land

This community consists of agricultural lands that are fallow or in the early stages of abandonment, and vacant lots within the urban setting. Plants commonly established here include velvet mesquite, (mostly resprouted from cut stumps), Jerusalem thorn, Athel tamarisk, burroweed, fiddleneck (*Amsinckia sp.*), globemallow (*Spharalcea* spp.), prickly Russian thistle, silverleaf nightshade (*Solanum eleagnifolum*), western tansymustard, shaggyfruit pepperweed (*Lepidium lasiocarpum*), and several species of grasses, mostly non-native. In general these lands are currently of low to moderate value to wildlife. This community comprises approximately 18.7 percent of the study area. It includes fallow agricultural fields, closed landfills, inactive gravel pits, and other areas that have been recently disturbed but are not currently receiving constant use. Most of these lands are owned by the City of Tucson or Pima County. Historically, these lands were part of the upper terrace and/or floodplains of the Santa Cruz River. During the 1950's and 1960's most of these areas were retired from agriculture. Some areas adjacent to the current channel were used for landfills (see Phase 1 Environmental Site Assessment for the Paseo de las Iglesias, Pima County, Arizona, SWCA. Inc., 2002). Wildcat dumping and woodcutting continues on these lands today (U.S. Army Corps of Engineers, 1999). Most perennial vegetation has been removed, and little annual vegetation is present. Buffelgrass and fountaingrass have invaded this community, and prickly Russian thistle is the dominant species in some small patches. Because of the absence of seeds and soil nutrients caused by mechanical soil disturbance, combined with packing of soil by machinery, most of the soil is barren or vegetated only by invasive, shallow-rooted plants. It would require many decades or centuries for natural processes to restore these lands to native vegetation. Most of the project area lands are vacant or fallow land.

Cultivated and Cultured Wetlands

This is a general category describing wetlands that are cultivated, cultured, or otherwise depended upon anthropogenic water sources. It includes artificial ponds and marshes, and urban drainages that have cement-lined banks and little or no native vegetation, and areas of riparian vegetation dependent entirely upon anthropogenic water sources. There is no natural water source within the study area, and no remaining natural wetlands in good condition, because the water table has dropped beyond the reach of plant roots. The only portion of the study area with wetlands is within or adjacent to a sand and gravel processing plant, where water used for washing materials forms a pond with emergent vegetation and riparian trees. That processing plant was active when reconnaissance for this BA was conducted, but has since terminated and the wetland is drying. It will be entirely gone by the time the proposed project begins construction. Therefore, the only type of cultured wetland to be discussed here is Urban Drainage.

Urban Drainage

Urban drainages may have originally been natural washes, but they have had mechanical destruction of natural conditions including bank stabilization structures and channel modification for integration into the city's floodwater drainage system. Some are entirely artificial in origin. They now contain non-native invasive species and escaped cultivars, along with varying amounts of remnant or re-established native xeroriparian vegetation. Vegetation cover ranges from barren to fairly dense, and structural diversity ranges from low to high. Common species include Jerusalem thorn, camphorweed, sunflower, Bermudagrass, red brome, mesquite, rough cocklebur, African sumac, desert broom, and desert willow. Some wildlife species have adapted to utilize this community. Most of those were present within the remnants of native riparian, strand, and xeroriparian communities. Fifteen species of birds were observed along urban drainages, including Abert's towhee, a Priority Vulnerable Species in Pima County. Mammals observed included rock squirrels and desert cottontails. Reptiles observed include the tree lizard, western whiptail, and desert spiny lizard. These drainages convey urban runoff and gray water, and they are subject to multiple impacts resulting from flooding, maintenance, camping, trash dumping, and vandalism.

Special Status Species

A special status species is defined herein as any species of expressed specific interest to any regulatory or management agency of the Federal, State or local government. These include species listed by the U.S. Fish and Wildlife Service as Threatened, Endangered, or Candidate species, and species designated as Wildlife Species of Special Concern In Arizona (WSCA) by the Arizona Game and Fish Department. In addition, species currently included as Priority Vulnerable Species (PVS) in Pima County's Sonoran Desert Conservation Plan are considered. PVS are those 55 species that Pima County has determined are at risk or have been extirpated but have potential to be reintroduced within the county. Consideration of these is included because the County is the non-

Federal sponsor of the proposed project and County projects are required by County policy to consider impacts to PVS. Table 2 lists the special status species considered in this document, and includes information on characteristics of habitats in which they may occur, and an evaluation of the likelihood of their occurrence in the study area. The order in which species are listed is as follows: general taxonomic group (plants, animals, invertebrates, fish, amphibians, reptiles, birds, mammals) followed by status (Federal endangered, threatened, proposed, candidate, species of concern, state status, and county status). Where several species have the same status within a taxonomic group, they are listed in alphabetical order.

There is no designated or proposed critical habitat within the project area, so no designated or proposed critical habitat would be adversely modified by the proposed project in any of the alternatives. Four Federally-listed or candidate species are considered as possibly occurring within the general area, and are discussed in greater detail following Table 2. None of these are likely to occur in the project area or be adversely impacted by the proposed project. In addition 12 PVS were determined to have potential to occur within the study area and are discussed in detail following the table. It is important to note, however, that none of these PVS species are currently protected under the authority of the Endangered Species Act. It is possible that restoration of vegetation and erosion control in areas that are currently barren or nearly so would adversely impact a few burrowing owls, which depend on barren land and gullies. Such adverse impacts are not likely to impact more than approximately three nesting pairs of burrowing owls, and this is not likely to result in adverse impacts to the species population that might lead to the necessity to list the species as endangered. Specific precautions can be followed so as to not disrupt nesting owls, and to provide suitable replacement nest sites for them as part of the project. It is highly unlikely that any of the alternatives would result in adverse impacts to any other special status species.

Table 2. Special Status Species Considered in the Paseo de las Iglesias Study Area

Status Definitions: USFWS E=Endangered, USFWS T=Threatened, USFWS P=Proposed Threatened or Endangered, USFWS C=Candidate for listing, USFWS CA= Conservation Agreement; USFWS SOC= Species of Concern; WSCA= Wildlife of Special Concern in Arizona; PVS= Priority Vulnerable Species in Pima County.

Species	Status	Range and Habitat Requirements	Likelihood of Occurrence
PLANTS			
Kearney's Blue Star (*Amsonia kearneyana*)	USFWS-E	Known only from a few locations in the Baboquivari Mountains at 3,600-3,800 feet with Arizona walnut, Mexican blue oak, and velvet mesquite.	Unlikely to occur. The study area is distant from the nearest known population, below the elevation range, and plant communities in the study area do not resemble those occupied by this species.
Huachuca Water Umbel (*Lilaeopsis schaffneriana* ssp. *recurva*)	USFWS-E PVS	A semi-aquatic plant (requiring permanent water) that inhabits springs, cienegas, and drainage systems in southeastern Arizona. Historically, this species was documented within the Santa Cruz River near Tucson, but that population was extirpated when the River dried. Critical habitat has been designated for this species, but none in Pima County.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No permanent water is present. There have been no recent records in the Santa Cruz River and conditions are no longer suitable for it.
Nichol's Turk's Head Cactus (*Echinocactus horizonthalonius* var. *nicholii*)	USFWS-E PVS	Known only from a very small area between 2,400-4,100 feet on dissected alluvial fans at the foot of limestone mountains or on limestone mountainsides.	Unlikely to occur. PVS indicate no potential habitat for the study area. The study area is distant from the known range of the species and there are no limestone substrates in the study area.

Pima Pineapple Cactus (*Coryphantha scheeri* var. *robustispina*)	USFWS-E PVS	The entire range is south of Tucson, between the Santa Rita and Baboquivari Mountains, where it occurs at elevations between 2,300 and 4,500 feet. Most of the known locations are in the Altar and Avra Valleys, Santa Cruz River Basin, and the alluvial fans of the Sierrita, Santa Rita, Empire, Coyote, and Pajarito Mountains.	Unlikely to occur. PVS maps indicate some of the study area may be high potential habitat. According to HDMS, this species has been recorded within three miles of the study area. The southern end of the study area is within the species' known geographic range, but because the entire study area is highly disturbed, the presence of the species is unlikely. None were found during field reconnaissance.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Acuña Cactus (*Echinomastus erectrocentrus* var. *acunensis*)	USFWS-C PVS	Inhabits Arizona Upland Subdivision of the Sonoran Desertscrub on well-drained knolls and gravel ridges at elevations between 1,300 to 2,000 feet. In 1992, known to occur in only two Arizona locations, near Organ Pipe Cactus National Monument and near Florence.	Unlikely to occur. PVS maps indicate low to medium potential habitat for the study area. Though the study area has Desertscrub vegetation, it is distant from known geographic range and populations.
Gooddings Onion (*Allium gooddingii*)	USFWS-CA	This species occurs in forested drainage bottoms and on moist north facing slopes of mixed conifer and spruce forest at elevations above 7,500 feet.	Unlikely to occur. The study area is well below the elevation range of this species and vegetation communities and substrates in the study area are not similar to those that this species inhabits.
Gentry Indigobush (*Dalea tentaculoides*)	USFWS-SOC PVS	Not currently known from Pima County, but unknown populations may occur in rocky canyon bottoms that are not grazed. Currently known only in Sycamore Canyon drainage in the Atascosa Mountains, Pajarito Mountains, Santa Cruz County, and Baboquivari Mountains.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is well below the elevation range this species and vegetation communities and substrates in the study area are not similar to those that the species inhabits.
Needle-spined Pineapple Cactus (*Echinomastus erectocentrus erectocentrus*)	USFWS-SOC PVS	Pima County encompasses much of the known range of this cactus variety with all records from southeast of Tucson. Occurs in Sonoran Desertscrub and Semidesert Grassland vegetation communities where it is found on alluvial fans and hills generally from 3,000 to 4,600 feet.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from known populations, lower in elevation, and substrates in the study area are not similar to those at locations known to support this species.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Tumamoc Globeberry (*Tumamoca macdougalii*)	USFWS-Delisted in 1993 PVS	The range of this plant covers some 31,000 square miles of Sonoran Desert from Sonora, Mexico to Tucson, Arizona, west to Organ Pipe Cactus National Monument and north to Pinal County, Arizona. In Tucson, found on hot, dry, south facing slopes of basalt and along desert washes. The largest population is found in creosotebush desertscrub on gravelly loams primarily derived from weathered granites.	May occur. PVS maps indicate low to medium potential habitat for the study area. According to HDMS, this species has been recorded within three miles of the study area. Although no individuals were observed during field visits, potential habitat was identified in the mesquite series of the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
ANIMALS			
INVERTEBRATES			
Arkenstone Cave Pseudoscorpion (*Albiorix anopthalmus*)	PVS	Known from only one cave (Arkenstone Cave) in Colossal Cave Park east of Tucson.	Unlikely to occur. PVS maps of modeled potential habitat are not available for this species. The study area is distant from the one known location.
Talus Snails (*Sonorella* spp.) (15 taxa)	USFWS-CA (one taxon only-*S. eremita*) PVS-all 15 taxa	All 15 taxa occur on steep, talus slopes (generally or exclusively of limestone) in isolated, undisturbed areas in mountains or hills.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area contains no known locations and landscape features are not similar to those at locations where these snails are known to occur.
FISH			
Desert Pupfish (*Cyprinodon macularius*)	USFWS-E WSCA PVS	Species historically present in the Santa Cruz River, but is considered extirpated.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No natural permanent aquatic habitat is present in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Gila Topminnow (*Poeciliopsis occidentalis occidentalis*)	USFWS-E WSCA PVS	In Arizona, most of the remaining populations occur in the upper Santa Cruz River system, Sonoita Creek, and Cienega Creek, and the middle Gila River.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No natural permanent aquatic habitat is present in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Loach Minnow (*Tiaroga cobitis*)	USFWS-T WSCA	Currently known populations are found in the upper Gila, San Francisco, Blue, Tularosa, and White rivers, as well as Aravaipa, Eagle, Campbell Blue, and Dry Blue creeks. A population was found in the Black River in 1996.	Unlikely to occur. No natural permanent aquatic habitat is present in the study area and suitable habitat is no longer present. This species is not known from Pima County, and there are no records from the Santa Cruz River.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Spikedace (*Meda fulgida*)	USFWS-T WSCA	In Arizona, populations are found in Aravaipa Creek, Eagle Creek, and a portion of the upper Verde River. Undiscovered populations may exit in unsampled Gila basin streams.	Unlikely to occur. No natural permanent aquatic habitat is present in the study area and suitable habitat is no longer present. This species is not known from Pima County, and there are no records from the Santa Cruz River.
Gila Chub (*Gila intermedia*)	USFWS-C WSCA PVS	The Gila chub is currently known from the following drainages: Santa Cruz River (Cienega Creek, Sabino Canyon, Sheehy Spring), middle Gila River, San Pedro River, Agua Fria River, and Verde River.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. No natural permanent aquatic habitat is present in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Desert Sucker (*Catostomus =Pantosteus clarkii*)	USFWS-SOC PVS	Historically this fish occurred in the Santa Cruz River. Occurs in the lower Colorado River downstream from the Grand Canyon, generally including tributary streams of the Gila River drainage upstream of Gila, Arizona. Has been recorded in Aravaipa Creek.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no natural permanent surface water in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Longfin Dace (*Agosia chrysogaster*)	USFWS-SOC PVS	Historically found throughout Arizona. Currently found in a broad area as disjunct populations. In Pima County, found in Cienega Creek in Springwater Canyon and in Buehman Canyon.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no natural permanent surface water in the study area. Historically this species occurred within the study area, but there have been no recent records and suitable habitat is no longer present.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Sonora Sucker (*Catostomus insignis*)	USFWS-SOC PVS	Historically this fish occurred in the Santa Cruz River. Native to the Gila and San Francisco drainages; widespread in the Gila and Bill Williams river basins.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no natural permanent surface water in the study area. Historically this species occurred within the study area, but there have been no recent records and conditions are no longer suitable for it.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
AMPHIBIANS AND REPTILES			
Chiricahua Leopard frog (*Rana chiricahuensis*)	USFWS-T WSCA PVS	This species typically occurs in a wide variety of permanent aquatic habitats in deserts, grasslands, chaparral, and oak woodlands.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. There is no permanent or long-lasting surface water in the study area. Suitable habitat is no longer present.
Lowland Leopard Frog (*Rana yavapaiensis*)	USFWS-SOC WSCA PVS	Occurs in south central, central, west central, and extreme northwestern Arizona, south and west of the Mogollon Rim. Recently found in 5 canyons in the Rincon Mountain District of Saguaro National Park in Pima County. Known from approximately 10-20 eastern Pima County sites.	Unlikely to occur. PVS maps indicate the study area is a Priority Conservation Area due to the potential for restoration or enhancement. There is no permanent or long-lasting surface water in the study area. Historically this species probably occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Sonoyta Mud Turtle (*Kinosternon sonoriense longifemorale*)	USFWS-C	The only known population of this species is from Quitobaquito Springs in Organ Pipe Cactus National Monument at 1,100 feet.	Unlikely to occur. There is no permanent or long-lasting surface water in the study area. Suitable habitat is not present and the study area is distant from the only known population.
Desert Box Turtle (*Terrapene ornata luteola*)	PVS	In Arizona, occurs in the southern portion of the state from the New Mexico border to the eastern base of the Baboquivari Mountains at elevations ranging from sea level to 6,600 feet. Has been observed in grasslands of the Empire-Cienega Resource Conservation Area and in the valley of the Santa Cruz River near Sahuarita. Primarily a prairie turtle that inhabits arid and semi-arid treeless plains and rolling grass and shrub lands where soils are sandy.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. Historical records exist for this species, and some suitable habitat may remain along the West Branch, but no individuals were reported by Rosen (2001).. Current habitat conditions are not suitable for this species in most of the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Sonoran Desert Tortoise (*Gopherus agassizi*)	USFWS-SOC WSCA	In Arizona, this species is generally found in rocky areas or along steep-sided washes in generally rocky areas, where it takes shelter under rocks or in small caves.	Possibly may occur within the study area, or nearby, and may occasionally traverse the project area, but the project area does not resemble habitat in which this species regularly occurs.
Giant Spotted Whiptail (*Cnemidophorus burti stictogrammus*)	USFWS-SOC PVS	In Pima County, this species has been recorded in the Santa Catalina, Santa Rita, and Baboquivari Mountains. Formerly common in Sabino Canyon. Extirpated from most of the Santa Cruz River valley. Inhabits mountain canyons, arroyos, and mesas, entering lowland desert along stream courses and riparian areas.	Known to occur. PVS maps indicate low potential habitat for the study area, and designates much of the study area as a Priority Conservation Area due to populations that must be within the reserve system. Documented within the West Branch (Rosen, 2001). This species was formerly found throughout much of the study area. It is possible that remnant populations may also occur in other isolated patches of mesquite.
Red-backed Whiptail (*Cnemidophorus burti xanthonotus*)	USFWS-SOC PVS	The entire range of this subspecies includes the southwest-central border of Arizona in Pima County and northern Sonora. In Pima County, known primarily from the Ajo Mountains at Organ Pipe Cactus National Monument.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from the known range.
Ground Snake (*Sonora semiannulata*)	PVS	In Pima County, small numbers occur in many small populations on the Tohono O'odham Nation, its eastern border between Marana and Eloy, and rarely around Tucson. Inhabits plains, valleys, and foothill habitats; found mostly near mountains with higher slopes.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. Landscape and terrain in the study area is not similar to that which the species inhabits.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Mexican Garter Snake (*Thamnophis eques megalops*)	USFWS-SOC WSCA PVS	In Pima County, currently known only from Cienega Creek; extirpated from the Santa Cruz and Rillito rivers, and Tanque Verde and Pantano washes in the Tucson area. Inhabits areas of permanent water with lush vegetation at elevations ranging from approximately 1,700 to 6,200 feet.	Unlikely to occur. PVS maps indicate low potential habitat for the study area, but also delineates much of the study area as a Priority Conservation Area due to critical landscape linkages and potential for restoration or enhancement. There is no permanent or long-lasting surface water in the study area. Historically this species probably occurred within the study area, but there have been no recent records and suitable habitat is no longer present.
Organ Pipe Shovel-nosed Snake (*Chionactis palurostris organica*)	PVS	In Arizona, most if not all of the current range is in Organ Pipe Cactus National Monument. May occur on the Tohono O'odham Nation in western and central Pima County.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from the known range.
Tucson Shovel-nosed Snake (*Chionactis occipitalis klauberi*)	PVS	Occurs from south of Tucson northward along Avra Valley to Pinal County and Maricopa County. Current distribution in Pima County poorly known, but it has never been recorded east of the Tucson Mountains and may have been eliminated from much of the Avra Valley. Found on lowland valley floors in areas with sand and loose soil.	Unlikely to occur. PVS maps indicate low to medium potential habitat for the study area. However, the study area is beyond the known geographic range of the species, is distant from known occurrences, and intensive disturbance of the Santa Cruz River valley floor over the last century reduces the likelihood of occurrence within the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
BIRDS			
Cactus Ferruginous Pygmy-owl (*Glaucidium brasilianum cactorum*)	USFWS-E WSCA PVS	Historically, the primary central and southern Arizona habitat for this owl was apparently cottonwood-willow forests, mesquite bosques, and Sonoran Desertscrub vegetation communities. Currently, it is known to occur in the following two vegetation communities: (1) Sonoran Desertscrub in braided-wash systems with paloverde, ironwood, and mesquite; and (2) Semidesert Grassland with drainages containing mesquite, hackberry, and ash. Geographically, the majority of current CFPO records are concentrated in northwest Tucson and the Altar Valley. Critical habitat was designated for this species in 1999, but was rescinded by a court order. New critical habitat was proposed in November 2002. The proposed study area is not within the formerly designated (USFWS, 1999a) or newly proposed critical habitat area (USFWS, 2002).	Unlikely to occur. PVS maps indicate no habitat potential for the majority of the study area, however small portions of the study area, particularly near the West Branch, are designated as having low to medium habitat potential. No specific surveys are known to have been conducted in the study area for this species. Historically this species is known to have occurred along the Santa Cruz River, but there have been no recent records and suitable habitat is no longer present.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	USFWS-E WSCA PVS	Nests in dense riparian habitats along streams, rivers, and other wetlands vegetated with cottonwood, willow, boxelder, buttonbush, and arrowweed.	Unlikely to occur. PVS maps indicate no potential habitat for the project area. Habitat is not similar to that in which the species has been documented. Historically this species may have occurred within the study area, but suitable habitat (cottonwood-willow forests) is no longer present, although it is remotely possible that individuals travel along the River and might briefly rest within the study area. No specific surveys were conducted for this species.
California brown pelican (*Pelacanus occidentalis californicus*)	USFWS-E	Nests in southern coastal areas and afterward forages northward along the Pacific before returning southward for the winter. This Pacific Coast subspecies is an uncommon transient to Arizona lakes and rivers, with individuals wandering up form Mexico during summer and fall. Diet consists primarily of fish. No breeding records in Arizona.	Unlikely to occur. There are no large permanent water sources or food resources within the project area.
Masked Bobwhite (*Colinus virginianus ridgewayi*)	USFWS-E WSCA	The one known population in the state is a reintroduced population at Buenos Aires National Wildlife Refuge.	Unlikely to occur. The study area is distant from the known range of the species and lacks "dense" grassland vegetation known to support the species.
Mexican Spotted Owl (*Strix occidentalis lucida*)	USFWS-T WSCA	Occurs in mature forest and woodland, shady wooded canyons and steep canyons at elevations from 4,100 to 9,000 feet.	Unlikely to occur. The study area is below the normal low elevation range of this species, and habitat is not similar to that which is known to support the species.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Bald Eagle (*Haliaeetus leucocephalus*)	USFWS-T WSCA	A small resident population of about 40 pairs nests primarily along the Salt and Verde rivers. Additional nest sites are along the Gila, Bill Williams, Agua Fria, and San Pedro River drainages. Nest sites are high in trees, on cliffs, or on pinnacles in close proximity to water.	May occur. No permanent water in study area and landform features are not typical of those known to be used for breeding by this species; however, the species may use the Santa Cruz River as a travel corridor and temporary resting spot during migration.
Mountain Plover (*Charadrius montanus*)	USFWS-P	Breeds in shortgrass prairies and shrub-steppe landscapes, primarily in the Rocky Mountains. Winters in small flocks on fallow fields and barren desert flats in Florence, Phoenix, Sulphur Springs Valley, and Gila Bend-Parker regions (Monson and Phillips, 1981). Wintering habitats consist of sites with short vegetation and bare ground, often with manure piles or rocks nearby (USFWS, 1999b).	Unlikely to occur. The study area is not within the known wintering or breeding areas for this species and does not contain appropriate habitat.
Yellow-billed Cuckoo (*Coccyzus americanus*)	USFWS-C WSCA PVS	In Arizona, yellow-billed cuckoos breed primarily in large blocks of cottonwood/willow riparian habitat (USFWS, 2001) along central and southern Arizona rivers (AGFD, 1996). Rarely observed as transient in xeric desert or urban settings (Corman, 1992).	Unlikely to occur. PVS maps indicate no potential habitat for the study area, and no potentially suitable habitat was observed. According to HDMS, this species has been recorded within three miles of the study area. No individuals were observed during field visits. It is remotely possible that individuals may travel along the River and could briefly rest within the study area. No specific surveys were conducted for this species.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Swainson's Hawk (*Buteo swainsoni*)	USFWS-SOC WSCA PVS	In Arizona, this species breeds throughout the state in suitable open grassland habitats and open desertscrub that includes a grassland component. Migrating Swainson's hawks are regularly sighted in the Gila and Santa Cruz River Valleys (Glinski and Hall, 1998). Prey items include insects, small mammals, and reptiles.	May occur. PVS maps indicate low to medium potential habitat for the study area. This species is rarely seen in urban or suburban developed areas, woodlands, forests, or dense scrublands. However, this species may make use of the study area during migration, especially near open fields along the West Branch.
Abert's Towhee (*Pipilo aberti*)	PVS	In Pima County, this species is relatively common along brushy washes and the effluent-dominated riparian woodland portion of the Santa Cruz River; may be present in urban backyards especially those that are along washes.	Known to occur. PVS maps indicate low to medium potential habitat for the study area. Individuals were observed in mesquite series, urban drainage, saltcedar disclimax, and maintained park portions of the study area.
Bell's Vireo (*Vireo belli*)	PVS	In Pima County, this species is a common summer resident in dense shrubs and trees of lower canyons, generally below the oak zone, and along desert streams and washes in dense riparian vegetation.	Known to occur. PVS maps indicate no potential habitat for most of the study area; however, the northern portion of the study area is within a designated Priority Conservation Area for the species. Individuals were observed at the artificially maintained cottonwood-willow area, which no longer exists. This species is likely to occur in mesquite.
Burrowing Owl (*Athene cunicularia*)	PVS	Considered rare in Pima County where it inhabits grasslands, open areas of desert-scrub vegetation, and disturbed areas. Recent reliable areas include the agricultural fields near Pinal Air Park and along the airstrip at Davis Monthan Air Force Base. Inhabits grasslands, pastures, desertscrub, edges of agricultural fields, golf courses, vacant lots, and road embankments.	Known to occur. PVS maps indicate low to moderate PVS potential habitat for the project area. According to HDMS, this species has been recorded within three miles of the study area. Individuals have been observed within and around Sonoran vacant-fallow land, mesquite series, and maintained park portions of the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Rufous-winged Sparrow (*Aimophila carpalis*)	PVS	In Pima County, this species is fairly widespread in appropriate habitat. Specific locations include Saguaro National Park (east) and the Tucson area. Inhabits flat or gently hilly Sonoran Desertscrub vegetation with scattered trees and shrubs, in close proximity to grassland.	Known to occur. PVS maps indicate low to medium potential habitat for the study area. The species has been documented along the West Branch (Rosen, 2001).
MAMMALS			
Lesser Long-nosed Bat (*Leptonycteris curasoae yerbabuenae*)	USFWS-E WSCA PVS	Day roosts are in caves, abandoned tunnels, and unoccupied buildings. Forages on nectar, pollen, and fruits of paniculate agaves and columnar cacti.	Unlikely to occur. There are no potentially suitable roost sites in the study area and very little suitable forage.
Jaguar (*Panthera onca*)	USFWS-E WSCA	Inhabits savannah, Sonoran Desertscrub and subalpine forests, usually near water; rarely found in extensive arid areas (USFWS, 1998).	Unlikely to occur. The study area is located within residential and highly modified landscapes that are not suitable for this species.
Mexican Gray Wolf (*Canis lupus baileyi*)	USFWS-E WSCA	Extirpated from the U.S. Has been re-introduced to sites in the Apache and Gila National Forests. Inhabits oak and pine/juniper savannahs in the foothills and mixed conifer woodlands above 4,000 feet.	Unlikely to occur. This species was extirpated from the region and only recently reintroduced to an area distant from the study area.
Ocelot (*Felis pardalis*)	USFWS-E WSCA	Inhabits desert scrub communities with dense cover; there are unconfirmed reports of individuals in extreme southern Arizona.	Unlikely to occur. Although the study area contains desert scrub vegetation, cover is not "dense". Also the study area is not within the current known range of the species.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Sonoran Pronghorn (*Antilocapra americana sonoriensis*)	USFWS-E WSCA	Small population in southwestern Arizona and adjacent Mexico.	Unlikely to occur. The study area is distant from the nearest population and does not contain "extensive" desert grassland vegetation.
Arizona Shrew (*Sorex arizonae*)	USFWS-SOC WSCA PVS	Has not been found in Pima County; previous records from the Santa Rita Mts. are from outside of Pima County. All records are from high mountain ranges in southeastern Arizona and western New Mexico. In Arizona, they have been recorded in the Huachuca, Santa Rita, and Chiricahua mountains.	Unlikely to occur. The study area is well below the elevation range of this species and vegetation communities and substrates in the study area are not similar to those from which this species is known.
Mexican Long-tongued Bat (*Choeronycteris mexicana*)	USFWS-SOC WSCA PVS	Known to occur at scattered locations in Pima County. In summer occupies mine tunnels, caves, and rock fissures primarily at elevations of 4,000 to 6,000 feet from the lower edge of the oak zone, through the pine-oak woodland, possibly to the pine-fir belt. In Pima County and elsewhere, paniculate agaves are the primary food source. Also known to occur along Cienega Creek in eastern Pima County.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is below the elevation range of this species, and does not include appropriate roost sites or habitats similar to those occupied by the species. There are no agaves except those occurring in landscaped areas.
Pale Townsend's Big-eared Bat (*Plecotus townsendii*)	USFWS-SOC WSCA PVS	In Pima County, this species is frequently found in inactive mines and caves, and occasionally in buildings. Diet consists of small moths and other insects. Occurs through a range of elevations and vegetation communities in Arizona including Sonoran Desertscrub, Madrean Evergreen Woodland, and coniferous forests.	May occur. PVS maps indicate low to medium potential habitat for the study area; although the study area does not contain suitable roost sites, such sites may occur in the mountains to the west and the species may forage in the study area.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
California Leaf-nosed Bat (*Macrotis californicus*)	USFWS-SOC WSCA PVS	Populations are known from inactive mines in most of the mountain ranges in Pima County. Nearby roosts include Tucson Mountain Park and Colossal Cave Mountain Park. Diet consists of large flying insects.	May occur. PVS maps indicate low to medium potential habitat for the study area. According to HDMS, this species has been recorded within three miles of the study area. Although the study area does not contain suitable roost sites, such sites may occur in mountains west of the study area, and the species may forage in the study area.
Allen's Big-eared Bat (*Idionycteris phyllotis)*	USFWS-SOC PVS	Not currently known from Pima County. In Arizona, most specimens have been collected from the southern Colorado Plateau, the Mogollon Rim, and adjacent mountain ranges. Inhabits ponderosa pine, pinyon-juniper, and riparian woodland vegetation types, as well as desertscrub.	Unlikely to occur. PVS maps indicate no potential habitat for the study area. The study area is distant from known occurrences, below the elevation range of the species, and does not include vegetation communities or roost sites that are similar to those the species is known to inhabit.
Cave Myotis (*Myotis velifer*)	USFWS-SOC	This bat is known to roost in caves and inactive mines in the general area and to forage widely over desert land.	Possibly may occur foraging over the project area. There are no suitable roost sites within the project area.
Merriam's Mouse (*Peromyscus merriami*)	PVS	Known primarily from heavy, forest-like stands of mesquite (bosques); also found in thick stands of mesquite, cholla, prickly pear, paloverde, and grasses. There apparently is only one record of this species from Pima County in the last 30 years (from Organ Pipe Cactus NM). Most historic locations have been altered and recent records are lacking. Unknown whether this species still occurs along the Santa Cruz River.	Unlikely to occur under current conditions. PVS maps indicate low to medium potential habitat for the study area and indicate that the species was historically documented along the Santa Cruz River several miles south of the study area. Very little suitable habitat for this species remains in the study area; however, it is possible that a remnant population might occur along the West Branch or in the mesquite patches west of Pima Community College.

Table 2. Special Status Species Considered continued			
Species	**Status**	**Range and Habitat Requirements**	**Likelihood of Occurrence**
Western Red Bat (*Lasiurus blossevillii*)	WSCA PVS	In Pima County, known to occur along riparian corridors with oaks, sycamores, and cottonwoods. Has been recorded at Santa Rita Experimental Range, Empire Gulch, SE of Baboquivari Mts., Rincon Mts., Santa Catalina Mts., and Colossal Cave Mountain Park.	Unlikely to occur. PVS maps indicate no potential habitat in the study area; and no potentially suitable habitat was observed.
Western Yellow Bat (*Lasiurus xanthinus*)	WSCA PVS	Most known records of yellow bats from Arizona are from urban Tucson and Phoenix where they are associated with planted fan palms. This bat roosts in palm trees and riparian deciduous trees.	May occur. PVS maps indicate no potential habitat in the study area; however, according to HDMS, this species has been recorded within three miles of the study area. The species may roost in planted palms in residential and industrial areas and forage within the river corridor.

SPECIES DISCUSSIONS

In the following section, species that are likely or known to occur in the study area are discussed. Also discussed are a few species that are not likely to occur in the study area, but which are of extreme regional interest to regulatory agencies. For those species that are considered unlikely to occur or to be affected by the project, specific reasons for that conclusion are presented. Species that are listed as threatened or endangered by the USFWS are considered first. An overall goal of the proposed project is to rehabilitate and improve existing habitats within the study area and to restore connectivity between habitats. This goal supports the greater goals of protecting and enhancing habitat for desirable wildlife species. If successful, the project would result in long-term benefits to several of the species addressed in this evaluation. There is only a very slight chance that any individual would be present in specific sites within the study area during construction, and none of the proposed alternatives are likely to result in a trend toward Federal listing or loss of population viability for any species.

Federal Listed And Candidate Species

Cactus Ferruginous Pygmy-Owl

Life History Information. Historically, the primary habitat of cactus ferruginous pygmy-owl (CFPO) in central and southern Arizona was apparently cottonwood-willow forests, mesquite bosques, and Sonoran Desertscrub vegetation communities (USFWS, 1997). According to USFWS (2000a), CFPO in southern and southwestern Arizona are currently found in Sonoran Desertscrub and Semidesert Grassland vegetation communities (as described by Brown, 1994). Both of these communities include Xeroriparian vegetation that occurs along washes. Within these vegetation communities, potentially suitable nest sites are provided by saguaro or other columnar cacti, or by ironwood, mesquite, paloverde, or other trees that are large enough to allow the formation of nest cavities. Geographically, the majority of current CFPO records are clustered in northwest Tucson and the northern end of the Altar Valley. The density of trees and the amount of canopy cover preferred by CFPOs is unclear (AGFD, 1999; USFWS, 2000a). No records of this species are known within three miles of the project area according to the Heritage Data Management System (Appendix 14.1). There are no known previous surveys for CFPO in the project area.

Habitat Evaluation and Suitability. The proposed project area is not within proposed critical habitat for this species (USFWS, 2002). The project area is, however, located within CFPO Survey Zone 2 as identified by USFWS, indicating that the area is within the current general geographic range of the CFPO and that the USFWS considers the general area to have moderate potential for occupancy by this species (USFWS, 2000b). The USFWS recommends conducting surveys when private actions without a Federal nexus removes pygmy-owl habitat in this zone.[2] The purpose of these surveys is to minimize the risk of inadvertent take of the species. Suitable habitat is broadly defined to include areas below 4,000 feet in elevation characterized by native vegetation communities including riparian vegetation, Sonoran desertscrub, and semidesert grassland, and in areas with trees that have a trunk diameter of 6 inches or greater measured at 4.5 feet above the ground.

Within the study area, remnant plant communities that include paloverde and mesquite trees, some of which are greater than 6 inches in diameter at 4.5 feet above the ground level, occur in isolated pockets surrounded by urban development and vacant land largely devoid of native vegetation. Animals that inhabit these areas are currently subject to frequent disturbance due to frequent foot and vehicle traffic and homeless encampments. Scattered trees that fit the size category provided above are also present throughout the landscape, but they are widely separated individuals in otherwise open habitats. There are no saguaros within the project area, and saguaros within the study area are limited to a few individuals that are elements of landscaped areas, none of which would be removed in association with this project. The fragmented nature of the habitat and the great distance to the nearest known currently occupied habitat for this species suggests that it is unlikely that CFPO would occur in the study area. No portion of the proposed project area resembles currently known habitat occupied by this species with regard to intact native vegetation in multiple strata, vegetation species composition, or connectivity to areas of relatively undisturbed conditions. The proposed project would not remove large native trees, with the possible exception of scattered isolated individuals that are at the edge of steep dirt banks that are actively eroding.

Analysis and Determination of Effects. There are no known current or historic occurrences of CFPO within the study area. Occurrence of CFPO within the project area is highly unlikely given the species currently known distribution, and the low habitat quality and degree of habitat fragmentation within the study area. Removal of habitat elements known to be used by this species is not an intended component of this project in any of its alternatives. Therefore, this project is unlikely to affect the cactus ferruginous pygmy-owl. Surveys of the study area lands are not recommended at this time. If however, during refinement of the alternatives it becomes evident that habitat that is potentially suitable for CFPO would be adversely modified, this determination should be reevaluated and the relevance and usefulness of surveys reexamined prior to full-scale project implementation efforts. Any surveys conducted should follow accepted USFWS and AGFD protocol.

Bald Eagle

Life History Information. The bald eagle occurs throughout much of North America, from northern Mexico to Canada and Alaska. These birds breed only along large rivers,

[2] U.S. Fish and Wildlife Service. 2000. Recommended Guidance for Private Landowners Concerning the Cactus Ferruginous Pygmy-owl.

lakes, creeks, and coastal areas where water is plentiful and where an abundant supply of prey (primarily fish but also carrion, reptiles, small mammals and birds) is available. Bald eagles build large stick nests in trees or on cliffs. Elevation and vegetation communities of suitable breeding habitat can vary widely. In Arizona, breeding pairs occur along the Salt River, Bill Williams River, Tonto Creek, Agua Fria River, Canyon Creek, Cibecue Creek, San Carlos River, Big Sandy River, Gila River, Verde River, San Francisco River, Burro Creek, and Black River drainages. As of 2002, 47 bald eagle breeding areas were known in Arizona. Most are located in the central part of the state, primarily along the Salt and Verde rivers (http://www.usbr.gov/lc/apo/SWBEMC). Occasionally, bald eagles visit the Tucson area during winter, and may frequent areas near water within the urban area. In January of 2002, an adult bald eagle lingered in the Tucson area for several weeks, but was eventually electrocuted by contact with electric transmission lines (http://www.co.pima.az.us/cmo/sdcp/sdcp2/fsheets/be.html).

Habitat Evaluation and Suitability. During multiple visits to the study area over the past five years, SWCA biologists have never observed bald eagles. Habitats present in the project area are not currently typical of those normally utilized by bald eagles. The small size of the trees present makes them inappropriate as rest or roost sites. Some terrestrial prey species are present, but in relatively low abundance. No fish are present within the study area, although an urban fishing lake is present in Kennedy Park, near the study area, that may occasionally attract wandering eagles. Although it is conceivable that the species could pass over or briefly rest in the study area during migration, it is highly unlikely that bald eagles would occur within the study area under any other conditions.

Analysis and Determination of Effects. Due to unlikelihood of occurrence of bald eagles, the lack of habitat for the species, and the relatively low prey availability in the subject portion of the Santa Cruz River, SWCA concludes that the proposed project, in any of its alternatives, is not likely to affect the bald eagle or its habitat.

Pima Pineapple Cactus

Life History Information. Pima pineapple cactus (PPC) occurs within the Semidesert Grassland and Sonoran Desertscrub biotic communities, generally at elevations between 2,300 and 5,000 feet (USFWS, 1998; Phillips and Phillips, 1981; Benson, 1982). In southeastern Arizona, the known range lies within Santa Cruz and Pima Counties and is generally bounded to the east by the Santa Rita Mountains, to the west by the Baboquivari Mountains, and to the north by the south side of Tucson (EES, 1992).

Dominant plant species associated with PPC vary, but generally include whitethorn acacia,, creosote bush, velvet mesquite, triangle-leaf bursage (*Ambrosia deltoidea*), snakeweed (*Gutierrezia sarothrae*), jumping cholla, burroweed, and Lehman's lovegrass (*Eragrostis lehmanniana*) (Mills, 1991; EES, 1992 in Federal Register 58:49875). Within its relatively limited range, PPC occurs most commonly in open areas on flat ridgetops or in areas with less than 10-15% slope (USFWS, 1998). Although PPC can be found within a range of soil types and depths, plants appear to prefer silty to gravelly deep alluvial soils (USFWS, 1998). Previous studies and surveys have demonstrated that

PPC generally do not occupy drainage bottoms or steep slopes (Phillips and Phillips, 1981; Mills, 1991; EES, 1992). PPC bloom from June through August and are pollinated by a small native bee (Mills, 1991 in EES, 1992).

Habitat Evaluation and Suitability. The entire project area consists of former farmland that is within the historic floodplain of the Santa Cruz River. Edaphic conditions within the project area do not resemble those in which this species has been found. Although some of the plant species that are often associated with PPC are present within the proposed project area, the habitat conditions do not closely resemble those at sites where PPC have been found. The drainage bottom and urban lands that typify the majority of the proposed project sites are not typical of habitats that support this species.

Analysis and Determination of Effects. Due to the lack of habitat characteristic for the species within the study area, and because no PPC were detected during reconnaissance of the study area, SWCA concludes that this species is not likely to occur within the study area. The proposed project, in any of its alternatives, is not likely to affect PPC or its habitat.

Yellow-billed Cuckoo

Life History Information. The western yellow-billed cuckoo is a neotropical migrant, arriving at drainages and cottonwood riparian forests in southern Arizona during early to mid-June. This species prefers substantial stands of mature riparian communities (Corman and Magill, 2000). Nests are usually constructed 10-24 feet above ground in mesquite or willow thickets. Most of the known Pima County populations are south of Tucson (RECON, 2001), although there are a few known reports of individuals observed during migration along the effluent-dominated portion of the Santa Cruz River downstream (north) of the study area (Sage, 2003). The yellow-billed cuckoo was recently designated a candidate for listing as endangered by the USFWS, with listing precluded by other priorities (USFWS, 2001). Loss of riparian habitat is the suspected cause of the decline of this species from northeastern Arizona and lower elevations throughout the State.

Habitat Evaluation and Suitability. Vegetation conditions similar to those known to be used by this species for nesting are not present within the proposed project area. This species evidently has the potential to pass through the project area during migration. It is possible that individuals might briefly rest in the mesquite areas while enroute to more suitable habitat. Individuals are not expected to linger in the area due to the limited resources available.

Analysis and Determination of Effects. The proposed project in any of its alternatives would not result in the removal of habitat typically occupied by this species. Any occurrences of this species within the study area are likely to be limited to resting or foraging during migration. For these reasons, SWCA concludes that the proposed project is not likely to adversely affect the yellow-billed cuckoo. It is possible that the proposed project may benefit this species by creating new or improved habitat conditions that may provide an increase in resources over the long term.

Other Special Status Species

Tumamoc Globeberry
This species was listed as endangered by the USFWS in 1986, but in 1993 after further survey revealed additional data regarding existing populations the species was removed from the endangered species list because it was more abundant and widespread than previously known. The species is still designated a Sensitive Species by the Bureau of Land Management and U.S. Forest Service, and is listed as Salvage Restricted under the Arizona Native Plant Law (ADA, 1997), and is listed as a PVS by Pima County. Tumamoc globeberry occupies a wide range of vegetation types from coastal scrub to saline hardpan to creosote desert scrub (RECON, 2001). The requirements for this species appear to be presence of a nurse plant that provides shade and elevated humidity for seed germination and support for this climbing vine. No individuals were observed during field reconnaissance of the PDLI study area. Potential habitat was identified within portions of the mesquite series of the study area, which comprises approximately 160 acres. All alternatives of the proposed project leave unaltered the intact stands of mesquite that might support this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species. The project would increase habitat that is potentially suitable for this species, but the potential for re-establishment of this species within the project area is unknown.

Giant Spotted Whiptail
Giant spotted whiptails were formerly found in the Santa Cruz River floodplain, but the species has been apparently extirpated, except along a small portion of the West Branch (Rosen, 2001). It is possible that this species may persist within other small remnant patches of dense cover within the study area. These reptiles inhabit mountain canyons, arroyos, and mesas descending to the lowland desert along permanent or intermittent streams (RECON, 2001). No individuals were observed during field reconnaissance by SWCA biologists. Potential giant spotted whiptail habitat was identified within portions of the mesquite series of the study area, which comprises approximately 160 acres. All alternatives of the proposed project leave unaltered the intact stands of mesquite that might support this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species. The project would increase habitat that is potentially suitable for this species, but the potential for re-establishment of this species within the project area is unknown.

Burrowing Owl
Burrowing owls inhabit open sites such as grasslands, coastal dunes, desertscrub, and disturbed areas. They can adapt well to various human activities inhabiting golf courses, agriculture fields, vacant lots and road embankments (Haug et al., 1993). They predominantly use old burrows excavated by other creatures to roost and fledge their young. They also are known to use artificially constructed nest boxes. The species is considered extremely rare in Pima County (RECON, 2001). A total of nine individual burrowing owls were observed during field reconnaissance within the study area. Two of these occupied the Santa Cruz River Park and seven inhabited Sonoran vacant-fallow land in areas generally devoid of vegetation and subject to erosion. An estimated 1,020 acres of potentially suitable habitat for burrowing owls is present in the study area under

current conditions. Because the purpose of the proposed project is to reduce erosion and increase vegetation cover on barren areas, it is likely that the project would result in a reduction of habitat quality for this species, and may result in reduction in the number of individuals of this species that inhabit the area. Precautions against direct disturbance of nests during nesting season, and construction of artificial burrows may be advisable. It is unlikely that any loss of habitat or individuals from the area would result in a need to list the species as endangered.

Rufous-winged Sparrow

Rufous-winged sparrows require flat or gently hilly desert grasslands, with scattered trees or shrubs. They require both seeds and arthropods for food. During hot hours in spring and summer, they forage in the deep shady shrub thickets, often in riparian habitats near grasslands. Pairs bond for life and they remain on their territories year-round. Although the Pima County distribution of the rufous-winged sparrow has generally improved in recent years following believed extirpation in the first half of the twentieth century, localized losses continue to occur along with increased urbanization. This species was reportedly observed once during a bird survey along the West Branch (2001). It may occur or travel through other portions of the project area that support mesquite, Sonoran interior strand, or saltcedar disclimax habitats. It was not observed during field reconnaissance within the study area for this BE. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Abert's Towhee

Abert's towhee inhabits low-elevation riparian sites throughout Pima County (RECON, 2001). This species tends to occur most often in Sonoran riparian deciduous woodlands and riparian scrublands with dense understories. Most of these communities are now fragmented throughout much of Arizona (Tweit and Finch, 1994). Within the survey area, Abert's towhees were observed during field reconnaissance for this BE. They were regularly observed in a variety of habitats including mesquite series, urban drainage, Sonoran interior strand, cottonwood-willow at the artificial wetland (now drying and dying), saltcedar disclimax, and maintained park. An estimated 517 acres of potentially suitable habitat for Abert's towhee is present in the study area although this species may move throughout the area between patches of suitable nest, roosting, and foraging habitat. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Bell's Vireo

Bell's vireos generally are found in dense, low, shrubby areas with riparian communities with tamarisk, cottonwood, mesquite, and seepwillow (RECON, 2001). They are fairly common in riparian areas along the effluent dominated portion of the Santa Cruz River (SWCA, Inc., 2000). Two individuals of this species were observed in the cottonwood trees at the artificial wetland during field reconnaissance within the study area. Potential habitat was also identified within the mesquite series of the study area. An estimated 160 acres of potentially suitable habitat for Bell's vireo is present in the study area. This includes areas of overlap with other species discussed. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Swainson's Hawk

The Swainson's hawk breeds throughout most of the western U.S., from northern Mexico to Alaska and winter chiefly in South America (NGS, 1987). In Arizona, this species breeds throughout the state in suitable open grassland habitats and open desertscrub that sustains a grassland component (Glinski and Hall, 1998). Migrating Swainson's Hawks occur throughout the state in open country, and migrating Swainson's Hawks are regularly sighted in the valleys of the Gila and Santa Cruz Rivers, from central Arizona south to Mexico (Glinski and Hall, 1998). They are rarely seen in urban or suburban developed areas, woodlands, forests, or dense scrublands. Conversion of native grassland habitats and agricultural lands to urban development may further reduce resources for both migrating and nesting birds. The diet of the Swainson's hawk includes small mammals, reptiles, insects and birds. Of 11 Arizona Breeding Bird Atlas records (2000) for Pima County, 1 was from Cultivated Woodlands, 1 from Arizona Upland Biome, 4 from Semidesert Grassland, 3 from Sonoran Savanna Grassland, and 2 from Sonoran Riparian Scrubland (dry wash). None were observed during field reconnaissance of the PDLI study area. Because the project area is surrounded by urban development, it is probably not well suited for use by nesting individuals of this species, but possibly may be used briefly by individuals foraging or resting during migration. All alternatives of the proposed project involve improving conditions that might foster this species. Therefore, it is highly unlikely that the proposed project would adversely affect this species, except, possibly, for a brief period during the construction phase.

Western Yellow Bat

This species is found along riparian deciduous woodlands and in association with fan palms, which it uses as roost sites. Little is known about the migration and corridor requirements of this species but its numbers are thought to be on the increase. In Pima County they are thought to be primarily associated with planted fan palms (RECON, 2001). No species-specific surveys were conducted for this species, and it is extremely difficult to detect. No individuals were observed during field reconnaissance. An estimated 6 acres of potentially suitable habitat for this species is present in the study area at a large planting of fan palms in a mobile home community. The proposed project in all of its alternatives would not affect potentially suitable roost trees, but may possibly improve foraging conditions for this species.

California Leaf-nosed Bat

In Arizona, the California Leaf-nosed Bat is known to occur throughout in the Sonoran desertscrub biome. This species consumes large flying insects, including grasshoppers, moths, and flying beetles; other appropriate food includes insect larvae, particularly lepidopterans. This species may also feed on cactus fruits (Hoffmeister, 1986). Males and females roost separately, primarily in caves and abandoned mines. This species does not hibernate and feeds year-round (AGFD, 1997). Basic requirements for this species include roost sites reasonably close to foraging sites. Limited information indicates that this species forages primarily along washes. Populations are known from inactive mines in most, if not all, of the mountain ranges in Pima County, and this bat is known to forage within a radius of several miles from roost sites. It is possible that individuals may occasionally forage within the study area, but there are no suitable roost sites present. This proposed project, in all of its alternatives, would have no affect on this species.

Pale Townsend's Big-eared Bat
In Pima County, this subspecies roosts in caves and inactive mines, and occasionally in buildings. The subspecies has been found in a wide variety of habitats from deserts to mountains, but is nowhere common (Hoffmeister, 1986; Noel and Johnson, 1993; AGFD, 1998b). This bat feeds primarily on small moths that it catches in flight. It may also glean insects off of vegetation while it is in flight (Noel and Johnson, 1993). Foraging typically takes place in darkness and this subspecies is rarely seen at dusk.
The subspecies is known to occur in Tucson Mountains Park (Hoffmeister, 1986), which is located several miles west of the study area. It is possible that individuals may occasionally forage within the study area, but there are no suitable roost sites present. This proposed project, in all of its alternatives, would have no affect on this species.

Merriam's Mouse
Merriam's mouse once inhabited large mesquite forests along rivers throughout Pinal, Pima, and Santa Cruz counties in Arizona and into Sonora, Mexico. It has also been found in thick stands of mesquite, cholla, prickly pear, paloverde and grasses (Hoffmeister, 1986). Most areas where Merriam's mouse was historically present have been altered and recent records are lacking as to whether the species persists in these areas. These areas include the Santa Cruz River area (San Xavier) where the bosques were removed in the early part of the twentieth century for firewood (Phillips et al., 1964), and at Wilmot Station southeast of Tucson where they were formerly taken in large numbers (BISON-M, 2000). There is no current information on Pima County populations, except that there have been very few records of this species in the past several decades. No species-specific surveys were conducted for this species. Although it is unlikely that this species remains in the Santa Cruz valley, it is possible that a remnant population may persist along the West Branch. If the species remains, the proposed project is likely to result in improved habitat conditions. It is not possible to predict whether the species might become reestablished in the area with improved conditions.

Conclusions

Of the 22 species that are listed or proposed for listing by USFWS and occur in Pima County, three were determined to have extremely limited potential to occur within the study area: Pima pineapple cactus, cactus ferruginous pygmy-owl, and bald eagle. The yellow-billed cuckoo, a candidate for listing, was also determined to have slight potential to occur within the study area. The proposed project is not likely to affect any of these species. Of the 55 PVS included in the draft Sonoran Desert Conservation Plan, 11 have potential to occur within the study area. None of these PVS are Federally listed or protected under the authority of the Endangered Species Act, and the proposed project is not likely to result in a trend toward Federal listing or a loss of population viability. It is likely that the proposed project would adversely modify habitat for the burrowing owl within the project area because this species is dependent upon barren, eroded conditions. Conditions for all other native species are expected to improve as a result of any and all action alternatives of the proposed project.

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14.3 404 (b)(1) Compliance Evaluation

1. INTRODUCTION

This appendix evaluates compliance of the recommended plan, Alternative 3E, with the guidelines established under the Federal Pollution Control Act (Clean Water Act) Amendments of 1972 (Public Law 92-500), as amended by the Clean Water Act of 1977 (Public Law 95-217), legislation collectively referred to as the Clean Water Act.

The Clean Water Act sets national goals and policies to eliminate the discharge of water pollutants into 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 Part 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 Paseo de las Iglesias project would require the discharge of dredged or fill material into the Santa Cruz 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 Santa Cruz 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. 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.

The Santa Cruz River and its tributaries are 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 Part 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)) were used to establish the jurisdictional limit of a waters of the United States.

With the exception of the "No Action" alternative, all alternatives receiving final consideration would modify (i.e., re-disturb) the same areas. These disturbances would include modifications to the river channel and banks, installation of water harvesting features and irrigation infrastructure, vegetation plantings, and soil amendment/ restoration activities. Therefore, all three action (with-project) alternatives would have essentially identical impacts to waters of the U.S., both for initial construction work and during future OMRR&R activities completed by the non-Federal sponsor.

Fundamental to the Guidelines is the precept that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern."

The procedures for documenting compliance with the Guidelines include the following:

- Examining practicable alternatives to the proposed discharge that might have fewer adverse environmental impacts, including not discharging into a water of the U.S. or discharging into an alternative aquatic site
- Evaluating the potential short- and long-term effects, including cumulative effects, of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment.
- Identifying appropriate and practicable measures to mitigate the unavoidable adverse environmental impacts of the proposed discharge
- Making and documenting the Findings of Compliance required by §230.12 of the Guidelines.

This Clean Water Act, Section 404(b)(1) evaluation of compliance with the Guidelines is not intended to be a "stand alone" document; it relies heavily on information provided in the Final Environmental Impact Statement (FEIS) to which this Appendix is attached.

2. STUDY AUTHORITY

A Paseo de las Iglesias, Pima County, Arizona Feasibility Report was specifically authorized by section 212 of the Water Resources and Development Act of 1999, Pub. L. No. 106-53, 33 U.S.C. 2332. Section 2332(a) states:

> The Secretary [of the Army] may undertake a program for the purpose of conducting projects to reduce flood control hazards and restore the natural functions and values of rivers throughout the United States.

Subsection (b)(1), 33 U.S.C. 2332(b)(1), provides authority to conduct specific studies "to identify appropriate flood damage reduction, conservation, and restoration measures." Subsection (c), 33 U.S.C. 2332(c), states the cost-sharing requirement applicable to studies and project conducted pursuant to section 2332. Subsection (e), 33 U.S.C. 2332(e), identifies priority areas. It states in pertinent part:

> In carrying out this section, the Secretary shall examine appropriate locations, including--

(1) Pima County, Arizona, at Paseo de las Iglesias and Rillito River; . . . .

3. STUDY PURPOSE AND NEED

The purpose of the proposed 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 ecosystem that would require only minimal ongoing human intervention.

The Study Area has suffered systematic and severe ecosystem degradation and loss of riparian habitat since the early 20th century. Before 1900, the Santa Cruz channel maintained groundwater-driven perennial flow that supported dense growths of native riparian trees such as cottonwood, willow, and mesquite. Historical accounts of conditions on the Santa Cruz River (circa 1900) describe a tree-lined, river, with dense vegetation, winding throughout a wide flood plain. The river channel formerly provided sufficient water to support rapidly increasing European settlement, increasing uses of the Santa Cruz waters for agricultural irrigation and sustained surface flow. Sustained surface flow has not existed in the Paseo de las Iglesias reach for more than half a century. The once verdant Santa Cruz riparian corridor has been transformed into a deeply incised, ephemeral ditch with either artificially hardened or unstable and eroding banks, that supports flow only briefly in response to storm runoff. These changes came about as a result of the uncontrolled appropriation of surface and groundwater to support expansion of agriculture and nascent industry, acceleration of head cutting resulting from human manipulation of the channel, and transformation of large areas of the landscape to increasingly urban land uses.

Without restoration, habitat values in the Study Area are expected to further decline and/or disappear within the next 50 years. This would decrease the overall habitat value for wildlife and reduce potential riparian habitat, a vanishingly scarce commodity in the Arizona Sonoran Desert ecosystem. This project is needed to provide an ecological riparian corridor connection along the Santa Cruz River. Restoration of the area may also provide new passive recreational opportunities by increasing the area of open space that is adjacent to recreational trails.

4. STUDY AREA DESCRIPTION

The City of Tucson is located in the northeast portion of Pima County in southeast Arizona, approximately 110 miles southeast of Phoenix. The Coronado National Forest is to the north and the Saguaro National Park to the east border Tucson. Tucson is the second largest city in Arizona and is the County seat of Pima County.

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it turns to flow northward and reenters Arizona about six miles east of Nogales. The river course continues northward to Tucson then northwest to its confluence with the Gila River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the Study Area. Throughout this reach, flow occurs only as a result of secondary treated wastewater effluent discharges or from increasingly violent runoff from storms.

The Paseo de las Iglesias Study Area, defined in coordination with the Pima County Flood Control District (the non-Federal sponsor) using such factors as jurisdictional boundaries, the present limits of urban development, physical impediments (i.e., highways), historical floodplain limits, and the opportunities and limits presented by the physical characteristics of the reach to be restored. The Paseo de las Iglesias Study Area is approximately 5005 acres and consists of a 7.5-mile reach of the Santa Cruz River main stem and the New and Old West Branch tributary washes (approximately 3.2 miles and 2.7 miles, respectively). Beginning where Congress Street crosses the river in downtown Tucson, the Study Area extends upstream (south) along the river to the boundary of the San Xavier District of the Tohono O'odham Nation. Interstates 10 and 19 represent the eastern study boundary. Mission Road and the San Xavier District of the Tohono O'odham Nation represent the western Study Area boundary.

The Study Area name, Paseo de las Iglesias, translates to "Walk of the Churches." The Study Area derives its name from the fact that it provides the physical and cultural connection between the 18th century San Xavier Mission and the Mission San Augustin archeological site. This area is the cradle of modern day Tucson and has a lineage of continued habitation dating thousands of years before settlement of the area by the Spanish missionaries.

The main channel of the Santa Cruz River is cut in a relatively straight northerly direction from the southern to the northern borders of the Study Area. The West Branch of the Santa Cruz River currently extends from the southern border of the Study Area to the north approximately 3.5 river miles to where it joins the main stem of the Santa Cruz River, just north of Irvington Road. The portion of this channel just north of Irvington Road, the New West Branch, has been re-routed. The former channel (before it was re-routed) is called the Old West Branch and extends from just north of Irvington to just south of 22nd Street where it joins the main stem of the Santa Cruz River. The Old West Branch was once the principal western channel of the Santa Cruz River; however, entrenchment of the eastern river channel isolated the western channel, cutting off its water supply. It became known as the West Branch of the Santa Cruz River and, following construction of the flood control diversion, the Old West Branch. Currently, the Santa Cruz main stem lacks native riparian vegetation, while fragments of stunted mesquite stands subsist along the New and Old West Branch reaches in the Study Area.

The Study Area also includes a portion of Tucson designated for redevelopment under the City of Tucson's Rio Nuevo Master Plan The Rio Nuevo plan includes historic restoration and landscaping initiatives, which could integrate with environmental restoration measures to increase project outputs. The Study Area has also been designated for inclusion in Pima County's Sonoran Desert Conservation Plan.

5. GENERAL DESCRIPTION OF PROJECT ALTERNATIVES

An array of 14 alternatives (not including the No-Action Alternative) was developed by the Los Angeles District of the U.S. Army Corps of Engineers (the "Corps") and Pima County Flood Control District (the "non-Federal sponsor") during the plan formulation process. The alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel modification, water features, infrastructure). Alternatives were initially developed based on the Corps' Federal planning objectives for water resource projects, specific planning objectives developed for the Paseo de las Iglesias Restoration Project, and project-specific opportunities and constraints for implementing restoration activities. These alternatives were later refined based on input received through public meetings and coordination with local, state and Federal resource agencies.

After formulation and refinement, alternatives were ranked and screened based on associated habitat benefits and implementation costs. A modified Hydrogeomorphic (mHGM) functional assessment model was used by the Corps' planning team to identify and quantify the anticipated habitat benefits associated with the proposed restoration alternatives. The mHGM generates numerical quantities to simulate functional values of existing riparian habitat types (e.g., water storage, plant community structural characteristics) and projects numerical values for proposed changes in functional values for various restoration alternatives.

Results of the mHGM assessment were incorporated into the Corps' standard economic evaluation analysis to identify the alternatives that provided the highest ecosystem benefits per unit of cost. The following ecosystem restoration features are common to all construction alternatives:

- Construction of vegetated habitat
- Eradication of exotic species (e.g., tamarisk, salt-cedar, buffelgrass, fountain grass and red brome.)

- Ground reshaping to alter significant features (e.g., reshaping the old sand and gravel sites, installation of irrigation systems, or creation topographic conditions needed to facilitate water retention.
- Use of supplemental water sources, such as irrigation, storm water harvesting, and/or effluent.
- Water distribution systems (e.g., canals, perforated piping, drip irrigation, harvesting basins, diversion structures, etc.)

Project alternatives differ primarily in the types and amounts of vegetation types that would be created, the extent of structural components and irrigation measures, the amount of water needed to support restored areas and the amount of site alteration that would occur. Project features would be constructed both in and adjacent to the river channel.

In each case, a Monitoring and Adaptive Management Plan would be established to evaluate the effectiveness of the restoration measures implemented and make adaptive changes, if required, to obtain project objectives

Operation, Maintenance, Repair, Rehabilitation and Replacement (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:

- Maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features;
- Mosquito vector control;
- Invasive species control;
- Environmental monitoring; and
- Periodic removal of sediment deposited by floods, surface reshaping, or replanting of project features damaged by flood events.

5.1 Recommended Plan

The Recommended Plan, Alternative 3E, would consist of the following features.

- Construction and planting of subsurface water harvesting basins on the upstream side of five existing grade structures and at the confluences of 8 tributaries. The water harvesting features would involve excavating to a depth of approximately four feet, soil compaction to reduce infiltration rates, and placement of layers of appropriately sized gravel covered with granular fill in the excavated areas.

- Modification of reaches of steep natural banks by cutting back into the historic floodplain to create gentler and more stable slopes. Where available land is not a constraint, banks would be graded at a 5 foot horizontal to 1 foot vertical slope and planted. In areas where insufficient space exists to accommodate vegetated slopes placement of riprap or soil cement may be necessary for bank protection.
- Planting of terrace and adjacent areas of the historic floodplain.
- Soil amendment of terrace and floodplain areas to include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade.
- Surface grading of some off channel areas to concentrate local runoff in the floodplain.
- Introduction of irrigation water into the lower reach of the Old West Branch and irrigation of the water harvesting basins. The irrigation would not be constant but would consist of adding water to extend the flow period following natural events. In this way, the volume and duration of flow in these areas would be increased to mimic mesoriparian conditions.
- Construction of permanent irrigation system that would combine construction of feeder pipelines to move water through the Project Area with use of gated pipe, flood or subsurface irrigation to distribute water at specific locations. In some cases, such as the water harvesting basins, a simple outflow would be sufficient.

Alternative 3E would result in the restoration of 718 acres mesquite cover, 356 acres of mesoriparian shrub, 18 acres of cottonwood-willow and 6 acres of emergent marsh. 3E has an estimated construction cost of $90,916,632 that, when annualized over a 50-year period yields an average annual cost of $5,765,687. OMRR&R costs are estimated at $1,869,961 so the total average annual cost of the alternative is $7,635,648. This alternative produces a net gain of 454 average annual Functional Capacity Units at a cost of $16,819 per unit.

6. PRACTICABILITY

Section 230.10(a) of 404(b)(1) guidelines state that "an alternative is practicable if it is available and capable of being done after taking into consideration costs, existing technology and logistics in light of overall project purposes."

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 cover 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 least damaging practicable alternative.

In the context of whether or not the alternatives developed for this project are practicable, all of them incorporate management measures that are feasible. Alternatives that are more complex and cover a larger area inevitably require greater effort to correctly implement, operate, and maintain, even if the non-Federal sponsor and the Corps can assume the cost.

6.1 Alternatives

The construction alternatives analyzed in detail through the NEPA process would each accomplish the identified project purpose. However, they would accomplish the project purpose to varying extents, with varying levels of benefits and varying adverse impacts to waters of the United States.

The types of OMRR&R activities necessary would generally be the same for each alternative, although the level of effort for OMRR&R activity would be proportional to the amount of new habitat created (i.e., Alternative 2A would require the least amount of OMRR&R and Alternative 4F would require the greatest amount of OMRR&R effort and associated cost).

The following is a summary of project elements for each alternative. In general, Alternative 4F entails the greatest amount of vegetative and structural work. Alternative 3E includes most of Alternative 4F's vegetation features but lacks some of its structural features. Alternative 2A entails the least amount of work in waters of the U.S., but creates an ecosystem dominated by xeroriparian shrub. Alternative 3E differs from Alternative 4F in area in acres of each vegetation type being created and has many of the same structural features of 4F. Alternative 3E provides approximately the same area of vegetation and structural features than Alternative 2A but fewer FCUs than Alternative 4F. These alternatives are described in detail in Chapter 3 of the EIS.

Alternative 4F includes:

- Construction of a low flow channel that would convey intermittent flows through the entire length of the Santa Cruz River within the project boundaries.
- Construction of depressional areas on each side of the low flow channel approximately ten feet in width where soil saturation conditions resulting from infiltration would be conducive to emergent marsh.

- Construction of low terraces varying in width from ten to twenty feet would be positioned adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.
- Construction and planting of subsurface water harvesting basins at the confluences of 11 tributaries.
- Installation of permanent irrigation systems for all planted areas including the water harvesting basins.
- Modification of existing steep and eroding banks by excavating to create stable slopes.
- Creation of 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh.
- A Monitoring and Adaptive Management Plan established to evaluate the effectiveness of the restoration measures implemented and make adaptive changes, if required, to obtain project objectives.
- A net gain of 519 average annual Functional Capacity Units (AAFCUs or FCUs; Appendix 14.4) compared to the No Action Alternative.

Alternative 3E includes:

- Introduction of irrigation water into the lower reach of the Old West Branch.
- Construction and irrigation of water harvesting basins on the upstream side of five existing grade structures.
- Creation of Creation of 718 acres of mesquite, 356 acres of mesoriparian shrub, 18 acres of cottonwood-willow and six acres of emergent marsh
- Replacing invasive plant species with native species.
- A Monitoring and Adaptive Management Plan established to evaluate the effectiveness of the restoration measures implemented and make adaptive changes, if required, to obtain project objectives
- A net gain of 454 FCUs compared to the No Action Alternative.

Alternative 2A includes:

- Construction of water harvesting basins on the upstream side of five existing grade structures.

- Construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch.
- Construction and planting of subsurface water harvesting basins at the confluences of 11 tributaries
- Soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography.
- Placement of rocks and coarse woody debris.
- Creation of 867 acres of xeroriparian shrub, 252 acres of mesquite and 6 acres of emergent marsh.
- A Monitoring and Adaptive Management Plan established to evaluate the effectiveness of the restoration measures implemented and make adaptive changes, if required, to obtain project objectives
- A net gain of 402 FCUs compared to the No Action Alternative.

Table 1 below summarizes the acreages of different habitat types that would be created under each alternative in areas considered waters of the United States.

Table 1. New Riparian Areas Associated with Each Construction Alternative

Increase in Habitat Acreage over No Action Alternative	Alternative		
	2A	3E	4F
New Cottonwood-Willow	0	18	79
New Mesquite	252	718	512
New Riverbottom	6	6	59
New Shrub	867	356	577
TOTAL ACRES	**1,125**	**1,098**	**1,227**

6.2 Comparison of Alternatives

All of the action alternative provide benefits and meet project objectives to varying degrees. If correctly implemented, Alternative 4F would provide the greatest habitat benefit, based on the calculated functional capacity unit output. It however, requires the greatest input of water and construction in the waters of the United States. Since water will always be a scarce resource in the region where consumptive uses compete with the needs of biological resources, use of the available water must be appropriately balanced. The primary differences between Alternatives 3E and 2A are in the number of acres of each type of habitat being created. Alternatives 3E and 2A are similar in the degree of activity required in waters of the U.S., and thus are similar in the level of potential effects. However, Alternative 3E creates more of the desirable vegetation and habitat.

Alternative 3E has been selected as the tentatively Recommended Plan because it meets the project goals of maximizing habitat benefit, 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.

7. FACTUAL DETERMINATIONS

7.1 Physical Substrate Determinations

A. Substrate Elevation and Slope: The Study Area includes river channel and overbank areas. The channel topographic relief is generally very low to flat (less than 1% gradient), ranging from an elevation of 2470 feet elevation in the Santa Cruz River bed at Los Reales Road at the upstream (south) end of the channel, to approximately 2345 feet at the downstream (north) end. In a channel cross-section perspective, nearly vertical topography is common for several thousand feet of unstable reaches. Stabilized banks (soil-cemented reaches) are less steep along the deeply incised channel. Local floodplain to channel bottom relief ranges from approximately 15 feet in the lowest sections, to nearly 40 feet in the vicinity of the gravel mine.

The dry, sandy Santa Cruz River bottom is highly disturbed by both natural processes and human activities. Substrate materials include water-rounded gravel, cobble and principally fine sand are unconsolidated and easily transported by water. Each flood event reconfigures the channel substrate that is continuously altered by uncontrolled foot, horse, motorcycle and all-terrain-vehicle travel. Similar and minor alteration of the river bottom by construction equipment used in creating stable side slopes and the transport of excavated materials is expected to occur during project implementation. Minor changes in topography of the stream banks would occur, but the overall elevations of the channel bottom and the historic flood plain would be altered insignificantly.

Minor (de minimus) quantities of native earth materials may be discharged into the jurisdictional limits of waters of the United States (in this instance, a typically dry condition) during construction of the water distribution and irrigation systems, grading of overly steep channel banks, construction of water harvesting basins and preparing the ground surface for planting. Construction material would consist of native alluvial soils from the Project Area. No dredged or fill materials would be imported into the project site as part of this project. No significant quantities of inadvertently discharged earth materials would remain above existing channel bottom elevations. Approximate pre-construction channel bottom contour would be reestablished to eliminate any potential changes flooding characteristics. Hydraulic modeling that some increases in the water elevations are likely to occur due to the establishment of vegetation within the active area of conveyance. However, cutting back existing vertical banks would create additional channel capacity and the net effect on flooding potential is considered negligible. Excess excavated materials would be incorporated into final grades in the historic floodplain, primarily incorporated into the final grade at the abandoned gravel mine site at the south end of the Project Area. The disposal of excavated materials outside the Project Area is thus not anticipated.

B. Sediment Type: The alluvial sediments deposited within the basin have been divided into four geologic units that are, in descending order of depth: surficial or recent alluvial deposits, the Fort Lowell Formation, the Tinaja Beds, and the Pantano Formation. The surficial deposits occupy the streambed channels and are generally less than 100 feet thick. The coarse surficial deposits allow the infiltration of surface water to recharge the underlying units (LMT 2002).

The alluvial deposits in the Study Area that would be affected by implementation of the selected restoration alternative consist mainly of recent stream channel and floodplain deposits. These alluvial sediments are generally fine sand, gravel and gravelly sand. Locally, the sediments in the Study Area are sand to sandy silt of fluvial origin. Lithified sediments do not crop out along the Santa Cruz River and, generally, they should not be present within excavation depths of the channel for structure installation. However, such formations do approach the riverbed elevation near 22nd Street.

The Santa Cruz stream banks are highly susceptible to erosion. The material generally encountered is typically fine sandy silt, with few cobble and gravel sized rocks. This material is not layered, has little plasticity, but is loosely cemented. The stability of the existing native embankments is low due to the existence of two mechanisms: an inherently unstable natural soil structure and, the processes of piping. The natural weak cementation of the soils as they dry allows banks to stand at a near vertical inclination at many locations along the reaches of the Study Area. The vertical banks, when saturated and exposed to stream flow energies, are susceptible to structural weakening as cement is dissolved, undercutting and thus tend to easily collapse into the streambed, becoming part of the unconsolidated flood-flow bed load. A second mechanism of stream bank erosion, piping, occurs as surface or subsurface water flowing over and through the soils, often along open root channels, forms increasingly large subsurface cavities. Water flow through the cavities erodes, enlarges and transports sediments out of piping voids in the embankment face. As soil faces saturate during flooding and piping voids fill with water and saturate deeply into banks, mass collapse frequently occurs that includes both blocks of soil material parallel to the channel and deep, irregular erosional invaginations into the uplands, perpendicular to the channel.

Care must be observed during construction of the selected restoration alternative to avoid working in channels during times of flooding. Typically, wetter seasons and, consequently, stream flow can be expected to occur during the monsoons of late July and August, the early fall time of late September and October, and during the December and January winter rains. During these times, the channel can fill and banks can become saturated and unstable, increasing the possibility of project construction induced erosion or the loss of partially completed work, materials and equipment.

For the most part, the damages from episodic flooding can be avoided by adherence to weather reports. The effects of wet-season channel flooding are usually brief, as the predominant material comprising the channel bed is a fine gravelly sand. Bed infiltration is extremely high during flows and quick drying of the stream bottom material occurs once the stream flow subsides in the majority of the Project Area. A few areas may hold water somewhat longer. Borings for bridges across the Santa Cruz have shown the presence of clay layers on which perched water could and, in some cases, does reside. In addition, there are cemented soils and/or rock at relatively shallow depths near 22nd and 29th (Silverlake) Streets. The depth of such formations is typically more than 20 ft. below the streambed elevation and, thus, would not be likely to significantly affect either erosion potential or construction.

C. Dredged/Fill Material Movement: Construction activities (e.g., creation of vegetated areas, bank flattening, creation of harvesting basins, removal of invasive species) would result in incidental movement of local soils and sediments into downstream areas during runoff events. In addition, surface runoff and alluvial fan flows after construction would erode loose soils and transport them downstream. 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. OMRR&R activities would include repair work after major flooding events; dredging and reconstruction and replacement of vegetation after flooding events may be required in the restoration areas. This would temporarily change substrate elevations and compaction, as the substrate is restored to design configurations.

Since the channel substrates are generally unconsolidated, natural embankments are highly unstable and human-induced perturbations have been both extensive and continuous, it is unlikely that construction of the selected restoration alternative would result in significantly increased erosion in or along the Santa Cruz 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.

D. Physical Effects on Benthic Macroinvertebrate Communities: The Santa Cruz River bed is dry except during brief post storm runoff flow events. There is no perennial source of water and no benthic macroinvertebrate communities in the Project Area. Construction of the selected restoration alternative would not result in extended ponding of water, nor perennial channel flow. It is not feasible that any new habitat for benthic organisms would be created.

E. Other Effects: Operation and maintenance activities to ensure adequate flood flow would require periodic inspections, mowing sediment removal, 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 to the area being maintained and not spread throughout the entire Project Area.

F. 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, potential impacts to water resources are presumed to be insignificant.

7.2 Water Circulation, Fluctuation, and Salinity Determinations

A. Effect on Water Quality: The Santa Cruz River supports ephemeral flows that are in direct response to rainfall events. Runoff from upstream areas and adjacent lands drain into the river channel. An AZPDES permit, administered by the Arizona Department of Environmental Quality, would be required for any proposed construction activity and a 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 DEIS, Design Documentation Report (DDR), and plans and specification for the project 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.

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 SWPPP would also contain provisions for spill prevention that properly identifies storage location, spill containment, and remediation measures for clean up.

B. Effects on Current Drainage Patterns and Circulation: The proposed project would not substantially alter the surface water hydraulics or drainage patterns into or in the Santa Cruz River. Proposed restoration measures and vegetation would mimic historical conditions and promote establishment of native vegetation.

Hydraulic modeling (see Appendix B of the Feasibility Report) for the with-project conditions shows that conveyance capacity of the channel and affected tributaries would not be significantly affected.

C. Effects on Normal Water Level Fluctuations: Channel reshaping and vegetation planting activities proposed under Alternative 3E have the potential to cause small increases 100-year water surface elevations at some locations and increase the potential for flooding in the Project Area. Hydraulic modeling conducted for Alternative 4F demonstrated some increases in water surface elevations, however these increases were not deemed significant and do not warrant mitigation.

D. Action Taken to Minimize Impacts: An erosion and sediment control plan would be prepared for project activities. This plan would also address Best management Practices (BMPs) for operation and maintenance.

7.3 Suspended Particulate/Turbidity Determinations at the Disposal Site

A. Expected Change in Suspended Particulate and Turbidity Levels in the Vicinity of Disposal Site: Short-term increases in suspended particulate and turbidity levels may occur during construction, if water is flowing. However, no long-term effects are anticipated.

B. Effects on Chemical and Physical Properties of the Water Column: Construction materials such as concrete would be separated from flowing water when present. All spills in the channel would be contained, controlled, and cleaned up in accordance with the requirements of the SWPPP. 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 resultant impacts.

C. Effects of Turbidity on Biota: Soil discharged into the river channel due to project construction is unlikely to significantly increase turbidity. The ephemeral and highly turbid flows in the Santa Cruz River are generally of short duration and do not, during flow periods, support aquatic biota. As a result, no adverse impacts are expected.

D. Actions Taken to Minimize Impacts: Refer to the three previous subsections for mitigation measures.

7.4 Contamination Determination

Buried materials found during construction would be evaluated and disposed of in accordance with local, state and Federal regulations.

7.5 Effect on Aquatic Ecosystem and Organism Determination

No permanent aquatic environment exists within the Project Area. The Santa Cruz River supports ephemeral flows during precipitation events, but these are not of sufficient duration to support an aquatic ecosystem. As a result, the proposed project would not have any adverse effects on aquatic ecosystems or organisms. No mitigation measures are required.

7.6 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 should ensure that adverse impacts to jurisdictional waters of the U.S. are minimized.

7.7 Determination of Cumulative Effects of Disposal of Fill on the Aquatic Ecosystem

The Recommended Plan, coupled with other ecosystem restoration projects in the area, would not contribute to negative cumulative impacts within the region for biological resources. Instead, the long-term result of this project in conjunction with the other regional restoration efforts would provide an overall benefit. Given the paucity of water in this desert ecosystem, it is unlikely the combination of ecosystem restoration projects would create any locally viable aquatic ecosystems. Combined restoration project construction could increase erosion and sedimentation in minor degrees. To minimize the potential for increased erosion and sedimentation during construction, BMPs would be implemented, with particular attention to their installation and maintenance during wet seasons.

7.8 Determination of Indirect Effects of Disposal of Fill on the Aquatic Ecosystem

The SWPPP would include adequate measures to reduce potential increases in erosion or sedimentation. Permanent fill is not anticipated within the or below the elevation of the approximate two-year frequency flood flow event. Since there are no aquatic ecosystem components or wetlands remaining in the Santa Cruz channel, it is unlikely that any adverse effects may result from implementation of the selected alternative.

8. 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.

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, is in compliance with the Clean Water Act, and meets the Section 404(r) exemption criteria. The Corps plans to seek an exemption from the requirement to obtain State water quality certification under Section 404(r) of the Clean Water Act.

In order for a Federal project to meet the conditions for exemption under Section 404(r) of the Clean Water Act, it must comply with NEPA, through an EIS transmitted to Congress prior to authorization of the proposed project or appropriation of funds for construction, and Section 404 of the Clean Water Act, including Section 404(b)(1). 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 will determine what type of permit (if any) is needed, and whether or not all or part of the required OMRR&R activities may proceed under exemption as described in Section 404(r) of the Clean Water Act. The Corps will assist the non-Federal sponsor with preparation of any permit application that may be needed.

ARIZONA DEPARTMENT
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ENVIRONMENTAL QUALITY

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Janet Napolitano
Governor

Stephen A. Owens
Director

August 18, 2004

U.S. Army Corps of Engineers
Environmental Resources Branch
Attn: Michael J. Fink
3636 North Central Avenue, Suite 900
Phoenix, Arizona 85012-1939

Re: Draft Environmental Impact Statement, Paseo de las Iglesias Ecosystem Restoration, Santa Cruz River, Pima County, Arizona

Dear Mr. Fink:

The Arizona Department of Environmental Quality (ADEQ), Water Quality Division has reviewed the Paseo de las Iglesias Ecosystem Restoration, Draft Environmental Impact Statement, submitted by the Arizona/Nevada Area Office of the Los Angles District of the U.S. Army Corps of Engineers (ACOE), for proposed riverine ecosystem restoration of the Paseo de las Iglesias reach of the Santa Cruz River (SCR) in Tucson, Arizona. The project is being proposed in partnership with Pima County Flood Control, the non-Federal sponsor.

The preferred alternative (Alternative 3E) for the Paseo de las Iglesias Ecosystem Restoration project provides for mesquite bosque creation as the dominant feature of the ecosystem restoration plan. Alternative 3E provides a nearly uniform mesoriparian hydrologic regime to all geomorphic positions in the floodplain above the low flow channel. This alternative creates approximately 718 acres of mesquite, 356 acres of mixed mesoriparian shrub-scrub, 18 acres of cottonwood-willow, and almost 6 acres of emergent marsh.

Alternative 3E consist of the following activities:

- Maintain the low flow channel of the SCR in an upland condition.
- Lower channel terraces (vegetated areas above the low flow channel but below the 2-year recurrence interval flow event) will be planted with a mixed shrub-scrub community, with supplemental water delivered by bank-mounted sprinklers.
- Upper channel terraces (those above the 2-year interval flow event); and the historical floodplain will be planted to mixed riparian communities.

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- Construct eight in channel water harvesting basins at the confluence tributaries with in the main channel of the SCR, and five grade control basins in the SCR channel.

- Approximately 56,000 linear feet of overly-steep highly eroded banks will be regarded and planted to improve channel stability. The graded reaches will be created by excavating historic floodplain, rather than filling into the active channel. Approximately 3,700 linear feet of unstable, eroding slopes will be stabilized using conventional soil cement slope protection along selected reaches where there is insufficient distance from the active channel create a stable graded and vegetated slope.

The U.S. Army Corps of Engineers and/or Pima County are responsible for obtaining all other permits certifications and licenses that may be required by federal, state or local authorities. Other approvals include, but are not limited to: construction activities (AZPDES Stormwater Permit), use of reclaimed wastewater for dust control or irrigation (Reclaimed Water Permit), or dewatering of construction sites to a surface water body (AZPDES Permit).

We have determined that the proposed Paseo de las Iglesias Ecosystem Restoration project should comply with State surface water quality standards. The Paseo de las Iglesias Ecosystem Restoration project should not have a negative impact upon the chemical, physical or biological integrity of the Santa Cruz Rive or its tributaries. We therefore concur with the 404(r) exemption for State 401 Water Quality Certification.

Our concurrence with the 404(r) exemption for these activities does not affect or modify in any way the obligations or liability of any person for any damages, injury, or loss resulting from an impacted area discharge. The Department may modify or withdraw its determination if the information relied upon is inaccurate or if the project is not implemented as proposed. If, in the future, the Department determines that discharges from the activities have caused or contributed to a violation of surface water quality standards, the Department may withdraw concurrence with the 404(r) exemption and require an Individual 401 Certification for the project. This concurrence is not intended to waive any other federal, state or local laws.

Sincerely,

Andrew Cajero Travers   8/18/04

Andrew Cajero-Travers   Date
Surface Water Permits Unit

cc: U.S. EPA, Wetlands Regulatory Office

SWPU04:0369

14.4 Habitat Valuation Analysis (HGM)

1.0 Ecosystem Restoration Evaluation Methodologies

1.1 Species-Based Habitat Indices

USACE presently uses the habitat unit concept to characterize the non-monetary outputs of ecosystems that must justify project costs. The concept is closely associated with development of the Habitat Evaluation Procedures (HEP) developed under the lead of the U.S. Fish and Wildlife Services (USFWS 1980a-c). HEP measures the effects of environmental change through a series of species-based Habitat Suitability Indices (HSI) developed for approximately 160 individual fish and wildlife species. The species-based HSI models rely on field measured habitat parameters, which are integrated into a single, probability-of-use index ranging from 0 to 1.0. HEP uses a simple multiplication product of impacted area in acres and HSI to calculate Habitat Units (HUs).

Species-based Habitat Suitability Index (HSI) models deployed in the traditional Habitat Evaluation Procedures (HEP) methodology are numerous, easy to use, are relatively inexpensive, but not immediately available or applicable to the arid southwest region, and do not capture all of the important habitat/ecosystem elements or all of the justifying value needed to restore ecosystems. Species-based HSI models are not scaled based on ecosystem integrity and should only be used to indicate a more naturally integrated ecosystem condition when the HSI value is known for the targeted restored condition. Few existing single-species HSI models satisfy these criteria well, but ecosystems might be characterized by new models for native dominant and keystone species, including dominant plant species and top-carnivore species, used in series with a few HSI models for rare species in the community. Several species-based HSIs might then "bracket" the community-habitat relationships satisfactorily, but the need for many new models offsets the main existing advantage.

1.2 Community-Based Habitat Indices

Existing community- based HSI models offer more promise than species-based HSI models because they are more efficient in capturing those habitat measures necessary for restoring ecosystem integrity and can be compared across a wide range of ecosystems for prioritization purposes (Stakhiv, et al. 2001). Community-based HSI models indicate relative ecosystem value more inclusively than species-based models because they link habitat more broadly to ecosystem components or functions. While species richness is relatively easy to link to habitat features in community-based HSI models, species richness may not predict the number of endangered species present in an ecosystem very well. Most species richness measures are limited to one to a few taxonomic categories, such as birds, fish, or aquatic insects. The taxonomic groups chosen for characterizing integrity may not characterize to fine enough degree the habitat needs of the endangered species. Complete models would need to account for this potential deficiency by assuring the diversity measure is inclusive of the vulnerable species or by including a separate relationship between vulnerable-species and habitat conditions. Again, each community would require a unique model of habitat-species relationships. Relatively few community prototype models have been developed, however, and most of the models would require considerable investment to cover the variety of ecosystems managed by the Corps.

1.3 Function-Based Indices

USACE's Environmental Laboratory (Engineer Research and Development Center, Vicksburg, MS) developed a similar approach to assessing the functional capacity of a wetland using standard wetland assessment protocols typically deployed in the regulatory arena. 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 model defines the relationships between one or more characteristics or 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 compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs) – quantifying the capacity of wetlands to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. 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 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. FCI models combine Variable Sub-indices VSIs in a mathematical equation to rate the functional capacity of a wetland on a scale of 0.0 (not functional) to 1.0 (optimum functionality). An HGM subclass model is basically an assimilation of several FCI models combined in a specific fashion to mimic a site's functionality. Users can review and select several FCI models to evaluate the overall site functionality. All FCI models are described using a single FCI formula (refer to the Single Formula Subclass Models section below). 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.

1.4 Process Simulation Models

Process simulation models are based (in theory) on ecosystem process and offer the greatest flexibility in use and management insight with respect to the output generated with incremental additions of restoration measures (Stakhiv, et al. 2001). Functional stability could in theory be analyzed directly. In terms of basic processes, similar principles operate across all ecosystems. However, process models rely on fundamental understanding of the way ecosystems operate and are extremely "information hungry". Much can be learned about how ecosystems work during assembly of process models, but the ultimate models for evaluating non-monetized environmental service are many years away even if research investment were substantially increased. The past objections to process models having to do with inadequate portability and computational capability are less likely to apply now. Even so, the details of resource partitioning into communities of different species richness and functional stability require much research and development. In the process of assembling such models, much more could be learned than from index models about managing ecosystem process for more reliable service delivery (sustainable development?) across all monetized and non-monetized services. Process simulation shows the most promise for incorporating tradeoff analysis within single model operations.

1.5 Selection of the HGM Method for the Arizona Studies

In 2002, the District began the process of formulating alternative designs for the five Arizona Ecosystem Restoration Planning Studies (El Rio Antiguo on the Rillito River, Paseo de las Iglesias and Tres Rios del Norte on the Santa Cruz River, Rio Salado Oeste and VaShly'ay Akimel on the Salt River). The District partnered with the U. S. Army Engineer Research and Development Center, Environmental Laboratory (EL), the U.S. Fish and Wildlife Service (USFWS), and the Arizona Game and Fish Department (AZGF) to ensure all stakeholder issues were considered.

Setting ecosystem restoration objectives and performance criteria on the holistic recovery of "non-use" benefits, such as wildlife habitat, hydrology and biogeochemical processes, was critical to the overall planning process for the studies. It is important to note that the basic ecological premise behind ecosystem restoration is the recovery of limiting components, defined by their primary functional characteristics, be they water, soils and/or habitat structure. The primary goal of the studies was therefore focused on the restoration of such functional components within the Study Area. To measure the success of the ecosystem restoration proposals, the best available science was brought to bear. In most ecosystem restoration studies, benefits are measured using quantifiable techniques rather than qualitative assessments. It was important then, that the technique selected to quantify benefits for the studies be repeatable, efficient and effective, as results could be questioned by outside interests. Many rapid assessment techniques were readily available to the Evaluation Teams in off-the-shelf formats in 2002, but for the various reasons described in the next section, HGM was selected (HydroGeoMorphic Assessment of Wetlands) to quantify the anticipated benefits gained by the proposed ecosystem restoration activities.

Again, HGM emphasizes the functions associated with the range of physical and chemical attributes comprising habitat of wetland ecosystems. It also incorporates a structural index based on a set of species identified for the specific model application. Although models used in a HEP methodology might be more appropriate to a riparian setting in this region, their overall evaluation of potential changes to the ecosystem dynamic are limited when capturing wetland functionality as a whole. The HGM approach has one important advantage over the HEP methodology (HSI models in particular) in that it is more inclusive of all ecosystem functions relevant to ecosystem services. Available HEP models were limited to the habitat function in support of species richness, and might overlook key hydrologic influences experienced in high-flow periods.

1.6 Introduction To The HGM Process

Wetland ecosystems share a number of common attributes including relatively long periods of inundation or saturation, hydrophytic vegetation, and hydric soils. In spite of these common attributes, wetlands occur under a wide range of climatic, geologic, and physiographic situations and exhibit a wide range of physical, chemical, and biological characteristics and processes (Ainslie et al., 1999; Ferren, Fiedler, and Leidy, 1996; Ferren et al., 1996a,b; Mitch and Gosselink, 1993; Semeniuk, 1987; Cowardin et al., 1979). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short time frame available for conducting assessments). Existing "generic" methods, designed to assess multiple wetland types throughout the United States, are relatively rapid, but lack the resolution necessary to detect significant changes in function. One way to achieve an appropriate level of resolution within the available time frame is to reduce the level of variability exhibited by the wetlands being considered (Smith et al., 1995).

The HydroGeoMorphic Assessment of Wetlands approach (HGM) was developed specifically to accomplish this task (Ainslie et al., 1999; Brinson, 1993). HGM identifies groups of wetlands that function similarly using three criteria (geomorphic setting, water source, and hydrodynamics) that fundamentally influence how wetlands function. "Geomorphic setting" refers to the landform and position of the wetland in the landscape. "Water source" refers to the primary water source in the wetland such as precipitation, overbank floodwater, or groundwater. "Hydrodynamics" refers to the level of energy and the direction that water moves in the wetland. Based on these three criteria, any number of "functional" wetland groups can be identified at different spatial or temporal scales. For example, on a continental scale, Brinson (1993) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al., 1995).

Table 1. HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depression wetlands may have any combination of inlets and outlets or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that range from diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, vernal pools, and cypress domes are common examples of depression wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries, and are under the influence of sea level. They intergraded landward with riverine wetlands where tidal current diminishes, and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bi-directional flows from tides dominate over unidirectional ones controlled by floodplain slope of riverine wetlands. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent, and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water. Fringe table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bi-directional, usually controlled by water-level fluctuations resulting from wind or seiche. Lacustrine wetlands lose water by flow returning to the lake after flooding and evapotranspiration. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.

Table 1. (cont.) HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or sites with saturated overland flow with no channel formation. They normally occur on sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface.. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by down-slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands.
Mineral Soil	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces Flats where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater.. They are distinguished from flat upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become organic soil flats. They typically occur in relatively humid climates. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.
Organic Soil Flats	Organic soil flats, or extensive peat lands, differ from mineral soil flats in part because their elevation and Soil Flats topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peat lands are examples of organic soil flat wetlands.

Table 1. (cont.) HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwoods on floodplains are an example of riverine wetlands.

In many cases, the level of variability in continental-scale wetland hydrogeomorphic classes is still too immense to develop assessment models that can be rapidly applied while being sensitive enough to detect changes in function at a level of resolution appropriate to the planning process. For example, at a continental geographic scale the depression class includes wetlands as diverse as California vernal pools (Zedler, 1987), prairie potholes in North and South Dakota (Kantrud et al., 1989; Hubbard, 1988), playa lakes in the high plains of Texas (Bolen et al., 1989), kettles in New England, and cypress domes in Florida (Kurz and Wagner, 1953; Ewel and Odum, 1984).

To reduce both inter- and intra-regional variability, the three classification criteria (geomorphic setting, water source, and hydrodynamics) are applied at a smaller, regional geographic scale to identify regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (Stewart and Kantrud, 1971; Golet and Larson, 1974; Wharton et al., 1982; Ferren, Fiedler, and Leidy, 1996; Ferren et al., 1996a,b; Ainslie et al., 1999). In addition to the three primary classification criteria, certain ecosystem or landscape characteristics may also be useful for distinguishing regional subclasses in certain regions. For example, depression subclasses might be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo, 1998). Slope subclasses might be based on the degree of slope, landscape position, source of water (i.e., through-flow versus groundwater), or other factors. Riverine subclasses might be based on water source, position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Examples of potential regional subclasses are shown in Table 2 (Smith et al., 1995; Rheinhardt et al., 1997).

Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of its geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process. Classifying wetlands based on how they function, narrows the focus of attention to a specific type or subclass of wetland, the functions that wetlands within the subclass are most likely to perform, and the landscape/ecosystem factors that are most likely to influence how wetlands in the subclass function. This increases the accuracy of the assessment, allows for repeatability, and reduces the time needed to conduct the assessment.

Table 2. Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source, and Hydrodynamics

Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina Bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizonal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (mineral soil)	Precipitation	Vertical	Peat bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizonal	Bottomland hardwood forests	Riparian wetlands

Designed to assess wetlands as a whole, the HGM technique focuses on a wetlands' structural components and the processes that link these components within a system (Bormann and Likens, 1969). Structural components of the wetland and the surrounding landscape (e.g., plants, soils, hydrology, and animals) interact with a variety of physical, chemical, and biological processes. Understanding the interactions of the wetlands' structural components and the surrounding landscape features is the basis for assessing wetland functions and the foundation of the HGM Approach. By definition, wetland functions are the normal or characteristic activities that take place in wetland settings. 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. Examples of wetland functions evaluated with Functional Capacity Index (FCI) models are found in Table 3.

Table 3. Wetland Functions Measured In HGM And Their Value To The Ecosystem

Functions Related to the Hydrologic Processes	Benefits, Products, and Services Resulting from the Wetland Function
Short-Term Storage of Surface Water: The temporary storage of surface water for short periods.	Onsite: Replenish soil moisture, import/export materials, and provide a conduit for organisms. Offsite: Reduce downstream peak discharge and volume, and help maintain and improve water quality.
Long-Term Storage of Surface Water: The temporary storage of surface water for long periods.	Onsite: Provide habitat and maintain physical and biogeochemical processes. Offsite: Reduce dissolved and particulate loading and volume, and help maintain and improve surface water quality.
Storage of Subsurface Water: The storage of subsurface water.	Onsite: Maintain biogeochemical processes. Offsite: Recharge surficial aquifers, and maintain base flow and seasonal flow in streams.
Moderation of Groundwater Flow or Discharge: the moderation of groundwater flow or groundwater discharge.	Onsite: Maintain habitat. Offsite: Maintain groundwater storage, base flow, seasonal flows, and surface water temperatures.
Dissipation of Energy: The reduction of energy in moving water at the land/water interface.	Onsite: Contribute to nutrient capital of ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Functions Related to Biogeochemical Processes	**Benefits, Products, and Services Resulting from the Wetland Function**
Cycling of Nutrients: The conversion of elements from one form to another through abiotic and biotic processes.	Onsite: Contributes to nutrient capital of the ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Removal of Elements and Compounds: The removal of nutrients, contaminants or other elements and compounds on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of the ecosystem. Contaminants are removed, or rendered innocuous. Offsite: Reduced downstream loading helps to maintain or improve surface water quality.
Retention of Particulates: The retention of organic and inorganic particulates on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of the ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.

Export of Organic Carbon: The export of dissolved or particulate organic carbon.	Onsite: Enhances decomposition and mobilization of metals. Offsite: Supports aquatic food webs and downstream biogeochemical processes.
Functions Related to Habitat	**Benefits, Products, and Services Resulting from the Wetland Function**
Maintenance of Plant and Animal Communities: the maintenance of plant and animal community that is characteristic with respect to species composition, abundance, and age structure.	Onsite: Maintain habitat for plants and animals (e.g., endangered species and critical habitats) forest and agriculture products, and aesthetic, recreational, and educational opportunities. Offsite: Maintain corridors between habitat islands and landscape/regional biodiversity.

Wetland functions represent the currency or units of the wetland system for assessment purposes, but the integrity of the system is not disconnected from each function, rather it represents the collective interaction of all wetland functions. Consequently, wetland assessments using the HGM approach require the recognition by both the Assessment Team and the end user that this link (i.e., between wetland function and system integrity) is critical. One cannot develop criteria, or models, to maximize a single function without having potentially negative impacts on the overall ecological integrity and sustainability of the wetland system as a whole. For example, one should not attempt to create a wetland to maximize water storage capacity without the recognition that other functions (e.g., plant species diversity) will likely be altered from those similar wetland types with less managed conditions. This does not mean that a wetland cannot be developed to maximize a particular function, but that it will typically not be a sustainable system without future human intervention.

The HGM approach is characterized and differentiated from other wetland assessment procedures in that it first classifies wetlands based on their ecological characteristics (i.e., landscape setting, water source, and hydrodynamics). Second it uses reference sites to establish the range of wetland functions. Finally, the HGM approach uses a relative index of function (Functional Capacity Index or FCI), calibrated to reference wetlands, to assess wetland functions. In the HGM methodology, a VSI, is a mathematical relationship that reflects a wetland function's sensitivity to a change in a limiting factor or variable within the Partial Wetland Assessment Area or PWAA (a homogenous zone of similar vegetative species, geographic similarities, and physical conditions that make the area unique). Similar to cover types in HEP, PWAAs are defined on the basis of species recognition and dependence, soils types, and topography. 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 an VSI = 1.0 represents a variable in abundance (not limiting) for the wetland.

Reference wetlands are wetland sites selected from a reference domain (a defined geographic area), selected to "represent" sites that exhibit a range of variation within a particular wetland type, including sites that have been degraded/disturbed as well as those sites with minimal disturbance (Ainslie et al., 1999). The use of reference wetlands to scale the capacity of wetlands to perform a function is one of the unique features of the HGM approach. Reference provides the standard for comparison in the HGM approach. Unlike other methods which rely on data from published literature or best professional judgment, the HGM approach requires identification of wetlands from the same regional subclass and from the same reference domain, collection of data from those wetlands, and scaling of wetland variables to those data. Since wetlands exhibit a wide range of variability, reference wetlands should represent the range of conditions within the reference domain. A basic assumption of HGM is that the highest, sustainable functional capacity is achieved in wetland ecosystems and landscapes that have not been subject to long-term anthropogenic disturbance (Smith et al., 1995). It is further assumed that under these conditions the structural components and physical, chemical, and biological processes within the wetland and surrounding landscape reach a dynamic equilibrium necessary to achieve the highest, sustainable functional capacity. Reference standards are derived from these wetlands and used to calibrate variables. However, it is also necessary to recognize that many wetlands occur in less than standard conditions. Therefore, data must be collected from a wide range of conditions in order to scale model variables from 0.0 to 1.0, the range used for each variable subindex. To assist the user, a list of key terms related to the reference wetland concept in the HGM methodology is provided (Table 4).

Table 4. Reference Wetland Terms and Definitions

Term	Definition
Reference domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected
Reference Wetland	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and disturbance and from human alteration.
Reference standard wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that wetlands is both sustainable and characteristic of the least human altered wetland sites in the least human altered landscapes. By definition, the functional
Reference standard wetlands variable condition	The range of conditions exhibited by model variables in reference standard wetlands. By wetland variable definition, reference standard conditions receive a variable subindex score of 1.0.
Site potential - Mitigation Project Context	The highest level of function possible, given local constraints of disturbance history, land use, (mitigation project or other factors. Site potential may be less than or equal to the levels of function in reference context) standard wetlands of the regio
Project target - Mitigation Project Context	The level of function identified or negotiated for a restoration or creation project.
Project standards - Mitigation Project Context	Project standards Performance criteria and/or specifications used to guide the restoration or creation activities (mitigation context) toward the project target. Project standards should specify reasonable contingency measures if the project target is not

In the HGM approach, an assessment model is a simple representation of a function performed by the wetland ecosystem (Ainslie et al., 1999). It defines the relationship between one or more characteristics or 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 compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs). An index of the capacity of wetland to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. 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 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. FCI models combine VSIs in a mathematical equation to rate the functional capacity of a wetland on a scale of 0.0 (not functional) to 1.0 (optimum functionality). An HGM subclass model is basically an assimilation of several FCI models combined in a specific fashion to mimic a site's functionality. Users can review and select several FCI models to evaluate the overall site functionality. All FCI models are described using a single FCI formula (refer to the Single Formula Subclass Models section below). 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.

Reference sites used for model calibration for Arizona Studies included The Nature Conservancy's Hassayampa River Preserve, the Verde River at the confluence with the Salt River, the Santa Cruz River at Tumacocori, the San Pedro River at the San Pedro National Riparian Conservation Area, and Tanque Verde Wash upstream of the Rillito River confluence. These sites were recommended based on the following criteria: 1) they were reasonable sites considering current conditions, 2) they were in a similar regional Riverine subclass to the Santa Cruz River with similar elevation, topography, gradient, and stream order, 3) they represented important aspects of pre-historical conditions, and 4) they were uniform across political boundaries. Model attendees agreed that no truly ideal reference site exists and restoration to the ideal was not achievable due to inability to remove all stressors. The goal in choosing these sites was that the hydrologic, biogeochemical and habitat characteristics be as undisturbed as possible.

HGM model variables represent the characteristics of the wetland ecosystem (and surrounding landscape) that influence the capacity of a wetland ecosystem to perform a function. HGM model variables are ecological quantities that consist of five components (Schneider, 1994). These include: 1) a name, 2) a symbol, 3) a measure of the variable and procedural statement for quantifying or qualifying the measure directly or calculating it from other measurements, 4) a set of values [i.e., numbers, categories, or numerical estimates (Leibowitz and Hyman, 1997)] that are generated by applying the procedural statement, and 5) units on the appropriate measurement scale. Table 5 provides several examples.

Table 5. Components Of A Typical HGM Model Variables

Name (Symbol)	Measure/Procedural Statement	Resulting Values	Units (Scale)
Redoximorphic Features (V_{REDOX})	Status of redoximorphic features/visual inspection of soil profile for redoximorphic features	Present/ Absent	unitless (Nominal Scale)
Floodplain Roughness (V_{ROUGH})	Manning's Roughness Coefficient (n) Observe wetland characteristics to determine adjustment values for roughness component to add to base value	0.01 0.1 0.21	unitless (Interval Scale)
Tree Biomass (V_{TBA})	Tree basal area/measure diameter of trees in sample plots (cm), convert to area (m), and extrapolate to per hectare basis	5 12.8 36	m^2/ha (Ratio Scale)

HGM model variables occur in a variety of states or conditions in reference wetlands (Ainslie et al., 1999). The state or condition of the variable is denoted by the value of the measure of the variable. For example, tree basal area, the measure of the tree biomass variable could be large or small. Similarly, recurrence interval, the measure of overbank flood frequency variable could be frequent or infrequent. Based on its condition (i.e., value of the metric), model variables are assigned a variable subindex. When the condition of a variable is within the range of conditions exhibited by reference standard wetlands, a variable subindex of 1.0 is assigned. As the condition deflects from the reference standard condition (i.e., the range of conditions that the variable occurs in reference standard wetland), the variable subindex is assigned based on the defined relationship between model variable condition and functional capacity. As the condition of a variable deviates from the conditions exhibited in reference standard wetlands, it receives a progressively lower subindex reflecting its decreasing contribution to functional capacity. In some cases, the variable subindex drops to zero. For example, when no trees are present, the subindex for tree basal area is zero. In other cases, the subindex for a variable never drops to zero. For example, regardless of the condition of a site, Manning's Roughness Coefficient (n) will always be greater than zero.

HGM combines both the wetland functionality (FCIs measured with variables) and quantity 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). Under the HGM methodology, one FCU is equivalent to one optimally functioning wetland acre. Like HEP, HGM can be used to evaluate further conditions and the long-term affects of proposed alternatives by generating FCUs for wetland functions over several target years. In such analyses, 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 outcomes, alternative designs can be formulated, and trade-off analyses can be simulated, to promote environmental optimization.

14.5 Comments and Responses

This appendix includes the public and agency comments received during the formal comment period conducted between October 8, 2004 and November 22, 2004. Comments were received via written letter and e-mail correspondence. The final public meeting was held on October 26, 2004 in the City of Tucson, Pima County, Arizona and the written and oral comments received at the meeting are included herein. Electronically scanned copies of all comments are located at end of this appendix, after Item No. 12.

Public comments and responses received on the Draft Feasibility Report (FR) and Draft Environmental Impact Statement are listed below:

1. E-mail from Pima County Natural Resources Parks and Recreation, sent October 4, 2004
2. Comment card from Kenneth Ford, undated, provided on October 26, 2004
3. Letter from the U.S. Department of the Interior, Office of the Secretary, dated November 4, 2004
4. Letter from Jonathan DuHamel, dated November 9, 2004
5. E-mail from Pima County Cultural Resources, sent November 12, 2004
6. Letter from the U.S. Environmental Protection Agency, Region IX, dated November 12, 2004
7. Letter from the City of Tucson, Office of the City Manager, dated November 15, 2004
8. Letter from the Arizona Game and Fish Department, dated November 18, 2004
9. E-mail from the Tucson Herpetological Society, sent November 21, 2004
10. Letter from Center for Biological Diversity, dated November 22, 2004
11. E-mail with attached comment letter from the Santa Cruz River Alliance, sent November 22, 2004
12. Transcript of Public Meeting, conducted on October 26, 2004

***1. E-mail from Mr. Darrin Brightman, Pima County Natural Resources Parks and Recreation, sent October 4, 2004*:**

Comment 1.1: Upon reviewing the current draft feasibility study for the Paseo de las Iglesias project in Tucson, I found that the bibliography did not *appear* to list any references detailing the source of your agency's experiences with or knowledge of stormwater detention basins as a means of habitat restoration, nor did the Prior Studies section. However, design standards for detention basins were included in the feasibility study.

I reviewed several other USACE studies (available on Pima County's websites), and again found no references specific to this question. (Unfortunately, the Arroyo Chico and Ajo Detention Basin studies are no longer available).

Are there references you or one of your colleagues could recommend? Perhaps USACE has completed its own studies, and therefore does not need to cite them?

I would like to see greater use of detention basins in our future park designs and/or enhancements, but am having difficulty finding studies which demonstrate that they work! Granted, visiting nearly any flood-control basin within the Tucson valley demonstrates it, but that's not always good enough when asking for money.

Response: The Recommended Plan does not include the use of detention basins per se. The Recommended Plan does however include the use of stormwater harvesting basins intended to retain a small measure of in-channel and tributary flows for the restored vegetative communities.

***2. Comment Card from Kenneth Ford, undated, provided on October 26, 2004*:**

Comment 2.1: Please connect the recreational bike trail/hiking trail between Ajo and Silverlake.

Response: The Recommended Plan, Alternative 3E, includes a pedestrian trail connection between Ajo Way and Silverlake Road. Please see Figure 6.2 of the Feasibility Report.

3. Letter from the U.S. Department of the Interior, Office of the Secretary, dated November 4, 2004:

Comment 3.1: Page 7 of the document indicates a source of water for the project is still being sought. The Bureau of Reclamation (BOR), as part of the Southern Arizona Water Rights Settlement Act (SAWRSA), owns the rights to 28,200 acre-feet per year of treated wastewater effluent. A portion of this amount has yet to be put to beneficial use by the BOR. Local sponsors have an agreement that allows use of locally controlled effluent for riparian restoration purposes; however, it would be advantageous to the Federal government if the BOR was paid to use SAWRSA effluent. We request the SAWRSA effluent be considered as a water source for the project. Should you have any questions, please contact Eric Holler, Bureau of Reclamation's Tucson Field Office, at 520-670-4825.

Response: The availability of treated effluent as part of the SAWRSA is noted and will be evaluated by the non-Federal sponsor during Preliminary Engineering and Design.

Comment 3.2: The Fish and Wildlife Service (Service) Arizona Ecological Services Field Office has participated in this project through funding agreements under the Fish and Wildlife Coordination Act. The current plan reflects Service input and the Service has no additional comment at this time.

Response: Comment noted.

4. Letter from Jonathan DuHamel, dated November 9, 2004:

Comment 4.1: What is the total amount of funding that the Corps was appropriated for environmental restoration projects nationwide in the current fiscal year?

Response: The 2005 Corps of Engineers Civil Works Budget included $408 million for restoration work.

Comment 4.2: What are the realistic chances of receiving an appropriation of the $59,667,000 for the federal cost of the Paseo de las Iglesias Environmental Restoration project?

Response: It is not possible to assign a probability that the Federal contribution will be appropriated by Congress. However, numerous environmental restoration projects around the country, both more and less costly, have received Federal funding in Federal Fiscal Year 2005 for construction, including the Rio Salado project in Phoenix, Arizona.

Comment 4.3: What is the estimated cost of the pre-construction engineering and design for the Paseo de las Iglesias project?

Response: The estimated cost of the Pre-Construction Engineering and Design for the proposed project is $4,658,627 for the restoration features (Table 6.1 in Chapter VI of the Feasibility Report) and $85,457 for the recreation features (Table 57 of the Economics Appendix).

Comment 4.4: Should the pre-construction engineering and design cost be expended, if there is uncertainty about the chances of receiving an appropriation of the federal funding for the Santa Cruz and Rillito Rivers in Pima County?

Response: It is beyond the scope of this document to advise on whether these costs should be expended while uncertainty remains regarding the appropriation for construction. However; it should be noted that funding for pre-construction engineering and design will be cost shared between the Local Sponsor and Federal government. Furthermore, while some funds could be expended while awaiting authorization, the majority of the costs would not be expended until after the project had been authorized for construction by Congress.

Comment 4.5: What are the realistic chances of receiving appropriations totaling $393,000,000 for the federal cost of all of the environmental restoration projects being studies for the Santa Cruz and Rillito Rivers in Pima County?

Response: See the response to Comment 4.2.

Comment 4.6: What is the estimated cost of the pre-construction engineering and design for all of the environmental restoration projects being studied for the Santa Cruz and Rivers in Pima County?

Response: The estimated cost of the Pre-Construction Engineering and Design for the proposed project is $4,658,627 for the restoration features (Table 6.1 in Chapter VI of the Feasibility Report) and $85,457 for the recreation features (Table 57 of the Economics Appendix). The estimated Pre-Construction Engineering and Design cost for the restoration project on the Rillito River (El Rio Antiguo) is $4,150,000 for the restoration features and $118,208. Pre-Construction Engineering and Design cost estimates for the other restoration projects for the Santa Cruz River have not yet been completed.

Comment 4.7: Should the pre-construction engineering and design costs for all of the projects on the Santa Crux Rivers be expended, if there is uncertainty about the chances of receiving an appropriation of the federal funding for all of these projects?

Response: See the response to Comment 4.4.

Comment 4.8: The Paseo de las Iglesias Ecosystem Restoration Feasibility Study includes a letter from the Pima County Flood Control District stating that it will bear the local sponsor agency costs for the project, and will bear the continuing costs for irrigation water and maintenance. When the Corps of Engineers is considering major federal expenditures for projects of this type, does the Corps audit or otherwise verify the financial capability of the local sponsor to fund the local sponsor construction costs and the continuing operation and maintenance costs?

Response: The non-Federal sponsor has indicated its ability and willingness to participate in the planning, engineering, design, and construction of the proposed project. A Statement of Financial Capability is provided in Feasibility Report, Chapter XI, Letters of Support and Financial Capability. The U.S. Army Corps of Engineers performs a detailed assessment of the non-Federal sponsor's financial capability prior to entering into the design and construction phases of the project.

Comment 4.9: According to the Annual report of the Pima County Flood Control District for Fiscal Year 2002-2003, the District had total tax revenues of $14,467,389. The operating expenses were 42% of this total, equal to $6,076,999. The capital improvements expenditures were 51$ of the total, equal to $7,378,000. Debt service was 7% of the total, equal to $1,013,000. Based on these numbers, the local sponsor agency share of the construction cost for the Paseo de las Iglesias project, $32,392,000, amounts to 4.4 years of the total amount of capital improvements funding for the District. The continuing annual costs for irrigation water and maintenance for the Paseo de las Iglesias project total $1,869,961. This constitutes 13% of the entire annual revenues of the District, and 31% of the annual operating expenditures. Has the Corps of Engineers audited or otherwise verified the financial capability of the local sponsor agency to fund the local sponsor construction costs and the continuing operation and maintenance costs for the Paseo de las Iglesias project?

Response: The U.S. Army Corps of Engineers has not audited or otherwise verified the financial capacity of the local sponsor to cooperate in the construction, or the annual maintenance of a federally funded cooperative project. During the design phase the Corps would conduct a financial assessment of the sponsor. Prior to initiation of design and construction, contractual agreements must be approved by the legal representatives of the sponsoring agency agreeing to the fee, the fee schedule and the assurance that the project will be operated and maintained as built. The Corps has a long standing history of successful partnering on large scale projects with Pima County and the Pima County Regional Flood Control District.

As a matter of clarification the $32,392,000 identified as the local sponsor's share of the construction cost is not exclusively a cash contribution. Per federal regulations, the minimum total cash contribution from the sponsor is 5 percent (approximately $4,650,000) of the total project cost. Several opportunities exist for the local sponsor to reduce their cash contribution. In addition to the provision of in-kind services during design and construction, the most significant way to reduce this amount is through land ownership. A large portion of the total project cost includes land valued by "gross" appraisal. It is the responsibility of the sponsor to secure ownership of the land. Given that a significant portion of the land identified for this project is already under local government ownership, the local sponsor's actual investment in construction will be less than the amount reported.

Comment 4.10: Should the pre-construction engineering and design costs for the Paseo de las Iglesias project be expended, if there is uncertainty regarding the financial ability of the local sponsor agency to fund its share of the construction costs and the continuing irrigation water and maintenance?

Response: See response to Comment 4.8.

Comment 4.11: If the local sponsor agency share of the construction cost of all of the environmental restoration projects being planned for the Santa Cruz and Rillito Rivers is approximately $138,000,000, this constitutes 18.7 years of the total amount of capital improvements funding for the District. If the continuing annual costs for irrigation water and maintenance for all of these projects is approximately $7,984,500, this constitutes 55% of the entire annual revenues of the District, and more than the total annual operating expenditures. Has the Corps of Engineers audited or otherwise verified the financial capability of the local sponsor agency to fund the local sponsor construction costs and the continuing operation and maintenance costs for all of the environmental restoration projects being studied for the Santa Cruz and Rillito Rivers in Pima County?

Response: See response to Comment 4.9. In addition, the TRDN and El Medio projects have multipule local sponsors which will further reduce the RFCD's financial responsibilities.

Comment 4.12: Should the pre-construction engineering and design costs for all of the environmental restoration projects being planned for the Santa Cruz and Rillito Rivers be expended, if there is uncertainty regarding the financial ability of the local sponsor agency to fund its share of the construction costs and the continuing irrigation water and maintenance?

Response: See response to Comment 4.8.

5. E-mail from Pima County Cultural Resources, sent November 12, 2004:

Comment 5.1: Feasibility Study, Chapter III. A. Prior Studies or Reports. I realize that this is a sample of the reports and studies not a comprehensive list, but I think it is important to add a couple more. These are: Scott O'Mack and Eric Klucas, 2002 San Xavier to San Augustin, An Overview of Cultural Resources for the Paseo de las Iglesias Feasibility Study, Pima County, Arizona, Statistical Research Inc., Tucson. McGann &

Associates, 2002, Master Plan for Pima County, Arizona Segment, Juan Bautista de Anza National Historic Trail.

Response: The intent of Chapter III of the Feasibility Report is to provide a sample of the types of studies that have been completed in the study area prior to the initiation of this feasibility study. Chapter III is not intended to be a comprehensive list. The two references cited in Comment 5.1 are cited in Section 10, References 10 of the Final Environmental Impact Statement.

Comment 5.2: Feasibility Report, Page IV-14 Cultural Resources. In the first paragraph please make a note that this information is based on O'Mack and Klucas 2002 (referenced above). In the second paragraph make note that SHPO will likely also be fully consulted.

Response: A reference the O'Mack and Klucas 2002 report has been added to the subject paragraph. The second paragraphs now indicates that "In accordance with 36 CFR 800, regulations implementing Section 106 of the National Historic Preservation Act, identification and evaluation studies will be coordinated with the Arizona State Historic Preservation Office (SHPO), Pima County, and interested Native American Indian tribes."

Comment 5.3: Draft EIS, Page 112 Section 5.6.2, first paragraph. I think it would be useful to add coordination with SHPO here as well.

Response: Reference to coordination with the SHPO has been included in Section 5.6.2

6. Letter from the U.S. Environmental Protection Agency, Region IX, dated November 12, 2004:

Comment 6.1: The Tucson Basin is home of the Tohono O'odham Nation and Pascua Tribe. The DEIS notes that a Memorandum of Agreement (MOA) and archeological site treatment plan will be developed if necessary to ensure protection of National Register of Historic Places (NHRP)-listed sites. However, there is no information regarding the status of consultation with these tribes or whether they were asked to be a cooperating agency. The Final EIS should include this information and any input or concerns the Tribes may have related to project implementation.

Response: Copies of the Draft Feasibility Report and Draft Environmental Impact Statement (EIS) were transmitted to the Tohono O'odham Nation and Pascua Yaqui Tribe for review during the public comment period. No comments were received. A copy of the distribution list is contained in Section 13 of this Final EIS. Formal coordination with Tribal representatives have been conducted. The Final EIS will include information regarding the status of tribal coordination and any input or concerns the Tribes may have related to project implementation.

Comment 6.2: The Final EIS should also include input or concerns that were expressed by land managers in the area and response to these concerns.

Response: All comments received from individuals or organizations owning land in the area of the proposed project have been included in this appendix.

Comment 6.3: EPA notes that once the bank stabilization has been completed, land use adjacent to the Project Area may change, allowing for the development of commercial, light-industrial, or residential use. The cumulative impacts of such efforts should be assessed to the extent possible as well as the ensuing effects to air quality, surrounding vegetation, and cultural resources. In addition, while there is a discussion about restoration projects in the area, there should be a discussion about non-restoration related projects that are ongoing or planned for the area by the Corps or other agencies, such as the Border Patrol and the Department of Homeland Security.

Response: There are no large tracts of land outside the project boundaries and currently within the established setbacks that would have their development status restricted by construction of the recommended plan. Section 6.1 of the FIES does identify the City of Tucson's planned riverside redevelopment, Rio Nuevo. While Rio Nuevo's early planning does include habitat restoration components, the project is primarily an urban recreational park and education facility. The Corps and Pima County are not aware of other reasonably foreseeable, non-restoration projects planned for the project area.

7. Letter from the City of Tucson (COT), Office of the City Manager, dated November 15, 2004:

COT Real Estate

Comment 7.1: According to the Real Estate plan (Appendix I) of the feasibility report, there is a total of 1223 acres designated as the Paseo de las Iglesias study area. Of this total, 512 acres or 42% is owned by the City of Tucson. According to the plan, all of the land is subject to floodplain and floodplain restrictions that place significant limitations on its highest and best use. This general statement would need much more supportable evidence that is not provided for in the plan. The plan places a gross appraisal estimate of the city property at $3,322,296, or approximately $6,500 per acre. The plan puts the county owned property at $42,833/acre and the privately owned property at $27,235/acre. Since the appraisal was not available in the report, there is no way to determine the legitimacy of these figures or where they came form. As it relates to the 17.45 acres of city property adjacent to the Airport Wash, this site has a value estimated (by city's appraiser) at approximately $1.9M or $109,000 per acre, so there I considerable concern over the values shown in the Real Estate Plan. We really need to see the appraisal used in order to determine how realistic the values are.

Response: Pima County will provide to the City of Tucson Real Estate Division all reports and supporting documentation that was utilized in establishing property values. Upon review of this information the County will work with City staff towards resolving their real estate concerns.

Comment 7.2: The Plan states that the city properties are zoned for River Park according to the Santa Cruz Area Plan. The parcels of city property along the east side of the River are currently zoned R-1 and the parcel located in the Parque De Santa Cruz subdivision is zoned R-1.

Response: Pima County Real Estate personnel will investigate this zoning discrepancy. If it is determined the Real Estate Plan is incorrect then the parcel zoning and all subsequent related data, including property valuation will be appropriately adjusted.

Comment 7.3: The Plan states that the parcels will be acquired as a Permanent Easement Estate...does this mean they have been valued as such, or has fee value estimate been considered? The plan states that due to the political and economic relationship of the city and county, it is not conducive to permit the transfer of fee title from one entity to another. Even if this may be case on occasion, I don't think this Plan should be stating the perceived relationship problems of the city and county, particularly as a reason not to convey fee title-we convey fee title to each other all the time.

Response: The permanent easement estate was included in the Real Estate Plan to allow the non-Federal sponsor to use an additional option if applicable, other than the standard fee title estate, to meet the real estate requirements. References to the City and County issues have been deleted from the Real Estate Plan.

Comment 7.4: The plan states the value estimates are based on the high end. This is a very general statement that provides no adequate support. The plan states that it is thought that some parcels may "fall out" of the final plan. This is an encouraging statement that perhaps some parcels identified should not be part of the plan... specifically, we would argue that the city parcel adjacent to the Airport Wash should not be in the plan.

Response: The use of each parcel considered for inclusion during the Feasibility Study will be reevaluated during detailed Pre-construction Engineering and Design phase. Detailed appraisals that would be required for each parcel included in the implemented plan would resolve any questions concerning values.

COT Department of Transportation, Engineering Division

Comment 7.5: It appears that this project will have a significant impact on private properties and municipally held properties along the affected reaches of the Santa Cruz Ricer (SCR). Although the City of Tucson is fully supportive of environmental restoration projects, we are also very interested in providing additional flood control protection for our existing public infrastructure in the vicinity of the affected reaches of the SCR as well as increasing our potential tax base through land reclamation for future development. It is our belief that there is a strong possibility that if the Corps were to work closely with individual abutting property owners, mutually beneficial options/alternatives could be identified that would achieve environmental restoration, flood control, and land reclamation. Additionally, it is very possible that some abutting property owners would be willing to share in the respective costs of both the environmental restoration element of the project (perhaps through the dedication of property) and the flood control element of the project (perhaps through direct financial contribution or through the installation/construction of improvements) if these efforts resulted in the reclamation of additional land.

Response: Section 2.3 of the FEIS Project Objectives indicated that the project would have incidental flood damage reduction benefits, but flood damage reduction measures would not be featured because they had been eliminated from Federal participation. The level of equivalent annual damages from both flood inundation and bank erosion damages were not at a level that would to justify Federal participation in structural flood damage reduction and/or bank stabilization. Reclamation of land for the purposes of future development is included as a federally significant project benefit.

COT Department of Environmental Services (ES)

Comment 7.6: The EIS identified six (6) closed landfills along the banks of the Santa Crux that are adjacent to or abutting the actual riverbank and in the path of proposed improvements. The landfills are Nearmont, Rio Nuevo South (Congress), "A:-Mountain, Mission, 29th Street, and Ryland. Several of these closed landfills have buried municipal solid waste (MSW) that is part of the riverbank. The report references any disturbance, excavation, or grading in these areas could expose old, buried MSW. Because the landfills operated prior to solid waste rules and regulations, hazardous materials may be present in the old MSW. The EIS does not specifically address how encountering MSW or hazardous materials will be handled, except to state a plan will be developed. Because disturbing these wastes can have far reaching implications with regards to federal, state, and local regulations, more information is necessary in the report.

Response: Section 3 of the DEIS identifies the Alternatives and how they were selected for consideration. This section begins by identifying planning objectives and constraints. Five planning constraints were identified that would frame the development of alternatives, one of which addressed the issue of landfills. As quoted from Section 3 of the DEIS: "Numerous landfills and/or Hazardous, Toxic or Radioactive Waste (HTRW) sites are known to exist within the study area. Throughout the plan formulation process, these sites have been avoided, to the greatest extent possible, in accordance with Corps guidelines. Landfills are likely to be encountered with bank excavation for creating new slopes. However, environmental assessment data (Appendix G) indicates that landfill contents are benign. A remediation and management plan will need to be developed for unknown HTRW and other deleterious material encountered during bank excavations."

Section 5.16.2 of the FEIS states - In the event of an unplanned discovery of HTRW materials during construction, work would be stopped and appropriate notification and coordination with appropriate regulatory authorities would be completed. Investigations would be conducted to characterize the nature and extent of the contamination and establish appropriate resolution

As identified in the Real Estate Plan, Appendix I of the Feasibility Report, the non-Federal sponsor is responsible for assessing the all lands required for project implementation for any potential or presence of hazardous waste materials as defined and regulated under CERCLA. There are no known Superfund 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. 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.*

Comment 7.7: Areas of "wildcat dumping" have been documented along the Santa Cruz channel. The EIS fails to address the proper disposal methods of orphan wastes associated with this project.

Response: The proposed action does not call for wholesale clean up of dumped materials from "wildcat dumping". See response to Comment 7.6.

Comment 7.8: The three alternate proposals include varying improvements such as re-grading riverbanks, removing soil cement erosion protection, and installing irrigation systems to provide water to the restored vegetation. The EIS indicated that potential recharge of the introduced water would have no significant impacts on the groundwater beneath the channel. Due to the proximity of several landfills and the variability of infiltration rates along the channel, additional investigation is necessary to ensure introduced irrigation water does not leach contaminants into groundwater and to demonstrate compliance with all regulations.

Response: No additional investigation is necessary. Lateral movement of infiltrating surface or irrigation water is minimal in the project area and restoration features are not in close proximity to known landfills. The Geotechnical Appendix outlines the recommended actions for addressing landfills and groundwater protection during the Pre-Construction Engineering and Design. See also the response to Comments 7.6 and 7.14.

Comment 7.9: The EIS does not clearly address what precautions will be taken to keep any introduced irrigation water from infiltrating into pockets of buried MSW and causing leachete or increased landfill gas products.

Response: The Geotechnical Appendix outlines the recommended actions for addressing landfills and groundwater protection during the Pre-Construction Engineering and Design. See also the response to Comments 7.6 and 7.14.

Comment 7.10: A common problem with "natural channels" in the basin and range provinces is bank migration during major flow events. The EIS proposals indicate removal of existing soil-cement and replacement with terraced vegetation. Additional research and investigation appears necessary to ensure bank migration will not occur during a major channel-flow event.

Response: There is no proposal to remove existing soil cement as part of the Recommended Plan, Alternative 3E.

Comment 7.11: The EIS does not identify the source of water needed for the alternate proposals.

Response: There are numerous potential sources of water available to the non-Federal sponsor. A discussion of available water sources is contained in Appendix C of the Feasibility Report titled Groundwater and Water Budget. At this time, it is not appropriate to identify a single source of water, as one or more sources may be utilized and additional water sources not currently identified may become available in the future.

Comment 7.12: The report lacks a thorough discussion of how the proposed alternate projects will comply with federal, State and local regulations with regards to MSW, landfill gas, and groundwater protection.

Response: Appendix F outlines the recommended actions for addressing landfills and groundwater protection during the Pre-Construction Engineering and Design. See also the response to Comments 7.8 and 7.9.

COT Department of Transportation, Stormwater Management Section

Comment 7.13: The proposal outlined in this study is very optimistic. The Cost is $93,000,000 the Local sponsor is responsible fro more than $40,000,000 in construction costs, and over $1 million annually in maintenance costs. Pima County is the Local Sponsor and has agreed with the Preferred Alternative. The City does not support utilizing precious flood control tax levy monies for environmental restoration when there are high priority urban drainage needs within the City that must be addressed first. Most of the project is restoration of the ecosystem, with only about $8,000,000 used for Flood Control/Floodplain Management.

<u>Response</u>: *The non-Federal sponsor is responsible for 35% of the project costs. Of this 35%, Lands, Easements, Rights-of-way, Relocations, and Disposal Areas (LERRDs) credit could potentially be a substantial portion of this 35%. Pima County, as a separate entity from the City of Tucson, has decided that ecosystem restoration and its incidental benefits are important enough to allocate support and funding for this purpose.*

The presently estimated non-Federal share of the total first cost of the project is $32,392,000, which includes $26,242,000 in estimated LERRDs credits and $5,579,000 in non-Federal contribution. In addition, maintenance and operation of the environmental restoration project is estimated to cost the non- Federal sponsor $1,906,221 annually.

<u>Comment 7.14</u>: Changing the designated use of the Santa Cruz River from ephemeral to effluent dominant will result in a change of Water Quality Standards for the river and will have long term impacts on all discharges (including effluent and stormwater).

<u>Response</u>: The Recommended Plan should not result in an effluent dominant watercourse.

1. Irrigation water for the Recommended Plan is projected to be reclaimed water. While it may slightly exceed standards for some metals or chloroform their levels should not be far from meeting thresholds.
2. The majority of the water will be delivered via furrow in the over bank or via subsurface leach field in the laid back banks. In both cases it is unlikely that any of that water will infiltrate below the root zones and so there is virtually no chance of it migrating through the soil to a point where it could commingle with the waters of the US. In addition, operational criteria will preclude irrigation of the laid back banks when they are likely to experience surface flow.
3. Relatively small quantities of the tertiary effluent will be delivered to the water harvesting basins. The design of the basin (soil compaction to reduce transmissivity) and operational considerations (precluding irrigation of the basins when they are likely to experience surface flow) should preclude a discharge of effluent into the river. Furthermore, the cleansing effect of the emergent wetland habitat should provide substantial treatment.
4. The only other irrigation is via guns mounted on the banks. While it is possible that some of this water could come to ground near the low flow channel it is highly unlikely that it could commingle to a measurable extent. Furthermore, delivery of the water through a high pressure sprinkler like the kind specified

effectively constitutes air stripping and should therefore remedy any remaining water quality problems.

5. The use of reclaimed water (treated wastewater effluent) for irrigation of restored native riparian plant communities along this reach of the Santa Cruz River may require compliance with specific AZPDES permit criteria for certain water quality parameters. This would be the case if there is the potential for such irrigation water (effluent) to reach the main channel of washes, streams and rivers regulated under the Arizona Administrative Code (A.A.C) R18-11-113.E., as a "receiving water" that has the following State of Arizona designated uses: Aquatic and Wildlife ephemeral (A&We), and Partial Body Contact (PBC). Given the designated uses stated above, the applicable narrative water quality standards are described in A.A.C. R18-11-108 and the applicable numeric water quality standards are listed in A.A.C. R18-11-109, and in Appendix A thereof. There are two standards for the Aquatic and Wildlife uses, acute and chronic. The standards for all applicable designated use are compared and the most stringent standard is applied, thus protecting for all applicable designated uses. However, under A.A.C. R18-11-106, the "Director [of the Arizona Department of Environmental Quality] may, by rule, modify a water quality standard on the ground that there is a net ecological benefit associated with the discharge of effluent to support or create a riparian and aquatic habitat in an area where water resources are limited."

Based on these considerations the Recommended Plan should not result in a change in the designated use of the Santa Cruz River.

Comment 7.15: From the level of detail provided in the Environmental Impact Statement and Draft Feasibility Report, it is difficult to determine exactly where structural features, such as soil cement bank protection and banks cut to a 5:1 slope, will occur. This is of concern because of ongoing erosion problems at the Ryland Landfill located at Ajo Road and the Santa Cruz River. Although Ryland has been closed and capped, the eastern bank of the Santa Cruz River consists of landfill material exposed during high flow events. This area of the river is a prime candidate for soil cement. If soil cement is not utilized in this area, high flows will continue to expose garbage, dating from the time when landfills were not required to restrict disposal of hazardous waste. Although the EIS recommends remediation and management for landfill materials encountered in bank excavations, Ryland Landfill is an area where river banks should be stabilized to prevent further exposure of unknown and possibly deleterious materials.

Response: Mapping provided in the Design Appendix to the Feasibility Report identifies those areas where bank cuts and new soil cement are proposed. The Geotechnical Appendix outlines the recommended actions for addressing landfills and groundwater protection during the Pre-Construction Engineering and Design. See also the response to Comment 7.6.

Comment 7.16: Of additional concern is the description under alternative 3E of construction of the stormwater harvesting basins. The description calls for minor excavation, followed by compacting the bottoms of the structures to promote lateral infiltration. However, as noted in the Biological Evaluation, soils within the river and wash channels are typically sand and gravel, with small silt deposits and very low organic content." (page 166) Sandy, silty, alluvial soils have poorly defined soil structure and do not compact. Because compaction is ineffective and these soils have extremely high infiltration rates, these structures will not serve their intended purpose. As described under Alternatives 2A and 4F, these structures include a liner membrane. This membrane may be a practical necessity to slow infiltration and maintain appropriate moisture levels.

Response: Use of a liner membrane in place of soil compaction will be evaluated during Pre-construction Engineering and Design phase and the design for construction of the basins will be revised if appropriate.

Comment 7.17: Vegetation in mildly draining, sandy soils requires more water. Does the water budget address the effect of the soils in the project area and on watering requirements?

Response: The water budget accounts for the local soils conditions, evapo-transpiration rates, and the biological needs to sustain the proposed vegetation.

Comment 7.18: The Old West Branch of the Santa Cruz River has a rich and varied riparian habitat. Planned measures to improve the water regime will safeguard this area which is currently threatened by low water availability. Care should be exercised to ensure that the methods utilized do not destabilize the area. In addition, this portion of the project may need to be accelerated to prevent further habitat losses.

Response: Comment noted.

Comment 7.19: The proposed diverting water from the West Branch Diversion channel to the Old West Branch to supplement habitat needs is a tricky concept. The effective FEMA delineated floodplain for the Old West Branch is well out of the channel banks. The existing "natural" channel has less conveyance capacity that the 10-year flood event in most places. Per standard hydrologic assumption the Old West Branch will likely flood at the same time the West Branch diversion channel floods due to similar meteorologic conditions. The current FEMA floodplain delineation for the Old West Branch does not account for the additional flows that the diversion would add. FEMA is very clear, changes that increase the flood water depths (base flood elevation) or that increase flooding potential to adjacent properties cannot be allowed.

Response: Although diverting water from the West Branch Diversion channel to the Old West Branch was considered as a potential restoration feature, the Recommended Plan does not include construction of such a feature.

Comment 7.20: The dry condition of the bank soils aids bank stability against erosion from short duration flow events. The soils along the Old West Branch contain a lot of silt that holds a slope when dry but is much more erodible when wet. Most of the erosion on the West Branch, and the Santa Cruz River, is generated by bank undercutting and sloughing. A continuously wet toe of bank may easily exacerbate bank erosion.

Response: The soil and bank conditions of the Old West Branch and Santa Cruz mainstem will be evaluated further during the Pre-Construction Engineering and Design phase to determine bank stability and erosion potential, as applicable.

Comment 7.21: The plan proposes compacted furrows in the flow line of the Santa Cruz River to convey water to vegetated areas. It is very doubtful that there is enough compactable material in the flow line of the Santa Cruz River, or that 600' of continuous compactable material exists. The flow line is relatively clean material. Flows will likely sink into the sediment until bioscum seals the pore spaces (usually more than a week). This should have been evident from the material handling the County has done for all the bank protection that has been installed, and from the post flood surface flow behavior displayed downstream of the treatment plants on the Santa Cruz River.

Response: The use of compacted furrows is proposed in the over bank area, not within the main channel.

Comment 7.22: The document credited the erosion hazard setback to zoning. The erosion hazard setback is part of the Floodplain Regulations, not zoning.

Response: References to the erosion hazard setback as zoning in the Impact Analysis Summary and Section 5.2.2 of the FEIS have been revised.

Comment 7.23: The document indicated that the Santa Cruz River watershed is 7,000 sq. mi. It is 2,222 sq. mi. at Congress, the downstream end of the project.

Response: The Sections 5.4.1.2 and 5.4.5.2 of the Final EIS have been corrected to indicate that the contributing watershed for the project area is 2,222 square miles (at Congress Street).

Comment 7.24: EIS, Section 3.1 states that there are "unlimited volumes of wastewater" available for the project. Water Dept., projections indicate a shortfall in supply around the year 2015. This has a clear indication the City may need to treat effluent to make up the difference, especially of the CAP allotment falls short due to extended drought. The City should be diligent in defining its future needs for using reclaim water, especially when the report states "7.3 Irreversible and Irretrievable Commitment of Resources. Implementing any of the action alternatives would irretrievably commit resources including construction materials, fuel used by construction equipment, water for irrigation, and plants/seedlings used to establish the habitat."

Response: The subject sentence in Section 3.1 of the Final EIS has revised to read "The alternative formulation analysis evaluated a range of water quantity delivery methods from reliance on the availability of wastewater, to reliance on atmospheric precipitation only." The text for Section 7.3 has also been revised to clarify that the Irreversible and Irretrievable Commitment of Resources is for water after it has been applied to the restoration features, and not the commitment of a dedicated water source.

Comment 7.25: EIS, Section 5.2.2 Land Use states miles of bank protection will increase land developability along the Santa Cruz River. Where along the river is this bank protection to be installed? Or are they talking about existing bank protection? All other discussion only mention vegetated earthen banks susceptible to erosion from larger events. Appears to need clarification.

Response: Section 5.2.2 of the Draft EIS reflects an erroneous assumption that the regarding and planting of the unprotected sections of the banks would result in a reduction of the setback requirements. This section has been revised in the Final EIS to eliminate the error.

Comment 7.26: Section 4.4.2 Surface Water Rights states "Surface water rights are not an issue along this reach of the Santa Cruz River because of the absence of sustained surface flows, those in possession of surface rights are not able to divert water." But, "5.4.3.2 Alternative 2A, Similar to the No Action Alternative, the Xeroriparian alternative does not include any proposed management change or construction methods that would change the existing water rights. The hydrologic factors existing in the Project Area are incorporated into an already fully adjudicated watershed." "5.4.3.3 Alternative 3E, the effects of surface water rights from implementing Alternative 3Ewould be the same as 2A." "5.4.3.4 Alternative 4F, the Pima County of Transportation and Flood Control is the primary sponsor for the project and would be responsible for bringing intermittent flows back into the channel, as part of this alternative. As such, the added discharges would be owned and managed by Pima County for the intended purpose of ecosystem restoration improvements. The hydrologic factors existing in the Project Area are incorporated into an already fully adjudicated watershed. Any actions resulting from this project will not change existing water rights."

Surface water rights are managed by the Arizona Department of Water Resources and the Courts. Alternatives using in-channel water harvesting are using appropriable waters. ADWR would likely grant Pima County the right (junior rights to anyone with pre-existing rights downstream) to use the surface waters for "beneficial uses" as they have in the past. The City needs to be represented here. If the County gets appropriable water rights for the tributaries to the Santa Cruz and to the tributaries to the West Branch of the Santa Cruz, they could hinder or stop the ability of the City to gain future use of upstream surface waters should the need arise. Paseo de las Iglesias, if built, will be maintained by the County and they should be able to use the surface waters, but perhaps the City should obtain the surface water rights and grant use to the County through an IGA.

Response: Pima County Regional Flood Control District is sponsoring this project in order to restore the riparian environment in a section of the Santa Cruz River that lies entirely within the City of Tucson. The aspiration is to make this reach of river esthetically pleasing. It is not the intent of Pima County or of the Flood Control District to hinder or impede the ability of the City to use its water rights. To the extent that the City relies on groundwater, this project does not involve potentially competing groundwater pumping. To the extent that the City has surface water rights, they would be senior to any appropriation rights that Pima County or the Flood Control District would secure as a new appropriation in connection with the Paseo de las Igelsias project. Under the rule of priority associated with the appropriation system, the City's rights would take precedence over any junior rights of the County or the Flood Control District.

Comment 7.27: The preferred alternative proposes water harvesting basins at the confluence of tributaries with the Santa Cruz River and with the West Branch of the Santa Cruz River. Not a habitat issue along the Santa Cruz River but removal of vegetation to support other vegetation on the other tributaries to the West Branch, most of which have code protected habitat, is not reasonable, and suggesting replacement with juvenile vegetation that would take 20 or more years to approximate the existing habitat is also unreasonable.

Response: Alternative 3E, the preferred alternative, does not have any water harvesting basins sited at confluences of tributaries on either the Old or New West Branch of the Santa Cruz River. As such, there would be no removal of vegetation as the comment indicates.

COT Water Department

Comments on Draft Feasibility Report:

Comment 7.28: Some alternatives propose removing soil cement. How will this be accomplished and what will happen to the material? This item will be a significant part of the project costs and should be broken out as a separate cost.

Response: None of the alternatives evaluated involved the removal of existing soil cement. Soil cement removal was only evaluated as a restoration measure and was eliminated from consideration due to adverse effects.

Comment 7.29: Water harvesting, enhanced recharge and various uses of storm flows are mentioned throughout the report. Has the Army Corps confirmed with the State of Arizona that the local sponsor has the legal right to divert natural surface water flows? Would this require an appropriation of surface water?

Response: Under most of the alternatives being considered, Pima County would not be diverting surface water flows. If Pima County were to divert surface water, then it would be incumbent on the County to file for surface water rights with the Arizona Department of Water Resources or to acquire, from an existing appropriator, surface water rights.

<u>Comment 7.30</u>: (p. iii) There are several mentions of reestablishing a perennial flow in the Santa Cruz River. The City has examined such ideas in the past and concluded that the risk of mobilizing contaminants from both known and unknown waste disposal sites was unacceptable. Also, the value of water will rise so dramatically during the 50-year life span of this project, it will be very difficult to sustain such an alternative. With these two hurdles, a very intense cooperative planning effort by many stakeholders would be needed to make such a project feasible.

<u>Response</u>: Reestablishing a perennial flow in the Santa Cruz River was identified as a restoration measure during the plan formulation process and formally considered in the DEIS within Alternative 4F. However, this measure was not selected as a measure within the Recommended Plan.

<u>Comment 7.31</u>: (p. II-2) Water planning will need to be an increasingly regional effort where many water use sectors have to be taken into account. The Corps would be a welcome participant in such planning efforts along with many other water users and providers in the Tucson Active Management Area. As noted by the City of Tucson in the Tres Rios del Norte and El Rio Medio feasibility studies, the needs of municipal water supply and environmental enhancements can complement one another if enough creativity and imagination are brought to bear. The focus, then, should be on multi-benefit type projects which can be win-win opportunities. If environmental enhancement is the only consideration in rapidly growing areas where water resources are limited, then the range of water sources that can potentially be available will be very limited.

<u>Response</u>: Comment noted.

<u>Comment 7.32</u>: (p. II-3) The use of CAP water and groundwater is mentioned more than once in the report. Within the next 20 years the City will be using all its CAP allocation and all its effluent for municipal supply of one type or another. The same use of resources seems likely for other providers as well. The most sustainable habitat will rely on sources that will be available for the 50-year span of the project, such as reclaimed water and any storm flows that can be appropriated. As noted above, the needs of municipal water supply and environmental enhancements can be complementary functions. The focus should be on multi-benefit projects which can be win-win opportunities. If environmental enhancement is the only consideration, then the range of water sources that can potentially be available will be very limited.

Response: Comment noted.

Comment 7.33: (p. II-8) *"The 100-year floodplain of the Santa Cruz River as it passes through the study area due to the effects of earlier channelization and down cutting of the river."* The river is also artificially maintained as it is due to soil cement banks. This statement should reflect that.

Response: Comment noted.

Comment 7.34: (p. III-3) *"The plan includes the following guidelines related to aesthetic resources: Restore and preserve natural areas. This may include floodplain acquisition, purchase of development and water rights, and limitations on rezoning."* Does the purchase of development and water rights here refer to purchasing rights to storm flows or to some other source of rights?

Response: The quoted sentences are from a section of the Feasibility Report identifying related Master Planning efforts and are excerpted portions of the Pima County Comprehensive Plan. If the Paseo de las Iglesias project is to be successful, it is important to consolidate the landholdings throughout the reach of the project. Thus, floodplain acquisition and the acquisition of other private property would be part of the project. When Pima County and/or the Flood Control District acquire parcels of real estate and it turns out that water rights are associated with those parcels, then the County and/or Flood Control District would attempt to acquire the water rights at the same time as the real estate.

Comment 7.35: (Chapter IV) What is the relationship between Partial Wetland Assessment Areas and the plant communities described by Brown (1994)? Brown's plant communities appear to be defined differently than those used in the analysis. How are the differences and overlaps reconciled to create a cohesive picture of the river?

Response: While there is not always a one to one correspondence, BLP Communities can be related to the Partial Wetland Assessment Areas. Both classification systems assign the same acreage using the same classification for "Parks" and "Mesquite". The acreage for the BLP classification "Urban Drainage" is equal to the PWAA Ditches and the acreage for the BLP "Paloverde-cacti" corresponds to the PWAA Desert. The sum of the acres assigned to the BLPs "Urban" and "Vacant-Fallow" varies from the acres assigned to the PWAAs Urban and Agcrop by less than 0.2%. Likewise, the acres assigned to the BLPs "Mixed shrub", "Saltbush" and "Saltcedar" vary from those assigned to the PWAAs Scrubshrub, Riverbottom and Soil Cement by less than 2%.

Comment 7.36: (p. IV-38) The use of untreated effluent is mentioned a number of times in the report. The complex legal relationships of effluent ownership will make it necessary to have cooperation and agreement from all the affected parties prior to commitment of effluent to a project.

Response: Comment noted. The water required for the proposed project is an associated non-Federal cost which is borne by the non-Federal sponsor. As such, the non-Federal sponsor would be responsible for any coordination and agreements required to provide water for the project.

Comment 7.37: (p. IV-50) *"Utilization of CAP and TARP water sources through future negotiated agreement"* TARP (remediated) water is currently treated to potable standards and delivered to the City's potable system as a result of a multi-agency agreement with the U.S. EPA. The project has a limited life span, is legally committed, and is well suited for its present purpose. Also there is an annually diminishing pumpage required for the remediation effort. Given the legal complexities of the project, the limited nature, and small supply, it would be an unlikely source for longer term project of this nature.

Response: The quoted sentence is from a section listing opportunities that were identified for consideration including water management opportunities. Utilization of TARP was considered and rejected for the reasons outlined in comment 7.37.

Comment 7.38: (p. IV-50) *"The opportunity exists to formulate a project that addresses multiple purposes by, for example, providing storage for local runoff in a manner, which facilitates groundwater recharge and helps to support habitat restoration."* One of the biggest keys for this project is to demonstrate a complementary use of water that would benefit both water users and a proposed restoration plan. This means coming up with a multi-benefit plan that would be a win-win for both "municipal water supply" and riparian restoration.

Response: Comment noted.

<u>Comment 7.39</u>: (p, V-4) *Lay Back Banks/Widen Channel"* The laying back of the banks along the river is mentioned more than once. How will this affect the bridges over the river, and who will be responsible for the cost of bridge modifications necessary to accommodate the changes.

<u>Response</u>: There are no proposed changes to the riverbanks in proximity to the existing bridges. These areas are currently protected by soil cement and shall remain unchanged. Measures such as laying back unprotected channel banks will not affect the existing bridges and no bridge modifications are proposed.

<u>Comment 7.40</u>: Alternative screening was done in a matrix with column headings related to the elevation from the channel and row labels related to the water demands of the habitat. The character of both the columns and rows is dependent on the water regime. The distance and elevation from the river determine the amount of water available while the type of plant community (hydroriparian, Mesoriparian, or Xeroriparian) is also dependent on the amount of water available. The result of this is only one critical issue was conducted in a matrix designed to consider two critical issues. A more meaningful matrix would have resulted from water use versus cost, effort, or habitat acreage. (P V-23, Table 5.8)

<u>Response</u>: Comment noted.

<u>Comment 7.41</u>: Why are NMX and NMM alternatives included for consideration? They each include a plant community at a terrace level that is wetter than the one below it. (See the statement on page V-24, Seven of the twelve alternatives based on Mesoriparian restoration in the active channel were not carried forward. Alternatives MNX, MNM,MXM, MHN, MHX and MHM all have at least one wetter plant community located up gradient from drier one and thus are inconsistent with natural patterns.") (p. V-26)

<u>Response</u>: The reason for including NMX and NMM is given on page V-24 as follows:

> "NMX and NMM were retained although they represent a departure from the screening criteria in that one would normally find a hydroriparian or mesoriparian plant community in the active channel if flow were frequent enough to support a mesoriparian community on the terraces. However, one of the other screening criteria was to avoid unacceptable reductions in flood conveyance. Leaving the

active channel undisturbed represents the least possible impact to conveyance short of avoiding both the channel and the terraces."

Comment 7.42: (p. V-28) *"Soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography suitable for concentration of rainfall along the placement of rocks and course woody debris to facilitate moisture retention and provide sun and wind shade."* What is the life expectancy of the soil amendments and micro-topographical changes?

Response: While there are continuing operations and maintenance activities required for the project the restored habitat should be self-sustaining so long as irrigation continues. Adaptive management practices will include evaluating the status of soil nutrients and determining if additional amendment is required to assist redevelopment of healthier soil through the natural processes at work in the restored habitat. Micro-topographic modifications are made to provide water control and temperature control advantages for seed germination and seedling survival during the establishment period. Micro-topographic changes made by placement of rocks and course woody debris will be superceded in large part by changes produced through maturation of restored vegetation.

Tucson Water Comments on Draft EIS:

Comment 7.43: Is the sand and gravel pit at the south end of the study area at risk of breaching in a flood? Is there anything noteworthy in jeopardy if this occurs?

Response: The potential risk of breaching was not evaluated during the study. The current plan calls for the gravel mining areas on either side of the channel to be regarded following placement of excess material from cutting back the channel banks. While these actions should reduce or eliminate any risk associated with such a breaching the possibility will be evaluated during detailed design.

Comment 7.44: (p. 7) *"Securing a permanent source of water remains an unresolved issue; several sources are being examined" and later, "The analysis of water sources shows that the wastewater treatment plant effluent is a reliable water source to the project."* Effluent is controlled by a number of entities. Over the 50-year project life, it will become an increasingly important water source for all of them. Water use for this project will require the planning and cooperation of all the effluent owners to successfully make a long term commitment of this water.

Response: Comment noted.

Comment 7.45: (p. 24) *Formal and informal coordination occurred with a variety of Federal, state and local agencies in addition to the public involvement efforts described above. Agencies contacted included the United State Fish and Wildlife Service (USFWS), the Arizona Department of Game and Fish (ADGF), the City of Tucson Parks, Tucson Water Department, City of Tucson Transportation, Pima County Department of Transportation, Pima County Cultural Resources, Pima Association of Governments, and Pima County Parks and Recreation."* The Bureau of Reclamation is not on the list of contacts, yet it owns more than 28,000 acre-feet per year of effluent, all of which is uncommitted at this point. Was the Bureau not contacted?

Response: See response to Comment 3.1.

Comment 7.46: (p. 66) *"The remainders of recorded sites within the Study Area are undetermined as to NRHP eligibility, unless destroyed."* Does this mean they will only be formally evaluated if destruction is planned? Clarification is needed.

Response: Subject text has been clarified as indicated below:

"The remainders of recorded sites within the Study Area are undetermined as to NRHP eligibility, unless they have been documented as destroyed in which case they would not be eligible for listing on the National Register".

The Area of Potential Effect will not be known with certainty until the completion of the Preliminary Engineering and Design phase. Final determination regarding which sites may or may not be affected will occur at that time.

Comment 7.47: (p. 75) *"The U.S. Federal Transit Administration (FTA) has established noise impact criteria founded on well-documented research on community reaction to noise based on change in noise exposure using a sliding scale (USFTA, 1995). The FTA Noise Impact Criteria groups noise sensitive land uses into the following three categories: Category 1: Buildings or parks where quiet is an essential element of their purpose,"* followed by *"Properties adjacent to the Project Area do not include any Category 1 properties, but there are Category 2 properties and Category 3 properties* *within the Study Area."* Does this last statement contradict the first bullet? There are parks in and around the study area.

Response: There is no conflict in the statements within the DEIS. The noise criteria definition for Category 1 parks refers specifically to parks where quiet is an integral part of the park's intended use (e.g., war memorial park or similar contemplative-type area. None of the parks in the Project Area have quiet identified as an integral part of the park's intended use. As such, the Santa Cruz River Park is not considered a Category 1 property. The text has been modified to emphasize the distinction relative to the categories.

Comment 7.48: (p. 76) Nothing is mentioned in the noise analysis about trains. NEPA considers trains within 3,000 feet of a project as a possible noise source. About 50 trains per day pass by the northern study reach less than 3,000 feet from the river. These are a significant source of noise and should be discussed in the study.

Response: Section 4.11 does identify the noise from nearby train traffic as repeated below:

Existing noise sources include highway traffic from nearby Interstates 10 and 19, traffic on urban streets with bridges crossing the river, distant railroads, air traffic from the Tucson International Airport and Davis-Monthan Air Force Base, and industrial activities including reconstruction of the I-10/I-19 interchange (temporary) and sand and gravel mining operations (soon to cease). High noise levels occur sporadically with the passage of aircraft and/or large trucks.

The National Environmental Policy Act (NEPA) does not articulate any specifics of noise effects quantification and the appropriate distances to consider effects. The potential for noise associated with rail transportation is viewed as inconsequential when taken in the context of other nearby noise sources within the project area.

Comment 7.49: (p. 95) *"Construction of housing units has been increasing over the last decade. An additional 348,508 housing units were constructed in Pima County in 1999 to accommodate population expansion in the area. This figure is up from 298,207 in 1990."* Is there an error here? There are a little over 850,000 people in Pima County, so it seems doubtful that enough housing was built for 40% of that population in one year.

Response: The text has been corrected and now reads that 50,301 units have been constructed during the last nine years and identifying 348,508 as the number of units constructed prior to 1999.

Comment 7.50: The Socio-economic discussion would be much more meaningful if there were some discussion of how all this compares with other cities. For example, is an 80% high school graduation rate high or low? Income data is available at the tract level and could be used to demonstrate, in a general way, more specific details about the population living in or near the study area.

Response: Comment noted.

Comment 7.51: *"It is therefore expected that groundwater quality would increase through the promotion of additional groundwater recharge into the regional aquifer."* (p. 95) It is not clear why water recharged through the soil as a result of any alternative would be superior to water recharged through the soil with no-project. This needs to be explained.

Response: The statement in question has been deleted from the Final Environmental Impact Statement

Comment 7.52: (P. 122) *"The El Rio Medio (translated "the middle) project will be developed between Tres Rios del Norte and Paseo de las Iglesias all within the mainstem of the Santa Cruz river."* Does this refer to the El Rio Medio study? There should be a global check on this since El Medio is mentioned a number of times.

Response: The reference to El Rio Medio relates to the El Rio Medio feasibility study.

8. Letter from the Arizona Game and Fish Department, dated November 18, 2004

Biological Monitoring and Adaptive Management Plan

The Department has been working closely with ACOE to ensure that adequate biological monitoring is incorporated into the plan. There is limited information available on the impacts and success of riparian restoration efforts in the arid southwest as it relates to wildlife response, and this is especially true of efforts undertaken in urban areas. A carefully designed monitoring plan is absolutely essential to determine if the project is meeting intended goals, to help make needed adjustments to reach identified goals, and to inform future restoration efforts. We appreciate ACOE efforts to incorporate both biological monitoring and an adaptive management plan into the project, and to do so during the early planning stages of the project. We provide the following recommendations:

Comment 8.1: The Draft Feasibility Report indicates that baseline ecological surveys will be conducted immediately preceding construction (page VII.3). We recommend that surveys are conducted for 2-3 years preceding construction and this should be explicitly stated in the document.

Response: Recommendation noted.

Comment 8.2: Under Operation and Maintenance Costs (Appendix J), it is stated that a qualitative survey will occur one day per month. This is in addition to the quantitative surveys. We are unsure as to what a qualitative biological survey entails and the value that such a survey would add to the overall monitoring of the restoration project.

Response: The provision for a qualitative survey is based on the assumption that one biologist spends one day a month reviewing the site and writes a brief report while the quantitative survey assumes 2 biologists sample for 2 weeks and write a brief report.

Comment 8.3: The cost estimate for the quantitative survey greatly underestimates the time needed to adequately monitor the area of potential affect (Appendix J page VI-6). The plan currently calls for two biologists to sample for two weeks, twice a year. From our experience working on the Rio Salado monitoring plan, it would take a crew of four or more biologists at least six months time to adequately sample the biological variables (e.g., species diversity, species abundance, indices of species viability, endangered species surveys) needed to assess the status of the restoration project.

Response: Comment noted. The assumptions regarding the annual biological survey requirements will be reviewed during detailed Pre-construction Engineering and Design and experience gained working on the Rio Salado monitoring plan will considered.

Comment 8.4: Under *Monitoring and Adaptive Management Plan* (Page VI-10, top of page), please revise the following sentence "The cost of **the first five years of** monitoring included in the total project cost..."

Response: The sentence has been revised for increased clarity as follows. "The cost of monitoring *that is* 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."

Comment 8.5: Under *Vegetation Monitoring – Frequency and Protocol* (Pages VI-11), the document states "Should the survival rate of plantings indicate that the species composition is less the prescribed, replanting will be undertaken to ensure that the species composition is maintained." If some plant species have higher than expected mortality rates, investigations should be conducted as to the reasons for this. Site conditions may be unfavorable for some species and this will need to be rectified before replanting; alternatively, species more appropriate to current site conditions could be used instead.

Response: Recommendation noted.

Comment 8.6: Under *Wildlife Monitoring – Frequency and Protocol* (Pages VI-12), it is stated that bird surveys will be conducted in restored cottonwood-willow riparian areas, which comprise only a small portion of the total project area. We recommend that wildlife surveys be conducted in the entire project area and in all vegetation communities (mesquite, riparian shrub, and cottonwood-willow). We also recommend including surveys for reptiles, amphibians, and medium and large animals. All mammal trapping should be conducted with live, not snap, traps.

Response: The section on Wildlife Monitoring has been revised by striking out the reference to cottonwood-willow and now reads as follows: "Bird surveys will be performed in the restored riparian areas during each of the four seasons for the first 5 years following construction." Inclusion of surveys for reptiles, amphibians and medium and large animals will be evaluated when the final monitoring plan is developed.

Comment 8.7: We recommend monitoring the impacts of human use (e.g., recreation) on the restoration sites, including effects on vegetation and wildlife.

Response: Monitoring of impacts of human use on restoration sites will be included in the monitoring plan.

Comment 8.8: The document states that a complete discussion of wildlife in the study area may be found in Appendix 14.2. However, this section addresses only special status species that *may* be found in the study area. If general wildlife surveys area conducted, as is implied here, we recommend including a list of all species detected in a separate appendix.

Response: General wildlife surveys were not conducted. The statements on page IV-15 and IV-16 have been revised to indicate that additional information regarding wildlife can be found in the Final Environmental Impact Statement in Section 4.5 and Appendix 14.2.

Comment 8.9: We recommend that more information be provided regarding surveys for federally listed species, such as who did what surveys and when these surveys took place.

Response: The information regarding the timing of field surveys and the biologist conducting the evaluation is provided in the Methods section of Appendix 14.2 to the FEIS.

Comment 8.10: While there are no known records of cactus ferruginous pygmy-owl within three miles of the project area (Heritage Data management System, Appendix 14.1), it is important to note that a dispersing female has been recorded within five miles southwest of the project area. Habitat improvement projects within this area may help promote dispersal of pygmy-owls from breeding area to the south with potential sites to the north. It may be advisable to coordinate with the US Fish and Wildlife Service on Safe Harbor Agreements for this and other federally listed species that may be attracted to the area due to vegetation and aquatic enhancement.

Response: Recommendation noted.

Construction Impacts

Comment 8.11: The project area, especially the Old West Branch of the Santa Cruz River north of Drexel Road and south of Irvington road, has many burrowing owls that could be directly impacted by earth moving activities associated with this project. It is important that ACOE and Pima County coordinate with the Department to minimize disturbance and impacts to the owls. This can potentially be done through a phased implementation approach where owls are moved away from the area of activity and then allowed to re-colonize. If habitat is permanently and negatively changed for this species, alternate locations for owls may need to be found and artificial burrow construction may be advisable.

Response: Recommendation noted.

Comment 8.12: There will likely be other bank-nesting species, such as rough winged swallows and barn owls, directly impacted by earth-moving activities. Concentrating these activities in the fall or winter when birds are not nesting will help alleviate these negative impacts.

Response: The timing of construction activities, which will be determined during final design, will be based on balancing a variety of concerns. Minimizing impacts to bank-nesting species will be included as a consideration in the scheduling process.

Other Biological Considerations

Comment 8.13: It is important that this project consider the overall landscape context within which it fits, both in terms of maintaining or improving hydrological connection between the river and the floodplain wherever possible and protecting neighboring uplands to improve overall health of the watershed. Additionally, this project should consider how animals may be moving through the landscape and how the location of key habitat restoration features may help facilitate wildlife movement and dispersal. Habitat fragmentation is one of the leading factors contributing to species endangerment and local extirpation, and urbanization is one of the leading causes of fragmentation.

Response: Comment noted.

Comment 8.14: To maintain viable population of many species within the Tucson Valley, it is vitally important to design project features in such a way as to create connectivity of natural areas or open space within the project area as well as between the project area and 1) upstream and downstream segments of the Santa Cruz River and 2) the surrounding uplands.

Response: Comment noted.

Comment 8.15: We recommend including how City of Tucson fits in to the proposed project plans. The City of Tucson is the primary landowner within the project area (42%; Table 5.5), but is not a local sponsor for the project.

Response: Comment noted. The City of Tucson has been involved as a study stakeholder and has provided comments on the Draft Feasibility Report and Draft Environmental Statement.

Comment 8.16: We understand that it is the local sponsor's responsibility to prevent future encroachments on *project lands* that might interfere with the proper functioning of the project (page VII-6). However, the Draft Feasibility Report states that most lands that did not need to be restored (those lands currently supporting moderate to high quality Sonoran Desert cactus-scrub vegetation) were not included in the study area boundaries (page V-17). Protection of those areas could be very important for the integrity of the restoration project and to provide connectivity and wildlife movement corridors. It is unclear how, or if, these nearby lands will be considered in the overall context of the project and if the goal is to maintain them in their current condition.

Response: These lands are not part of the proposed project. Any effort to preserve these lands would have to be pursued as a separate initiative outside of the Corps of Engineers participation.

Comment 8.17: For this study, it was assumed that no new flood control projects would be in place before construction of a federal project. However, if a new feature was to be constructed, it could potentially be considered a compatible part of the federal plan if prior approval was obtained (page IV-44). Currently, no measures appear to be in place to prevent incompatible features from being established before project authorization and/or construction. If this project receives congressional approval, it will likely be several years before construction begins. We recommend that the Pima County Flood Control District, the ACOE Regulatory Branch, and the ACOE Civil Works program work together as much as possible to restrict new flood control projects that would compromise aspects of the restoration project during the interim period (e.g., soil cementing currently unprotected banks that would be re-graded and planted as part of the project).

Response: Comment noted.

Comment 8.18: We understand that erosion control will be needed in some areas of the Santa Cruz River as it passes through the project area. The Department would prefer that re-graded and native vegetation be utilized to stabilize banks to the maximum extent practicable and that soil cement and rock gabions are kept to a minimum.

Response: Comment noted.

Recreational Impacts

Projected growth for the City of Tucson is approximately 20% between now and 2020 (Table 2.1). This will increase not only the demand for recreational opportunities in Tucson, but also the impact of these activities on natural resources. While the primary purpose of this project is environmental restoration, we understand that recreational components will be incorporated as well. It will be important to design recreational trails and facilities in such a manner as to limit the impact on the newly established vegetation and the wildlife inhabiting the area. We offer the following recommendations:

Comment 8.19: Provide a buffer zone by placing trails away from the riparian corridor as much a possible. In particular, place trails away from the nicest stands of riparian vegetation.

Response: The final location of recreation trails, which will be determined during final design, will be based on a balancing a variety of concerns. Minimizing impacts to restored areas will be included as a primary consideration.

Comment 8.20: Provide a screening of vegetation between the trails and the sensitive riparian areas/restoration sites.

Response: Recomendation noted.

Comment 8.21: Provide spur paths that go to overlooks at key locations. This will allow for wildlife viewing opportunities while hopefully limiting harassment of wildlife.

Response: Recomendation noted.

Comment 8.22: Provide physical barriers to keep people from creating social trails (i.e., unofficial trails) and to prevent unauthorized OHV use.

Response: Recomendation noted.

Comment 8.23: The prohibition of motorized vehicles (OHV) in the river should be adequately posted and enforced.

Response: Operation and Maintenance requirements for the project will be determined as the project nears completion. Minimizing the effects to restored areas, including wildlife, will be a primary consideration.

Comment 8.24: Require that dogs be kept on a leash to minimize harassment of wildlife.

Response: This issue would be within the jurisdiction of the City of Tucson, and not the Corps or County's purview to establish or enforce.

Comment 8.25: Minimize the amount of lighting in recreational areas near the river so that nocturnal animals can move freely within the corridor. Orient lights at comfort stations and parking lots away from the river and provide adequate screening. Locate high-use recreational facilities well away from the riparian corridor.

Response: The quantity, placement, and orientation of lighting, which will be determined during final design, will be based on a balancing a variety of concerns. Minimizing impacts to restored areas, including nocturnal wildlife, will be included as a primary consideration.

9. E-mail from the Tucson Herpetological Society, sent November 21, 2004

Comment 9.1: The Tucson Herpetological Society (THS) is a non-profit organization dedicated to conservation, education, and research concerning the amphibians and reptiles of Arizona and Mexico. The THS Board of Directors has reviewed *the Paseo de las Iglesias Ecological Restoration Proposal* and we want to express our support of the project. We believe this proposal is based on sound science and the project will bring educational and conservation benefits to our community.

Restoration of these sites will provide habitat for imperiled riparian plants and animals along the Santa Cruz River corridor. During the summer of 2004, a THS supported Urban Amphibian Study of Tucson discovered several small isolated populations of Great Plains Narrow-mouthed Toads living along the dry channel. These toads represent evidence that other species may also remain despite drastic habitat destruction and may benefit from this restoration proposal.

The Tucson community has a history of support for preservation of our natural habitat as exemplified by the overwhelming support for the open space bonds and the Sonoran Desert Conservation Plan. The Paseo de las Iglesias Ecological Restoration Proposal will enhance wildlife viewing and other activities for outdoor enthusiasts and residents along the Santa Cruz River. The THS strongly urges the Army Corps of Engineers to initiate this project as a positive step toward restoring a centerpiece of Tucson's natural heritage that will not only facilitate the return of native wildlife but will also encourage pride in our community.

Response: Comment noted.

10. Letter from Center for Biological Diversity, dated November 22, 2004

Comment 10.1: On behalf of our 11,000 members across Arizona and the nation, we offer our general support for the proposed Paseo de las Iglesias project for restoration of part of the Santa Cruz River in Tucson.

We urge you to incorporate the recommendations of the Santa Cruz River Alliance and Tucson Audubon Society in to the final plan.

The Center is interested in helping to refine, implement and monitor the restoration plan, so please ensure we are fully informed as this project advances.

Response: Please see responses to Comment 11.1 through 11.9. In addition, Ann Phillips of the Audubon Society attended the Public Meeting and her comments, as well as the responses, can be found beginning on page 56 of the following transcript.

11. E-mail with attached comment letter from the Santa Cruz River Alliance, sent November 22, 2004

Comment 11.1: Water could be put into the West Branch to create a perennial or intermittent stream at much lower cost than estimates for the main channel of the river. A perennial system could be created, and/or the existing bosque greatly enhanced and meso-hydro riparian habitat added, including cottonwood-willow. This need not entail damage to the existing resource, but only limited management to ensure that natural succession was not dominated by exotic trees and bunch grasses. With a long-term approach, this transition would be organic and not damaging. This would then be an area where stable, rather than flood-vulnerable meso-hydro-riparian vegetation and associated biota could be created; non-flying animals depend on this stability, some of which remain at West Branch but appear to be declining toward extirpation in the absence of adequate water. Their presence at West Branch likely reflects a previous wetter environment.

Response: The recommended plan calls for habitat be restored and managed in both the SCR main stem and the West Branch. The recommended plan calls for a mesoriparian approach to vegetation reestablishment, which will require intermittent irrigation as part of the recommended plan. Cottonwood willow habitat is only planned for isolated basins adjacent to SCR-tributary confluence areas due to the high water needs of this habitat type and the ability to augment irrigation with higher volumes of captured stormwater at those locations.

Roughly 75% of the proposed project area would be out of the current Santa Cruz River 100-year floodplain, so stable habitat areas should persist post future catastrophic flood events. Note that post flood damages, appropriate areas will be re-established. The Recommended Plan does not call for establishment of perennial irrigation water flow in the SCR or elsewhere in the study area. Establishing perennial or intermittent flow was considered for the main stem SCR, but was deemed undesirable, too water intensive, and too costly by many public participants (1/26/04 public meeting comments) and County staff. Establishment of perennial flow in the West Branch area was not considered due to numerous factors including the effects that vegetation overgrowth would have on existing at-risk residential property in mapped floodplain.

Comment 11.2: Water delivery in many areas could be done via the traditional acequia method, rather then in irrigation lines. This approach could make maintenance of the irrigation delivery system simpler, more low-tech, and potentially cheaper. More importantly, it would create excellent habitat along the acequias, and the water in them (like the water suggested for West branch in #1) could be designed to range from intermittent (supporting turtles), semi-perennial (supporting frogs), or locally perennial (supporting fishes). In contrast to the chaos of exotic species, low fish density, and potentially higher mosquito abundance in the hydroriparian environments planned for the main channel, these more stable environments could be more easily regulated and managed to ensure low mosquito populations and high native aquatic vertebrate species participation.

Maintenance could range from matching herbaceous vegetation growth in the West Branch channel to the vegetation-removing force of natural flooding, to the simple periodic re-trenching of the acequias by machine and hand. The acequia margins could be planted with native and heirloom trees and shrubs. The acequia system could provide a nexus of the public restoration habitat to reconciliation habitat in adjoining communities.

Response: Irrigation delivery systems throughout the project area are yet to be finalized; use of acequias in the West Branch area is under consideration. Exotic species management will be part of the regular maintenance. Mosquito monitoring is currently underway, and mosquito management is planned. No fish habitat is planned, as there will not be perennial flow established in the project area.

Comment 11.3: The planning should expand to include its setting within the broader environment. The Paseo planning process should become an integrated part of the broader picture for the Santa Cruz floodplain and immediately adjacent bajadas and corridors to upland. This should include planned city parks, disposition of current landfill areas, explicitly mapped indications of city plans to urbanize current open space directly on the historic floodplain surface, and explicit mapping of corridors that will connect wildlife and plant populations (1) within the Paseo restoration area and between the Paseo and (2) the rest of the Santa Cruz and (3) the uplands. It may be difficult to put a dollar value on this connectivity, but there is little or no debate among biologists of its importance.

Response: The corridor studied in this Environmental Restoration Feasibility Study encompasses the restoration of riparian ecosystem function in the historic floodplain of the SCR & WB from Congress to Los Reales. Upland considerations and regional planning are not within the scope of USACE ecosystem restoration studies. However, integration through formal and informal planning meetings and ongoing coordination between agencies working on restoration is providing a measure of coordinated planning. Furthermore, Pima County supports and participates in regional planning and conservation efforts. The Paseo de las Iglesias Study is a complement to the regional Sonoran Desert Conservation Planning effort. Discussion of existing and future land use was included in the study.

Comment 11.4: Connectivity should be addressed by focusing on specific corridors. Wildlife corridors and direct connections are needed at crucial places like A Mountain to the River; some of the washes south of 29th Street to the West Branch; and the saguaro forests south and west of Ajo to the river. The connection of A Mountain to the river may require an "ecoduct" (a depressed roadbed with land bridges for wildlife), a causeway, or some other approach that is costly, though important for the local neighborhoods, future park users, and wildlife. The site is one of the few where saguaros can approach bosque, a key habitat feature for the pygmy owl.

Response: This is beyond the scope of the Paseo de las Iglesias Feasibility Study, but Pima County actively supports the preservation of viable wildlife corridors. As part of the Sonoran Desert Conservation Plan and the 2004 Bond election, Pima County continues to acquire and preserve unique lands, including wildlife corridors. The City of Tucson has jurisdiction over the land and roadway between A-Mountain and the Santa Cruz, and they would be the ones to permit a wildlife bridge in that area.

Comment 11.5: It is important that this plan also be considered in relation to a model for allocation of hydrological resources to ecological restoration in the entire Tucson Basin.

If significant water is to be consumed at Paseo, will there still be enough left for more cost-efficient restoration, such as near La Osa Ranch? Is the high use-value to a restored setting in central Tucson adequate justification for such a tradeoff? What are the relative wildlife benefits, and recreation benefits of these two broad kinds of options? Can both be done?

How do these proposals compare to raising the water table upstream of San Xavier, in terms of cost and wildlife and native vegetation benefits? How might doing that positively reduce the cost for the Paseo project by reducing some of the need for perpetual irrigation?

These are key questions that have a broader geographic scope and somewhat longer time scale than explicitly analyzed with the Paseo and other USACE studies, but they need to be answered. Currently, they probably are being answered, but only privately and according to the whims and plans of unseen officials and leading citizens. The public (citizenry, electorate) should be involved in these greater conceptions of the future.

Response: : The Paseo de las Iglesias area is of special interest and warrants environmental restoration for numerous reasons including existing and previous valuable habitat, cultural resource values, and best use of flood prone lands. Without undertaking this project, the current available vacant lands will likely get converted to urban uses, and the opportunity to preserve, enhance, and protect the habitat will be lost. In order to assure establishment and growth of the restored vegetation within the approximately 1100 acres of habitat along both the main stem and West Branch of the Santa Cruz River, generous evapo-transpiration rates were used to calculate irrigation water needs. Based on recently published evapo-transpiration data, we expect that the irrigation water amount to be reduced after vegetation establishment. In addition, the currently unknown amount of water able to be captured through water harvesting will further reduce the stated water need (and cost) of the project.

Pima County acknowledges that water resources are limited and regional water needs must be considered; nonetheless, the amount of water necessary to sustain the Paseo project will not likely have a significant effect on other regional restoration efforts. Raising the water table south of A-Mountain or south of San Xavier is not within the control of Pima County, is not required by the State, and is not within the plans or goals of Tucson Water or other local water providers.

Comment 11.6: Another long-term and large-scale issue is whether to avoid or remediate landfills. Having landfills in the riverbed is a poor situation, and sealing them off from water is, presumably, a reasonable short-term fix but probably not a suitable long-term fix. If their ultimate fate when sealed off from water is to become an insignificant problem, then the long-term plan should be to re-elevate the groundwater table at that appropriate time. If that is true, then the Paseo project should be conceived in the context of an eventual return to dependence on shallow groundwater with the greatly enhanced options that brings, along with the associated problems that would need to be solved.

If, on the other hand, the landfills cannot be expected to become innocuous within some reasonable time frame, then they should be removed or actively remediated, rather than left to fester in the center of the metropolis, where people will be exposed to their problems and the most prime real estate will be left in a nearly useless condition. And under this scenario as well, the long-term option can still be for re-elevating the groundwater table, etc.

These potentialities should be incorporated into the thinking about the purpose, duration, and long-term contribution of the Paseo project to the future of Tucson and the Santa Cruz River.

Response: The Paseo project design does not call for irrigation on or immediately adjacent to landfills, or significantly raising the water table. Remediating old landfills in the study area is beyond the scope of the Paseo Study. If wildcat dumping is discovered during construction, it will be addressed and remediated as necessary. Other local landfill related concerns should be directed to City of Tucson Environmental Services Department.

Comment 11.7: Species-specific issues should be incorporated into the planning process. Some species could be destroyed during the construction phases, especially non-flying animals and plants with limited populations and low dispersal abilities. For some of these, the cost of re-establishment could prove much higher than anyone would want to incur. It would, in at least some cases, be preferable to cause them to flourish (perhaps with some active management) where they remain, and then naturally colonize restored areas via well-planned corridors. In this sense, the planning needs to involve a design for phased implementation that integrates species needs as well as engineering considerations.

Response: Planning, design, and construction will include species-specific needs to avoid and mitigate disturbance or destructions as possible. Given the size and complexity of the project it will take several construction seasons to implement and adaptive management activities during that period will allow consideration of these effects. Also, see response to Comment 8.12.

Comment 11.8: Neighborhoods and businesses in and adjoining the Paseo project area should be actively encouraged to participate in the restoration process. While this is not the immediate responsibility of the USACE, the participation or non-participation in adjoining non-public lands (both residential and semi-urban in character) will have a partially determining impact on the ecological result in the restored public lands. Thus, the planning should be properly framed within plans for reconciliation ecology within the City of Tucson setting in and around the Paseo.

Response: We appreciate all the participation to date, and will actively encourage more participation in the upcoming design phase.

Comment 11.9: The existing plan seems to be a reasonable one, and is likely to greatly enhance the social and natural environments of central Tucson, as well as increase land values and the attractiveness of Tucson as a tourist destination. It will be an excellent complement to the Rio Nuevo downtown area revitalization process, and will help eliminate unfair and unappealing dichotomy between the "two-Tucsons" – the decaying inner city and flourishing foothills!

Response: Comment noted.

12. Transcript of Public Meeting, conducted on October 26, 2004

PASEO DE LAS IGLESIAS - SANTA CRUZ RIVER
ECOSYSTEM RESTORATION FEASIBILITY STUDY
PUBLIC MEETING

OCTOBER 26, 2004
PIMA COMMUNITY COLLEGE DESERT VISTA CAMPUS
5901 2. CALLE SANTA CRUZ
TUCSON, AZ 85709

REPORTED BY: CINDY J. SHEARMAN, CCR #50718

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MS. JOHNSON: If I could ask you all to take a seat. I'd like to welcome you all to this meeting of the Paseo de las Iglesias Ecosystem Restoration Feasibility Study for the Santa Cruz River. It's a meeting of U.S. Army Corps of Engineers in cooperation with Pima County Flood Control District.

My name is Freda Johnson and I've been invited to serve as moderator for the meeting and I'm just here to welcome you right now and then toward the midpoint of the meeting when we open for comment period, I will moderate that.

In the meantime, if you refer to the agenda you should have received when you came in, we will have opening remarks from both Pima County and the U.S. Army Corps of Engineers. Following that, we will have a presentation that summarizes the recommendations that you are here to listen to and comment on.

Comments are invited tonight in a couple of different ways. You were given a yellow comment sheet that you can take home if you wish, fill it out, and mail it in, or you can fill it out tonight and turn it in to any of us.

Later in the meeting, if you choose to make a public comment during that period tonight, I ask you to fill out an index card simply with your name on it so we have the correct spelling of your name, and I will call on people in the order I receive them. So if you need a card, raise your hand and one of us will get these to you. Okay.

A court reporter is documenting tonight's meeting, so we're going to have a word-by-word rendering of everything that goes on here.

Last, but not least, I want to acknowledge the newsletter that has been put out by Pima County describing the county's perspective on restoration possibilities along the Santa Cruz River.

Are there any questions about what we're doing and how we're proceeding tonight? Good.

In that case, what I'd like to do is take a moment to introduce to you Suzanne Shields, who is the deputy director of the Department of the Flood Control District of Pima County Department of Transportation and Flood Control. Suzanne has a background in hydrology with a bachelor of science and a master of science from the University of Arizona. She's a registered professional engineer in civil engineering in the state of Arizona. Suzanne has had 25 years of professional experience in the fields of civil engineering, flood control, environmental management, and surface and groundwater hydrology. She currently serves as deputy director for the flood control district and she's had that role since 2001. She is currently responsible for floodplain management, flood control, and capital improvement programs, planning for flood control, water resources, and not -- last, but not least, riparian habitat protection. So, Suzanne, I invite you to come up and let's continue with the program.

MS. SHIELDS: Good evening. Welcome to this meeting. In 1994, we were beginning to look at some of our river systems a little differently. Earlier -- and we've had a long career working with the Corps of Engineers -- they had done a watershed study for the Santa Cruz River. We wanted to step back after several years of doing emergency work after the floods of '83 and the flooding of the early '90s and saying, well, what if, and can we do something different?

As you were driving here tonight, you may have noticed some of the very early work that maybe the Corps of Engineers did in Tucson early on to help protect both the flooding that came from

Davis-Monthan and downtown Tucson. There was what's known as the Tucson Diversion Channel or Julian Wash, also called Julian Wash and the Ajo Detention Basin. That was something very early on, very structural.

But things change, and most recently in the last few years we did a restoration project at the Ajo Detention Basin, and that was a learning process, both in terms of trying to take something which was best described as an ugly hole in the ground and how to recontour it, put out plantings, and see what we could do as environmental restoration in a very urban area off of, you know, Ajo Way and Campbell area, an area that gets runoff from an urban area, industrial area, Tucson, as well as Davis-Monthan.

We feel we've been very successful. It's turned out to be an amenity to the neighborhood. It's something the people go to, both for recreation, bird watching, and most surprisingly of all for us, is we've been able to use that facility for irrigation on our stadium district and the surrounding ballfields and parks.

The water use for that area for our turf is 300 acre-feet a year. The last several years, just since it's been running -- and this has been the drought -- we have only had to use 30 acre-feet of reclaimed water. The rest has been storm water that we captured during the summer months that we store, recirculate it so it's part of the flowing water system of the park, and then use it on our fields.

This is the kind of thing that is a new way of looking at things. As we get into this, you'll find out there's a lot of balancing on resources. I was here and worked at the flood control district in '83 when the floods came through, and we know how volatile our river systems are.

Erosion is horrifying. There are some areas that you couldn't recognize. It looked like someone had turned on a large fire hose and just blasted it.

In this area, we're lucky on the Santa Cruz River in that there's not the kind of major infrastructure, like major pipelines or wastewater treatment plants, and there's not a lot of homes that are right up next to the banks. In some areas, all we could do is bank protect. Here, we have a lot of land that's owned either by the City or by Pima County and so we have options.

That doesn't mean that we may not have to do something structural. We want to make sure the river system doesn't degrade. There are some old landfills out there. There's still a large sand and gravel operation. So there are some challenges there, including the challenge of having enough water in this desert environment to do restoration, but the great thing of working with the Corps of Engineers is they bring in experts on these type of subjects that perhaps locally we don't have. And they help us pull together people to come on and look at the what if.

And that's what we're doing here with the feasibility setting. We're very excited to be able to get this study completed. It doesn't mean that there's not a lot more work to do. In fact, we'll have to do a lot more modelling to make sure the sediment balance, to understand the soils, but we've done enough to say we think something like this is feasible to do and so we're putting it forward to you for your comments.

I would like to introduce my staff that has worked so hard on this project that you probably know pretty well from some of the other meetings. Jennifer Becker; Tom Helfrich; she's not my staff but a friend, Linda Mayo, who is our cultural resources for Pima County; and then you've met Carol and Alicia outside handing out information. They work really hard with a number of individuals from city departments, state and federal agencies, Pima College, a lot of different groups, a lot of different shareholders to come up with something that we think is a reasonable plan.

We won't have all the answers tonight, but we do have something that is a good step forward and looking forward and beginning some design work.

I will mention that part of 2004 bonds, we did pass locally as a community $16 million to begin some of the first phase studies and restoration work in this area. So, we're excited. We're excited because we have some kind of a concept plan.

Flood control is new in this community. We didn't have a flood control district until 1979. We did not have a plan in the world. It was just a new idea, and now we're coming full circle where we're having restoration, we're thinking of water harvesting, we're thinking of all of our water resources and the environment.

With that, I'd like to turn it over to the

Corps of Engineers. This is their meeting and they will be making the presentation. There's -- they have brought their experts with them that they'll introduce.

Lt. Col. Guenther is the deputy chief engineer for the L.A. district. He has had a very distinguished career in the military, as well as engineering, graduating from West Point in 1977. I was looking at his long list of accomplishments and I can't even begin to tell you everything he's done, but being the chief engineer for the Supreme Headquarters for the Allied Powers in Europe begins to tell you what he may have done.

But, more importantly, because we all don't realize how much the Corps of Engineers do, he has been the public works director at Fort Monroe, Virginia, basically running a Samoan community, as well as most recently stationed as a volunteer to work with the engineering division in Afghanistan. And the Corps has been doing a tremendous amount of work in Afghanistan, Iraq, and helping to rebuild those societies.

So, I'm very pleased to introduce the colonel and he will introduce the rest of his staff and their presentation. Thank you.

COLONEL GUENTHER: Thank you for the introduction. I have to warn you that a lot of that is a little overstated. I was at Supreme Headquarters in Belgium. The biggest challenge there was trying to deal with 40 some odd different general officers from about 11 or 12 different NATO nations who all thought that they knew best how to get things done, but I don't know if I caused more trouble or solved more problems in that type of a position.

Anyway, as she stated, I'm the deputy district engineer for the Los Angeles District of the Corps of Engineers. I'd like to thank you for coming here this evening. I came from Los Angeles this afternoon. I'm probably getting the better end of the deal right now because in Los Angeles, they're supposedly getting three to seven inches of rain overnight and tomorrow while I'm here. So it's not often I would say I like Tucson's weather better than L.A., but this is one of those times probably.

Tonight, we're going to be presenting to you our findings of the Paseo de las Iglesias feasibility study and a draft environmental impact statement. The feasibility study is a joint effort by the Pima County Flood Control District and the U.S. Army Corps of Engineers to determine if the federal government can share the cost of restoring the ecosystem along the Paseo de las Iglesias reach of the Santa Cruz River. We'll summarize our plan formulation process and describe our recommended plan for ecosystem restoration and recreation.

Before we get on with that briefing, I would like to introduce a few people. She introduced -- or Suzanne originally said we brought along our technical experts and whatnot. I am not the technical expert, that's why I've got to introduce other people so that you can actually get answers for your questions.

First, I have Mrs. Ruth Villalobos. She's the chief of our planning division for the Los Angeles District. Mr. Kim Gavigan -- oh, there he is. Okay. He is the study manager and actually, he's the one that's probably most intimately involved with the overall project and putting it together. Mr. John Drake sitting up here, he's the project manager. We also have Ms. Kathleen Bergmann, Richard -- she's in the back. Richard Legere, he's running the computer there. And Mr. Bill Miller, I know he's here; he came with me.

There he is, way in the back, from our plan formulation branch, and we also have Mr. Mike Fink from -- as the environmental coordinator for this project who works out of our Phoenix area office.

Also like to introduce a couple of people from the Arizona Game and Fish Department, Dr. Mike Ingraldi and Ms. Laurie Averill-Murray, if I have that right. And you're the chief --

DR. INGRALDI: I'm a research biologist.

COLONEL GUENTHER: No, someone said that you're the chief researcher.

DR. INGRALDI: Lead researcher.

MS. AVERILL-MURRAY: I'm a habitat specialist.

COLONEL GUENTHER: Okay. We were also going to try to have some people from the U.S. Fish and Wildlife Division, but they were unable to make it tonight. I would like to thank the staff of Pima County Flood Control District for arranging the setup that we've got here tonight and also for the cooperation and the great cooperation that we have with Pima County in terms of trying to do some of these studies and restoration projects for the ecological system in this area of Arizona. We've got a fairly good relationship.

They -- Pima County officials, including Suzanne, were at our place, was it last week or the week before?

MS. SHIELDS: The week before.

COLONEL GUENTHER: The week before to talk with us about a lot of ideas and projects that they see here in the future for this area.

Okay. The purpose here today that -- ultimately, the purpose is to hear from you as interested parties or individuals in the community, get your ideas, your concerns, your questions regarding the plan that your Pima County representatives and the Corps have been working on in terms of trying to provide ecosystem restoration and recreational opportunities for the Santa Cruz River.

This meeting is required by law and is intended to inform the public of the recommended plan and provide opportunity for the public to comment on the plan.

We -- tonight, after we're done with our presentation, we will be taking comments from those of you wishing to speak, and we will be accepting and recording this evening. At the end of the --

at the end of the presentation, everything that you say is going to be recorded, taken into account, and addressed as we go on with work in this study.

If you -- as Freda mentioned earlier, if you want to present, please fill out one of the 3x5 cards with your name and present it to her so that she can call you off later on in the presentation. And if you do have comments, but you don't want to -- you don't wish, for whatever reason, to come up and verbalize them here, we do also take written comments that you can either write down and present to one of our people here tonight or mail in at an address or e-mail in too, we'll be giving you an e-mail address later on that you can also, you know, put anything that you want to verbalize or write down for our consideration.

And everything that you provide us, whether it's verbally here or in writing tonight or, you know, at some future date in the near future, we do take it into account and record it as part of the proceedings. As stated earlier, there's a verbatim transcript provided of the hearing as we go -- as we go along tonight.

So -- and if you do make comments, pass it in writing, we will provide a comment back of some sort acknowledging that we did receive it.

Okay. The remainder of tonight's agenda, we're first going to be presenting the study findings and summary of our proposed plans, and some of it you've been able to see along on some of the display boards up here.

What the presentation will include is the study area description that we're looking at, 'cause the study area is actually bigger than the actual plot of land that we're going to do work on. Study area encompasses a lot more surrounding that area because nothing is done in isolation by itself. The study authorization, the problems that we have that we're looking at in the study, the public involvement process, objectives and considerations, alternative planning.

We also -- we always have to consider alternatives, analyze alternatives, including the no action alternative. And then coming up with our recommended plan and where we go from here in terms of timing and the process as we move on towards determining whether we'll actually turn this into a project and then get it approved by Congress.

So, following the technical presentation, then once that's done, then we'll have the opportunity -- we'll allow the opportunity for your verbal comments. Are there any questions before we go ahead at this point? Kim, I guess it's your bailiwick.

MS. JOHNSON: Should I get the light?

COLONEL GUENTHER: Can people out there see well enough with or without the light?

MS. JOHNSON: Is that good?

MR. GAVIGAN: Just the front one perhaps.

COLONEL GUENTHER: How's that?

MR. GAVIGAN: Thank you, Colonel Guenther.

Good evening, ladies and gentlemen, and can everyone hear me, please? Great. I won't bother with this then; it's kind of cumbersome. My name is Kim Gavigan, and I'm the water resources planner with the U.S. Army Corps of Engineers out of our Phoenix office. I've been working in this study for approximately two years with the Pima County Flood Control District. I'd also like to recognize Mr. Eldon Kraft and Mr. Rob Wiley with David Miller and Associates. They've been instrumental in getting us through this process and report preparation and plan preparation as well.

The slide you see before you, and there are several here on the right, depict the study area which is called the Paseo de las Iglesias, which in Spanish means walk of the churches. It's the reach of the Santa Cruz River starting at the downstream end of West Congress Street and the upstream end at Los Reales Road and, of course, it flows from south to north. It's one of those oddities.

The study area also includes tributaries of the New and Old West Branches. It's approximately seven and a half miles in length, like I said, from Los Reales to West Congress Street. And it encompasses about 5,005 acres.

Approximately 95 percent of the area is located within the city of Tucson limits and the remaining 5 percent is within the unincorporated areas of Pima County. The reach between Los Reales Road and downtown Tucson is characterized by an arroyo with mostly high flows entirely contained within the main channel, which is fairly deep at this point in most reaches. There is intermittent soil cement bank protection in some areas as a result of the '83 and '93 floods that Suzanne Shields mentioned.

A 100-year floodplain narrows as it passes through the entire study reach, and historically has begun to down cut in the river. And I'll get to what the down cut causes are a little bit later. Significant amounts of land are publicly owned, up to 5,005 acres, approximately one quarter of that study area is publicly owned either by the City of Tucson or Pima County. The areas adjoining those public lands are either residential, some light industrial and commercial as well.

It should be noted that, as Colonel Guenther mentioned, we're not looking at doing something on the entire 5,005 acres. Approximately, you know, 1,000 acres or a fifth of that is the area you see in the green on most of these maps here on your left. They're the actual areas of impact where we actually propose to do restoration.

To back up. The Corps of Engineers, we cannot enter into agreements with nonfederal sponsors such as Pima County or begin studies without a study authority. We've had a longstanding authority through the Flood Control Act of 1938. Santa Cruz River is a major tributary to the Gila River and this Flood Control Act of 1938 authorized studies on the Gila River and its tributaries. Again, this was bolstered by House Resolution 2425 which actually specifically mentions the Santa Cruz River as an emphasis for study.

I'll briefly go over some of the specific methods and procedures that we typically go through in our plan formulation process. Sometimes it can be lengthy and the iterations are numerous, many in this room can attest to. We begin by identifying the baseline or "without-project" conditions, that means if no federal project occurs, what is the study area or the river condition likely to be, say, 50 years out from now as we project out. It's also referred to as our no action alternative. This becomes the baseline to which all other alternatives are compared to.

Next, we identify the problems and opportunities. And then, of course, we try to develop an array of alternatives and measures to address those problems and opportunities. Those alternatives are then compared and evaluated in detail and we do that -- we state that the alternatives must be complete. What we mean by that is they must be technically, socially, economically, and environmentally feasible and acceptable.

Of course, one of the most important steps in the process is receiving public input and going through that process, just like we are here tonight. Of course, in any study of federal projects, we do have to comply with the National Environmental Policy Act as part of this study, which is currently out under public review. There's a draft environmental impact study, and an environmental impact statement will be the result of that process.

The draft and final, I guess, basically have to include strategies for minimizing and avoiding and mitigating any impacts for the alternatives we are proposing. Of course, the culmination of that is to select the recommended plan which is in compliance with the all applicable federal, state, and local policy regulations.

Just to recap, the public process began back in March of 2001, and then in subsequent years, we've had, you know, detailed workshops with, in 2002, 2003, many people in this room were participants in that and, most recently, we had an open public house in this very room on January 22nd of this year, and again, I see a lot of familiar faces. And, of course, the County has kept the newsletter that Freda Johnson mentioned and a website up with information on the progress of this project.

Again, public involvement, tonight's meeting is a pig part of that and, again, at the conclusion of this presentation, we will be accepting comments on the draft documents. They were published in the Federal Register of Availability on October 8th of this year, and the official public comment period, which is 45 days, ends on November 22nd of 2004. Copies of the documents are currently contained in the Pima County and Tucson Public Libraries and the Pima Community College and University of Arizona libraries, as well as they're also available at the county's website. You don't have to write that down, we can provide that to everyone who wants to review it from a website.

We also have CDs that we brought. I'm not sure we have enough, but if we don't, we can take your name and address and we'll be happy to send you a CD with a digital copy of the report.

Okay. Getting back to the multi-step process I explained earlier is identifying the problems. This is summarized. Basically, the problems, we have primary problems we identified. The biggest one was ecosystem degradation. There are many causes of that, human intervention, erosion, sedimentation, water availability is a large factor in there, and, of course, in frequent flooding.

From a historic perspective, the primary problem again is severe ecosystem degradation and loss of riparian habitat along the Santa Cruz River and its tributaries since probably in the late 19th century. Riparian habitats are associated directly with these watercourses and water once flowed in this area on a perennial basis, which supported dense growths of cottonwoods, mesquite bosques or forests and emergent wetland areas, excuse me. This provided lush wildlife corridors, connecting, you know, the west slope for the Santa Rita Mountains to the Rillito River confluence and, of course, a corridor from the south into the north as well.

And again, the previous slide showed what the base of A Mountain looked like in 1904 and, of course, the current condition, you can see what that looks like today from the same perspective.

Increasing appropriation of the surface and groundwater to support both agriculture and growing population in the Tucson area has transformed the river really into a dry, barren wash which seldom flows, only in response to storms. The river is now a ten to 40 feet channel where most of the banks have been hardened with soil cement, as I mentioned earlier. But where the banks are not protected with soil cement, they're eroding and are vertical or near vertical and are quite unstable if you walk near them.

Here in the southwest, riparian ecosystems are now designated as a critically endangered habitat type. Native riparian habitat is nearly absent in the study area and throughout Pima County, for that matter. Loss of riparian habitat is devastating to the ecosystem in the desert. Originally comprising only one percent of the landscape historically, over 95 percent of that riparian habitat has been lost in Arizona.

It is estimated that 75 to 90 percent of all wildlife in the Southwest is riparian dependent during some part of its life cycle. As a direct consequence of the extensive degradation of the Santa Cruz River and loss of this habitat, the area has experienced a major reduction in species diversity and abundance.

In addition, increase in invasive and nonnative plant species, such as salt cedar, has become more predominant because they're tolerant of the drought conditions and the disturbed conditions that exist out there today.

Continuing on with the problem summary. Excuse me. Riparian ecosystems are dependent on high water tables typically which are at or near the surface most of the year-round. In some parts of the study area, the groundwater is now over 150 feet below the ground surface. Disconnection of the surface ecosystem from the groundwater supply has had a devastating effect on riparian vegetation and the wildlife that depends on it.

Another problem considered in the study area is that of erosion, and what I mean by that is the down cutting that has happened over the last 100 years, and more recently from the 1983, '93 floods. And the cause of that is -- there are many factors in that, such as man-made impacts such as straightening the channel or severe flood flows, diversion of flows for agriculture, lack of sediment flowing into the study area, as well as over pumping of the groundwater that has occurred over the last hundred years.

Our next step was to identify our planning objectives. Of course, these are very self-explanatory. Overall, we want to restore the vegetative communities to a less degraded and more natural condition. We're never going to restore it back to what it was like in 1904, so that's just simply not going to happen because the groundwater is not there to support it. So any improvement on the conditions out there is a less degraded, more natural condition, that's what I mean to say by that.

We'd like to increase the acreage of functioning riparian and floodplain habitat within the study area and, of course, increase wildlife habitat diversity by providing a mix of habitats within the river corridor, the flood fringe, and the overbank or historic floodplain outside of the channel.

Additional objectives we identified, of course, were providing passive recreation opportunities. Trails do exist out there now. We'd like to continue that opportunity for the citizens. And, of course, reducing the bank erosion and sedimentation is another planning objective as a result of restoration, as well as improving storm water quality that is consistent with the ecosystem restoration project.

Some important considerations that we identified -- and this was done in -- with Pima County and public input that we got in our workshops -- availability of water, of course. In the arid Southwest, we all know how important that is, in the Tucson area, Arizona, in general; the proximity to numerous cultural, historical resources that are located within the study area; of course, the recreational areas being the trails that I mentioned.

Another consideration was not to increase flood damages over the level they are right now. We don't want to put in anything that is so dense or is going to raise the flood levels when you get a hundred-year flood, for instance.

Suzanne mentioned landfills. There are at least seven known landfills in the area. Those have impacts on what you do, and any kind of proposed alternative may impact the landfills. So avoidance of the landfills was a key consideration.

Vector control issues is a very heightened awareness in the Southwest right now, primarily with regard to vector-born diseases. That's also a consideration. Public acceptability is also, you know, a very large consideration in this process. And, of course, remaining consistent with local plans as much as possible, such as the Sonoran Desert Conservation Plan.

So, to start our plan formulation process for ecosystem restoration, we needed to identify our alternatives. As I mentioned throughout the workshops and with Pima County, we identified numerous ecosystem restoration measures, the biggest is water harvesting features, capture the storm water and make use of those instead of just letting them run through the system and downstream; what type of irrigation feature is an important measure; we -- how we're going to treat the riverbank and terraces and, of course, what kind of native trees and shrubs and wetland plant communities were we going to try to introduce into the area.

These measures were organized into groups associated with the areas of habitat that could be restored, and what we want to do is match those measures to the active channel, which is the sandy bottom of the river itself, the terraces that are above that, and, of course, the overbank historic floodplain areas.

The restoration measures were then grouped into three categories, essentially low, medium, and high water uses based off the amount of water that would be needed for implementation of various alternatives. Each category of restoration measures was then assigned, you know, one or more of the three landscape settings which I just mentioned, while these were being again the active river channel, the terraces, and the above bank historic floodplain. This resulted in 47 potential alternatives and, of course, the 48th would be the no action alternative.

As part of the initial screening, we started eliminating alternatives that, one, were either not consistent with the natural vegetation patterns, failed to produce sufficient habitat diversity, or would increase -- reduce flood conveyance of waters there. So, if it didn't meet any of these three criteria, those alternatives were screened out in our initial screening process. This left us with 14 alternatives, 15 if you consider the no action alternative.

What we did then was a mathematical model for measuring the functionality of the riparian ecosystem developed specifically for use in Southern Arizona. This was done in cooperation with scientists from a variety of expertise and fields. This group included those from, of course, the U.S. Army Corps of Engineers, the Corps of Engineers research and development center, various environmental consultants, the local sponsors -- and not for just Pima County, we had sponsors from Maricopa County and the City of Tucson were involved in that process as well. We had university professors and representatives of various federal and state agencies, many of those people from the local area, and some of which are in the room tonight.

The next step was the cost of each plan was then compared to the habitat value that the model predicted would be produced by each alternative to identify which plans were cost effective. From the cost effective plans, we came up with two best buy alternatives and one locally preferred cost effective plan that we carried forward. So three plans were carried forward into the final array.

The first of which is Alternative 2A, or a low water use alternative. These can be -- like I say, Alternative 2A, 3E, and 4F, which you see on your left are again synonymous with low, medium, and high water usage.

Since we're dealing with an arid water environment, where water is already in short supply, the ability to provide water over the long-term is of great important.

Alternative 2A focuses on water harvesting, including soil amendment, surface low flow diversions, and construction of what we refer to as subsurface water harvesting basins. Implementation of these measures allow for the creation of new plant communities, as well as enhancement of existing community such as mesquites, riparian shrub, and emergent wetlands. This alternative would require establishment irrigation to get it going, so to speak, and periodic irrigation throughout prolonged drought periods.

Although the plan would only require 253 acre-feet per year, it would not provide a sufficient level of ecosystem restoration desired by the general public and the residents in the area in Pima County.

The second of the three alternatives would be alternative 3E, or the medium water use. Alternative 3E essentially builds on Alternative 2A. It provides irrigation -- that's the main difference -- to all the planted areas, you know, including, as I mentioned, the subsurface water harvesting basins and, in addition to the water harvesting, soil amendment, soil grading, and irrigation of the lower reaches of the Old West Branch are also included in this alternative.

Mesquite would be the dominant restored habitat and this is an example in this photo that you see in front of you. This would also -- the irrigation would also allow for the planting of cottonwood-willow species and riparian shrubs and the emergent wetlands in the bottom of the channel.

Alternative 3E does, however, provide a much higher level of restoration than Alternative 2A does, while limiting the annual water requirement to approximately 1925 acre-feet per year. Pima County does believe that this water can be provided in perpetuity.

Moving on to alternative 4F, or the high water use alternative, again, the photo gives an example of that. Alternative 4F would require the most water for irrigation, almost 9,000 acre-feet per year, for having a perennial flow in the low flow channel. This alternative does focus on establishment of that perennial flow, laid back vegetative banks for those banks that do not have soil protection, of course, soil amendments, surface grading, and construction of the subsurface water harvesting basins, and implementation of these measures allows for planting of more cottonwood-willow species. Of course, mesquite would still be the dominant species and riparian shrub and emergent wetlands. Pima County did, however, have concerns over being able to provide this amount of water on a perpetual basis, so this alternative was essentially screened out and eliminated at that point.

This next table compares the areas of habitat acres which could be restored by each of the alternatives, and the habitat value which was assigned for the mathematical that I referred to earlier. Alternatives 2A, 3E, and 4F, as well as the no action alternative, would restore or enhance slightly larger areas. Again, 2E -- excuse me, 2A would restore a slightly larger area than 3E. However, it only provides one-third as much mesquite habitat as 3E does. In addition, Alternative 2A would not enhance cottonwood-willow habitat, which we felt was important to the river system. Alternative 3E again provides approximately 18 acres of that cottonwood-willow habitat.

Alternative 4F, however, would provide the greatest amount of restored habitat value, but the expected costs associated with the irrigation of the water was just simply cost prohibitive.

Again, to describe the recommended plan, which is alternative 3E, here we have the slide showing the recommended plan. This is characterized by irrigated planting of mesquite and riparian shrub on terraces above the low flow sandy bottom in the channel and in the historic floodplain areas, with small areas of emergent marshes and cottonwood-willow. This plan does provide approximately 718 acres of mesquite, 356 acres of riparian shrub, and 18 acres of cottonwood-willow, and six acres of emergent marsh.

The construction and planting of subsurface harvesting water basins would occur at the eight confluences coming into the Santa Cruz River and at six existing grade control structures which are located at various sections within the seven and a half miles.

A variety of methods could be used to provide permanent irrigation systems for the plantings, including these basins. The reaches of steep eroded banks would be modified by cutting back into the historic floodplain. This would create safer and more stable slopes, and we propose to cut those back at a five-to-one horizontal-vertical ratio. This would reestablish the hydrologic connection from historic overbank floodplain down into the channels.

This depiction here is basically an artist's rendering from a perspective -- here we're looking at -- this is looking north from Ajo Way and Congress is up here. Again, down in the lower right is an artist's rendition of what it could possibly look like with Alternative 3E in the future. And we do have posterboards in the back. Feel free to look at them after the presentation.

This is a summation of the estimated plan costs. We did a detailed cost analysis of all the alternatives and, of course, of the recommended plan. This slide shows what goes into that cost estimate. It's not just a first construction cost. There are other considerations to be factored into that. The costs of construction and real estate are estimated at approximately 73 million dollars. Of course, we have to include the cost for contingencies, engineering and design, management and monitoring after the project is implemented. These costs are then annualized over a 50-year period to get an average annual cost of approximately $5.8 million. Annual operation and maintenance costs, including the cost of the water, are approximately $1.87 million. And the total average annual cost of alternative 3E is approximately $7.6 million down in the lower right-hand corner. These figures include costs for periodic replacement because once every ten, 25 years, you're going to get a large flood which is going to damage and remove some of the vegetation you put in, so that cost of replacement is incorporated into that overall cost estimate.

This slide depicts what the cost estimate or, excuse me, ecosystem restoration cost-sharing plans are. As I mentioned, the total estimated cost is almost $91 million. The federal cost sharing requirements are 35 percent nonfederal, or Pima County, and 65 percent federal. It's important to note that of the local share, which is nearly $32 million, Corps policy allows for crediting of lands towards that 35 percent, and that's been estimated at a cost of $26 million, so that's the public lands that I was mentioning earlier.

Also mentioned earlier is Pima County would be required to provide the irrigation and the water for Alternative 3E. Right now that's estimated at approximately $1.1 million, but there is a caveat to that. That was only developed and plan formation and cost comparison for economic purposes.

The $1.1 million per year you see there is based on the current market rate there of purchasing reclaimed water from the City of Tucson. Pima County does feel that this could be brought down significantly, depending upon what the final water source is, so we're not identifying the purchase of reclaimed water as the sole source of water for the project.

Okay. Moving on to the recreational plan. We -- from the public meetings and from dealing with Pima County staff and parks and recreation of the City of Tucson, it became very apparent that it was important to develop a passive recreation plan in any restoration effort that we do. The purpose of that, you know, is to encourage the restoration and the enjoyment of the environment by the users of the recreation elements.

The elements of this plan were developed based off public input, as I mentioned. Recreation plan includes the elements shown here, multi-purpose trails, approximately six parking areas, three rest room facilities, interpretive signage. The purpose of the signage, you know, is to have the user enjoy and understand what the restoration efforts are all about.

We also looked at connections to the north and south where there are existing Santa Cruz River parks. It was also important to fill in the missing gaps of the Juan Bautista de Anza historic trail. Only portions of that are constructed through the study reach. The de Anza trail is a historic trail about 1200 miles long which begins in Mexico, Nogales, and goes all the way to San Francisco, actually. An economic analysis was performed and we did get a positive benefit-to-cost ratio of 1.29 to one, with additional annual recreational benefits of approximately $30,000.

The recreation plan first cost is

approximately $1.14 million. The cost sharing requirements for that is 50 percent federal, 50 percent nonfederal, and the annual operation cost, which are borne by Pima County, are approximately $36,000.

The study included consideration of opportunities to improve the environment and the impacts of the alternative plans. This analysis complied with National Environmental Policy guidelines, or NEPA guidelines, and U.S. Army Corps of Engineer operating principles.

Ecosystem function would be expected to increase sixfold over the without project or no action alternative.

Other benefits associated with the recommended plan are summarized on the slide as well. Some of the benefits include recreation opportunities, incidental flood damage reduction by the lay back of eroded banks, and improved aesthetics, as the artist's rendition depicts.

The anticipated impacts of the construction would be considered of a temporary nature. Although there are no threatened or endangered species known within the study area, there are seven species of local concern to Pima County that either occur or have the potential to occur or migrate into the area should the restoration plan be accepted. And the project would obviously benefit from local and migratory wildlife species, including birds using the Pacific flyway.

Vegetation would be expected to increase in abundance and diversity with concurrent reduction in the coverage influx of the invasive salt cedar. The increased habitat value should increase the biodiversity and biological productivity of the area.

Several different types of wildlife are also expected to benefit from the project. Riparian-obligate species such as the southwestern willow flycatcher, shorebirds and water fowls, such as the Yuma clapper rail, as well as raptors, mammals, amphibians, and reptiles would all experience long-term benefits through the establishment and reestablishment of vegetation in the area.

In summation, where we go from here after the -- tonight's public meeting. As I mentioned, the end of the public comment period is November 22nd of this year. There are several intermediate steps, the Division Engineer's public notice and final review. Once the Chief of Engineers' report would be finished April of 2005, the project may be authorized in an upcoming Water Resources Development Act, and that's projected to be in 2006.

After final design and specifications are completed with the county, the Corps would then enter into a project cooperation agreement, it's a legal agreement with the county officials, and construction, assuming word of cooperation is achieved, could begin as early as May of 2005.

That essentially concludes my portion of the technical presentation. We will open it up to the public comments.

MS. JOHNSON: Okay, thank you. For those of you who came in late, I'd like to let you know that if you wish to make a public comment to the group and to the panel here, we'd like to have you put your name on an index card and hand it in to me. This helps us keep an accurate record of who spoke. The proceedings are being recorded by a court reporter tonight. Would anyone like a card?

And for those of you who came in a little later, just as a reminder, you may also submit written comments, and it's been mentioned more than once that the deadline for these would be November 22nd; that's the closing.

So if you have a question or a comment, then give me your name on the card. This may be a very short comment period. All right. We'll start -- and I'm going to ask people to make your comments succinct, maybe two to three minutes, if that's acceptable. And the first card I have is from David Steimle. David? You may speak from there.

COLONEL GUENTHER: Just a few things before we get started. I want to make sure when you -- if you could stand up or whatever and speak very clearly your name and any organization you might represent, if you do that, primarily so that the recorder can get it correctly. That's our main concern is just so that it gets recorded accurately.

MR. STEIMLE: My name's Dave Steimle. I'm representing myself, no affiliation with any specific group at this time. I do have a couple of comments or, actually, questions about some of the things I heard tonight.

I notice that you have a recreation plan that includes -- I would assume that they are bike paths or hiking paths. Were there any other considerations for alternate recreation in those areas such as horseback riding, ATV use, other issues like that, other recreations in that manner?

MS. SHIELDS: We looked at a lot of different recreation. Equestrian use is very prevalent in this area, and so we've met with different people, especially say between the north of Ajo, but there are several areas that people still retain horses. So we still want to make sure that there's equestrian use.

ATV use is something that we don't encourage in our river systems. Something like that, especially in a restoration project, would be very detrimental.

In some of the -- as we mentioned before, some of this is City or County property. Alternatively, in looking with the city parks and recreation department, some of the land they own is perhaps not included in this for restoration 'cause it might be a more active type of recreation, and if both along our existing Santa Cruz River system and Rillito, you'll notice there might be a trail system, then there will be an area where there's more active recreation.

Here, because we'd have a wider area, the ability to separate bike from pedestrian from equestrian should add to the complete trail system.

MR. STEIMLE: I've lived in the area for 23 plus years and I can tell you that ATV and alternate types of vehicles like that used in this area are heavy and probably will continue. So how would you end up restricting their use in that area so you don't damage anything that you've already put in there?

MS. SHIELDS: We tried to come up with several ways, and I have to tell you I'm not as successful as I'd like to be on the retort or something else, because we try to put up barricades, but barricades that horses can get around but not a vehicle, put up rocks.

The City and County have formed an ATV task force. We're trying to target certain areas where there's heavy usage and complaints. And, Carol, perhaps you can get him a phone number that he can contact if he has something.

Part of it is educational, is telling people where there are opportunities besides just getting down into the river system. It would be a real challenge. Some of it is designing it so that it's hard for them to get in or out.

MR. STEIMLE: Okay. Also I -- in looking at your maps of the study area, you included a lot of urbanized areas. Were there any plans for restriction of building in those areas that are urbanized right now or was that status quo, but just -- how was it considered part of the study area if it is urban area and you don't plan on doing anything with it?

MS. SHIELDS: Both the City and the County looked at the erosion hazard setback for the river, so since we're not doing the strict bank protection, there still would be an area that would need to be set back, where it would have to be -- you could not have habitable structures.

I really can't speak for the zoning per se because some of it is for the City. I mean, we work with their economic development group. I believe you know there's some economic development up there by -- north of Drexel, and there may be more. Even this facility is on that kind of land. So there still may be some urban development, but it would be away from this erosion hazard setback, which varies from anything from 500 feet to 1200 feet from the channel. So it's a pretty wide area.

MR. STEIMLE: And one last question, and I appreciate your time. You indicated that you're going to be increasing water retention in the riparian areas and you indicated that there will be additional mesquite and other vegetation in the area, and that there was a cost benefit ratio that, if I got this right, you had an annual recreational benefit of somewhere around $30,000. What is that specifically? Does that mean there's going to be a fee for parking in these areas or what does that mean? I'm not sure what that means.

MS. SHIELDS: Okay. That wasn't referring to a fee. Kim, can you --

MR. GAVIGAN: No, that's not referring to a fee. How we do the economic analysis on recreation is based off of -- the user days are assigned a value. There was just -- there would be an increase and influx of people using the area. That's the benefits that they get. That's compared to the cost. So recreation is the only one we did a benefit cost ratio on.

MR. STEIMLE: I don't understand how an influx of people would increase the dollar value on the recreation of that area. Is it the amount of use?

MR. GAVIGAN: It is based off the amount of use.

COLONEL GUENTHER: It's somewhat an intangible benefit, similar to the -- you saw the units there for 52 or the 401 or whatever the numbers happened to be, for the environmental benefit of the various alternatives, and then making a comparison. It's something -- it's not a straight dollar amount as they said it, but it's kind of a valued thing.

So it's not going to be an exact science, obviously, because your time may be more valuable to you than, say, what he values his time at per hour or per day or whatever, but you -- a lot of it is measured on just the same way you have -- you build a road and you anticipate how many people are going to use it, and if only five people are going to use it a day, are you going to build the road? No. If 70,000 are going to use it a day, yeah, then it might serve a benefit if, you know, that road reduces traffic problems or issues at some point or other in the community. The same type of thing.

MR. STEIMLE: And the value of $90 million or whatever, 32 million of that coming out of Pima County pocketbooks, I would assume, is that a -- how much is that going to increase our taxes? I mean, that's the brass tacks of it all.

MS. SHIELDS: It is -- it is, and it does sound expensive. A couple of things and I'll refer back to the estimate for water use. At this stage of what the Corps is doing, they try to look at the real high end because when they go to Congress and get authorization, they don't want it low because if you go over what you're authorized, then you have to go back to Congress.

They have placed a value on the land that the City and County already own, as they said, $26 million. We already own it. But for purposes of the project, they valued it. For purposes of the project, when it comes to -- and I have sticker shock when I hear a million dollars in maintenance, that's where I get real sticker shock. But that -- from what we found at other facilities, most -- a lot of that is the establishment period, and then the amount of water use goes away. As I said earlier, when we started this, we have found that we can harvest an amazing amount of storm water really. It's different.

What I will tell you from the local, even our most recent bond election, we structured it so that there was not going to be an increase in taxes. It's something that is -- the local government is very conscious of. You know, we'll have to work out something with them because they'll look at our financial capabilities as well before they enter into an agreement. It may be something that, quite frankly, we're going to have to face. This would be a huge project.

As I said, I started with the County back in '79 when we were first created as a flood control district. We didn't have any river parks. People think it's taken a long time, but they forget we started with nothing.

So the question is, is how do we phase it in? For this most recent bond project, we looked at from Ajo to 29th. We own a lot of the land in that area, including the Old West Branch. There -- we thought we could do that fairly inexpensively. We put $16 million, that was assuming no funding from the Corps. If the Corps comes in, then we can do more.

It will have to be something that we're going to have to look at and pencil in and look at very carefully, both in terms of -- we can do bonds and that's a little easier for the capital, but that was one reason why, when we were looking at the high water use, not only do we not have that much resources here, but that would have been an enormous burden that would be an annual tax that we'd have to pay. So we're trying to balance it.

MR. STEIMLE: Thank you.

MS. VILLALOBOS: In reality, the amount that the County needs to come up with for their share of the project is approximately $6 million in a cash contribution. The rest is out of the lands that would be contributed for the project.

MR. STEIMLE: Is this project when it's completed projected to increase property values in the area, in the study area? That's pretty subjective, I know, and I'll leave it at that.

MS. VILLALOBOS: And we didn't use that increased value on the justification, but what we've seen in other areas in the country, it tends to do that.

MR. FINK: Yes, there's many research studies done on greenways, as they call them, throughout the United States, and in almost every situation studied, property values do rise.

MR. STEIMLE: So our taxes will go up, the baseline of it is.

MS. SHIELDS: Yes, but at least you have more value there.

MS. JOHNSON: Thank you. The next person is Aaron Graham.

MR. GRAHAM: Thank you for taking my comments. My name is Aaron Graham. I'm a resident of Menlo Park, which is at the northern boundary of the project. I think it's a very exciting project. I think this sort of thing should be done to all the rivers and washes in Tucson. I think it's a really valuable asset to the community.

I had a couple of questions. One was, you mentioned the landfills along the study area. I know the one nearest to Congress is being remediated and I wonder why remediation of the landfills wasn't taken into consideration as part of the project. You said you were going to avoid them and try not to disturb them, and I know landfill remediation is coming along, there's a lot of technology and projects already to remediate these landfills. Was that looked at at all?

MS. SHIELDS: Well, I'll talk about

landfills; it's my other favorite thing. You can't handle rivers without dealing with the landfills in this area. There has been, in the City of Tucson, with as long as -- as well as the Arizona Department of Environmental Quality have been looking at the groundwater at the one landfill that's being remediated. They did find a problem with landfill gases that they needed to control and started doing the remediation. We haven't seen any indication in the groundwater or soils, so we haven't done complete studies to know if, you know, if there's a problem with the other ones.

One thing, we try to avoid it just because of the cost. It may just drive up the cost. I will tell you, though, there's a side benefit to the landfills, and some of the work that we've done on some of the other landfills along both Pantano, Park of Rillito, there's been as many landfills along the Rillito and the Santa Cruz and the Pantano, where there has been flood control, not necessarily bank protection, but flood control that kept water from getting into the landfills, that's where we have not had the problems, that's where the landfills just have been, if you will -- we're fortunate because we didn't have a lot of high industry here, but there haven't been problems.

The landfills that were flooded in one fashion or another have been the ones that have -- we've had to do remediation on on the Santa Cruz River or the Rillito, so there will be side benefits to providing something that keeps the water from getting into those landfills.

One of the things, though, that we can work with, and it may not even be a part of this project, but just as we were talking about working with parks and recreation with the City of Tucson is hearing what they might do.

One of the best ways to, if you will, remediate the landfill is have a thick enough landfill cap of clean dirt on top and then have just low water grass, that's what's called, you know, a landfill cap, that allows water to drain out so it doesn't infiltrate in. And in a few places north along like the Camino del Sero and a few places like that where the City and County have landfills, that's what we've kind of looked at.

We've got maybe riparian vegetation down in the channel and we've been thinking of creating an uplands area, if you will. Again, it's open space. You might not encourage people to go there and play, but it could still be remediated in that.

I think it was just the cost and the unknowns. You don't know on one of these until you get into it. And as we do the design work, the environmental evaluation along here will increase. There's a lot more studies that we'll do in all these areas.

COLONEL GUENTHER: If I can add just a little bit to that. One of the things that you asked in your question was why wasn't it included with the project. When we go through and come up with these feasibility studies, the -- actually, the first step is a reconnaissance, which the federal government does out of its pocket. And what that is to determine is basically is there a feasible project which we need to do a deeper study on and does the federal government have an interest in it.

In the case of the landfills, the government doesn't necessarily have an interest, not that they don't care, but an interest in terms of the cost-sharing agreements that will be put in place for the project. The landfills primarily are a city or a county or whatever agency is -- has oversight on those things, so that's one reason why they're not included in the project, because it's not defined as part of the project for cost sharing. I hope that answers your questions.

MR. GRAHAM: I'm just looking for work, that's all. My other comment was talking about widening the channel, and I suspect that would slow down the flow and potentially increase accidental recharge of the groundwater aquifer in the area. I was wondering if there are other things that can be done to increase recharge in the project that might offset some of the water costs or the overall costs of the project. Has that been looked at, recharge?

MS. VILLALOBOS: I think the storm water harvesting is one of those aspects where there will be empty ponds or depressions in areas where you can pond water either when you don't have flows, but you've got some rainfall, or when you have basically the tail end of a flood, when you're getting the slower waters that could pond, and that will help in not only recharge but help to save on this annual water cost to keep the habitat in place.

MR. GRAHAM: I mean, I think you can do the active management area through the department of water resources. I mean, there's a dollar value on every gallon of water and every acre-foot that gets in the aquifer. So, I mean, if the project is somehow adding to incidental recharge in the Tucson valley, that's -- I mean, that's dollars right there. So it may be worthwhile to look at those estimates of recharge. Thank you.

MS. JOHNSON: Thank you. I have a question and a comment that I've been asked to read. It is from Irene Brown at Lamar Acres. She's on Columbia Street. And her question is: Will recycled water be used in the planted areas? And then she comments: Right now our river park from Ajo to Irvington is using city well water for trees and shrubs.

MS. SHIELDS: One of the challenges where can we get the water, what we've called for this for is reclaimed water, and we've talked with the City of Tucson water department. They're correct. The main lines do not come down this far.

What we do have an opportunity that we're looking at is I mentioned there's a new reclaimed water plant that's at the Reid Park area that is taking water. We installed a water line, a wastewater, City of Tucson and Pima County, to the Ajo Detention Basin. It's a fairly short downhill, which is always important, way to come along St. Julian Wash, which would be one way to get reclaimed water into this area.

Right now there aren't any reclaimed water lines and it is a problem. So one of the -- one of the advantages of having the federal government here who can look at these alternatives, we looked at a lot of alternatives to bringing reclaimed water lines, even -- even bringing water over, if you will, Robles Pass from the Avra Valley water plant that the Pima County has out in Avra Valley.

Again, we'll be looking at those alternatives to bring in reclaimed water. We think it's really important to minimize the use of what would be drinking water. There might be some other opportunities, like I said, the storm water or where can we bring in reclaimed water, and that's something that during this time we'll have to figure out.

MS. JOHNSON: Okay. Thank you. Then we have a card from Ann Phillips from the Tucson Audubon Society. Ann?

MS. PHILLIPS: Thank you. Can you

remind me again how many acres of impact you were projecting? Was it a thousand, 1200? Just that amount.

MR. GAVIGAN: Yeah. 1,098.

COLONEL GUENTHER: That's for the recommended option.

MS. PHILLIPS: Okay. And I'm assuming -- I haven't had time to go through the whole CD of the feasibility study -- that is going to have breakdown of species lists, species density, and cross-sections, profiles of the river at different locations showing the setback and whatever kind of stabilization you're going to do in those setback areas, this is all going to be spelled out in the report?

MS. VILLALOBOS: Right. We have typical cross-sections in there for different areas, different treatments, and we have plant lists, we have approximate numbers, you know, because that's what we use to develop our cost estimate as well. So those will all be in the report.

MS. PHILLIPS: Okay. I have to admit I'm really having like a sticker shock moment here. This $91 million comes out to about $91,000 per acre of cost to implement it and then something like seven or eight thousand dollars a year per acre to maintain it, which -- and I'm not speaking from Audubon right now, I'm really speaking from my perspective as a taxpayer -- seems like a phenomenal amount of money to make the desert green again, and I'm speaking from working on restoration projects, that's what I do at Tucson Audubon is riparian restoration projects. I just will be interested to go to the report and look at the plant densities and your assumptions about cost to see where it's even possible to spend as much money as what you're talking about.

Would local businesses be some of the people who get the work to do -- to implement this? Is that an intention of this process? Would this be of benefit locally to local businesses that would implement this, nurseries, construction companies?

MS. VILLALOBOS: Yes. When we go to a construction phase, we then put out the project for competitive bid, and so it would be local industries, as well as anybody else, could bid on the job, but certainly I would think that most of the local businesses would have a little bit of an edge because they don't have to mobilize into the area, you know, bring equipment, et cetera, in here. So generally what happens is it's predominantly local contractors.

And we did, on the cost estimate, again, as Suzanne had said earlier, we tend to take a conservative approach or a higher sticker end on our costing because we don't want to underestimate the project so much that you look at it and you go, oh, we could never do it for, you know, 10,000 an acre or whatever.

So it's based on individual costs that all have a contingency in there and that each one of those costs is probably on the higher end rather than the lower end.

MS. PHILLIPS: Okay.

COLONEL GUENTHER: Something else I would add to that too. You've got to remember -- and it goes back to his points and questions that he was bringing up earlier also, is that a lot of that money is not actual outlay of cash. A lot of it is accounting for the real estate that goes into it. Even if the County already owns the land, it's still placed in the accounting of this project, and a lot of the contribution the County makes is actually the value of the land because -- and the reason you account for it is because it is also an opportunity lost to use that land for something else, whether it's development, more landfills, you know, whatever people want to try and design it for.

So don't get wrapped up in the fact that that's $90 million we've got to come up with either through federal tax raising or county taxes or whatever. A lot of it is in-kind type of things that are being accounted for because of the lost opportunity for not being able to use it for something else.

MS. PHILLIPS: That's decreasing it by 25 million under the cost of the land.

MS. SHIELDS: It's still -- some of the larger costs for construction is one that you are in an urban area and sometimes you have to work around. There's utilities out there, a lot -- a river system is a utility corridor. Earthwork, a lot of this assumes that there's a lot of earthwork to bench the near vertical 20-foot slopes we have. That's a real challenge to do something with those slopes.

The other thing, and because we were

talking about water, not just because we don't want to do groundwater, I mean, the cheap thing would be to plunk in a couple of wells and just pump. We don't want to do that. So you drive up the cost by that.

I know I've worked with Ann on the West Branch, Old West Branch in acquiring that property. That's one reason why it's so critical for us to acquire areas that are existing riparian. It's still not cheap. It's still cost for land and we still have to do some maintenance and some clean-up, but it also shows the public what it costs to try to reestablish the restorations in an urban area, as opposed to a cost for preservation.

Some areas are cheaper to restore. Lower Santa Cruz, you already have effluent out in the river. That makes it a lot easier. Right here, it's a real challenge to bring in water, and there would have to be a lot of earthwork to reform the river system.

MS. PHILLIPS: And is there an assumption that additional land would be purchased as part of this process or as part of this sharing?

MS. SHIELDS: There's very little. We did look at some, I mean, you can't avoid it if you want to have a trail system that's continuous, and whenever you come in to some of these major streets near where the bridges are and it's very constrained. It's a high end cost.

MS. PHILLIPS: When you talked about the river, the flooding taking out some of the improvements and having to go back in, I mean, how much of the work that you're talking about is actually in the bottom of the channel or in a place that's going to be vulnerable to being washed out?

MR. GAVIGAN: Yeah, most of the improvements you're referring to are in the terraces, like I said, the low flow active channel and the terraces, anywhere from three to five feet higher than that. Those are where most of the infrastructure is at. We don't anticipate the distribution system to be taken out.

Most of it is actually the established vegetation that gets taken out that needs to be replanted and initiate an establishment period again. So we had two such, you know, large events, say a 25-year event or larger coming through the area. And again, a lot of the vegetation is on laid back slopes and out above the channel in the historic floodplain, so those would not be impacted in large floods obviously.

MS. PHILLIPS: And I'm assuming that the habitat that you're trying to create isn't really going to be what it was when it was supported by shallow groundwater. I mean, basically, you're talking about shrubbing, mesquites, and a nice understory, isn't that correct? Or are you trying to push it up with the supplemental water?

MR. GAVIGAN: No, we're not trying to do that.

COLONEL GUENTHER: You basically need to restore groundwater table to do that kind of concept. We could theoretically do it, but then your county taxes would definitely go up.

MS. PHILLIPS: And your projections of channel configuration, I'm sure you're working with flood control district, have you estimated any increase in the peaks or the duration of floods with increased urbanization 50 years from now, 75 years from now? How -- what is your planning horizon on the project in terms of projecting flood flows and things like that?

MR. GAVIGAN: Our hydraulic model -- we project out 50 years in the future from the date of project implementation, which I believe was 2062 in this case, 'cause we initially thought we'd implement it in 2012. So 50 years in addition to that. We looked at the overall size of the watershed. The Santa Cruz River watershed is so large, the urbanization that typically happens isn't very close to the river. We didn't project that the peaks would increase significantly in that area.

MS. SHIELDS: And some of that is going back, as I mentioned, was initially a watershed study for the Santa Cruz River, and it kind of built on some other studies that we did. One reason why we've acquired Canoa Ranch is it's farther upstream and also created, if you will, areas that were to remain natural floodplains in both Green Valley and Sahuarita has carried that forward is that so we don't increase the -- we don't lose that floodplain upstream that increases the downstream. Really, at this edge of the Tahona Ohdam San Xavier district, we don't anticipate upstream encroachment. Though, you know, the side tributaries, complete hydrology was done on that.

MS. PHILLIPS: Okay. Thank you.

MS. JOHNSON: Thank you. Is there

anyone else who would like to ask a question or make a comment? Yes, say your name and spell it for us. Is that good?

MR. CRAIG: Yeah. My first name is John, last name is Craig, C-r-a-i-g.

MS. JOHNSON: Thank you.

MR. CRAIG: I've got -- Kim had mentioned three options and, I'm sorry, maybe it got lost in the discussion, the low, medium, and high options. Now, in our pamphlet here, the numbers are a little bit higher from what you projected, which is ultimately neither here nor there, but which option was -- you said the high was ultimately not cost effective, so I'm assuming this was either the low or the medium.

MR. GAVIGAN: The medium, actually. Alternative 3E was the one that's being recommended at this point, yes.

MR. CRAIG: Okay. So -- I noticed on your scale and your maps, my wife and I live on the south end, just north of Los Reales, and you're projecting some rather large parking areas and so, as a result, I suspect that you're planning a large increase in traffic. With that in mind, has there been any thought to widening of any of the streets in the area or was that even a thought?

MR. GAVIGAN: No, that was not included. I mean, the scale might be off. The parking areas you're referring to are only like 12 to 15 parking spaces. They're just small trailheads. Nothing, you know, substantive like half of a Wal-Mart parking lot, which would warrant that kind of a street improvement.

MR. CRAIG: Yes, I guess it was somewhat hard to tell. It looked like it was fairly massive.

MR. GAVIGAN: They're just places so that people could be aware of where they're located. There will be a lot of design that goes into that and working with the surrounding properties and community.

MR. CRAIG: So you don't necessarily expect a large -- abnormally large influx of traffic to the area?

MR. GAVIGAN: No.

MR. CRAIG: That's all I had. Thank you.

MS. JOHNSON: Thank you. Is there anyone else who would like to ask a question?

MS. PHILLIPS: I just had one more.

MS. JOHNSON: One more from Ann.

MS. PHILLIPS: I realize you guys are really far down the line in your plan at this point, but is there any chance you could think about putting an ecoduct to connect A Mountain with the Santa Cruz River to cross Mission Road as a conductivity element related to the river? Ecoduct like a bridge for wildlife.

MS. SHIELDS: Okay. Okay. Again, they go to the federal interest, which a lot of it is looking at, you know -- our wildlife person can talk about it. You know, part of our open space bond was to look at that 36th Street corridor, and I see that as a way to get from the Tucson Mountains. You were talking about an ecoduct from A Mountain?

MS. PHILLIPS: Actually, at the closest place from A Mountain and the river, right where the bend hits the mountain and they've cut the mountain off, and it used to just connect and a wildlife bridge over there -- they do it in Europe. They actually do echoducts in a lot of the places.

MR. DRAKE: One of the issues that we have is that when we -- we have to relate benefits to a feature. And when we talk about a mesquite bosque, we can add a value to that. We talk about certain type of habitat, there's values for those. But when you talk about a conduit, it is difficult for biologists to tell you what is the habitat value that you get for putting in an expensive bridge, and so we don't typically do a lot of bridges. I mean, incrementally justified, you know, it would not be cheap in relation to other features of the project.

MR. GAVIGAN: I'll add that we've, you know, had extensive discussions with the City of Tucson and the Rio Nuevo efforts, although their plans aren't solidified, those are possibly making that connection in the future. That might be an alternate way of addressing that.

MS. PHILLIPS: Through the Rio Nuevo?

MR. GAVIGAN: Through the Rio Nuevo, yes.

MR. FINK: We are definitely interested in the interconductivity of the wildlife migratory use, and the 32 miles of the river that we're looking at in one feasibility study or another, the habitat conductivity is a very big issue, very big concern.

MS. JOHNSON: Thank you. Anyone else?

In that case, it's almost 20 after eight. I'm sure in the remaining ten minutes that we announced for this meeting you could visit informally with the Corps people and the local people who are here. Thank you all for coming.

COLONEL GUENTHER: We'll be here more than ten minutes. We're not going to walk out at 8:30 and turn into pumpkins or something. We'll leave this slide up here too. It gives the address if you want to send written comments and it doesn't have to necessarily be on the nice yellow form or whatever, but if you want to mail in comments to that address, it also tells you. You can write down the places that the draft -- the documentation is available.

(Concluded at 8:20 p.m., October 26, 2004.)

STATE OF ARIZONA)
)
COUNTY OF PIMA)

I, Cindy J. Shearman, a Registered Merit Reporter,

DO HEREBY CERTIFY that I recorded in shorthand (Stenotype) the foregoing proceedings had and made of record in the above-entitled matter at the time and place hereinbefore indicated.

I DO HEREBY FURTHER CERTIFY that the foregoing and attached typewritten pages contain a full, true, accurate, and correct transcript of my shorthand (Stenotype) notes, as they purport to contain, then and there taken.

Dated at Tucson, Arizona, this 4th day of November, 2004.

Cindy J. Shearman, RMR, CCR
Arizona Certificate #50718

Gavigan, Kim M SPL

Subject: FW: Ecosystem Restoration - Stormwater Detention

1.1

-----Original Message-----
From: Darrin Brightman [mailto:Darrin.Brightman@parks.pima.gov]
Sent: Monday, October 04, 2004 12:11 PM
To: 'Kathleen.M.Bergmann@spl01.usace.army.mil'
Subject: Ecosystem Restoration - Stormwater Detention

Ms. Bergmann -

Upon reviewing the current draft feasibility study for the Paseo de las Iglesias project in Tucson, I found that the bibliography did not *appear* to list any references detailing the source of your agency's experiences with or knowledge of stormwater detention basins as a means of habitat restoration, nor did the Prior Studies section. However, design standards for detention basins were included in the feasibility study.

I reviewed several other USACE studies (available on Pima County's websites), and again found no references specific to this question. (Unfortunately, the Arroyo Chico and Ajo Detention Basin studies are no longer available).

Are there references you or one of your colleagues could recommend? Perhaps USACE has completed its own studies, and therefore does not need to cite them?

I would like to see greater use of detention basins in our future park designs and/or enhancements, but am having difficulty finding studies which demonstrate that they work! Granted, visiting nearly any flood-control basin within the Tucson valley demonstrates it, but that's not always good enough when asking for money.

I appreciate any assistance you can offer!

Darrin

Darrin Brightman
Pima County Natural Resources Parks and Recreation
Planning and Development Division
3500 West River Road
Tucson, Arizona 85741

520-877-6242

Paseo de las Iglesias
Ecosystem Restoration
Feasibility Study
Comment Forms

Public Meeting 10/26/2004

US Army Corps of Engineers.

Name Kenneth Ford

Address 1053 W. District City Tucson State AZ Zip 84

Email Address ______________ Daytime Telephone ______________

Association/Organization Resident

How did you hear about the public meeting?

Paseo de las Iglesias

- ☐ Received Mailing
- ☐ Advertisement
- ☐ Other ______________

COMMENTS: 2.1

Please connect the recreation bike trail/Hiking trail between Ajo & Silverlake

Thank you for providing us with this information. You may also mail or fax your comments to:

Kim Gavingan or Michael Fink
U.S. Army Corps of Engineers
3636 N. Central Avenue, Suite 900
Phoenix, AZ. 85012-1939

FAX: 602-640-5382

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
1111 Jackson Street, Suite 520
Oakland, CA 94607

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November 4, 2004

ER 04/736

Colonel Alex Dornstauder
District Engineer, Los Angeles District
U. S. Army Corps of Engineers
P. O. Box 532711
Los Angeles, California 90053-2325

Review of the Draft Environmental Impact Statement for the Santa Cruz River, Paseo de las Iglesias Feasibility Study Report, Pima County, Arizona

Dear Colonel Dornstauder:

The U. S. Department of the Interior has reviewed the Draft Environmental Impact Statement for the Santa Cruz River Paseo de las Iglesias Project near Tucson, Arizona. Our comments are as follows.

3.1 Water Resources

Page 7 of the document indicates a source of water for the project is still being sought. The Bureau of Reclamation (BOR), as a part of the Southern Arizona Water Rights Settlement Act (SAWRSA), owns the rights to 28,200 acre-feet per year of treated wastewater effluent. A portion of this amount has yet to be put to beneficial use by the BOR. Local sponsors have an agreement that allows use of locally controlled effluent for riparian restoration purposes; however, it would be advantageous to the Federal government if the BOR was paid to use SAWRSA effluent. We request that SAWRSA effluent be considered as a water source for this project. Should you have any questions, please contact Eric Holler, Bureau of Reclamation's Tucson Field Office, at 520-670-4825.

3.2 Fish and Wildlife Resources

The Fish and Wildlife Service (Service) Arizona Ecological Services Field Office has participated in this project through transfer funding agreements under the Fish and Wildlife Coordination Act. The current plan reflects Service input and the Service has no additional comment at this time.

Thank you for the opportunity to provide our comments.

Sincerely,

Patricia S. Port

Patricia Sanderson Port
Regional Environmental Officer

cc: Chief, Environmental Resources Branch, Los Angeles District, Corps of Engineers, Los Angeles, CA
Arizona/Nevada Area Office, Los Angeles District, Corps of Engineers, Phoenix, AZ
Director, OEPC, Washington DC.

Jonathan DuHamel
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jedtaz@mindspring.com

November 9, 2004

Mr. Kim Gavigan
U.S. Army Corps of Engineers
3636 N. Central Ave., Suite 900
Phoenix, AZ 85012-1939

Dear Mr. Gavigan:

I am writing in response to the request for public comments regarding the Paseo de las Iglesias Ecosystem Restoration Feasibility Study.

I have read through much of the Feasibility Study on-line. I have some serious concerns regarding the proposed project, and these concerns have prompted a number of questions.

One of my main concerns is that a huge amount of money will be spent for the pre-construction engineering for this project, and the other major environmental restoration projects under study in Pima County, and the projects will not be able to proceed to construction. This could happen because no local sponsor agency will be able to afford the local cost share for construction of these projects or the continuing cost for the irrigation water and maintenance required for these projects. Or, it could happen because the federal funding will not be available for the construction of these projects.

My second main concern is that, if these projects are able to proceed to construction, the continuing costs for irrigation water and maintenance will be too much for the local sponsor agency to afford. This could lead to discontinuing the irrigation and maintenance, which would cause all of the federal and local tax funds invested in these projects to be wasted, as all of the environmental restoration plants put in place by these projects are allowed to die. Or, the attempt by the local sponsor agency to fund the continuing cost of the irrigation water and the maintenance could result in bankrupting the local sponsor agency.

According to the Feasibility Study, the Paseo de las Iglesias project will restore wildlife habitat for 7.5 miles along the Santa Cruz River. The total cost of the project is estimated to be $92,059,000. Federal funding will provide $59,667,000 of this cost, and the local sponsor agency will be responsible for the $32,392,000 balance. Irrigation will require 1925 acre-feet per year, at an estimated cost of $1,099,175 per year. Additional maintenance costs are estimated at $770,786 per year.

It is my understanding that all of the environmental restoration projects currently being studied for cost sharing with the Pima County Flood Control District total 32 miles of restoration work along the Santa Cruz and Rillito Rivers. These projects are Paseo de las Iglesias, Tres Rios del Norte, and El Rio Medio on the Santa Cruz River, and El Rio Antiguo and the Swan Wetlands on the Rillito River.

I have not seen cost estimates for each of these individual projects. But, if the cost estimates for the Paseo de las Iglesias project are representative, the total of 32 miles of restoration could have a total cost of $393,000,000, a federal cost of $255,000,000, and a local cost of $138,000,000. The irrigation water required could total 8220 acre-feet per year, at an annual cost of $4,693,500. Additional annual maintenance costs could total $3,291,000.

I would appreciate answers to the following questions:

4.1 1. What is the total amount of funding that the U.S. Army Corps of Engineers was appropriated for environmental restoration projects, nationwide, in the current fiscal year?
4.2 2. What are the realistic chances of receiving an appropriation of the $59,667,000 for the federal cost of the Paseo de las Iglesias Environmental Restoration project?
4.3 3. What is the estimated cost of the pre-construction engineering and design for the Paseo de las Iglesias project?
4.4 4. Should the pre-construction engineering and design cost be expended, if there is uncertainty about the chances of receiving an appropriation of the federal funding for the Paseo de las Iglesias project?
4.5 5. What are the realistic chances of receiving appropriations totaling $393,000,000 for the federal cost of all of the environmental restoration projects being studied for the Santa Cruz and Rillito Rivers in Pima County?
4.6 6. What is the estimated cost of the pre-construction engineering and design for all of the environmental restoration projects being studied for the Santa Cruz and Rillito Rivers in Pima County"
4.7 7. Should the pre-construction engineering and design costs for all of the projects on the Santa Cruz and Rillito Rivers be expended, if there is uncertainty about the chances of receiving appropriations of the federal funding for all of these projects?
4.8 8. The Paseo de las Iglesias Ecosystem Restoration Feasibility Study includes a letter from the Pima County Flood Control District stating that it will bear the local sponsor agency costs for the project, and will bear the continuing costs for irrigation water and maintenance. When the Corps of Engineers is considering major federal expenditures for projects of this type, does the Corps of Engineers audit or otherwise verify the financial capability of the local sponsor agency to fund the local sponsor construction costs and the continuing operation and maintenance costs?
4.9 9. According to the Annual Report of the Pima County Flood Control District for Fiscal Year 2002-2003, the District had total tax revenues of $14,467,389. The operating expenditures were 42% of this total, equal to $6,076,000. The capital improvements expenditures were 51% of the total, equal to $7,378,000. Debt service was 7% of the total, equal to $1,013,000. Based on these numbers, the local sponsor agency share of the construction cost

for the Paseo de las Iglesias project, $32,392,000, amounts to 4.4 years of the total amount of capital improvements funding for the District. The continuing annual costs for irrigation water and maintenance of the Paseo de las Iglesias project total $1,869,961. This constitutes 13% of the entire annual revenues of the District, and 31% of the annual operating expenditures. Has the Corps of Engineers audited or otherwise verified the financial capability of the local sponsor agency to fund the local sponsor construction costs and the continuing operation and maintenance costs for the Paseo de las Iglesias project?

4.10 10. Should the pre-construction engineering and design cost of the Paseo de las Iglesias project be expended, if there is uncertainty regarding the financial ability of the local sponsor agency to fund its share of the construction cost and continuing costs for irrigation water and maintenance?

4.11 11. If the total local sponsor agency share of the construction cost of all of the environmental restoration projects being planned for the Santa Cruz and Rillito Rivers is approximately $138,000,000, this constitutes 18.7 years of the total amount of capital improvements funding for the District. If the continuing annual costs for irrigation water and maintenance for all of these projects is approximately $7,984,500, this constitutes 55% of the entire annual revenues of the District, and more than the total annual operating expenditures. Has the Corps of Engineers audited or otherwise verified the financial capability of the local sponsor agency to fund the local sponsor construction costs and the continuing operation and maintenance costs for all of the environmental restoration projects being studied for the Santa Cruz and Rillito Rivers in Pima County?

4.12 12. Should the pre-construction engineering and design costs for all of the environmental restoration projects being planned for the Santa Cruz and Rillito Rivers be expended, if there is uncertainty regarding the financial ability of the local sponsor agency to fund its share of the construction costs and the continuing costs for irrigation water and maintenance?

Thank you for your attention to this letter.

Sincerely,

Page 3 of 3

Fink, Michael J SPL

From:	Roger.Anyon@pw.pima.gov
Sent:	Friday, November 12, 2004 5:06 PM
To:	Fink, Michael J
Subject:	FW: Paseo de las Iglesias Draft Feasibility Study and DEIS commen ts

Mike - my first attempt got bounced - let's see if this works.

Roger Anyon
201 N. Stone, 7th Floor
Tucson, AZ 85701
(520) 740-6405
(520) 740-6320 (fax)
roger.anyon@pw.pima.gov

> -----Original Message-----
> From: Roger Anyon
> Sent: Friday, November 12, 2004 5:04 PM
> To: 'Michael.J.Fink@spl01.usace.army.mil'
> Cc: Tom Helfrich; Linda Mayro
> Subject: Paseo de las Iglesias Draft Feasibility Study and DEIS
> comments
>
> Mike:
>
> Having just realized, about an hour ago, that I need to get my comments in
> by November 14, I've given the Draft Feasibility Study and Draft EIS dated
> July 2004 for the Paseo de las Iglesias project a quick review. Overall,
> the cultural resources issues are adequately dealt with at this stage to
> ensure that the National Historic Preservation Act is fully complied with
> during the following stages of this proposed project. I have a couple of
> comments, as follows:
>
> Feasibility Study
>
> Chapter III. A. Prior Studies or Reports.
> I realize that this is a sample of reports and studies not a comprehnesive 5.1
> list, but I think it is important to add a couple more. These are:
> Scott O'Mack and Eric Klucas, 2002, San Xavier to San Agustin, An Overview
> of Cultural Resources for the Paseo de las Iglesias Feasibility Study,
> Pima County, Arizona. Statistical Research Inc., Tucson.
> McGann & Associates, 2002, Master Plan for Pima County, Arizona Segment,
> Juan Bautista de Anza National Historic Trail.
>
> Page IV-14 Cultural Resources.
> In the first paragraph please make note that this information is based on
> O'Mack and Klucas 2002 (referenced above). 5.2
> In the second paragraph make note that SHPO will also be fully consulted.
>
> Page IV-30 Recreation
> Add mention that some portions of the Juan Bautista de Anza National 5.3
> Historic Trail are in place along the proposed project area.
>
> Bibliography Page B-1
> Add O'Mack and Klucas 2002. 5.4
>
> Draft EIS
>
> Page 112 Section 5.6.2, first paragraph.
>
> I think it would be useful to add coordination with SHPO here as well. 5.5
>
> Thank you for providing us the opportunity to review these documents. We

> appreciate all the diligent work you and your colleagues have put into
> them. The proposed project will provide be a major positive force for the
> citizens of Pima County.
>
> Roger Anyon
> 201 N. Stone, 7th Floor
> Tucson, AZ 85701
> (520) 740-6405
> (520) 740-6320 (fax)
> roger.anyon@pw.pima.gov
>

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

November 12, 2004

U.S. Army Corps of Engineers
Los Angeles District
Arizona/Nevada Area Office
ATTN: Mr. Michael J. Fink
3636 North Central Avenue, Suite 900
Phoenix, AZ 85012-1939

Subject: Santa Cruz River, Paseo de las Igelsias Feasibility Study Report Draft Environmental Impact Statement (DEIS) [CEQ # 040460]

Dear Mr. Fink:

The Environmental Protection Agency (EPA) has reviewed the document 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. Our detailed comments are enclosed.

The Corps of Engineers (Corps), in conjunction with the Pima County Flood Control District, is assessing opportunities for riverine ecosystem restoration for the seven-mile Paseo de las Iglesias reach of the Santa Cruz River. We support habitat restoration in this area and the goals of the project. We have rated this Draft EIS as Lack of Objections-(LO) (see enclosed "Summary of Rating Definitions"). However, there is some additional information we would like to see included in the Final EIS.

6.1 The Tucson Basin is home of the Tohono O'odham Nation and Pascua Tribe. The DEIS notes that a Memorandum of Agreement (MOA) and archeological site treatment plan will developed if necessary to ensure protection of National Register of Historic Places (NRHP)-listed sites. However, there is no information regarding the status of consultation with these tribes or whether they were asked to be a cooperating agency. The Final EIS should include this
6.2 information and any input or concerns the Tribes may have related to project implementation. The Final EIS should also include input or concerns that were expressed by land managers in the area and response to these concerns.

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6.3 EPA notes that once the bank stabilization has been completed, land use adjacent to the Project Area may change, allowing for the development of commercial, light-industrial, or residential use. The cumulative impacts of such effects should be assessed to the extent possible as well as the ensuing effects to air quality, surrounding vegetation, and cultural resources. In addition, while there is a discussion about other restoration projects in the area, there should be a discussion about non-restoration related projects that are ongoing or planned for the area by the Corps or other agencies, such as the Border Patrol and the Department of Homeland Security.

We appreciate the opportunity to review this Draft EIS. When the Final EIS is released for public review, please send two copies to the address above (mail code: CMD-2). Questions regarding this letter should be directed to Summer Allen, the lead reviewer for this project at (415) 972-3847 or allen.summer@epa.gov.

Sincerely,

Lisa B. Hanf

Lisa B. Hanf, Manager
Federal Activities Office

MI# 003655

Enclosures:
Summary of Rating Definitions

2

SUMMARY OF EPA RATING DEFINITIONS

This rating system was developed as a means to summarize EPA's level of concern with a proposed action. The ratings are a combination of alphabetical categories for evaluation of the environmental impacts of the proposal and numerical categories for evaluation of the adequacy of the EIS.

ENVIRONMENTAL IMPACT OF THE ACTION

"LO" (Lack of Objections)

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

"EC" (Environmental Concerns)

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

"EO" (Environmental Objections)

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

"EU" (Environmentally Unsatisfactory)

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

ADEQUACY OF THE IMPACT STATEMENT

Category 1" (Adequate)

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

"Category 2" (Insufficient Information)

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

"Category 3" (Inadequate)

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

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

November 15, 2004

CITY OF
TUCSON
OFFICE OF THE
CITY MANAGER

Attention: Michael J. Fink
U.S. Army Corps of Engineers
Los Angeles District
Arizona/Nevada Area Office
3636 North Central Avenue
Phoenix, AZ 85012-1939

Re: Paseo de las Iglesias, Pima County, Arizona

Dear Mr. Fink:

Attached are the compiled comments from City of Tucson staff based on our review of the Draft Environmental Impact Statement (DEIS) and Draft Feasibility Report for Paseo de las Iglesias along the Santa Cruz River in Tucson, Pima County, Arizona. The City appreciates the opportunity to comment on the documents, and we thank you and your colleagues for making the CD-ROM containing the documents readily available to us.

We think this is a worthwhile project; nonetheless, the City of Tucson staff comments raise concerns regarding the proposed project and the DEIS. Staff does not believe the following most significant concerns have been adequately addressed in the DEIS:

- the source of water needed for irrigation for the Preferred Alternative;
- analysis regarding the groundwater impacts of irrigation in or near areas of known landfills;
- strategies for dealing with orphan waste from currently unidentified wildcat dump sites, which may be encountered during construction;
- the amount of City of Tucson-owned land needed for the project and the appraised value of the City of Tucson-owned land; and
- the method of funding the local share of construction and maintenance.

Staff comments also cite numerous other concerns regarding the Preferred Alternative and the analysis in the DEIS.

I'm not sure the City of Tucson can support the Preferred Alternative until the issues raised in the staff review comments are adequately addressed. It is imperative that the City have the information necessary to ensure the City's groundwater supply be properly protected, both from possible contamination and from uses which may deprive the residents of this community of a future water resource. The supplemental Intergovernmental Agreement between Pima County and the City of Tucson signed in 2000 provides Pima County with an annual allocation of 3,500 acre-feet of effluent that can be used to support irrigation needs for this project.

If the Paseo project is part of a Fish and Wildlife approved Habitat Conservation Plan, the IGA would permit the Conservation Effluent Pool to be utilized. The City of Tucson requires additional information regarding the source of water for the Paseo project.

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Paseo de las Iglesias
November 15, 2004
Page 2 of 2

The City must also protect its citizens' economic interests regarding the possible use, or acquisition of, City-owned land and the future commitments of construction and maintenance costs for the projects. The Preferred Alternative proposes to utilize 512 acres of City-owned land. This will require further review by City staff. Some of these parcels have development potential, and some do not; therefore, further investigation is appropriate.

Paseo de las Iglesias is the first of three such USACE feasibility studies along the Santa Cruz River to reach the Preferred Alternative stage of the USACE planning process. The other projects are at different phases of completion.

In the context of the three USACE studies along the Santa Cruz River covering a 29 mile reach of the river, including the entire reach within the corporate limits of the City of Tucson, it appears the prudent and proper course of action is to not finalize any of the feasibility studies until all of the studies have produced Preferred Alternatives. Once all of the Preferred Alternatives are on the table, a complete analysis of the anticipated benefits, costs, and drawbacks of all of the Preferred Alternatives can be completed. Such a comprehensive approach to restoration along the 29-mile reach of the river would ensure compatibility of project outcomes, comprehensive analysis of impacts, and a complete accounting of all costs, including the amount of water needed for the three projects. The current, piecemeal approach to these contiguous studies does not allow for adequate analysis by the local governments, nor does it offer the citizens of our local communities the true vision for this reach of the Santa Cruz River.

It appears Paseo de las Iglesias is proposed for Water Resources Development Act (WRDA) funding in the Federal FY 2006. It also appears that Tres Rios Del Norte and possibly El Rio Medio would be WRDA 2008. The potential two-year delay for Paseo to properly analyze all of the Preferred Alternatives from the three studies does not appear unreasonable.

I would like to propose a meeting with representatives from the USACE, Pima County Flood Control District, Town of Marana, and City of Tucson to establish this comprehensive review process for all of the Preferred Alternatives coming out of the feasibility studies.

Again, the City of Tucson appreciates the opportunity to comment on Paseo de las Iglesias and we are very interested in a more comprehensive review of restoration projects.

Sincerely,

for James Keene
City Manager

JK/AE/ts

Attachment: City of Tucson Staff Comments on Paseo de las Iglesias Draft EIS and Draft Feasibility Report: November 3, 2004

c: Benny J. Young, Assistant City Manager
Albert Elias, Urban Planning & Design Director

City of Tucson Staff Comments on Paseo de las Iglesias Draft EIS and Draft Feasibility Report: November 3, 2004

Real Estate Comments

7.1 According to the Real Estate plan (Appendix I) of the draft feasibility report, there is a total of 1223 acres designated as the Paseo de las Iglesias study area. Of this total, 512 acres or 42% is owned by the City of Tucson. According to the plan, all of the land is subject to floodplain and floodway restrictions that place significant limitations on its highest and best use. This general statement would need much more supportable evidence that is not provided for in the plan. The plan places a gross appraisal estimate of the city property at $3,322,296 or approximately $6,500/acre. The plan puts the county owned property at $42,883/acre and the privately owned property at $27,235/acre. Since the appraisal was not available in the report, there is no way to determine the legitimacy of these figures or where they came from. As it relates to the 17.45 acre city property adjacent to the Airport Wash, this site has a value estimated (by city's appraiser) at approximately $1.9M or $109,000 per acre, so there is considerable concern over the values shown in the Real Estate Plan. We really need to see the appraisal used in order to
7.2 determine how realistic the values are. Additionally, the Plan states that the city properties are zoned for River Park according the Santa Cruz Area Plan. The parcels of city property along the east side of the River are currently zoned R-1 and the parcel located in the Parque De Santa Cruz subdivision is zoned P-I.

7.3 The Plan states that the parcels will be acquired as a Permanent Easement Estate...does this mean they have been valued as such, or has a fee value estimate been considered? The plan states that due to the political and economic relationship of the city and county, it is not conducive to permit a transfer of fee title from one entity to another. Even if this may be the case on occasion, I don't think this Plan should be stating the perceived relationship problems of the city and county, particularly as a reason not to convey fee title–we convey fee title to each other all the time.

7.4 The plan states the value estimates are based on the high end. This is a very general statement that provides no adequate support. The plan states that it is thought that some parcels may "fall out" of the final plan. This is an encouraging statement that perhaps some of the parcels identified should not be part of the plan...specifically, we would argue that the city parcel adjacent to the Airport Wash should not be in this plan.

City of Tucson Department of Transportation, Engineering Division

7.5 It appears that this project will have a significant impact on private properties and municipally held properties along the affected reaches of the Santa Cruz River (SCR). Although the City of Tucson is fully supportive of environmental restoration projects, we are also very interested in providing additional flood control protection for our existing public infrastructure in the vicinity of the affected reaches of the SCR as well as increasing our potential tax base through land reclamation for future development. It is our belief that there is a strong possibility that if the Corps were to work closely with individual abutting property owners, mutually beneficial options/alternatives could be identified that would achieve environmental restoration, flood control, and land reclamation. Additionally, it is very possible that some abutting property owners would be willing to share in the respective costs of both the environmental restoration element of the project (perhaps through the dedication of property) and the flood control element of the project (perhaps through direct financial contribution or through the installation/construction of improvements) if these efforts resulted in the reclamation of additional land.

<u>**City of Tucson Department of Environmental Services (ES)**</u>

ES recommends further information be provided for the following topics to ensure environmental regulation compliance and to prevent unintentional environmental degradation.

7.6 • The EIS identified six (6) closed landfills along the banks of the Santa Cruz that are adjacent to or abutting the actual riverbank and in the path of proposed improvements. The landfills are Nearmont, Rio Nuevo South (Congress), "A"-Mountain, Mission, 29th Street, and Ryland. Several of these closed landfills have buried municipal solid waste (MSW) that is part of the riverbank. The report references any disturbance, excavation, or grading in these areas could expose old, buried MSW. Because the landfills operated prior to solid waste rules and regulations, hazardous materials may be present in the old MSW. The EIS does not specifically address how encountering MSW or hazardous materials will be handled, except to state a plan will be developed. Because disturbing these wastes can have far reaching implications with regards to federal, state, and local regulations, more information is necessary in the report.

7.7 • Areas of "wildcat dumping" have been documented along the Santa Cruz channel. The EIS fails to address the proper disposal methods of orphan wastes associated with this project.

7.8 • The three alternate proposals include varying improvements such as re-grading riverbanks, removing soil cement erosion protection, and installing irrigation systems to provide water to the restored vegetation. The EIS indicated that potential recharge of the introduced water would have no significant impacts on the groundwater beneath the channel. Due to the proximity of several landfills and the variability of infiltration rates along the river channel, additional investigation is necessary to ensure introduced irrigation water does not leach contaminants into the groundwater and to demonstrate compliance with all regulations.

7.9 • The EIS does not clearly address what precautions will be taken to keep any introduced irrigation water from infiltrating into pockets of buried MSW and causing leachate or increased landfill gas production.

7.10 • A common problem with "natural channels" in the basin and range provinces is bank migration during major flow events. The EIS proposals indicate removal of existing soil-cement and replacement with terraced vegetation. Additional research and investigation appears necessary to ensure bank migration will not occur during a major channel-flow event.

7.11 • The EIS does not identify the source of water needed for the alternate proposals.

7.12 • The report lacks a thorough discussion of how the proposed alternate projects will comply with federal, state and local regulations with regards to MSW, landfill gas, and groundwater protection.

City of Tucson Department of Transportation, Stormwater Management Section

7.13 The proposal outlined in this study is very optimistic. The Cost is $93,000,000 the Local sponsor is responsible for more than $40,000,000 in construction costs, and over $1 million annually in maintenance costs. Pima County is the Local Sponsor and has agreed with the Preferred Alternative. The City does not support utilizing precious flood control tax levy monies for environmental restoration when there are high priority urban drainage needs within the City that must be addressed first. Most of the project is restoration of the ecosystem, with only about $8,000,000 used for Flood Control/Floodplain Management.

7.14 Changing the designated use of the Santa Cruz River from ephemeral to effluent dominant will result in a change of Water Quality Standards for the river and will have long term impacts on all discharges (including effluent and stormwater).

7.15 From the level of detail provided in the Environmental Impact Statement and Draft Feasibility Report, it is difficult to determine exactly where structural features, such as soil cement bank protection and banks cut to a 5:1 slope, will occur. This is of concern because of ongoing erosion problems at the Ryland Landfill located at Ajo Road and the Santa Cruz River. Although Ryland has been closed and capped, the eastern bank of the Santa Cruz River consists of landfill material exposed during high flow events. This area of the river is a prime candidate for soil cement. If soil cement is not utilized in this area, high flows will continue to expose garbage, dating from a time when landfills were not required to restrict disposal of hazardous waste. Although the EIS recommends remediation and management planning for landfill materials encountered in bank excavations, Ryland Landfill is an area where the river banks should be stabilized to prevent further exposure of unknown and possibly deleterious materials.

7.16 Of additional concern is the description under alternative 3E of construction of the stormwater harvesting basins. The description calls for minor excavation, followed by compacting the bottoms of the structures to promote lateral infiltration. However, as noted in the Biological Evaluation, "soils within the river and wash channels are typically sand and gravel, with small silt deposits and very low organic content." (page 166) Sandy, silty, alluvial soils have poorly defined soil structure and do not compact. Because compaction is ineffective and these soils have extremely high infiltration rates, these structures will not serve their intended purpose. As described under Alternatives 2A and 4F, these structures include a liner membrane. This membrane may be a practical necessity to slow infiltration and maintain appropriate moisture levels.

7.17 Vegetation in rapidly draining, sandy soils requires more water. Does the water budget address the effect of the soils in the project area and on watering requirements?

7.18 The Old West Branch of the Santa Cruz River has a rich and varied riparian habitat. Planned measures to improve the water regime will safeguard this area which is currently threatened by low water availability. Care should be exercised to ensure that the methods utilized do not destabilize the area. In addition, this portion of the project may need to be accelerated to prevent further habitat losses.

7.19 The proposed diverting water from the West Branch Diversion channel to the Old West Branch to supplement habitat needs is a tricky concept. The effective FEMA delineated floodplain for the Old West Branch is well out of the channel banks. The existing "natural" channel has less conveyance capacity than the 10-year flood event in most places. Per standard hydrologic assumption the Old West branch will likely flood at the same time the West Branch diversion channel floods due to similar meteorologic conditions. The Current FEMA floodplain delineation for the Old West Branch does not account for the additional flows that the diversion would add. FEMA is very clear, changes that increase the flood water depths (base flood elevation) or that increase flooding potential to adjacent properties cannot be allowed.

7.20 The dry condition of the bank soils aids bank stability against erosion from short duration flow events. The soils along the Old West Branch contain a lot of silt that holds a slope when dry but is much more erodible when wet. Most of the erosion on the West Branch, and the Santa Cruz River, is generated by bank undercutting and sloughing. A continuously wet toe of bank may easily exacerbate bank erosion.

7.21 The following is not so much an issue as a questionable design feasibility comment. The plan proposes compacted furrows in the flow line of the Santa Cruz River to convey water to vegetated areas. It is very doubtful that there is enough compactable material in the flow line of the Santa Cruz River, or that 600' of continuous compactable material exists. The flow line is relatively clean material. Flows will likely sink into the sediment until boiscum seals the pore spaces (usually more than a week). This should have been evident from the materials handling the County has done for all the bank protection that has been installed, and from the post flood surface flow behavior displayed downstream of the treatment plants on the Santa Cruz River.

7.22 **Correction:** The document credited the erosion hazard setback to zoning. The erosion hazard setback is part of the Floodplain Regulations, not zoning.

7.23 **Corrections:** section 5.4.1.2 indicated the Santa Cruz River watershed is 7,000 sq. mi. It is 2,222 sq. mi. at Congress, the downstream end of the project.

<u>The following issues deal more with how the project is developed than with the EIS report</u>

ISSUE:

7.24 Section 3.1 states there are "unlimited volumes of wastewater" available for the project. Not the case. Water Dept projections indicate a shortfall in supply around the year 2015. This has a clear indication the City may need to treat effluent to make up the difference, especially of the CAP allotment falls short due to extended drought. The City should be diligent in defining its future need for using reclaim water, especially when the report states "**7.3 Irreversible and Irretrievable Commitment of Resources**

Implementing any of the action alternatives would irretrievably commit resources including construction materials, fuel used by construction equipment, **water for irrigation**, and the plants/seedlings used to establish the habitat."

ISSUE:

7.25 Section 5.2.2 Land Use states that 9 miles of bank protection will increase land developability along the Santa Cruz River. Where along the River is this bank protection to be installed? or are they talking about existing bank protection? All other discussion only mention vegetated earthen banks susceptible to erosion from larger events. Appears to need clarification.

7.26 ISSUE:
Water rights: section 4.4.2 Surface Water Rights states "Surface water rights are not an issue along this reach of the Santa Cruz River because of the absence of sustained surface flows; those in possession of surface rights are not able to divert water."

But,

"5.4.3.2 Alternative 2A
Similar to the No Action Alternative, the Xeroriparian alternative does not include any proposed management change or construction methods that would change the existing water rights. The hydrologic factors existing in the Project Area are incorporated into an already **fully adjudicated watershed.**"

"5.4.3.3 Alternative 3E
The effects to surface water rights from implementing Alternative 3E would be the same as 2A."

"5.4.3.4 Alternative 4F
The Pima County Department of Transportation and Flood Control is the primary sponsor for the project and would be responsible for bringing intermittent flow back into the channel, as part of this alternative. As such, **the added discharges would be owned and managed by Pima County** for the intended purpose of ecosystem restoration improvements.

The hydrologic factors existing in the Project Area before construction of this alternative are incorporated into an already fully adjudicated watershed. Any actions resulting from this project will not change existing water rights."

Surface water rights are managed by the Arizona Dept of Water Resources and the Courts. Alternatives using in-channel water harvesting are using appropriable waters. ADWR would likely grant Pima County the right (junior rights to anyone with pre-existing rights downstream) to use the surface waters for "beneficial uses" as they have in the past. The City needs to be represented here. If the County gets appropriable water rights for the tributaries to the Santa Cruz and to the tributaries to the West Branch of the Santa Cruz, they could hinder or stop the ability of the City to gain future use of upstream surface waters should the need arise. Paseo de las Iglesias, if built, will be maintained by the County and they should be able to use the surface waters, but perhaps the City should obtain the surface water rights and grant use to the County through an IGA.

7.27 ISSUE:
The preferred alternative purposes water harvesting basins at the confluence of tributaries with the Santa Cruz River and with the West Branch Santa Cruz River. Not a habitat issue along the Santa Cruz River but removal of vegetation to support other vegetation on the tributaries to the

West Branch, most of which have code protected habitat, is not reasonable, and suggesting replacement with juvenile vegetation that would take 20 or more years to approximate the existing habitat is also unreasonable..

City of Tucson Water Department

Draft Feasibility Report

7.28 *General Comment #1*: Some alternatives propose removing soil cement. How will this be accomplished and what will happen to the material? This item will be a significant part of the project costs and should be broken out as a separate cost.

7.29 *General Comment #2*: Water harvesting, enhanced recharge, and various uses of storm flows are mentioned throughout the report. Has the Army Corps confirmed with the State of Arizona that the local sponsor has the legal right to divert natural surface water flows? Would this require an appropriation of surface water?

"However, it will reestablish a hydrologic connection to the river, reduce the frequency of bank failure during intermediate events and should reduce the need to reestablish habitat due to
7.30 *washout."* (p. iii) There are several mentions of reestablishing a perennial flow in the Santa Cruz River. The City has examined such ideas in the past and concluded that the risk of mobilizing contaminants from both known and unknown waste disposal sites was unacceptable. Also, the value of water will rise so dramatically during the 50-year life span of the project, it will be very difficult to sustain such an alternative. With these two hurdles, a very intense cooperative planning effort by many stakeholders would be needed to make such a project feasible.

"[T]he identification of the opportunity and the role for Corps participation in environmental restoration and related water resources planning." (p. II-2) Water planning will need to be an
7.31 increasingly regional effort where many water use sectors have to be taken into account. The Corps would be a welcome participant in such planning efforts along with the many other water users and providers in the Tucson Active Management Area. As noted by the City of Tucson in the Tres Rios del Norte and El Rio Medio feasibility studies, the needs of municipal water supply and environmental enhancements can complement one another if enough creativity and imagination are brought to bear. The City's Sweetwater Wetlands is an example where a project can have multiple purposes. The focus, then, should be on multi-benefit type projects which can be win-win opportunities. If environmental enhancement is the only consideration in rapidly growing areas where water resources are limited, then the range of water sources that can potentially be available will be very limited.

"• *Evaluating water sources such as storm water harvesting, treated effluent and the Central Arizona Project (CAP).*
• *Ensuring habitat is sustainable with available water . . .*
• *Promoting groundwater recharge."* (p. II-3)

7.32 The use of CAP water and groundwater is mentioned more than once in the report. Within the next 20 years the City will be using all its CAP allocation and all its effluent for municipal supply of one type or another. The same use of resources seems likely for other providers as well. The most sustainable habitat will rely on sources that will be available for the 50-year span of the project, such as reclaimed water and any storm flows that can be appropriated. As noted above, the needs of municipal water supply and environmental enhancements can be complementary functions. The focus should be on multi-benefit type projects which can be win-win opportunities. If environmental enhancement is the only consideration, then the range of water sources that can be made available will be very limited.

7.33 *"The 100-year floodplain of the Santa Cruz River is narrow as it passes through the study area due to the effects of earlier channelization and down cutting by the river."* (p. II-8) The river is also artificially maintained as it is due to soil cement banks. This statement should reflect that.

7.34 *"The plan includes the following guidelines related to aesthetic resources: • Restore and preserve natural areas. This may include floodplain acquisition, purchase of development and water rights, and limitations on rezoning." (p. III-3)* Does the purchase of development and water rights here refer to purchasing rights to storm flows or to some other source of rights?

7.35 *What is the relationship between Partial Wetland Assessment Areas and the plant communities described by Brown (1994)?* Brown's plant communities appear to be defined differently than those used in the analysis. How are the differences and overlaps reconciled to create a cohesive picture of the river? (Chapter IV)

7.36 *"While delivery systems are not in place, wastewater treatment plants within several miles of the study area represent potential sources of treated effluent that could be used to support restoration."* (p. IV-38) The use of untreated effluent is mentioned a number of times in the report. The complex legal relationships of effluent ownership will make it necessary to have cooperation and agreement from all the affected parties prior to commitment of effluent to a project.

7.37 *"Utilization of CAP and TARP water sources through future negotiated agreements"* (p.IV-50) TARP (remediated) water is currently treated to potable standards and delivered to the City's potable system as the result of a multi-party agreement with the U.S. EPA. The project has a limited life span, is legally committed, and is well suited for its present purpose. Also there is an annually diminishing pumpage required for the remediation effort. Given the legal complexities of the project, the limited tenure, and small supply, it would be an unlikely source for a longer-term project of this nature.

7.38 *"The opportunity exists to formulate a project that addresses multiple purposes by, for example, providing storage for local runoff in a manner, which facilitates groundwater recharge and helps to support habitat restoration."* (p. IV-50) One of the biggest keys for this project is to demonstrate a complementary use of water that would benefit both water users and a proposed restoration plan. This means coming up with a multi-benefit plan that would be a win-win for both "municipal water supply" and riparian restoration.

7.39 *"Lay Back Banks/Widen Channel"* (p. V-4) The laying back of the banks along the river is mentioned more than once. How will this affect the bridges over the river, and who will be responsible for the cost of bridge modifications necessary to accommodate the changes?

7.40 Alternative screening was done in a matrix with column headings related to the elevation from the channel and row labels related to the water demands of the habitat. The character of both the columns and rows is dependent on the water regime. The distance and elevation from the river determine the amount of water available while the type of plant community (hydroriparian, Mesoriparian, or Xeroriparian) is also dependent on the amount of water available. The result of this is only one critical issue was considered in a matrix designed to consider two critical issues. A more meaningful matrix would have resulted from water use versus cost, effort, or habitat acreage. (P V-23, Table 5.8)

7.41 *Why are the NMX and NMM alternatives included for consideration?* They each include a plant community at the terrace level that is wetter than the one below it. (See the statement on page V-25, "Seven of the twelve alternatives based on Mesoriparian restoration in the active channel were not carried forward. Alternatives MNX, MNM, MXM, MHN, MHX and MHM all have at least one wetter plant community located up gradient from a drier one and thus are inconsistent with natural patterns.") (p. V-26)

7.42 *"Soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade."* (p. V-28) What is the life expectancy of the soil amendments and micro-topographical changes?

<u>Tucson Water Comments on the Draft Environmental Impact Statement</u>

7.43 *General Comment*: Is the sand and gravel pit at the south end of the study area at risk of breaching in a flood? Is there anything noteworthy in jeopardy if this occurs?

7.44 *"Securing a permanent source of water remains an unresolved issue; several sources are being examined"* and later, *"The analysis of water sources shows that the wastewater treatment plant effluent is a reliable water source to the project."* (p. 7) Effluent is controlled by a number of entities. Over the 50-year project life, it will become an increasingly important water source for all of them. Water use for this project will require the planning and cooperation of all the effluent owners to successfully make a long-term commitment of this water source.

7.45 *"Formal and informal coordination occurred with a variety of Federal, state and local agencies in addition to the public involvement efforts described above. Agencies contacted included the United States Fish and Wildlife Service (USFWS), the Arizona Department of Game and Fish (ADGF), the City of Tucson Parks, Tucson Water Department, City of Tucson Transportation, Pima County Department of Transportation, Pima County Cultural Resources, Pima Association of Governments, and Pima County Parks and Recreation."* (p. 24) The Bureau of Reclamation is not on the list of contacts, yet it owns more than 28,000 acre-feet per year of effluent, all of which is uncommitted at this point. Was the Bureau not contacted?

7.46 *"The remainders of recorded sites within the Study Area are undetermined as to NRHP eligibility, unless destroyed."* (p. 66) Does this mean they will only be formally evaluated if destruction is planned? Clarification is needed.

7.47 *"The U.S. Federal Transit Administration (FTA) has established noise impact criteria founded on well-documented research on community reaction to noise based on change in noise exposure using a sliding scale (USFTA, 1995). The FTA Noise Impact Criteria groups noise sensitive land uses into the following three categories: • Category 1: Buildings or parks where quiet is an essential element of their purpose,"* followed by, *"Properties adjacent to the Project Area do not include any Category 1 properties, but there are Category 2 properties and Category 3 properties within the Study Area."* (p. 75) Does this last statement contradict the first bullet? There are parks in and around the study area.

7.48 *Nothing is mentioned in the noise analysis about trains.* NEPA considers trains within 3,000 feet of a project as a possible noise source. About 50 trains per day pass by the northern study reach less than 3,000 feet from the river. These are a significant source of noise and should be discussed in the study. (p. 76)

7.49 *"Construction of housing units has been increasing over the last decade. An additional 348,508 housing units were constructed in Pima County in 1999 to accommodate population expansion in the area. This figure is up from 298,207 in 1990."* (p. 77) Is there an error here? There are a little over 850,000 people in Pima County, so it seems doubtful that enough housing was built for 40% of that population in one year.

7.50 *The Socio-economic discussion would be much more meaningful if there were some discussion of how all this compares with other cities.* For example, is an 80% high school graduation rate high or low? Income data is available at the tract level and could be used to demonstrate, in a general way, more specific details about the population living in or near the study area.

7.51 *"It is therefore expected that groundwater quality would increase through the promotion of additional groundwater recharge into the regional aquifer."* (p. 95) It is not clear why water recharged through the soil as the result of any alternative would be superior to water recharged through the soil with no-project. This needs to be explained.

7.52 *"The El Medio (translated "the middle") project will be developed between Tres Rios del Norte and Paseo de las Iglesias all within the mainstem of the Santa Cruz river."* (P. 122) Does this refer to the El Rio Medio study? There should be a global check on this since "El Medio" is mentioned a number of times.

THE STATE OF ARIZONA
GAME AND FISH DEPARTMENT
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November 18, 2004

Michael Fink
U.S. Army Corps of Engineers
Los Angeles District
Arizona/Nevada Area Office
3636 N. Central Ave, Suite 900
Phoenix, AZ 85012-1939

Re: Paseo de las Iglesias Draft Feasibility Study/Draft Environmental Impact Statement and Letter of Support

Dear Mr. Fink:

The Arizona Game and Fish Department (Department) has reviewed the Draft Feasibility Study and Draft Environmental Impact Statement (DEIS) for the Paseo de las Iglesias project. The U.S. Army Corps of Engineers (ACOE) has been coordinating with the Department on wildlife-related aspects of this project over the last few years. We appreciate the high level of coordination that we've experienced with ACOE in regards to this project, as well as the opportunity to comment on these draft documents. The Department is supportive of efforts by the local sponsor, Pima County Flood Control District, and the ACOE to investigate options to restore and enhance riparian vegetation along this stretch of the Santa Cruz River.

We understand that the primary goal of this study is to assess the feasibility of restoring and protecting riparian habitat along a seven-mile stretch of the Santa Cruz River, including tributaries and associated floodplains, from Los Reales Road on the south to West Congress Street on the north. This river reach historically had perennial surface flow and vegetation typical of hydro and meso-riparian systems in the desert southwest. Currently, this system is severely degraded with no surface flow (other than what is provided through storm events), steeply eroded banks, no cottonwood-willow vegetation, and only small remnants of the mesquite woodlands formerly associated with the river, such as can be found along the Old West Branch within the project area.

Riparian areas in the arid southwest are greatly diminished from historical extent, comprising a rare but vital resource for Arizona's wildlife. While riparian systems comprise less than one percent of the landscape, a vast array of wildlife are dependent on these areas for some or all of their life stages. The Old West Branch, which still contains areas of dense mesquite and natural scour pools, has high biological diversity, including several species currently found nowhere else

Mr. Michael Fink
November 18, 2004
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in the Tucson Valley (giant spotted whiptail, Sinaloan narrow-mouthed toad), six species of breeding amphibians, and at least three Priority Vulnerable Species as defined by Pima County in the Sonoran Desert Conservation Plan. This project can help maintain these species as part of Tucson's fauna into the future, and provide increased opportunities for wildlife movement through the area.

This stretch of the Santa Cruz River is located in a rapidly urbanizing locale. Yet, the area has high biological value and options exist to establish or enhance riparian vegetation along both the Old West Branch, where water deficiencies are contributing to a lack of mesquite regeneration, as well as the main-stem Santa Cruz River. Although depth to ground water is high, water harvesting techniques could be used, and supplemental water (e.g., reclaimed water, treated effluent) made available, to allow for riparian vegetation development. Additionally, undeveloped land remains in the floodplain, as do stretches of riverbank not lined with soil cement, thereby providing great opportunities for riparian restoration. These opportunities will not be available in the future unless plans are in place and action is taken to protect and enhance the riparian corridor.

The preferred alternative as identified in the DEIS would create approximately 718 acres of mesquite, 356 acres of riparian shrub-scrub, 18 acres of cottonwood-willow, and six acres of marsh vegetation along this stretch of the Santa Cruz River. Water harvesting basins would be created at eight tributary confluences and five grade control structures in the main channel. These areas would be planted with hydro-riparian vegetation such as cottonwood, willow, and riparian grasses and supplemental irrigation would be provided as needed. Irrigated plantings of mesquite and riparian shrubs would be located on terraces and in the historic floodplain, and irrigation water would be introduced into the lower reach of the Old West Branch. For as long as the project remains authorized, the non-Federal sponsor would be obligated to provide sufficient water for construction, operation, and maintenance of the project. Where feasible, steep eroded banks would be re-graded to an approximate maximum 5:1 horizontal to vertical ratio slope by excavating into the historic floodplain, and the banks would be stabilized with plantings.

We understand that the feasibility study examines an array of general restoration alternatives, and therefore represents a "broad-brush" approach. We believe the preferred alternative is a reasonable approach to enhancing this urban riparian corridor. If project funding is approved by Congress, the Department would like to continue working with the U.S. Army Corps of Engineers, Pima County Flood Control District, and other local partners to address specific concerns regarding wildlife and biological monitoring that may develop during the design and implementation phases. The Department's specific comments are included as an attachment to this letter.

Mr. Michael Fink
November 18, 2004
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The Department appreciates the opportunity to provide comments on the Draft Feasibility Study and DEIS. Please contact Laurie Averill-Murray, Tucson Region Habitat Specialist, at 520.628.5376 x550 if you have any questions regarding this letter.

Sincerely,

Bob Broscheid
Habitat Branch Chief

BB:aam

cc: Joan Scott, Habitat Program Manager, Region V
Rebecca Davidson, Project Evaluation Program Supervisor
Michael Ingraldi, Research Biologist, Research Branch
Doug Duncan, US Fish and Wildlife Service, Tucson Office
Mike Martinez, US Fish and Wildlife Service, Phoenix Office

Attachment

Arizona Game and Fish Department Comments on the Draft Feasibility Study and Draft Environmental Impact Statement for the Paseo de las Iglesias Project

November 18, 2004

Biological Monitoring and Adaptive Management Plan

The Department has been working closely with ACOE to ensure that adequate biological monitoring is incorporated into the plan. There is limited information available on the impacts and success of riparian restoration efforts in the arid southwest as it relates to wildlife response, and this is especially true of efforts undertaken in urban areas. A carefully designed monitoring plan is absolutely essential to determine if the project is meeting intended goals, to help make needed adjustments to reach identified goals, and to inform future restoration efforts. We appreciate ACOE efforts to incorporate both biological monitoring and an adaptive management plan into the project, and to do so during the early planning stages of the project. We provide the following recommendations:

8.1 • The Draft Feasibility Report indicates that baseline ecological surveys will be conducted immediately preceding construction (page VII-3). We recommend that surveys are conducted for 2-3 years preceding construction and this should be explicitly stated in the document.

8.2 • Under Operation and Maintenance Costs (Appendix J), it is stated that a qualitative survey will occur one day per month. This is in addition to the quantitative surveys. We are unsure as to what a qualitative biological survey entails and the value that such a survey would add to the overall monitoring of the restoration project.

8.3 • The cost estimate for the quantitative survey greatly underestimates the time needed to adequately monitor the area of potential affect (Appendix J and page VI-6). The plan currently calls for two biologists to sample for two weeks, twice a year. From our experience working on the Rio Salado monitoring plan, it would take a crew of four or more biologists at least six months time to adequately sample the biological variables (e.g., species diversity, species abundance, indices of species viability, endangered species surveys) needed to assess the status of the restoration effort.

8.4 • Under *Monitoring and Adaptive Management Plan* (Page VI-10, top of page), please revise the following sentence "The cost of **the first five years of** monitoring included in the total project cost..."

8.5 • Under *Vegetation Monitoring- Frequency and Protocol* (Pages VI-11), the document states "Should the survival rate of plantings indicate that the species composition is less than prescribed, replanting will be undertaken to ensure that the species composition is maintained." If some plant species have higher than expected mortality rates, investigations should be conducted as to the reasons for this. Site conditions may be unfavorable for some species and this will need to be rectified before replanting; alternatively, species more appropriate to current site conditions could be used instead.

8.6 • Under *Wildlife Monitoring- Frequency and Protocol* (Pages VI-12), it is stated that bird surveys will be conducted in restored cottonwood-willow riparian areas, which comprise only a small portion of the total project area. We recommend that wildlife surveys be conducted in the entire project area and in all vegetation communities (mesquite, riparian shrub, and cottonwood-willow). We also recommend including surveys for reptiles, amphibians, and medium and large animals. All mammal trapping should be conducted with live, not snap, traps.

8.7 • We recommend monitoring the impacts of human use (e.g., recreation) on the restoration sites, including effects on vegetation and wildlife.

8.8 • The document states that a complete discussion of wildlife in the study area may be found in Appendix 14.2. However, this section addresses only special status species that *may* be found in the study area. If general wildlife surveys were conducted, as is implied here, we recommend including a list of all species detected in a separate appendix.

8.9 • We recommend that more information be provided regarding surveys for federally listed species, such as who did what surveys and when these surveys took place.

8.10 • While there are no known records of cactus ferruginous pygmy-owl within three miles of the project area (Heritage Data Management System, Appendix 14.1), it is important to note that a dispersing female has been recorded within five miles southwest of the project area. Habitat improvement projects within this area may help promote dispersal of pygmy-owls from breeding areas to the south with potential sites to the north. It may be advisable to coordinate with the US Fish and Wildlife Service on Safe Harbor Agreements for this and other federally listed species that may be attracted to the area due to vegetation and aquatic enhancement.

Construction Impacts

8.11 The project area, especially the Old West Branch of the Santa Cruz River north of Drexel Road and south of Irvington road, has many burrowing owls that could be directly impacted by earth moving activities associated with this project. It is important that ACOE and Pima County coordinate with the Department to minimize disturbance and impacts to the owls. This can potentially be done through a phased implementation approach where owls are moved away from the area of activity and then allowed to re-colonize. If habitat is permanently and negatively changed for this species, alternate locations for owls may need to be found and artificial burrow construction may be advisable.

8.12 There will likely be other bank-nesting species, such as rough-winged swallows and barn owls, directly impacted by earth-moving activities. Concentrating these activities in the fall or winter when birds are not nesting will help alleviate these negative impacts.

Other Biological Considerations

8.13 It is important that this project consider the overall landscape context within which it fits, both in terms of maintaining or improving hydrological connection between the river and the floodplain wherever possible and protecting neighboring uplands to improve overall health of the watershed. Additionally, this project should consider how animals may be moving through the landscape and how the location of key habitat restoration features may help facilitate wildlife movement and dispersal. Habitat fragmentation is one of the leading factors contributing to species endangerment and local extirpation, and urbanization is one of the leading causes of fragmentation.

8.14 To maintain viable populations of many species within the Tucson Valley, it is vitally important to design project features in such a way as to create connectivity of natural areas or open space within the project area as well as between the project area and 1) upstream and downstream segments of the Santa Cruz River and 2) the surrounding uplands. To this end, we offer the following more specific comments:

- 8.15 We recommend including how City of Tucson fits in to the proposed project plans. The City of Tucson is the primary landowner within the project area (42%; Table 5.5), but is not a local sponsor for the project.
- 8.16 We understand that it is the local sponsor's responsibility to prevent future encroachments on *project lands* that might interfere with the proper functioning of the project (page VII-6). However, the Draft Feasibility Study states that most lands that did not need to be restored (those lands currently supporting moderate to high quality Sonoran Desert cactus-scrub vegetation) were not included in the study area boundaries (page V-17). Protection of these areas could be very important for the integrity of the restoration project and to provide connectivity and wildlife movement corridors. It is unclear how, or if, these nearby lands will be considered in the overall context of the project and if the goal is to maintain them in their current condition.
- 8.17 For this study, it was assumed that no new flood control projects would be in place before construction of the federal project. However, if a new feature was to be constructed, it could potentially be considered a compatible part of the federal plan if prior approval was obtained (page IV-44). Currently, no measures appear to be in place to prevent incompatible features from being established before project authorization and/or construction. If this project receives congressional approval, it will likely be several years before construction begins. We recommend that the Pima County Flood Control District, the ACOE Regulatory Branch, and the ACOE Civil Works program work together as much as possible to restrict new flood control projects that would compromise aspects of the restoration project during this interim period (e.g., soil cementing currently unprotected banks that would be re-graded and planted as part of this project).
- 8.18 We understand that erosion control will be needed in some areas of the Santa Cruz River as it passes through the project area. The Department would prefer that re-grading and native vegetation be utilized to stabilize banks to the maximum extent practicable and that soil cement and rock gabions are kept to a minimum.

Recreational Impacts

Projected growth for the City of Tucson is approximately 20% between now and 2020 (Table 2.1). This will increase not only the demand for recreational opportunities in Tucson, but also the impact of these activities on natural resources. While the primary purpose of this project is environmental restoration, we understand that recreational components will be incorporated as well. It will be important to design recreational trails and facilities in such a manner as to limit the impact on the newly established vegetation and the wildlife inhabiting the area. We offer the following recommendations:

8.19 • Provide a buffer zone by placing trails away from the riparian corridor as much as possible. In particular, place trails away from the nicest stands of riparian vegetation.

8.20 • Provide a screening of vegetation between the trails and the sensitive riparian areas/restoration sites.

8.21 • Provide spur paths that go to overlooks at key locations. This will allow for wildlife viewing opportunities while hopefully limiting harassment of wildlife.

8.22 • Provide physical barriers to keep people from creating social trails (i.e., unofficial trails) and to prevent unauthorized OHV use.

8.23 • The prohibition of motorized vehicles (OHV) in the river corridor should be adequately posted and enforced.

8.24 • Require that dogs be kept on a leash to minimize harassment of wildlife.

8.25 • Minimize the amount of lighting in recreational areas near the river so that nocturnal animals can move freely within the corridor. Orient lights at comfort stations and parking lots away from the river and provide adequate screening. Locate high-use recreational facilities well away from the riparian corridor.

Gavigan, Kim M SPL

From: Taylor [taylore@u.arizona.edu]
Sent: Sunday, November 21, 2004 7:23 PM
To: Gavigan, Kim M
Subject: Support for Paseo De Las Iglesias Proposal

PASEO DE LAS IGLESIAS ECOLOGICAL RESTORATION PROPOSAL
COMMENTS TO U.S. ARMY CORPS OF ENGINEERS
TUCSON HERPETOLOGICAL SOCIETY LETTER OF SUPPORT

Dear Kim M. Gavigan, U.S. Army Corps of Engineers,

9.1 The Tucson Herpetological Society (THS) is a non-profit organization dedicated to conservation, education, and research concerning the amphibians and reptiles of Arizona and Mexico. The THS Board of Directors has reviewed *the Paseo de las Iglesias Ecological Restoration Proposal* and we want to express our support of the project. We believe this proposal is based on sound science and the project will bring educational and conservation benefits to our community.

Restoration of these sites will provide habitat for imperiled riparian plants and animals along the Santa Cruz River corridor. During the summer of 2004, a THS supported Urban Amphibian Study of Tucson discovered several small isolated populations of Great Plains Narrow-mouthed Toads living along the dry channel. These toads represent evidence that other species may also remain despite drastic habitat destruction and may benefit from this restoration proposal.

The Tucson community has a history of support for preservation of our natural habitat as exemplified by the overwhelming support for the open space bonds and the Sonoran Desert Conservation Plan. The Paseo de las Iglesias Ecological Restoration Proposal will enhance wildlife viewing and other activities for outdoor enthusiasts and residents along the Santa Cruz River. The THS strongly urges the Army Corps of Engineers to initiate this project as a positive step toward restoring a centerpiece of Tucson's natural heritage that will not only facilitate the return of native wildlife but will also encourage pride in our community.

Sincerely,

Taylor Edwards
President
Tucson Herpetological Society
PO Box 709
Tucson, AZ 85702-0709
http://tucsonherpsociety.org

cc: Jennifer Becker, Pima County Flood Control District

6/27/2005

Center for Biological Diversity

Protecting and restoring endangered species and wild places of North America and the Pacific through science, policy, education, citizen activism and environmental law.
Because life is good.

November 22, 2004

Richard Legere
Michael Fink
USACE
3636 N. Central Ave., #900
Phoenix AZ 85012
602.640.5382 fax

10.1 On behalf of our 11,000 members across Arizona and the nation, we offer our general support for the proposed Paseo de las Iglesias project for restoration of part of the Santa Cruz River in Tucson.

We urge you to incorporate the recommendations of the Santa Cruz River Alliance and Tucson Audubon Society in to the final plan.

The Center is interested in helping to refine, implement and monitor the restoration plan, so please ensure we are fully informed as this project advances.

Thank you,

Daniel R. Patterson
Ecologist

cc: U.S. Rep. Raul M. Grijalva
Pima County Supervisor Richard Elias
Jennifer Becker, Pima County Flood Control District

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From: Philip C. Rosen [pcrosen@cox.net]
Sent: Monday, November 22, 2004 12:14 PM
To: Kim.M.Gavigan@spl01.usace.army.mil; Tom.Helfrich@dot.pima.gov; Jennifer.Becker@dot.pima.gov
Subject: Paseo Comments PC Rosen (Santa Cruz River Alliance)

Hi All,

Attached are comments based on the Oct. 26, 2004 meeting presenting the progress on the Paseo de las Iglesias ecological restoration study for Tucson. As president of the Santa Cruz River Alliance, I present these after discussion of them among our steering committee.

We are heartened by the progress being made, and thank all of you for your efforts. It will be a giant step forward for Tucson if the Paseo is implemented in any of the alternatives (except "No Action"!), and in general, we support the direction taken so far.

I am sure you can take the attached comments in that positive vein!

Perhaps unsaid, and as such this would be from me personally here, is that I am not convinced that this project has been examined from the standpoint of the very longest term planning. Whereas now it seems impractical to re-elevate the water table in the inner city Santa Cruz reach, or to restore natural floodplain function there, perhaps we should not foreclose those prospects for the more distant future.

Should we and can we work toward a future in which the greater metropolitan region builds its urban structure around, rather than on the floodplains? That would then allow us to live with and enjoy the benefits of, rather than prevent, natural floodplain function. I suggest this general concept could be stated in a way that addresses it to the diverse elements of the community that is thinking of and designing future plans for the region.

Yours,
Phil Rosen
(SCRA President)

Paseo de las Iglesias Ecological Restoration Proposal
Comments to U.S. Army Corps of Engineers

Philip C. Rosen, Santa Cruz River Alliance

28 October 2004

11.1 1. Water could be put into the West Branch to create a perennial or intermittent stream at much lower cost than estimates for the main channel of the river. A perennial system could be created, and/or the existing bosque greatly enhanced and meso-hydro riparian habitat added, including cottonwood-willow. This need not entail damage to the existing resource, but only limited management to ensure that natural succession was not dominated by exotic trees and bunch grasses. With a long-term approach, this transition would be organic and not damaging. This would then be an area where stable, rather than flood-vulnerable meso-hydro-riparian vegetation and associated biota could be created; non-flying animals depend on this stability, some of which remain at West Branch but appear to be declining toward extirpation in the absence of adequate water. Their presence at West Branch likely reflects a previous wetter environment.

11.2 2. Water delivery in many areas could be done via the traditional acequia method, rather then in irrigation lines. This approach could make maintenance of the irrigation delivery system simpler, more low-tech, and potentially cheaper. More importantly, it would create excellent habitat along the acequias, and the water in them (like the water suggested for West branch in #1) could be designed to range from intermittent (supporting turtles), semi-perennial (supporting frogs), or locally perennial (supporting fishes). In contrast to the chaos of exotic species, low fish density, and potentially higher mosquito abundance in the hydroriparian environments planned for the main channel, these more stable environments could be more easily regulated and managed to ensure low mosquito populations and high native aquatic vertebrate species participation.

Maintenance could range from matching herbaceous vegetation growth in the West Branch channel to the vegetation-removing force of natural flooding, to the simple periodic re-trenching of the acequias by machine and hand. The acequia margins could be planted with native and heirloom trees and shrubs. The acequia system could provide a nexus of the public restoration habitat to reconciliation habitat in adjoining communities.

11.3 3. The planning should expand to include its setting within the broader environment. The Paseo planning process should become an integrated part of the broader picture for the Santa Cruz floodplain and immediately adjacent bajadas and corridors to upland. This should include planned city parks, disposition of current landfill areas, explicitly mapped indications of city plans to urbanize current open space directly on the historic floodplain surface, and explicit mapping of corridors that will connect wildlife and plant populations (1) within the Paseo restoration area and between the Paseo and (2) the rest of the Santa Cruz and (3) the uplands. It may be difficult to put a dollar value on this connectivity, but there is little or no debate among biologists of its importance.

11.4 4. <u>Connectivity should be addressed by focusing on specific corridors</u>. Wildlife corridors and direct connections are needed at crucial places like A Mountain to the River; some of the washes south of 29th Street to the West Branch; and the saguaro forests south and west of Ajo to the river. The connection of A Mountain to the river may require an "ecoduct" (a depressed roadbed with land bridges for wildlife), a causeway, or some other approach that is costly, though important for the local neighborhoods, future park users, and wildlife. The site is one of the few where saguaros can approach bosque, a key habitat feature for the pygmy owl.

11.5 5. <u>It is important that this plan also be considered in relation to a model for allocation of hydrological resources to ecological restoration in the entire Tucson Basin</u>.

If significant water is to be consumed at Paseo, will there still be enough left for more cost-efficient restoration, such as near La Osa Ranch? Is the high use-value to a restored setting in central Tucson adequate justification for such a tradeoff? What are the relative wildlife benefits, and recreation benefits of these two broad kinds of options? Can both be done?

How do these proposals compare to raising the water table upstream of San Xavier, in terms of cost and wildlife and native vegetation benefits? How might doing that positively reduce the cost for the Paseo project by reducing some of the need for perpetual irrigation?

These are key questions that have a broader geographic scope and somewhat longer time scale than explicitly analyzed with the Paseo and other USACE studies, but they need to be answered. Currently, they probably are being answered, but only privately and according to the whims and plans of unseen officials and leading citizens. The public (citizenry, electorate) should be involved in these greater conceptions of the future.

11.6 6. <u>Another long-term and large-scale issue is whether to avoid or remediate landfills</u>. Having landfills in the riverbed is a poor situation, and sealing them off from water is, presumably, a reasonable short-term fix but probably not a suitable long-term fix. If their ultimate fate when sealed off from water is to become an insignificant problem, then the long-term plan should be to re-elevate the groundwater table at that appropriate time. If that is true, then the Paseo project should be conceived in the context of an eventual return to dependence on shallow groundwater with the greatly enhanced options that brings, along with the associated problems that would need to be solved.

If, on the other hand, the landfills cannot be expected to become innocuous within some reasonable time frame, then they should be removed or actively remediated, rather than left to fester in the center of the metropolis, where people will be exposed to their problems and the most prime real estate will be left in a nearly useless condition. And under this scenario as well, the long-term option can still be for re-elevating the groundwater table, etc.

These potentialities should be incorporated into the thinking about the purpose, duration, and long-term contribution of the Paseo project to the future of Tucson and the Santa Cruz River.

11.7 7. Species-specific issues should be incorporated into the planning process. Some species could be destroyed during the construction phases, especially non-flying animals and plants with limited populations and low dispersal abilities. For some of these, the cost of re-establishment could prove much higher than anyone would want to incur. It would, in at least some cases, be preferable to cause them to flourish (perhaps with some active management) where they remain, and then naturally colonize restored areas via well-planned corridors. In this sense, the planning needs to involve a design for phased implementation that integrates species needs as well as engineering considerations.

11.8 8. Neighborhoods and businesses in and adjoining the Paseo project area should be actively encouraged to participate in the restoration process. While this is not the immediate responsibility of the USACE, the participation or non-participation in adjoining non-public lands (both residential and semi-urban in character) will have a partially determining impact on the ecological result in the restored public lands. Thus, the planning should be properly framed within plans for reconciliation ecology within the City of Tucson setting in and around the Paseo.

11.9 9. The existing plan seems to be a reasonable one, and is likely to greatly enhance the social and natural environments of central Tucson, as well as increase land values and the attractiveness of Tucson as a tourist destination. It will be an excellent complement to the Rio Nuevo downtown area revitalization process, and will help eliminate unfair and unappealing dichotomy between the "two-Tucsons" – the decaying inner city and flourishing foothills!

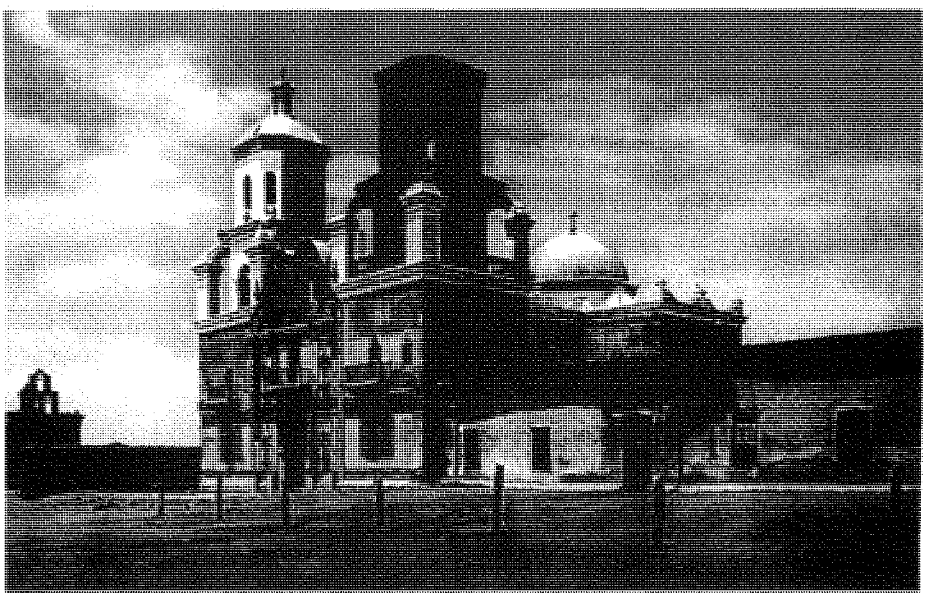
11.10 10. We appreciate the efforts and assistance from the USACE and Pima County Flood Control District.

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Study

Volume 2 of 3
Technical Appendices A - E



July 2005

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
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US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX A

HYDROLOGIC INVESTIGATION

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
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PREFACE

Hydrologic analysis for the Paseo de Las Iglesias Feasibility Study included both the mainstem Santa Cruz River and its tributaries within the study area. The study area extended from Los Reales Road on the south to Congress Street on the north. Peak discharges for the Santa Cruz River mainstem (Santa Cruz River at Tucson) had recently been updated by the U.S. Army Corps of Engineers, Los Angeles District, within a separate study. Peak discharges for the Santa Cruz River tributaries were provided by the the Pima County Department of Transportation & Flood Control District. This report presents summarizes the surface water hydrology for the study area, and the hydrologic "base conditions" or "without project" conditions used to describe and quantify the potential flooding problem in the study area resulting from runoff to the Santa Cruz River and its tributaries. Included in this report are discharge-frequency values provided by Pima County and an evaluation of those discharges performed by the Los Angeles District as well as additional tributary discharges estimated by the Los Angeles District based upon the results of the evaluation and the information provided by Pima County.

Supplemental Hydrology Report

PASEO DE LAS IGLESIAS

FEASIBILITY STUDY

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1 INTRODUCTION

1.1 STUDY AREA: The Paseo de Las Iglesias Feasibility Study encompasses the Santa Cruz River bounded on the upstream side by Los Reales Road and on the downstream side by Congress Street. In addition the study area includes tributary runoff to the Santa Cruz River from the Old West and New West Branches, as well as other local intervening drainage areas.

1.2 PURPOSE: The hydrologic information presented in this report will be used to support sedimentation analyses, develop overflow mapping, and assist in economic evaluation of without project conditions.

1.3 SCOPE: Hydrologic information presented in this report is taken from previously published reports by the Los Angeles District, U.S. Army Corps of Engineers (LAD), and from information provided by the Pima County Department of Transportation & Flood Control District (referred to hereinafter as PCFCD). This report includes without project discharge-frequency values for the mainstem Santa Cruz River, the Old West Branch and the New West Branch of the Santa Cruz River, and tributary washes which deliver local runoff to the Santa Cruz River within the study area. The discharges for the mainstem were developed by the LAD for the location near Congress Street in Tucson, AZ[1], as a component of the Santa Cruz River Watershed Management Study. Discharges for the Old and New West branches and other tributaries were multi-source and provided by PCFCD except for locations noted herein . In addition to discharge-frequency values for the mainstem Santa Cruz River, synthetic flood hydrographs, developed from available volume-frequency information, are included in this report. This report documents several aspects involved in generating the hydrologic information described above.

1.3.1 Evaluation of discharge-frequency values provided by PCFCD for tributaries of the Santa Cruz River.

1.3.2 Extension of the discharge-frequency values for New West Branch Wash provided by PCFCD to include the 500-year peak flow rates (0.2% chance of exceedance during any given year), and estimation of n-year peak flow rates for the Los Reales Improvement District.

[1] Congress Street is at the downstream end of the study area. Discharges in the mainstem Santa Cruz River do not vary significantly within the study area.

1.3.3 Development of Synthetic Hydrographs (Balanced Hydrographs) for use in sedimentation analysis of the Santa Cruz River within the study area. Peak discharge-frequency values for flood control analysis of the Santa Cruz River presented in this report were developed in reference 2.3, as mentioned in the previous paragraph.

1.3.4 Development of Risk/Uncertainty information for economic evaluation of base conditions and formulation/evaluation of project flood control alternatives.

2 REFERENCES AND ASSOCIATED REPORTS

Reports pertinent to the hydrology for the Paseo de Las Iglesias Feasibility Study are included below:

2.1 EL RIO ANTIGUO, RILLITO RIVER ENVIRONMENTAL RESTORATION, DOCUMENTATION FOR HYDROLOGIC STUDIES, prepared by Pima County Department of Transportation and Flood Control District, Flood Control Engineering Division, for the U.S. Army Corps of Engineers, Los Angeles District, March 2002.

2.2 SANTA CRUZ RIVER, PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA, FEASIBILITY STUDY, HYDROLOGY REPORT, Pima County Flood Control District, November 2001.

2.3 GILA RIVER, SANTA CRUZ RIVER WATERSHED PIMA COUNTY FINAL FEASIBILITY STUDY, APPENDIX E-1, Los Angeles District, U.S. Army Corps of Engineers, August 2001.

2.4 RISK-BASED ANALYSIS OF FLOOD DAMAGE REDUCTION STUDIES, DRAFT, EM 1110-2-1619, US Army Corps of Engineers, 1 March 1996.

2.5 REQUEST FOR A LETTER OF MAP REVISION FOR THE LOS REALES IMPROVEMENT DISTRICT LOCATED IN PIMA COUNTY, ARIZONA, AND IN THE CITY OF TUCSON, ARIZONA, prepared by Arroyo Engineering, Inc., December 1994.

2.6 METHODS FOR ESTIMATING MAGNITUDE AND FREQUENCY OF FLOODS IN THE SOUTHWESTERN UNITED STATES, U.S. Geological Survey Open File Report 93-419, 1994.

2.7 FLOOD DAMAGE REPORT, STATE OF ARIZONA, FLOODS OF 1993, US Army Corps of Engineers, Los Angeles District, August 1994.

2.8 SANTA CRUZ RIVER HYDROLOGIC DOCUMENTATION FOR FEASIBILITY STUDIES, LOWER SANTA CRUZ RIVER FLOOD CONTROL STUDY, PINAL COUNTY ARIZONA, Los Angeles District, U.S. Army Corps of Engineers, July 1990.

2.9 METHODS FOR ESTIMATING MAGNITUDE AND FREQUENCY OF FLOODS IN THE ARIZONA, by R.H. Roeske, United States Geological Survey Water Resources Division, Report: ADOT-RS-15[121] Final Report, September 1978.

3 DRAINAGE AREA DESCRIPTION

The Santa Cruz River is a tributary to the Gila River, which in turn is a tributary to the Colorado River. The Gila River Basin comprises 58,200 mi^2 in New Mexico, Arizona, and Mexico. The Santa Cruz River Basin consists of approximately 8200 mi^2 in southern Arizona and 400 mi^2 in Mexico. A map delineating the Santa Cruz River drainage basin from its headwaters downstream into Pinal County, and its location within the State of Arizona is provided in Plate E1-1.

The Santa Cruz River rises in the Patagonia and Huachuca Mountains in southern Arizona near the town of Lochiel, flows south across the international boundary and makes a 35 mile long loop westward through Sonora, Mexico and then turns northward and reenters the United States about 6 miles east of Nogales. The channel continues north to Tucson, then turns northwestward and flows 42 miles to Greene Canal. From here, most of the flow is diverted to Greene Canal and continues through several distributary channels about 75 miles towards Laveen at the confluence with the Gila River (about 10 miles upstream of the Salt River confluence and about 80 miles upstream of Painted Rock Dam on the Gila River).

The Santa Cruz River basin is characterized by a wide valley broken by several broad, low hills and mountains. The basin area has a maximum length of approximately 175 miles and is about 80 miles wide at its widest point. Stream gradients in the basin range from about 29 feet per mile near Lochiel to 18.5 feet per mile at Tucson to 8 feet per mile at the Gila River confluence.

The Santa Cruz River and principle tributaries are mostly ephemeral, being dry for long periods of time. Flows in the river are a result of direct or upstream precipitation or irrigation tailwater in the basin. For a short distance downstream of Tucson, the river conveys a perennial flow of sewage effluent from a sewage treatment plant.

Analysis of the basin indicates the confluence with Los Robles Wash marks a change in the character of the runoff; just upstream the Los Robles Wash system (Altar Wash, Brawley Wash, drainage area = 1390 mi^2) enters the Santa Cruz River and is the last major source of uncontrolled runoff from mountainous terrain.

From the headwaters to the confluence with Los Robles Wash, the Santa Cruz River is a "gaining" river, meaning discharge generally increases with drainage area. Downstream from the confluence to the mouth (at the confluence with the Gila River), the flood plain flattens and broadens out in the area known as the "Santa Cruz Flats" and becomes a "losing" river. In this reach flood flows are dramatically attenuated such that discharge decreases with an increase in drainage area. Flows originating in the upper reaches of the Santa Cruz River rarely reach the Gila River; when they do reach the Gila River, they are usually augmented by tributary flows originating in the lower part of the basin. The streambed materials are extremely permeable especially from Cortaro to Laveen, resulting in high rates of infiltration.

Total rainfall and the areal distribution of rainfall are affected by relative elevations of the various parts of the drainage area. Elevations in the basin range from 9432 feet NGVD at Mount Wrightson in the Santa Rita Mountains to about 1000 feet NGVD at the Gila River confluence. The crest-stage gage at Congress Street in Tucson was located at datum 2317.82 feet, National Geodetic Vertical Datum of 1929 (it has since been moved about 300 feet downstream).

Valleys occupy almost 70% of the area and the primary land use in the basin is irrigation agriculture, both on Indian as well as private land. Agriculture is limited by the available water supplies. Irrigation water is supplied principally from groundwater sources, which are recharged by precipitation over the area. The growing season in the basin is fairly long and a wide variety of crops are produced. Much of the flood plain contains soil suitable for growing such crops as cotton (the principle agriculture crop), grains, and pecans where irrigation water is available.

Vegetation in the Santa Cruz River basin is sparse and consists of typical desert cover of creosote bush, sagebrush, paloverde, desert shrubs, and cacti in the lower elevations, assorted grasses in the upper valleys, and fir, pine, juniper, chaparral, and pinon forests in the higher mountains. Along the stream channels thicker and denser vegetation made up of mesquite forests, cottonwood and willow trees and various reeds and grasses can be found.

Soils in the Santa Cruz River watershed are extremely varied. The mountains consist of weathered native rock, while the valley floors contain unconsolidated gravels, sands, silts, and the clays derived from these rocks. The soils of the mountain area are shallow and stony with occasional rock outcrops. Desert and semi-desert soils occur in the hills and valleys. The valley surface soils generally range from fine silty clays to clay and are fairly deep. The stony or gravelly alluvial fans, formed by coarse material shed from the mountains, are underlain by subsoil material that is highly calcareous and more or less firmly cemented.

4 PRECIPITATION AND RUNOFF

4.1 GENERAL. The climate in the Santa Cruz River Basin is typically desert in character with short, mild winters and long, hot summers. High diurnal temperature variations are characteristic of the region. Temperature extremes range from about 12° Fahrenheit in the winter to 122° Fahrenheit in the summer. The prevailing winds are from the east and are usually light, although severe windstorms occur at rare intervals.

Mean annual precipitation ranges from 11 inches in the valleys to over 37 inches at elevations greater than 8000 feet NGVD. Studies conducted in the Tucson vicinity show an extremely low percentage (about 1%) of the rainfall appears as runoff, generally evaporating or returning to groundwater. The mean annual precipitation at the station Tucson NWSO (National Weather Service Office) for the period 1894 - 2000 is 11.3 inches. At the station Tucson 17 NW, the mean annual precipitation is 12.8 inches for the period from 1982 - 2000. The latter station is at an elevation of 2561 feet above mean sea level, or 83 feet higher than the NWSO station.

Annual precipitation at the NWSO station has varied from a maximum of 24.2 inches (1905[2]) to a minimum of 11.3 inches (1924). The maximum monthly precipitation occurred in July of 1984 (7.56 inches) while the minimum total (0.00 inehes) has occurred in numerous months/years. The wettest months of the year on average are August and July (2.14 inches and 2.05 inches, respectively), while the wettest winter month is December (1.0 inches).

Precipitation occurs in two distinct seasons of the year; summer (late June, July, August, September, and into October; and winter - December, January, February, and March.

4.2 MONSOON SEASON. Summer rains in the form of thunderstorms originating in moist air that flows into Arizona from the Gulf of Mexico generally occur in middle to late afternoon and are usually of local extent. Approximately 80% of the thunderstorms over the basin occur in the summer months. Floods associated with summer thunderstorms can be extremely flashy (up to 3 hours) and are of short duration.

[2] Note: February, March, April, and November of 1905 were the wettest individual February, March, April, and November months during the entire period of record.

4.3 CYCLONIC SEASON. Some general summer storms do occur during the period July through September. They are associated with an influx of tropical maritime air originating over the Gulf of Mexico or the south Pacific Ocean and entering the area from a southeast or a southwest direction. Usually the influx of tropical air is caused by the circulation about a high-pressure area centered in the southeastern United States, but occasionally is caused by remnants of a tropical hurricane. There is often relatively heavy precipitation for periods of up to 24 hours and showers may continue intermittently for as long as 3 days. Flooding commonly covers a wide area with durations of about 24 hours.

4.4 FRONTAL SEASON. 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 areal extent, with slow and steady intensity. Winter floods from these storms are of longer duration with lower flood crests.

4.5 RECORDED DATA. Currently the United States Geological Survey (USGS) operates streamflow recording gages on the Santa Cruz River at the locations listed in the following table:

Table 1: USGS Streamgage Information for Santa Cruz River

USGS Streamgage Number	Location	Drainage Area (mi^2)	Period of Record	
			Systematic	Historic
09480000	Santa Cruz River nr. Lochiel	82.2	1949-present	1926-present
09480500	Santa Cruz River near Nogales	533	1930-present	1892-present
09482000	Santa Cruz River at Continental	1662	1940-present	1892-present
09482500	Santa Cruz River at Tucson	2222	1915-1981, 1984-present	1892-present
09486500	Santa Cruz River at Cortaro	3503	1940-1984, 1990-present	1914-present
09489000	Santa Cruz River near Laveen	8581[(a)]	1940-present	1940-present

[(a)] 1780 mi^2 is controlled by Tat Momolikot Dam

[**Note:** Locations of pertinent stream gages are included on the accompanying maps on the following page.]

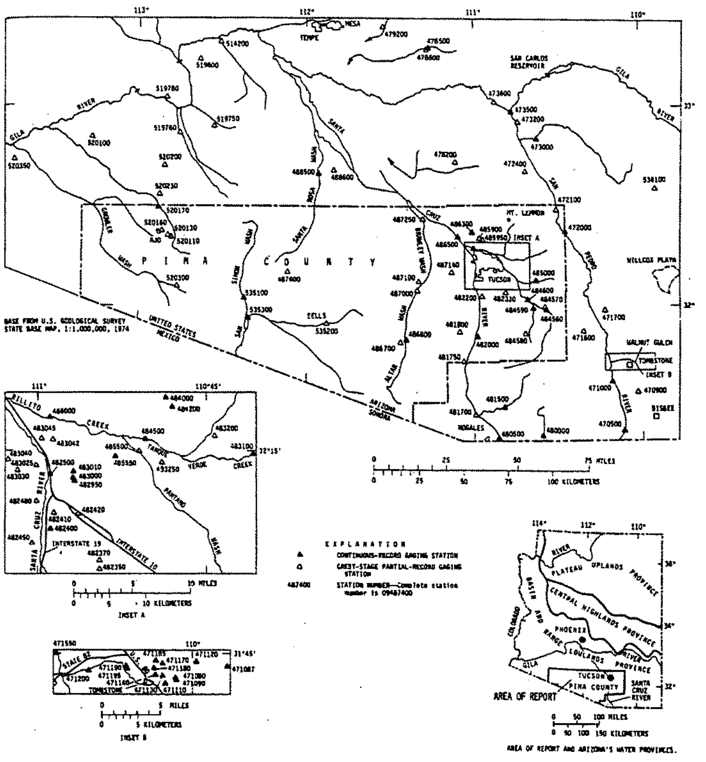

Figure 1 Locations of Stream Gages

5 HISTORIC STORMS AND FLOODS

Available streamflow records, most commonly collected by the USGS, indicate significant floods occurred in the Santa Cruz Basin in 1887, 1926, 1945, 1961, 1962, 1964, 1965, 1967, 1977, 1983, 1991, 1993, and 1996 The largest flood of record for most of the basin occurred in October of 1983. Following is a historical account of some of the flooding and precipitation in the Santa Cruz River basin.

5.1 SEPTEMBER 1887. The Santa Cruz River and Rillito Creek experienced heavy freshets from the 9th to the 12th which destroyed bridges over Rillito Creek and several miles of railroad tracks near Pantano. Water stood "two-miles wide" in the valley north of Tucson. A fifty-foot-high railway embankment near Dragoon was washed out for eight miles.

5.2 FEBRUARY 1890. A general rainstorm covered the area for three days or more with little let-up. The Salt, Gila, Colorado, and Santa Cruz Rivers all overflowed their banks. Farmlands, as well as livestock, were washed away and people all over were stranded.

5.3 AUTUMN 1891. A large cloudburst in the mountains caused flooding along the Santa Cruz River. The river overflowed through agriculture land and washed away crops, animals, and structures. Within a short period of time the river was completely dry.

5.4 DECEMBER 1914. The month of December was generally wet throughout Arizona, probably as an indirect result of low-latitude north Pacific Ocean storms spawned by El Nino conditions. It was the storm series of December 17-24 that produced flooding in southeastern Arizona. Below Marana and Cortaro, railroad tracks were inundated below 4 feet of water and 25 miles of track was washed out. A flood peak of 15,000 cfs occurred on the Santa Cruz River at Tucson (2222 mi^2) on the 23rd, while on the same day the peak observed at the Rillito Creek gage (918 mi^2) was 17,000 cfs. December 1905 was the wettest "winter" month in history at the Tucson NWSO station (5.85 inches).

5.5 SEPTEMBER 1926. One of the most damaging rainstorms over central and southeastern Arizona occurred on the 26th and 27th of this month. Precipitation durations of up to 48 hours were recorded as the storm ranged as far south as central Mexico and as far east as El Paso, Texas. The Arizona cities of Thatcher, Nogales, Douglas, and Safford all received extensive flood damages. A flood peak of 11,400 cfs occurred on the Santa Cruz River at Tucson on the 28th.

5.6 SEPTEMBER 1929. The middle and latter part of the month brought a scattering of relatively heavy thunderstorms to many parts of Arizona. Perhaps aided by favorable overall atmospheric conditions associated with a minor El Nino in the eastern Pacific, there was a deep flow of moist tropical air into Arizona from the 15th to the 25th. Tucson measured 3.40 inches of precipitation for the period between the 22nd and 24th, including 1.39 inches on the 23rd and 2.00 inches on the 24th. Rillito Creek experienced the second largest peak of record, 24,000 cfs, on the 23rd; the Santa Cruz River peaked at 10,400 cfs on the 24th at Tucson.

5.7 AUGUST 1935. Above normal rainfall fell in practically all sections of the state resulting from a moist flow of air from out of the south augmented by a tropical storm that hit the coast of southern California. In Santa Marguerita, 4.10 inches occurred in about an hour and a half on the 22nd and a total of 9.09 inches fell during the month. The heavy rains resulted in numerous flash floods in ordinarily dry washes which caused considerable loss of life and property. On the 31st, flood waters overwhelmed sections of the Rillito Valley and significant damage occurred at other localities between Tucson and Nogales. This storm produced flood peaks of 13,400 cfs and 10,300 cfs on Rillito Creek and the Santa Cruz River at Tucson, respectively. August 1935 was the wettest August recorded at the Tucson NWSO station in history (5.610 inches).

5.8 DECEMBER 1940. The year was one of strong El Nino conditions in the Pacific Ocean. The last three days of December climaxed a wet month with moderately heavy storms all over Arizona. Large flows on Rillito Creek (with a peak of 9900 cfs) were primarily responsible for the 7800 cfs peak observed on the Santa Cruz River at Cortaro (3503 mi^2).

5.9 AUGUST 1945. A storm of cloudburst proportions occurred over ordinarily dry washes in Pima County causing flood waters which rushed downstream and tore a fifteen-foot gap in a bridge on the highway four miles south of Tucson. Four automobiles plunged into the torrent and ten people drowned. The Santa Cruz River had estimated peaks of 7820 cfs at Continental (1662 mi^2) on the 9th, 14,000 cfs at Cortaro (3503 mi^2) on the 10th, 10,800 cfs at Tucson (2222 mi^2) on the 10th, and 1200 cfs near Laveen (8581 mi^2) on the 11th. Rillito Creek peaked at 7000 cfs on the 10th.

5.10 AUGUST 1961. On August 22, about 9:00 PM, over two inches of rain fell in one hour in the Tucson area. The heavy runoff produced by the storm caused severe damage to city streets and county roads along with damage to private property. This storm produced a peak discharge of 16,600 cfs, on the Santa Cruz River at Tucson.

5.11 SEPTEMBER 1962. Tropical storm "Claudia" moved onshore approximately 300 miles southwest of the southern Arizona border near Cedros Island, Baja California late in the evening of the 22nd. The path of the storm was generally northeastward. Five to seven inches of precipitation fell over the headwater areas of Santa Rosa, Jackrabbit, and Brawley Washes, with the heaviest rain falling during the night of the 25th and most of the 26th. Precipitation diminished to about 1 inch in the Vaiva Vo area downstream. The duration of the storm was about 14 to 15 hours and the highest recorded precipitation amount (5.95 in.) was observed at the Arizona-Sonora Museum, about 12 miles west of Tucson. Depths up to 7 inches were estimated for other locations. The major damage area from the flooding extended approximately 100 miles along the Santa Cruz River and tributaries and attained a maximum width of about 8 miles in the area south of Stanfield, where floodwaters from the Santa Cruz River merge with Santa Rosa and Greene Washes. Flow in the channels reached depths of 20 feet with 4 to 5 feet waves. The overflow depths varied from less than one foot to over six feet in the flood plain. Agricultural damages of about $8 million included losses to crops, principally cotton, which was in the early picking stage. Structural damages to levees, dikes, and spreader dams accounted for another $1 million. Road damage was very severe throughout the flooded area. Damages in Pima and Pinal Counties were in excess of $11 million. Santa Rosa Wash had an estimated peak discharge of 53,100 cfs near Vaiva Vo (1782 mi^2). The Santa Cruz River near Laveen peaked at 9200 cfs and Los Robles Wash near Marana (1170 mi^2) had an estimated peak of 32,600 cfs. Estimates for ungaged locations include Sells Wash at Sells (17,200 cfs) and Greene Wash near Eloy (24,100 cfs).

5.12 SEPTEMBER 1964. The storm was caused by an influx of warm, moist, unstable air from hurricane "Tillie". The period of the most intense rainfall occurred during the late hours of the 9th and early morning hours of the 10th, when a cold front moved across southeastern Arizona from the north. The greatest observed rainfall, 6.75 inches, occurred at two locations, the A.K. Mayer Ranch in the Catalina Mountain foothills and at a point west of Sahuarita. The widespread showers and thunderstorm activity that occurred during the period 5-8 September over the upper Santa Cruz River basin produced favorable runoff conditions for this storm. Estimates of peak discharges on the Santa Cruz River include: 2320 cfs near Lochiel (82 mi^2), 1900 cfs near Nogales (533 mi^2), 14,000 cfs at Continental (1662 mi^2), 14,300 cfs at Tucson (2222 mi^2), 15900 cfs at Cortaro (3503 mi^2), and 1340 cfs near Laveen (8581 mi^2). Rillito Creek (918 mi^2) had an estimated peak of 9400 cfs.

5.13 DECEMBER 1965. During the month of December, precipitation was above normal in all sections of the state, but heaviest totals were reported in the mountains with another band of unusually heavy totals running southward through eastern Pinal and Pima Counties. On the 23rd, additional precipitation caused flooding in the southern part of the state along the Santa Cruz River. Damage to roads, utilities, farmlands, crops, livestock, homes, and automobiles was widespread over most of southern Arizona. In Pima and Pinal Counties several hundred acres of cotton and grain land along the Santa Cruz River were flooded, and Rillito Creek ruptured sewage lines, contaminating a number of wells in the Tucson area. The Santa Cruz River had estimated peaks of 5990 cfs at Continental on the 23rd, 16,800 cfs at Cortaro on the 22nd, and 2940 cfs near Laveen on the 26th. Also peaking on the 22nd were Tanque Verde Creek with a peak of 2760 cfs, Rillito Creek with a peak of 12,000 cfs, and Rincon Creek with a peak of 3100 cfs.

5.14 DECEMBER 1967. From the 12th through the 20th, one of the most severe snowstorms in the history of Arizona occurred at higher elevations over much of the state. From a meteorological standpoint, there were actually two main storms, following so close together they were mistaken as one storm. During this nine-day period, some of the heaviest snow in the climatological history of the state brought widespread damage to Arizona. The peak discharge on Greene Canal below Eloy was 10,000 cfs. On Greene Wash, above the Santa

Rosa Wash confluence, near the town of Chuichu the peak was 7200 cfs, and on the Santa Cruz River near Laveen the peak was measured at 2940 cfs.

5.15 SEPTEMBER 1970. Tropical storm Norma, located in the Pacific Ocean below Baja California, initiated a flow of moist air over the Gulf of California toward the desert southwest on the afternoon of the 1st. This heavy rainfall caused rapid runoff that washed out roads and several bridges near Tucson and flooded homes. Flooding occurred in Altar and Brawley Washes, northwest of Cortaro, primarily due to heavy rainfall near the border town of Sasabe. Sabino Creek, which drains the Catalina Mountains near Tucson, experienced a record peak stream flow of 7730 cfs. Agricultural damage was light as was loss of livestock and damage to field crops.

5.16 AUGUST 1971. An unusually well-developed summer monsoon brought abundant moist air into the state on a consistent basis throughout the month. This moisture caused extensive thundershowers over the state, producing monthly rainfall totals which were above normal in many sections. The monthly totals at some stations were great enough to set new records for the month.

5.17 OCTOBER 1977. One of the most notable weather events of 1977 occurred during the first part of October. Several days of heavy rains caused severe flooding on the Santa Cruz and San Pedro Rivers (and other tributaries) in the southern portions of the state. The flooding produced severe damage to crops, goods, livestock, water supplies, and property. The heavy rains were due to tropical storm Heather which moved toward Baja California on the 5th as a hurricane. On the 6th at noon, its classification was downgraded to a tropical depression. Although almost all of Arizona received some precipitation, the most notable aspect of the storm was the persistently localized and intense rainfall in extreme southern portions of the state and into Mexico. Nogales officially reported 8.3 inches, but unofficial reports of up to 12 inches were reeeived in various parts of that community. Recorded peak discharges for the October 1977 flood include: Santa Cruz River at Continental, 26,500 cfs; Santa Cruz River at Tucson, 23,700 cfs; Santa Cruz at Cortaro, 23,000 cfs; Los Robles Wash near Marana, 2400 cfs; Brawley Wash near Three Points, 7300 cfs; Santa Cruz River at Greene Canal, 5200 cfs (5180 mi^2; Santa Cruz River above Santa Rosa Wash near Stanfield, 4700 cfs; drainage area not measured), and Santa Cruz River near Laveen, 2010 cfs.

5.18 DECEMBER 1978. The storm originated when a large low-pressure trough dropped southward off the California coast from out of the Gulf of Alaska. As circulation around the low plunged deep into the tropics, a very deep and intense current of tropical moisture streamed northward into Arizona from off a very active equatorial zone. On the Santa Cruz River, upstream from Rillito Creek, the flood was the 3rd highest winter in the period that began in 1905 and was exceeded only by the peaks of December 1914 and December 1967. All of these were later exceeded by the January 1993 flood. Flow from Rillito Creek combined with flows from a few minor tributaries to produce a peak of 18,800 cfs at the Santa Cruz River at Cortaro. A second crest of 18,200 cfs occurred when the peak passing

Tucson was superimposed on the recession hydrograph for Rillito Creek. The Santa Cruz River had peak discharges of 7,000 cfs at Continental (1662 mi^2), 13,500 cfs at Tucson (2222 mi^2), and 4120 cfs near Laveen (8581 mi^2). Rillito Creek near Tucson (918 mi^2) was measured at 16,400 cfs, and Canada Del Oro (250 mi^2) had a estimated peak of 1380 cfs. Smaller tributary peaks include 12,700 cfs for Tanque Verde Creek (219 mi^2), 1530 for Pantano Wash (599 mi^2), 1400 cfs for Bear Creek (16.3 mi^2), 7400 cfs for Sabino Creek (35.5 mi^2), 334 for Tucson Arroyo (8.2 mi^2), and 234 cfs for Ventana Canyon Wash (6.46 mi^2).

5.19 OCTOBER 1983. Tropical storm Octave off the coast of Baja California, was the main cause of large floods (in numerous cases the period-of-record peak flow) on the San Francisco, Gila, San Pedro, Santa Cruz Rivers, and other smaller streams. The long period of rainfall from September 27 to October 3 was the result of the interaction of a high-altitude low-pressure trough and a persistent supply of moist tropical air that was vastly increased on September 30 by the arrival of moisture associated with tropical storm Octave. As much as 11 inches of precipitation fell during the 7-day storm period. Rainfall during the storm period contributed to the highest annual precipitation and the highest September-October seasonal precipitation at many of the precipitation stations in the area. The highest recorded precipitation in the Santa Cruz Basin was measured at an elevation of 7,000 feet in the Santa Catalina Mountains, just north of Tucson. Before the storm period began, rainfall had been above normal in most parts of the area, soil conditions being mostly saturated. Flood flows in the Santa Cruz River Basin originated mostly between Nogales and Cortaro, with large volumes of water breaking out of the channel and spreading out over a broad area, especially downstream from Red Rock (refer to Plate 1 for location of Red Rock). The flood on the Santa Cruz River was the largest on record from Continental to the junction with the Gila River. At Interstate 8, the inundation area was more than 8 miles wide. Large channel changes took place on many streams. Total damages were estimated to be $226.5 million. The following peaks were recorded or estimated on the Santa Cruz River: 3880 ft^3/s near Lochiel, 16,200 ft^3/s near Nogales, 45,000 ft^3/s at Continental, 52,700 ft^3/s at Tucson, 65,000 ft^3/s at Cortaro, and 33,000 ft^3/s near Laveen. Other peak discharges in the Santa Cruz River basin included 29,700 ft^3/s on Rillito Creek (the greatest flow of record), 12,500 ft^3/s on Los Robles Wash, 19,100 ft^3/s on Brawley Wash, 6600 ft^3/s on Canada Del Oro, and 1890 ft^3/s on Santa Rosa Wash, (**note**: this is outflow from Tat Momolikot Dam). October 1983 was the wettest October recorded at the Tucson NWSO station (5.78 inches) in history.

5.20 JANUARY 1993. Heavy rains of January 1993 followed an above average rainfall season in 1991-1992, in which above normal precipitation was measured at many stations. January 1993 was the wettest January recorded at the Tucson NWSO station (5.58 inches) in history. This followed December 1992, in which 3.60 inches of precipitation were recorded at that station, nearly 3 times the monthly average. A series of disturbances to the moist flow of subtropical air resulted in widespread storms throughout the state of Arizona. The single-day maximum recorded value at Tucson NWSO was 1.50 inches on the 8th and a combined 2-day total of 2.14 inches on the 7th and 8th. An additional 0.40 inches was recorded on the

9th. Two subsequent systems moved into Arizona during the period 10-11 January, and 12-19 January. The first resulted in heavier precipitation and runoff in the central part of the state. The latter produced 2 heavy periods of precipitation in the Santa Cruz River basin during the 13th and the 14th of January (1.15 inches recorded at the Tucson NWSO); and during the 19th and 20th of January (0.74 inches recorded at the same station). Most Arizona stations reported 1-3 inches of precipitation from the 16th to through the 19th, as disturbances in the fast, moist flow over the region produced frequent periods of precipitation. Flash flood warnings and watches were issued for many streams as a results of the saturated soil conditions combined with periods of heavy precipitation. A flash flood warning was prompted for the Santa Cruz River from Tucson northward on 19 January. During the latter event the peak discharges on the Santa Cruz River were recorded (or estimated) of 32,400 cfs at Continental (estimated, 2nd greatest flow in history), 37,400 cfs at Tucson (2nd greatest flow in history), and more than 40,000 cfs at Cortaro (estimated by the LAD[3] and others, also the 2nd greatest flow in history). Several large tributaries of the Santa Cruz River in the vicinity of Tucson, Arizona, also recorded significant peak discharges during the initial storm period around 8 January. The peak discharge in Sabino Creek near Tucson (estimated gage height from high-water mark) was 12,900 cfs and the peak-of-record, as was the recorded peak flow in Tanque Verde at Tucson of 24,500 cfs. The recorded peak flow in Rillito Creek at La Cholla Boulevard near Tucson (24,400 cfs) was the 2nd largest peak flow in history.

[3] Source: Santa Cruz River Watershed Management Study, Final Feasibility Report, Appendix E-1, Los Angeles District, U.S. Army Corps of Engineers, August 2001.

6 DISCHARGE-FREQUENCY ANALYSIS - SANTA CRUZ RIVER TRIBUTARIES

6.1 GENERAL. The following table contains hydrologic information, including peak discharges for tributaries of the Santa Cruz River in the Study Area. The locations of these tributaries are shown in maps accompanying reports "a" and "b" as referenced in Section 2 of this report.

Table 2: Pima County Discharge-Frequency Relationships

		Frequency, years						
Stream Name	DA, sq. mi.	500	100	50	25	10	5	2
Peak Discharges: Santa Cruz Tributaries, cfs								
Hughes Wash	8.34		2376	1875	1258	738	334	93
Santa Clara Wash	0.39		389	314	221	143	86	47
El Vado Wash	2.29		1558	1327	1003	716	474	287
Valencia Wash	1.64		1510	1292	1026	721	441	230
Airport Wash	22.73		5164	3981	2691	1549	740	346
Wyoming Wash	0.70		877	719	519	335	184	82
Irvington Wash	0.25		427	343	237	145	75	40
Rodeo Wash	8.39		3453	2839	2448	1340	744	321
Julian Wash	43.53		5962	6697	3202	1901	945	389
Mission View Wash	1.62		1802	1538	1201	885	599	355
18th St Wash	3.66		3085	2503	1921	1363	886	523
Cushing St Wash	0.50		1165	993	770	562	375	221
Ajo Wash	1.91		3465	2817	2007	1286	689	242
Enchanted Hills Wash	3.11		3968	3270	2386	1540	801	256
San Juan Wash	1.14		1757	1470	1104	757	423	152
Cholla Wash	1.30		2273	1882	1379	920	529	224
Old W Br Santa Cruz	10.22		6621	5417	3818	2447	1352	397
New W Br Santa Cruz	33.20	14,000	9908	7925	5250	3665	2020	595
Los Reales Road	19.06	10,600	7638	6000	4000	2780	1530	450
Peak Discharges: Rillito River (Creek) Tributaries, cfs								
Craycroft Wash	3.07		2540	1908		891	568	234
Flecha Caida Wash	1.47		1619	1223		579	372	154
Valley View Wash	4.11		3003	2254		1049	667	275
Finger Rock Wash	6.09		3730	2798		1298	823	339
Camino Real Wash	1.86		1878	1415		667	427	176
Campbell Wash	2.50		2249	1692		793	506	209
Alamo Wash	9.90		4809	3608		1671	1058	438
Alvernon Wash	3.32		2658	1996		931	593	244
Christmas Wash	3.32		2658	1996		931	593	244

Notes: 7900 indicates peak discharge estimated by LAD; 7900 indicates peak discharge provided by PIMA for this current study; 7900 indicates peak discharge provided by PIMA for the El Rio Antiguo study.

PCFCD provided discharge-frequency values for 18 tributaries to the Santa Cruz River within the study reach (bounded on the south by Los Reales Road, and on the north by Congress Street) as indicated in the previous table. The data was contained in a document entitled "Santa Cruz River, Paseo de Las Iglesias, Pima County, Arizona, Feasibility Study, Hydrology Report", dated November 2001. These results were taken from pre-existing hydrologic information generated using rainfall-runoff procedures. In addition to this information peak flow rates for the New West Branch (100-year) of the Santa Cruz River were provided separately. All discharges provided are for locations at the confluence with the Santa Cruz River[4]. At the request of the LAD, Mr. Tom Helfrich of PCFCD provided an expanded list of estimated peak discharges for a range of frequencies (2-, 5-, 10-, 25-, and 50-year) for the New West Branch of the Santa Cruz River at the confluence with the Santa Cruz, as well as an estimate of the 100-year (1% chance annual exceedance probability) peak discharge in the New West Branch of the Santa Cruz River upstream at the Los Reales Improvement District.

No evaluation of these peak flow rates was included in the documentation. Subsequent hydraulic/economic analysis by the LAD required additional information, namely estimates of the 500-year (0.2% annual exceedance probability) peak flow rate in the New West Branch of the Santa Cruz River at the confluence with the Santa Cruz, and at the Los Reales Improvement District. At the latter location, the only available peak flow rate was for the 100-year event. Hence, two additional tasks remained:

(1) Evaluate the discharge-frequency values provided.

(2) Estimate the peak flow rates for the 500-year event for the New West Branch at the Los Reales Improvement District (drainage area = 19.06 sq. mi.[5]), and at the confluence with the Santa Cruz River (drainage area = 33.2 sq. mi.[5]). The 500-year discharges were required in order to fully evaluate potential flood damages and possible benefits of flood control alternatives for the New West Branch. In addition to the 500-year discharge, a full range of discharge-frequency values (2-, 5-, 10-, 25-, 50-, and 100-year) was required to perform hydraulic and economic evaluation of without project conditions for the Los Reales Improvement District.

6.2 EVALUATION OF PEAK FLOW RATES FOR SANTA CRUZ RIVER TRIBUTARIES. Peak discharge-frequency values for the Santa Cruz River tributaries in the study area were evaluated in a generalized manner by plotting the peak flow rates against drainage. Linear

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[4] Except for the New West Branch of the Santa Cruz River at Los Reales Road (the Los Reales Improvement District), which is upstream of the confluence with the Santa Cruz River.

[5] Drainage Area (DA) provided by Pima County.

regression relationships for the log-discharge against the log-DA were developed for each frequency (2-, 5-, 10-, 25-, 50-, and 100-year[6]).

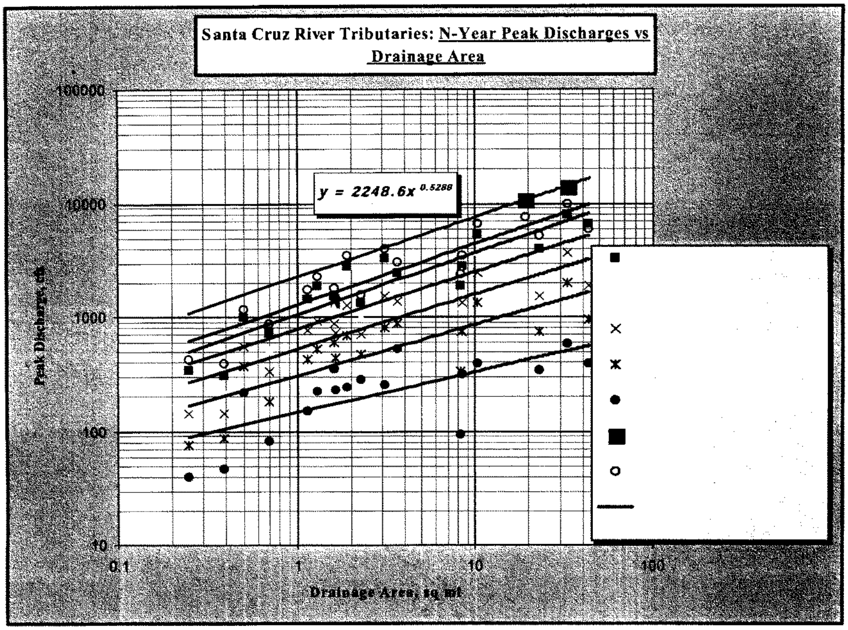

Figure 2. N-year Peak Discharge vs Drainage Area Curves - Santa Cruz River Tributaries.

A reasonable and consistent family of regression curves resulted from this analysis (refer to Figure 1, above). For comparison purposes, peak flow rates for tributaries of the Rillito River (Creek), recently determined by PCFCD[7], were included in the plots and compared to the regressed curves (refer to the following Figures 2-7.

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[6] Referred to hereinafter as "n-year" discharges or curves.

[7] El Rio Antiguo, Rillito River Environmental Restoration, Documentation for Hydrologic Studies, prepared by Pima County Department of Transportation and Flood Control District, Flood Control Engineering Division, for the U.S. Army Corps of Engineers, Los Angeles District, March 2002. Based upon regional equations for Southern Arizona (Region 13, Figure 42 and Table 17) from the USGS report "Methods for Estimating Magnitude and Frequency of Floods in Southwestern United States", 1994.

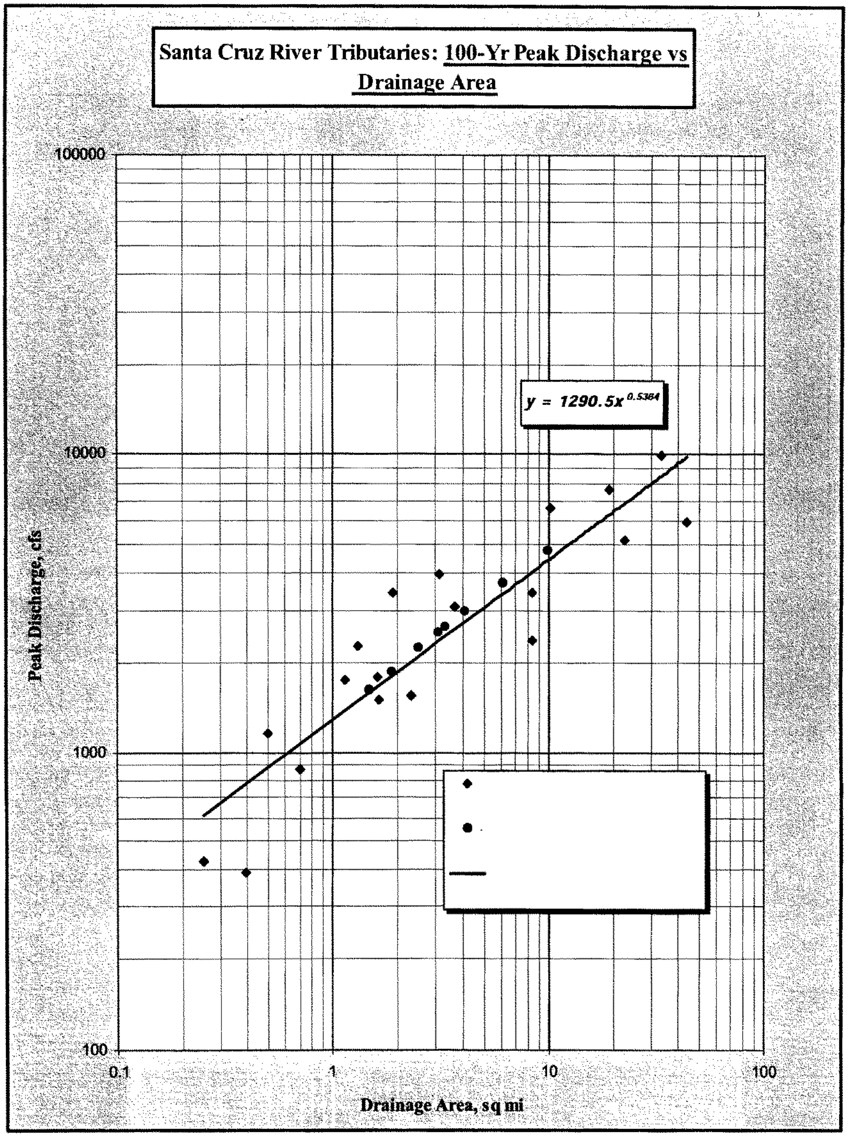

Figure 3. 100-yr Peak Discharge vs Drainage Area - Santa Cruz River Tributaries.

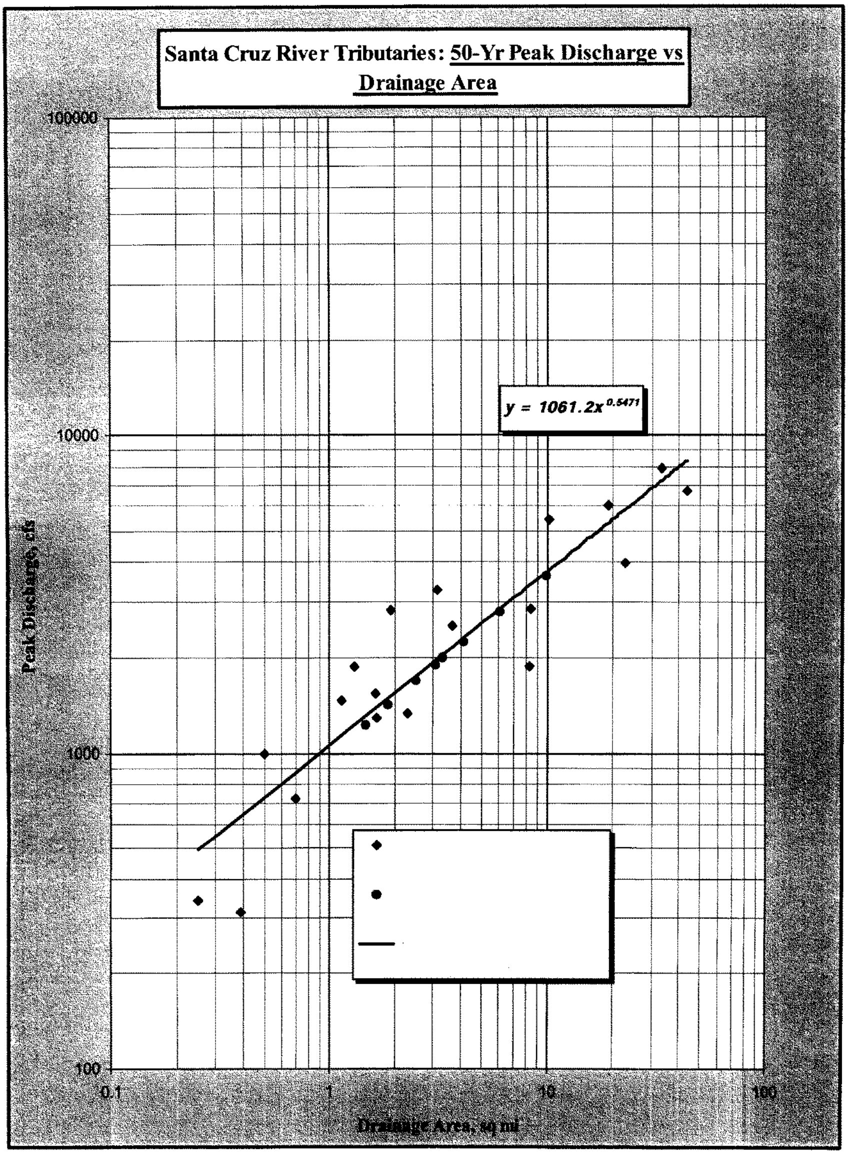

Figure 4. 50-yr Peak Discharge vs Drainage Area- Santa Cruz River Tributaries.

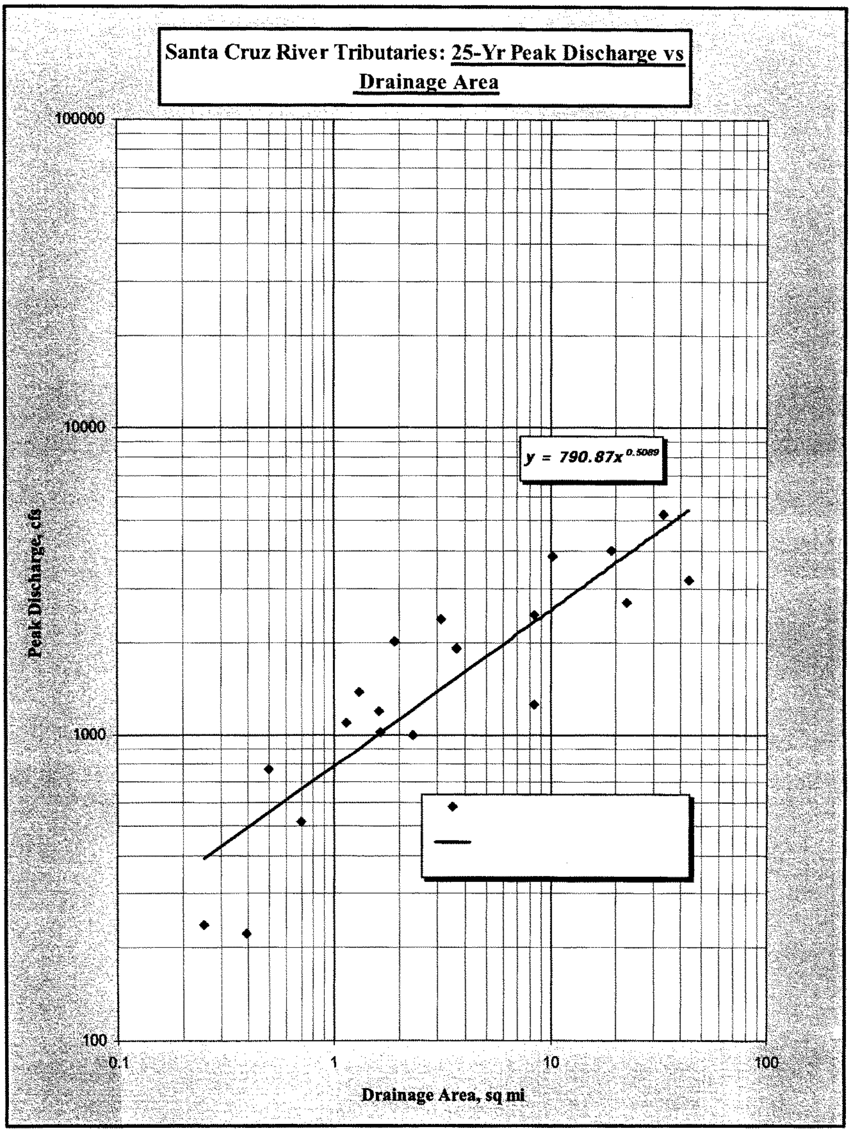

Figure 5. 25-yr Peak Discharge vs Drainage Area - Santa Cruz River Tributaries.

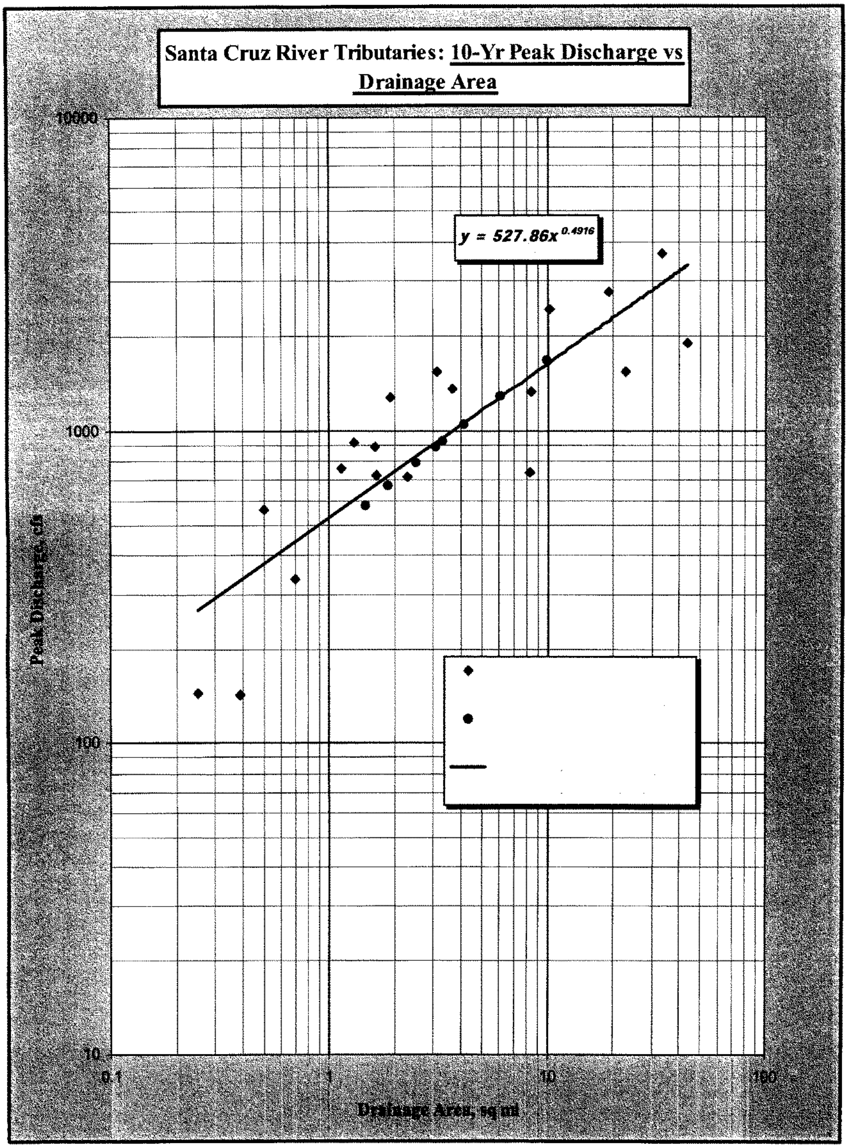

Figure 6. 10-yr Peak Discharge vs Drainage Area - Santa Cruz River Tributaries.

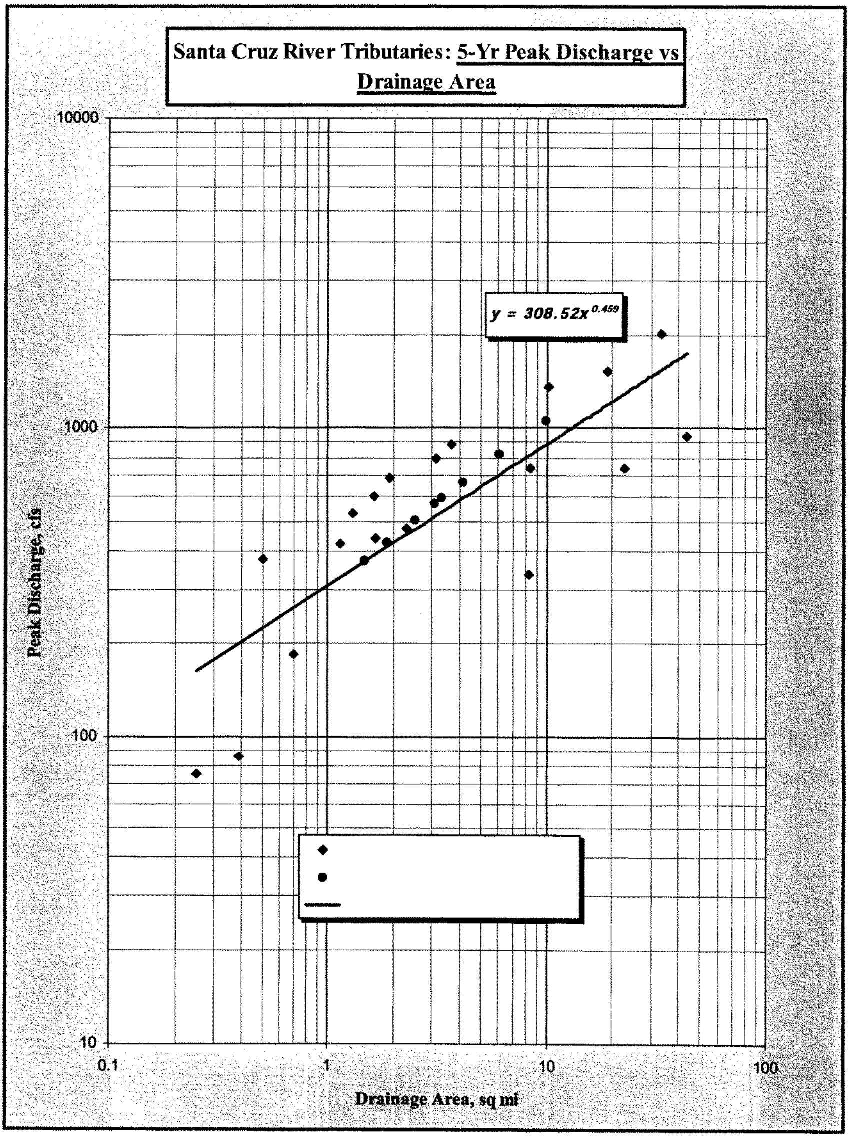

Figure 7. 5-yr Peak Discharge vs Drainage Area - Santa Cruz River Tributaries.

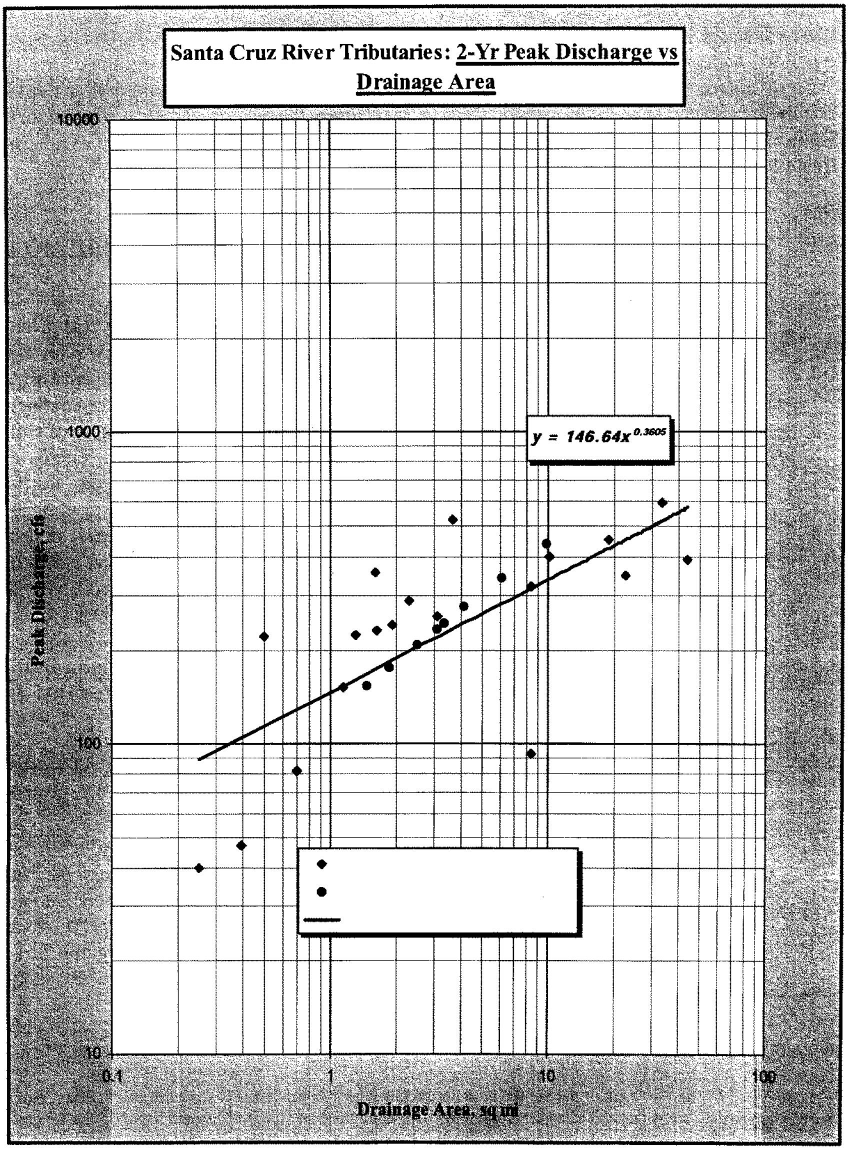

Figure 8. 2-yr Peak Discharge vs Drainage Area - Santa Cruz River Tributaries.

In all instances the Rillito tributary inflow compared well to the regression curves for the Santa Cruz River tributaries. Since the Rillito peak flow rates were developed directly from the USGS regional equations, and since these flow rates are consistent with the regression curves developed from the Santa Cruz River tributary flow rates, it is apparent that the Santa Cruz River tributary flow rates are likewise consistent with the USGS regional equations. Hence, the peak flow rates generated for the Santa Cruz River are likewise consistent with peak flows rates recently developed for the nearby Rillito River (Creek), and are suitable for use in this study.

6.3 ESTIMATION OF PEAK FLOW RATES FOR NEW WEST BRANCH TRIBUTARY OF THE SANTA CRUZ RIVER.

6.3.1 *N-year Discharges at Los Reales Improvement District.* Consideration was given to directly utilizing the n-year regression curves for estimation of peak flow rates in the New West Branch of the Santa Cruz River at the Los Reales Improvement District. However, since the peak flow rates for the downstream location (at the confluence with the Santa Cruz River) were > the regressed value for that drainage area size, it is likely that use of the regression curves to estimate upstream peak flow rates would yield discharges which were inconsistent with the downstream flows. Hence, the peak flow rates at the Los Reales Improvement District were estimated by prorating the downstream peak discharges by ratio of the square root of the respective drainage areas[8] for each n-year return period. Variation of peak flow rate in direct proportion to the square root of drainage area is not uncommon in hydrologic applications. The use of this ratio (0.758) was supported by two independent computations:

(1) The peak 100-year flow rate computed for the Los Reales Improvement District, 7638 cfs[9], is approximately 77% of the peak flow rate for the New West Branch at the mouth, 9908 cfs.

(2) The n-year regression curves indicate that the peak flow rates for a DA of 19.06 sq. mi. are proportionally about 75% of the flow rates for a DA of 33.20 sq. mi. for the entire range of frequencies.

6.3.2 *Discharge-Frequency Curve for New West Branch at the Confluence with the Santa Cruz River.* In order to provide an estimate of the 500-year peak discharge in the New West Branch consistent with the discharges provided by PCFCD, several approaches could have been taken. The USGS regional equations (paragraph 2.5) do

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[8] The computed ratio is $(19.06^{1/2}/33.20^{1/2}) = 0.758$. The 100-year discharge reported, 7638 cfs, was provided by PCFCD (refer to the following footnote).

[9] Re: "Request for a Letter of Map Revision for the Los Reales Improvement District Located in Pima County Arizona, and in the City of Tucson, Arizona" prepared by Arroyo Engineering, Inc. and submitted to the Pima County Department of Transportation and Flood Control District and the City of Tucson Department of Transportation in December 1994.

not include peak flow rates beyond the 100-year event. Rainfall-runoff modeling, consistent with that used to develop n-year peak discharges could have been used. However, in order to provide information for Risk/Uncertainty Analysis (including both rare and frequent events) and to maintain consistency with the set of n-year discharges, the approach taken was to develop a synthetic discharge-frequency relationship. A quasi-analytical[10] discharge-frequency curve was fitted to the computed values provided by PCFCD. This curve was generated using a trial-and-error procedure based upon developing a set of log-Pearson Type III parameters that would yield equivalent discharges.

6.3.2.1 **Estimated Log-Pearson Type III Distribution Synthetic Parameters**. The following parameters describe a continuous curve consistent with the n-year discharge-frequency values provided by PCFCD:

1) Log-Mean = 2.681
2) Standard Deviation = 0.750, and
3) Skew = -0.80.

6.3.2.2 **500-Year Discharges for New West Branch Tributary**. The 500-year discharge for the New West Branch of the Santa Cruz River at the mouth (the confluence with the Santa Cruz River) was estimated from the quasi-analytical discharge-frequency curve constructed using these synthetic parameters. The intersection of the 0.2% annual exceedance probability event (the 500-year event) and the peak discharge is approximately 14,000 cfs. Subsequently the 500-year peak flow rate for the New West Branch at the Los Reales Improvement District was estimated in the same manner as were the other frequency events by applying the square root of the drainage area ratio to the downstream 500-year peak discharge (0.758 x 14,000 cfs = 10,600 cfs).

6.3.3 *Discharge-Frequency Curve for New West Branch at the Los Reales Improvement District.* Again, in order to provide information for Risk/Uncertainty Analysis (including both rare and frequent events), a synthetic discharge-frequency relationship was developed from the n-year discharges. A quasi-analytical discharge-frequency curve was fitted to the computed values prorated from the downstream discharges, and the 100-year discharge provided by PCFCD. This curve was generated in the same manner as the curve for the New West Branch at the

[10] The procedure is referred to as "quasi-analytical" because the basis for the curve-fitting parameters was a set of synthetic statistics which yielded a discharge-frequency curve consistent with the discrete values provided by PCFCD. The statistics were based upon the likelihood that the n-year values provided were consistent with a log-Pearson Type III Distribution.

confluence, using a trial-and-error procedure based upon developing a set of log-Pearson Type III parameters that would yield equivalent discharges.

6.3.3.1 Estimated Log-Pearson Type III Distribution Synthetic Parameters. The following parameters describe a continuous curve consistent with the n-year discharge-frequency values:

1) Log-Mean = 2.555
2) Standard Deviation = 0.755, and
3) Skew = -0.80.

6.3.4 *Summary and Comparison of Results.* The following table presents a summary of the discharge-frequency values provided by PCFCD for the New West Branch tributary, along with the supplemental discharge-frequency estimates made by the LAD. Included are a comparison of these values to synthetic or quasi-analytical results and statistical parameters generated within this study to augment the data and to facilitate Risk/Uncertainty Analysis.

Table 3: <u>Discharge-Frequency Relationships</u> - New West Branch of Santa Cruz River

Name	DA, sq. mi.	Frequency, years 1000	500	200	100	50	25	10	5	2
LOCATION		**Peak Discharges: Santa Cruz Tributaries - New West Branch, cfs**								
at Santa Cruz River	33.2	16000	14000	12000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
at Los Reales Road	19.06		10600	8900	[illegible]	6000	4000	2780	1530	450
		Exceedance Probability, %								
		0.1	0.2		1	2	4	10	20	50

Discharges from Computed Statistics		Exceedance Probability, % 0.1	1	5	10	30	50	70	90
LOCATION		**Peak Discharges: Santa Cruz Tributaries - New West Branch, cfs**							
at Santa Cruz River	33.2	16000	9680	5200	3550	1350	600	230	47
at Los Reales Road	19.06	12200	7390	3950	2700	1020	450	185	35

Computed Statistics	M	S	G
at Santa Cruz River confluence	2.681	0.75	-0.8
at Los Reales Road	2.555	0.755	-0.8

[illegible]

Data computed by LAD-COE

7 **SYNTHETIC FLOOD HYDROGRAPHS - Santa Cruz River at Tucson**

7.1 VOLUME-FREQUENCY RELATIONSHIPS. In order to develop synthetic flood hydrographs (*Balanced Hydrographs)* for use in sedimentation analysis for the Santa Cruz River within the study area, a necessary first step is to develop volume-frequency relationships.. **Note: volume-frequency is a term for discharge-frequency relationships incorporating a series of duration-discharges, e.g. peak or instantaneous flow, 1-day flow, 2-day flow, 3-day flow, etc. The resulting discharge-frequency relationships are typically displayed as a family of curves.** Durations are selected to provide adequate definition for the stream/drainage area of interest. Data is typically derived from annual maxima for each duration of interest, and represents the maximum average flow (or volume) from a contiguous set of observed discharges. The best source of contiguous duration data is a recording streamgage. For the Santa Cruz River in the study area, recorded or systematic daily flow record is available from the USGS (Station 09482500) from as early as 1905 (although the early record is fragmented) to the present at a series of closely situated gaging sites at/near Congress Street in Tucson, Arizona.

For this current sediment transport analysis volume-frequency relationships developed for the July 1990 Corps of Engineers Report (ref. 2.8), SANTA CRUZ RIVER, Hydrologic Documentation for Feasibility Studies, Lower Santa Cruz River Flood Control Study, Pinal County, Arizona, were selected for incorporation into this study (Plate 24 of that study). Likewise, peak discharges were available from the report (ref: 2.3) SANTA CRUZ RIVER WATERSHED MANAGEMENT STUDY, APPENDIX E-1, Los Angeles District, U.S. Army Corps of Engineers, August 2001. The peak discharge-frequency values[11] were developed from a "mixed population" analysis, while the volume-frequency values were developed from an analysis of annual maxima. **Note: it was considered reasonable that the largest duration flows for each year (annual maxima) would be adequate to address sedimentation issues, since the approach taken was to establish a sediment budget rather than perform a detailed sediment routing procedure.** Inspection of the volume-frequency values indicated that durations of 3-days adequately described flood events. For example, the 100-year, 3-day volume is 48,790 ac-ft. Contrasted to that, the 100-year, 5-day volume (not shown in table below) is 50,580 ac-ft, an increase of only 1790 ac-ft (< 4%) over the additional 2-day period, or an additional average flow of only 450 ft^3/s. The "blended" data is shown in the following table.

[11] The peak discharge-frequency values were also used for the flood control analysis of the Santa Cruz River, and are included in the following table.

Table 4: <u>Santa Cruz River at Tucson:</u> Volume-Frequency Values

Frequency (years)	Flow Duration			
	Instantaneous	1-Day	2-Day	3-Day
	Average Discharge for each Duration			
500	120000	33000	22000	16000
200	75000	22000	15000	11000
100	55000	17000	11000	8200
50	35000	12000	8000	5800
20	20000	7600	5275	3600
10	14000	5000	3300	2350
5	9500	3050	2000	1450
2	4900	1300	880	430

Note: all duration discharges shown are in ft^3/s.

7.2 <u>BALANCED HYDROGRAPH DEVELOPMENT</u>. A *Balanced Hydrograph* is a hypothetical flood event having the same probability of exceedance for every duration. As such, it is a convenient tool to analyze situations requiring both volumetric information, where storage may exert an influence (such as impoundments or channel routing and overflow mapping), as well as peak information, which is necessary for channel capacity determination and outlet sizing. *Balanced Hydrographs* are typically developed from volume-frequency relationships, in order to establish boundary conditions (i.e. duration discharges for each frequency of interest) for computation/interpolation of flow rate versus time. In this case the boundary conditions were limited to the peak discharge, and the 1-, 2-, and 3-day average discharges for each n-year frequency (please refer to the preceding table). For example, the boundary conditions to describe the 100-year *Balanced Hydrograph* (or 1% chance annual exceedance flood) were the 1% annual exceedance probability instantaneous discharge (55,000 ft^3/s), the 1% annual exceedance probability 1-day average discharge (17,000 ft^3/s), the 1% annual exceedance probability 2-day average discharge (11,000 ft^3/s), and the 1% annual exceedance probability 3-day average discharge (8200 ft^3/s). Since each duration discharge is selected from a consistent family of frequency curves, and these duration discharges are used as boundary conditions, it is reasonable to assume that the flow rate for any intermediate duration (e.g., $Q_{nstantaneous} < Q_{ntermediate\ duration} < Q_{1\text{-}day}$, and $Q_{1\text{-}day} < Q_{ntermediate\ duration} < Q_{3\text{-}day}$) within these hypothetical flood hydrographs has the same frequency of exceedance.

Balanced Hydrographs can be developed in a variety of ways, including manual or graphical interpretation of the volume-frequency results. Such synthetic floods can also be developed in an automated procedure using the HEC-1 Flood Hydrograph Package (The "HB-card" allows the user to input boundary conditions for automatic processing; when linked to a set of initial conditions, i.e. a "pattern" input hydrograph – in this case the October 1983 flood was utilized - there is sufficient hydrologic information to compute hydrograph ordinates for each event). Required input includes the computation interval and duration of flow, along with a pattern hydrograph and boundary conditions. Use of the HEC-1 package allows easy graphical depiction of the resulting *Balanced Hydrographs* through use of the HEC-DSS (data storage system). *Balanced Hydrographs* for each of the n-year synthetic flood events described are provided in Exhibits 1 through 8; each synthetic flood hydrograph is compared to the "pattern hydrograph" for informational purposes.

8 RISK AND UNCERTAINTY

8.1 GENERAL. "*Risk* involves exposure to a chance of injury or loss. The fact that risk inherently involves chance leads directly to a need to describe and to deal with *uncertainty*. Because of the lack of technical knowledge of the complex interaction of uncertainties in predicting hydrologic, hydraulic, and economic functions and because of the complexities of the mathematics required to do otherwise, the engineer must describe the uncertainty in choice of the hydrologic, hydraulic, and economic functions, describe the uncertainty in the parameters of the functions, and describe explicitly the uncertainty in results when the functions are used. Through this risk and uncertainty analysis (also known as uncertainty propagation), and with careful communication of the results, more informed decisions can be made." Reference 2.4.

ER-1105-2-101 requires "risk-based analysis" for Feasibility studies for several aspects of these studies, including Hydrology. The analysis of the Santa Cruz River in the study area as well as the New West Branch tributary includes hydrologic uncertainty in the determination of average annual damages. Since the hydrologic analysis of both the mainstem Santa Cruz River and the New West Branch tributary were non-traditional (i.e. the final results were not portrayed by a set of analytical parameters[12]), the accompanying uncertainty estimates were developed in accord with ETL-1110-2-537 (October 1995), UNCERTAINTY ESTIMATES FOR NON-ANALYTICAL FREQUENCY CURVES.

8.2 PREVIOUS EXPERIENCE . Economic analysis based upon Risk and Uncertainty has brought to light some conflicts in the sampling process resulting from the use of "graphical" discharge-frequency data. Since the flood data developed in hydrologic analyses typically includes only peak discharges for potentially- "damaging" events (the mean annual flood event - 2-yr, or 50% annual chance of exceedance - and greater events), the algorithm used to randomly generate a range of possible peak discharges for each event was constrained. Analytically-derived statistics permit random generation of discharges for any frequency event based upon a "normal" distribution (in this case log-Pearson Type III). In order to

[12] Note: the "mixed population" analysis for the Santa Cruz River did involve traditional or analytical procedures for each of the 3 identified storm-producing event types, i.e. *monsoonal, cyclonic, and frontal*. However, no integrated statistics were available for the final, combined product. Hence, the results were treated as "graphical" as far as incorporation into the Flood Damage Assessment model (HEC-FDA). On the other hand, as discussed in Section 6 of this report, quasi-analytical parameters were developed for the New West Branch tributary. Hence these "statistics" were input to the HEC-FDA model for without project damage assessment.

more completely describe the "normal" distribution, it was necessary to estimate frequent flood events (e.g. events more frequent than the mean annual maximum flood). This additional data provided realistic bounds to the sampling process which greatly improved the economic evaluation.

8.3 APPLICATION TO CURRENT STUDY. Risk and uncertainty information was required for the mainstem Santa Cruz River and the New West Branch tributary in order to determine without- project flood damages. The following hydrologic information was generated within this or previous studies and used in conjunction with accompanying hydraulic and economic data to generate risk-based damages for the aforementioned streams.

8.3.1 *Equivalent years of record.*
8.3.2 *Peak discharge-frequency values/curves.*
8.3.3 *Synthetic discharge-frequency curves/parameters*

8.4 EQUIVALENT YEARS OF RECORD. Uncertainty in hydrologic results was accounted for by assigning an *equivalent record length* to both the Santa Cruz River and the New West Branch tributary data, estimated using table 4-5 in EM 1110-2-1619 (Table A-1 of ETL 1110-2-537), with consideration of uncertainty associated with the source, applicability, and length of streamflow record associated with the discharge-frequency values.

8.4.1 *Santa Cruz River.* The discharge-frequency values for the Santa Cruz River (at Tucson, near Congress St.) were considered to be very reliable because of the long-period from which estimated discharges were available, tests made as to consistency of data, and the fact that a complex study for that area had recently been completed which corroborated independent results. As a result, an equivalent record length of 106 years was assigned to the Santa Cruz River data (extended to 1891 because of historic information; refer to ref. 2.3 for further information/discussion).

8.4.2 *New West Branch Tributaries.* The regional analysis used to evaluate/generate the Table 3 discharges was based upon an average of 21 years of systematic record (please refer to Figure 42, ref. 2.6) . Hence, the equivalent years of record assigned to the 2 New West Branch tributary locations is 21.

8.5 PEAK DISCHARGE-FREQUENCY VALUES/CURVES.

8.5.1 *Santa Cruz River.* Discharge-frequency values for the Santa Cruz River at Tucson (Drainage Area = 2222 sq.mi.) are listed in Table 4. For risk and uncertainty analysis the list of discharges was expanded to provide a more complete, quantitative description of the underlying discharge-frequency relationship. Please refer to Table 5, which follows for an expanded summary of the values, and to Figure 8 for the source data (i.e. the discharge-frequency curve) from which these values were obtained.

Table 5. Santa Cruz River at Tucson: Risk/Uncertainty Peak Discharge-Frequency Values

Annual Exceedance Probability	Peak Discharge, ft^3/s
0.002	120000
0.005	75000
0.01	55000
0.02	35000
0.05	20000
0.1	14000
0.2	9500
0.5	4900
0.8	2800
0.9	1450
0.95	1300
0.99	850
0.998	510

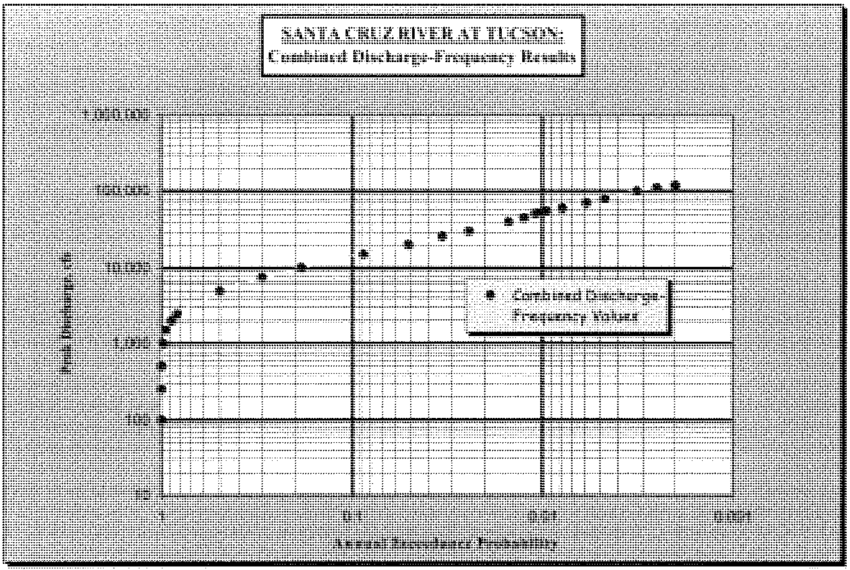


Figure 9. Mixed Population Discharge-Frequency Curve - Santa Cruz River at Tucson.

8.5.2 *New West Branch Tributaries.* Synthetic statistics for the upstream location (at the Los Reales Improvement District) and the downstream location (at the confluence with the Santa Cruz River) were presented in Table 3. Figure 9 (following page) portrays the synthetic discharge-frequency curves generated from these statistics and the discharge-frequency values from which the statistics were developed.

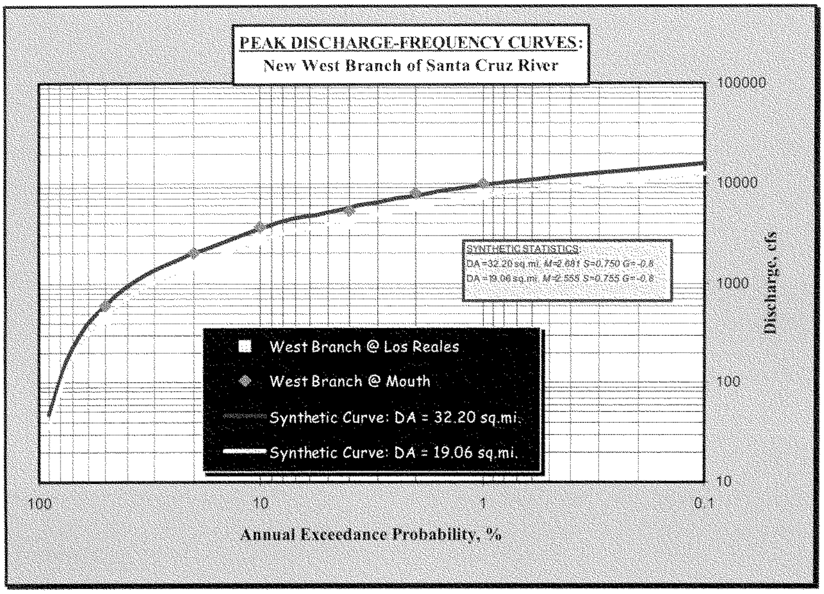
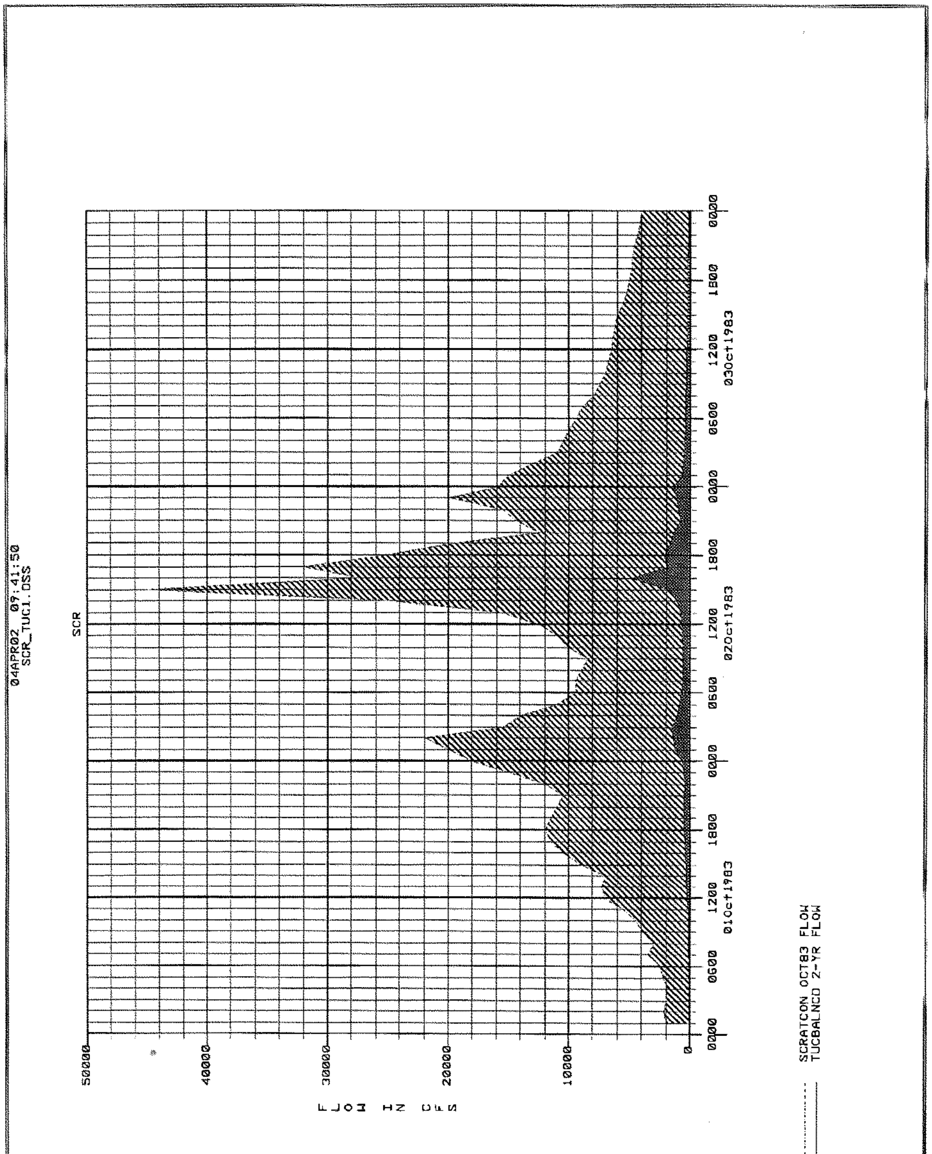


Figure 10. Synthetic Discharge-Frequency Curves - New West Branch Tributary.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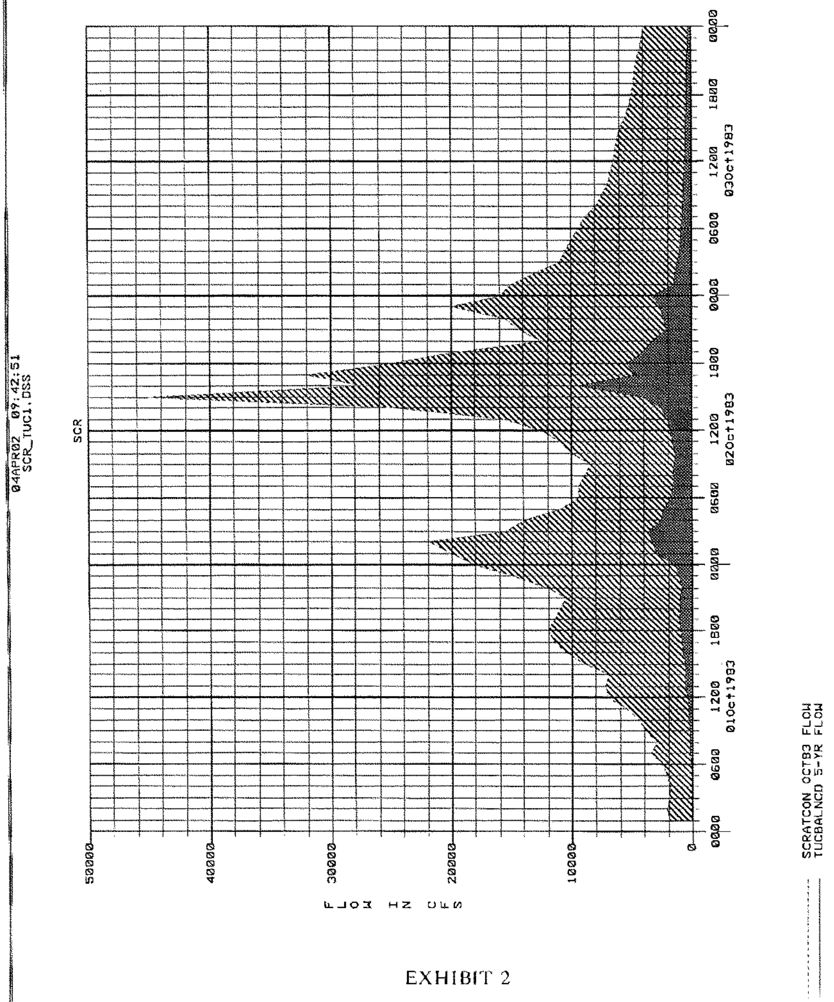
03Oct1983
SCRATCON OCT83 FLOW
TUCBALNCD 2-YR FLOW

EXHIBIT 1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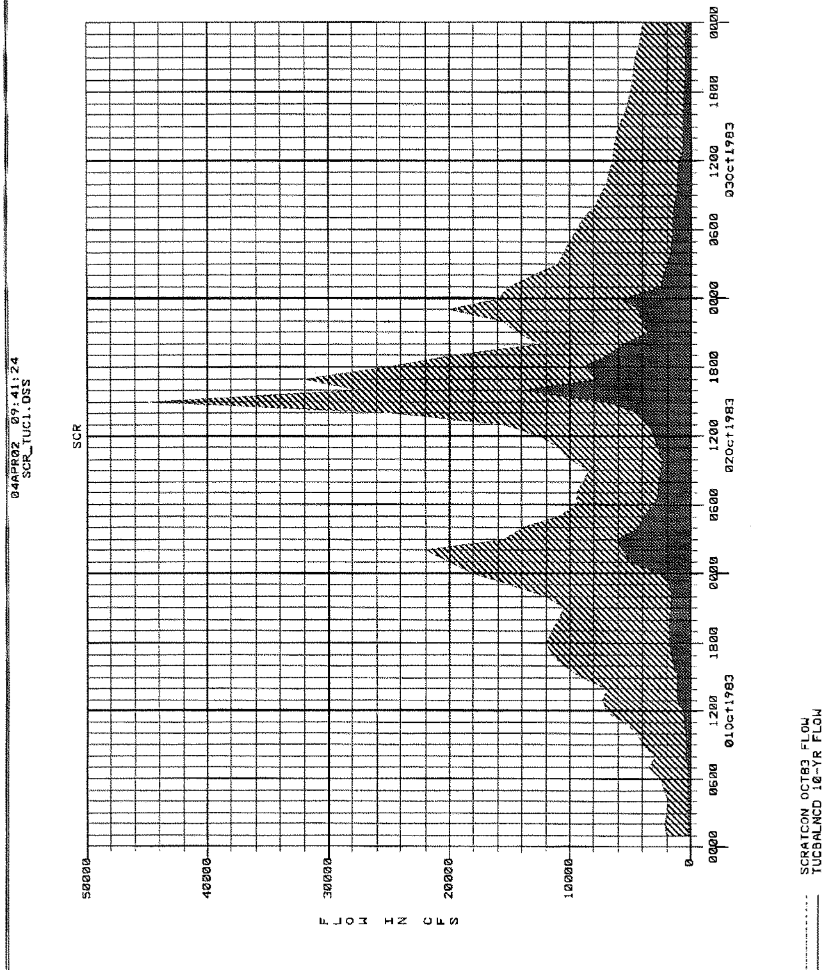
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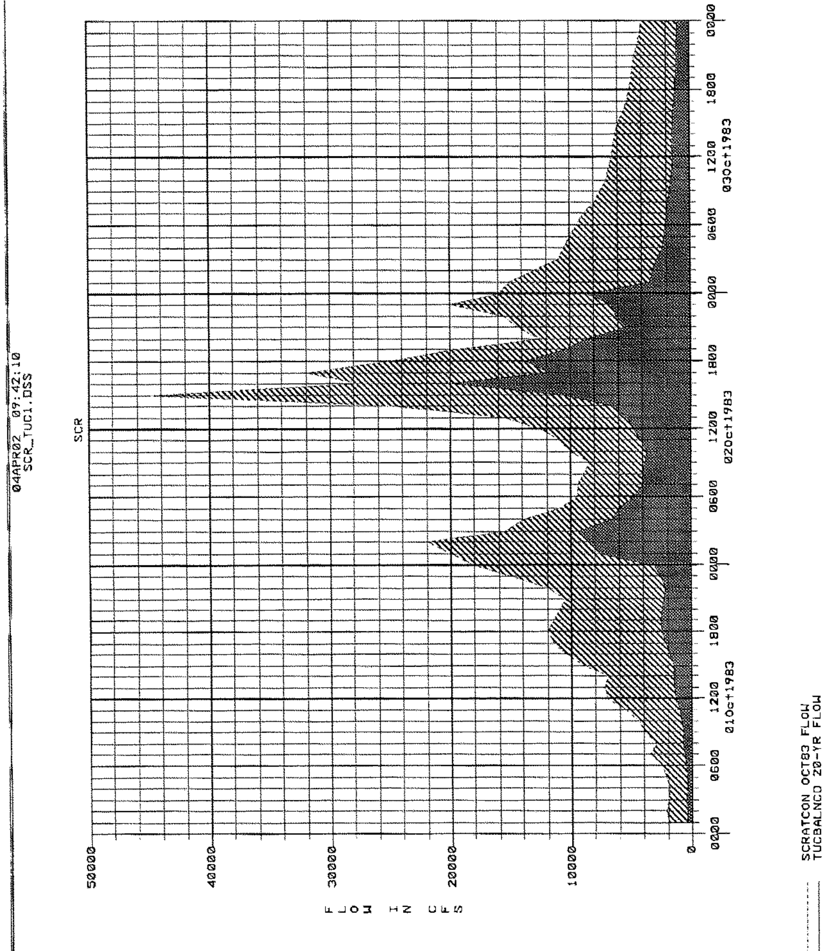
EXHIBIT 3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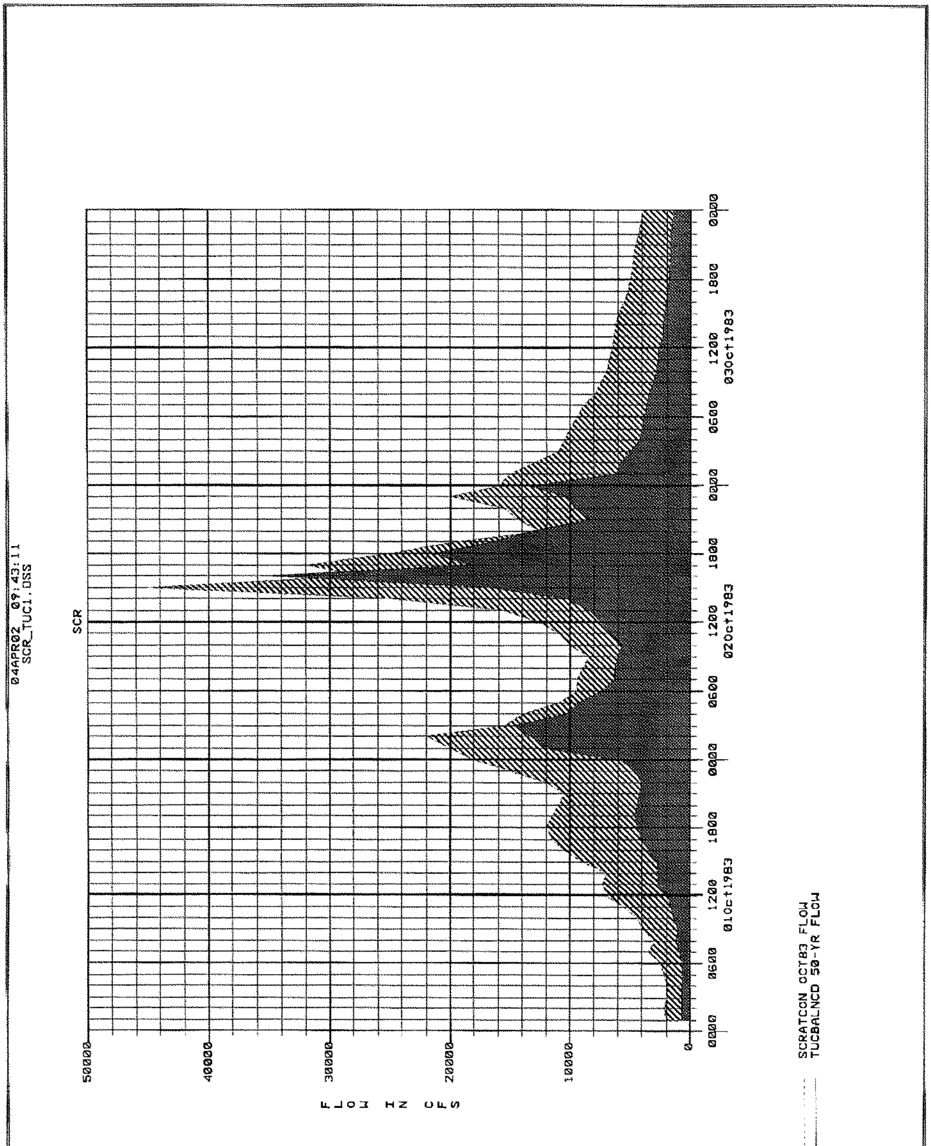

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EXHIBIT 5

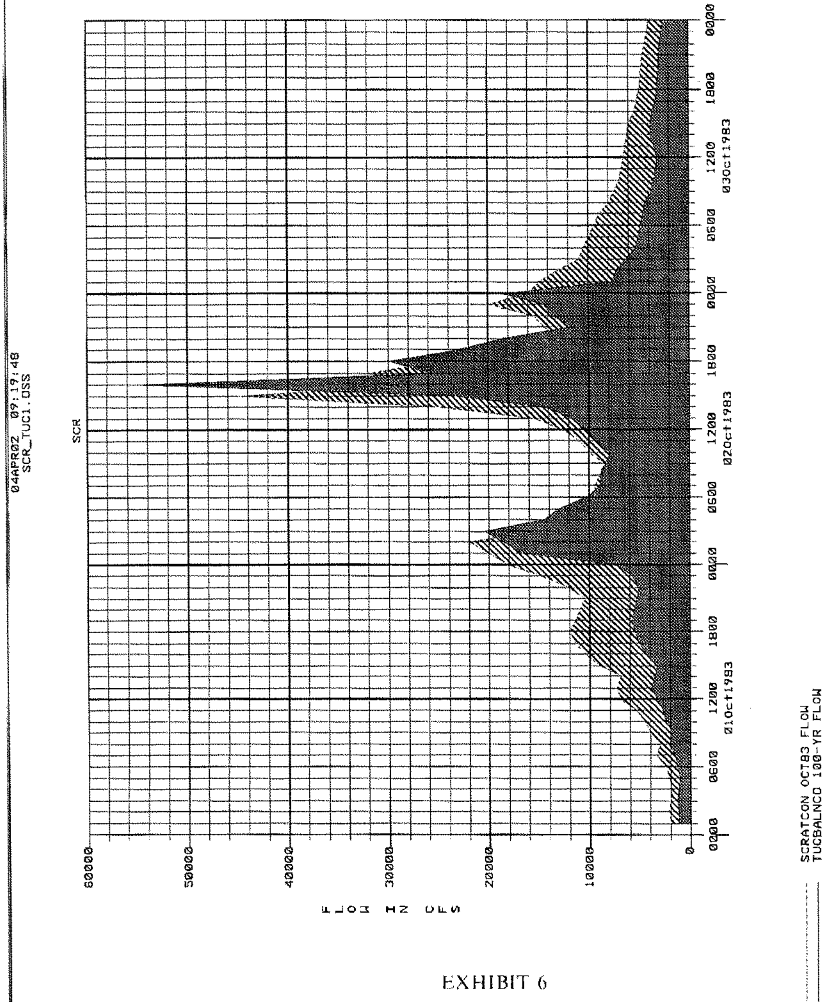
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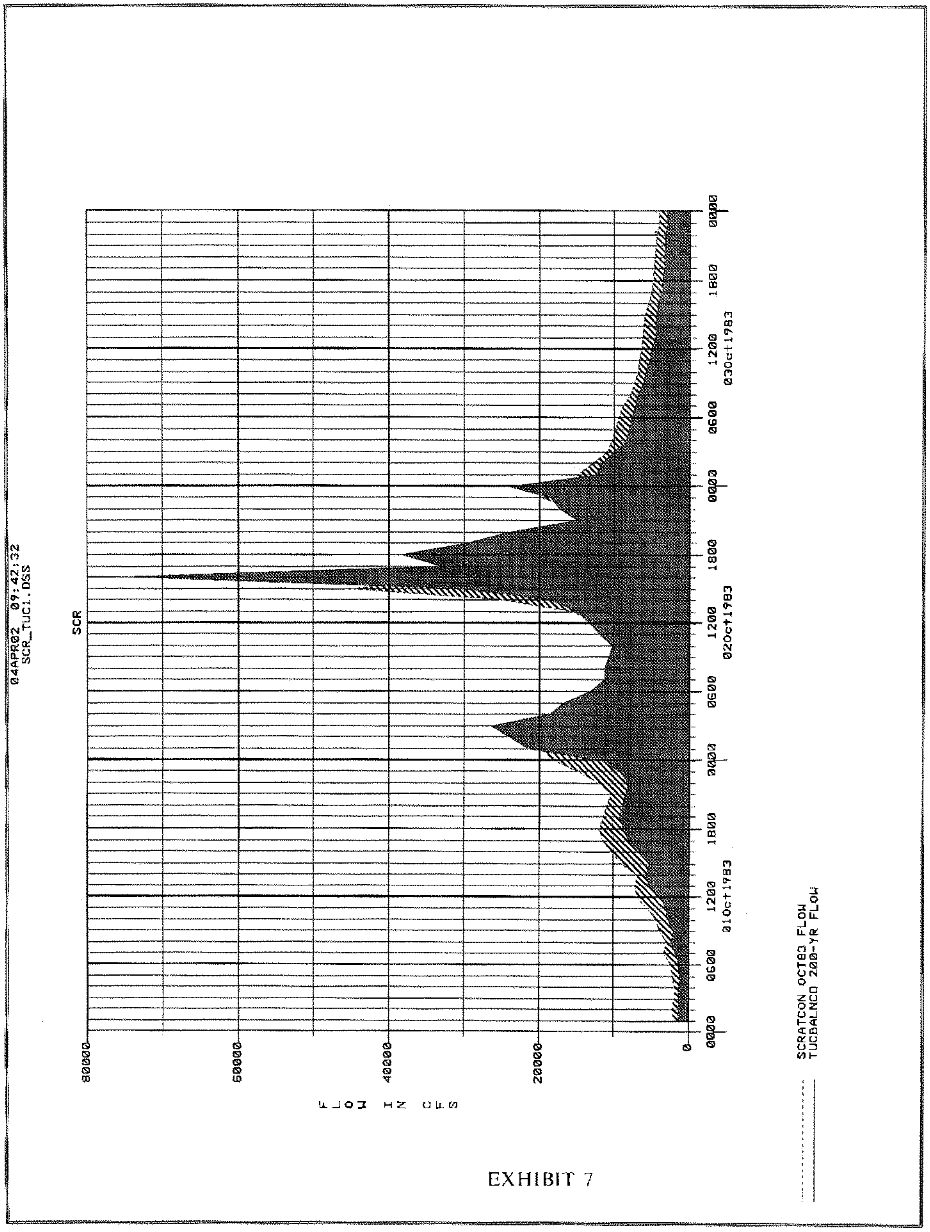
EXHIBIT 6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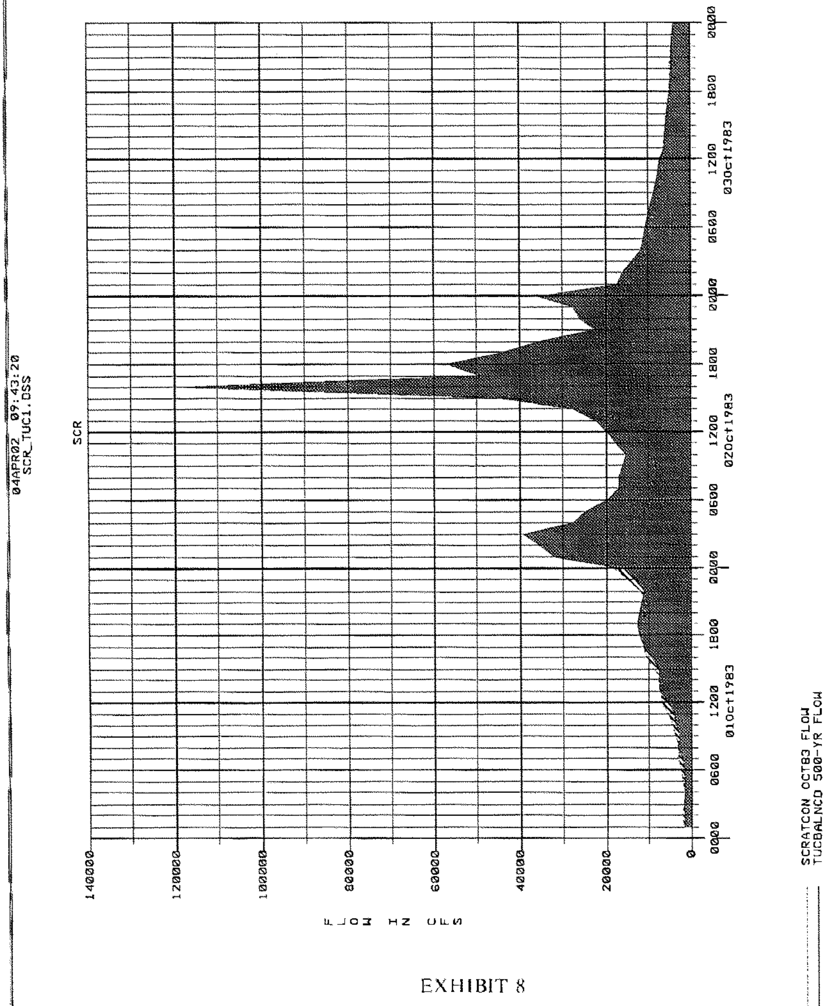
SCRATCON OCT83 FLOW
TUCBALNCD 200-YR FLOW

EXHIBIT 7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0600
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0600
1200
03Oct1983
1800
0000
SCRATCON OCT83 FLOW
TUCBALNCD 500-YR FLOW

EXHIBIT 8

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX B

HYDRAULIC INVESTIGATION

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

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Appendix 3: Request for a Letter of Map Revision for the Los Reales Improvement District Located in Pima County, Arizona, and the City of Tucson, Arizona: study boundaries, HEC-2 input and output printout for the West Branch of the Santa Cruz River from Valencia Road to the Reservation Boundary, HEC-2 input and output printout for the South Channel

Appendix 4: Midvale Park Master Drainage Report: study boundaries, West Branch Channel typical cross sections

I INTRODUCTION

The Paseo de Las Iglesias Study Area is traversed by several watercourses including the Santa Cruz River (SCR) and the West Branch of the Santa Cruz River (WBSCR). The study area is located between the Los Reales Road alignment and Congress Street within Township 14, Range 13, Sections 14, 22-24, 25-27, 34 and 35, as well as Township 15, Range 13, Sections 2-3, 10-11, 14, and 15 (Figure 1). Five separate studies contain hydraulic data for the watercourses traversing and immediately adjacent to this reach. This report summarizes the available hydraulic information, including HEC-2 analyses, work maps, and hydraulic information for bridges and culverts within and adjacent to the study area. Much of the information sited is available within the attached appendices.

II DESCRIPTION OF CURRENT HYDRAULIC STUDIES

1.1 The most recent SCR **Flood Insurance Study** (FIS) that includes the Paseo de Las Iglesias study area was performed on March 26th, 1990, by CMG Drainage Engineering Inc. The CMG Drainage Engineering study area covers the reach of the SCR downstream of the I-19 bridge (south of the study area) north past Congress Street through Tucson (Figure 1). The FIS was issued by the Federal Emergency Management Agency (FEMA) on February 8, 1999. The peak discharges of the SCR at both Drexel Road and Congress Street are reported to be 16800, 41000, 60000, and 93000 cfs for the 10-, 50-, 100-, and 500-year flood events, respectively. The drainage areas at Drexel Road and Congress Street are 2101 and 2222 square miles, respectively. The cross section elevations were determined using the 1984, 1"=200' aerial topography maps with a 2' contour interval based on the North American Vertical Datum (NAVD) 1929. The complete set of mylars of these orthophoto-topographic maps with floodplain delineations is available through the Pima County Department of Transportation, Mapping and Records Division. The FIS document is available through the FEMA Publication Center. Although no formal written report was prepared, CMG Drainage Engineering Inc. provided the input files for the HEC-2 analyses. A diskette containing the HEC-2 model input files for the 10-, 50-, 100-, and 500-year floodplain (PC25uf5.DAT) and the floodway (PC25ux5.DAT) for the Santa Cruz River from the I-19 bridge to Camino Del Cerro are available in Appendix 1.

1.2 **Master Drainage Study, Tohono O'odham Nation-San Xavier District Phase 1- Panhandle Area Existing Conditions** was prepared by McGovern, MacVittie, Lodge, and Associates, Inc. (MMLA) on July 31, 2001. The area studied is immediately adjacent to the south and west of the Paseo de Las Iglesias study area (Figure 1). Hydraulic information contained in this report includes details regarding four culvert crossings on Valencia Road, the Los Reales Improvement District collector and conveyance channels, and floodplain analysis utilizing HEC-RAS.

The culvert under Valencia Road at Valencia Wash (west of the Master Drainage Study area) is a seven-cell, 10' x 6' RCBC, with a design capacity (Q_{Design}) of 5257 cfs, which will fully contain 100-year flood discharge (Q_{100}) of 3680 cfs. A single-cell 10' x 4' RCBC culvert at the southwest corner of Mission Road and Valencia Road conveys flows under Valencia Road into a concrete lined channel that conveys flows into the WBSCR. The Q_{Design} of 360 cfs is sufficient to pass the Q_{100} of 251 cfs, assuming all flow will concentrate at the headwall of the culvert. A three-cell, 71" x 47" CMPA is located in the historic alignment of the WBCSR at Valencia and Mission Road, 900' west of the WBSCR channel realignment. The Q_{Design} of 512 cfs conveys low flows under Valencia Road. The final culvert documented in this MMLA report conveys the flows from the relocated WBSCR under Valencia Road, east of Mission Road. It is a ten-cell 12' x 8' RCBC with upstream channel improvements. The Q_{Design} of 8000 cfs could pass the Q_{100} of 6900 cfs, as determined in this MMLA Master Drainage Study, under Valencia road without breakout, except earthen berms near the relocated WBSCR prevent some runoff from entering the channel, contributing to a wide floodplain in the area. This relocated WBSCR culvert design was also analyzed in the Midvale Park Master Drainage Report, which is presented in Section 1.4 (below).

Collector and conveyance channels information described in the MMLA Master Drainage Study are based on information more completely documented in the Arroyo Engineering Inc. report described in section 1.3 (below). HEC-RAS analyses of the floodplains in the Panhandle Study Area were performed based on discharges obtained from Manning Equation calculations. Topographic mapping based on aerial topography taken November 15, 1992 was completed by Kucera International Inc., with a horizontal scale of 1"=200' and a vertical contour interval of 2', based on NAVD 1929. A summing of hydrographs was done to obtain the 100-year discharge of 6809 cfs for Mission Wash upstream of Valencia Road. The HEC-RAS output files, as well as maps showing cross section locations are included in Appendix 2.

1.3 The **Request for a Letter of Map Revision for the Los Reales Improvement District Located in Pima County, Arizona, and the City of Tucson, Arizona** report was completed by Arroyo Engineering Inc. in December of 1994. This Letter of Map Revision (LOMR) was approved by FEMA prior to the issuance of the February 8, 1999 FIS, so the information contained in the current FIS reflects this LOMR. The Los Reales Improvement District (LRID) is located south of Valencia Road, entirely within Section 15 of Township 15 South, Range 13 East (Figure 1). The report contains detailed hydraulic analysis based on existing conditions including a new floodwall and associated drainage channels. The ground-profile data for the eastern portion of the report was based on 1984 Cooper Aerial Survey Co. aerial topographic maps, and the western portion was based on the 1986, McLain Aerial Surveys aerial topography maps. Both map sets have a horizontal scale of 1"=200' and a 2' contour interval based on NAVD 1929. Two HEC-2 models were assembled. The first detailed the depth of ponding against the floodwall, determined flood depths south of Valencia Road along the WBSCR, and performed split flow analysis to differentiate water flowing into the South Channel or westward into the SCR. The second HEC-2 model and split flow analysis was used to predict water surface elevations in the South Channel, and quantify the amount of floodwater that will either flow northward along Indian Agency Road, or eastward in the South Channel.

Ground profile data used to represent the improved portions of the South Channel were taken from field survey data and approved constructions plans. In evaluating breakout flows, a value of 2.6 was assigned to the weir-loss coefficient "C" to represent the flow over the roadways and channel levees. Areas of ineffective flow downstream of channel expansions were assigned specific cross sections, and an expansion ratio of 4:1 was used to delineate these areas. A 100-year peak discharge of 7638 cfs (determined by Buck Lewis and Associates, Inc., 1982) was used to establish flood heights for the WBSCR.

Based on the split flow calculations, output data predicted that 3131 cfs will flow northward in the "West Branch Channel" (WBSCR) during a 100-year flood, 3308 cfs will flow northward from the Reservation into the South Channel, and 1199 cfs will flow directly eastward into the SCR. A split flow calculation performed on the 3131 cfs flowing northward in the WBSCR predicted that approximately 219 cfs and 123 cfs will breakout at two locations and sheet flow to the east. This 342 cfs of break-out flow will concentrate south of Valencia Road, then be conveyed under the road by a 2-cell, 10'x 4' RCBC, into a 30' wide flood control channel that trends northwesterly and feeds back into the WBSCR. A separate split flow calculation predicted that the 3308 cfs that flows in the South Channel during the 100-year flood would be entirely contained within the South Channel. Full printouts of the input and output files, the plotted hydraulic cross sections, and river profiles for the HEC-2 model of the SCR are contained in Appendix 3. Printouts contain a summary of the split flow calculations.

1.4 The **Midvale Park Master Drainage Report** was completed in July of 1983 by Dooley-Jones & Associates, Inc. This study covers an irregular area south of Irvington Road and west of the SCR, within Township 15 South, Range 13 East, Sections 3, 10, and 15 (Figure 1). The report described the general design of numerous hydraulic structures. Tables and graphs for roadway capacities were provided, but were not tied to specific locations. Numerous generalized typical, as well as some alternative, cross sections and plans are provided for roadways, drainage channels, detentions basins, spillways, etc., but no specific location information was provided for this hydraulic information. The typical cross sections for the West Branch Channel are included in Appendix 4.

1.5 The **Old West Branch of the Santa Cruz River Letter of Map Revision Study** was completed in 1994 by McGovern, MacVittie, Lodge, and Associates, Inc. No project report document was prepared. The Letter of Map Revision was approved by FEMA on July 24, 2000. The area studied includes the historic WBSCR north of Irvington Road to its confluence with the SCR (Figure 1). The cross section elevations were based on 1983, 1"=200' Cooper Aerial Survey Co. aerial topography maps with a 2' contour interval based on the NAVD 1929. The discharges used in the models were based on the Tucson Stormwater Management Study. Copies of the applicable work maps, and a diskette with the WBSCR HEC-2 input files are located in Appendix 1.

III. HYDRAULIC INVESTIGATION OF WITH PROJECT CONDITIONS

1.1 INTRODUCTION

1.1.1 PURPOSE

The purpose of this section is to document the hydraulic analysis completed in support of the Alternative Formulation Briefing (AFB) milestone for the Santa Cruz River, Paseo de las Iglesias Feasibility Study. This hydraulic analysis has been conducted to determine the "With Project" hydraulic conditions on the Santa Cruz River for the final array of alternatives. With Project hydraulic analysis was not performed on the Old West Branch and Los Reales tributaries, because no flood damage reduction or ecosystem restoration measures are being proposed for these reaches.

1.1.2 STUDY AREA DESCRIPTION

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it turns to flow northward and reenters Arizona about six miles east of Nogales. The river continues northward to Tucson then northwest to its confluence with the Gila River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the study area. Throughout this reach, flow occurs only because of effluent discharges or following major storms.

The Paseo de las Iglesias study area (see Figure 2) encompasses approximately 5005 acres and consists of a 7.5 river mile reach of the Santa Cruz River and its tributary washes. Beginning where Congress Street crosses the river in downtown Tucson the study area extends upstream to the south along the river to the boundary of the San Xavier District of the Tohono O'Odham Nation. The eastern study boundary is represented by Interstates 10 and 19. The western study area boundary is represented by Mission Road and the San Xavier District of the Tohono O'Odham Nation. Soil cement bank protection exists on both channel banks between Irvington Road and Ajo Way; near Valencia Road; and on both banks of the river between Silver Lake Road (29th Street) and Congress Street. All other portions of the river are unprotected with near vertical eroded banks. Bridges in the study area include Valencia Road, Irvington Road, Ajo Way, Silverlake Road, 22nd Street, and Congress Street.

The main channel of the Santa Cruz River flows in a relatively straight northerly direction from the southern to the northern borders of the study area. The West Branch tributary of the Santa Cruz River currently extends from the southern border of the study area to the north approximately 3.5 river miles to where it joins the mainstem of the Santa Cruz River, just north of Irvington Road. The portion of this channel just north of Irvington Road, the New West Branch, has been re-routed. The former channel (before it was re-routed) extends from just north of Irvington to just south of 22nd Street where it joins the mainstem of the Santa Cruz River.

The reach investigated for this hydraulic analysis includes approximately seven and one-half (7.5) river miles of stream channel and historic floodplain areas and is characterized by an incised, partially bank protected river with a narrow 100-year floodplain. Between Ajo Way and Irvington Road, the New West Branch tributary joins the Santa Cruz River at a confluence marked by a large concrete drop structure and energy dissipater.

1.1.2.1 Major Tributaries

Old West Branch: The Old West Branch of the Santa Cruz River is an entrenched natural channel that extends from Irvington Road to 22nd Street where it joins the river. The average base width is 20 ft and the average bank height is 10 ft. There is a significant amount of vegetation (e.g., mesquite) growing along the banks and some vegetation growing in the channel bed. There is a large concrete drop structure at the confluence of the New West Branch and the Santa Cruz River. Vehicular bridges exist at the Silverlake Road and Ajo Way crossings.

Los Reales Improvement District: The Pima County Department of Transportation and Flood Control District (FCD) formed the Los Reales Improvement District in 1987 in order to construct a flood-control levee and associated drainage ways. The District is located at the upstream end of the New West Branch, between Los Reales and Valencia Roads. The purpose of this project was to divert flows around the development and dispose of these flood flows either into the Santa Cruz River or into the New West Branch channel. Along the south boundary of this Improvement District, there is a 4 ft high, 1400 ft long floodwall, which extends between the Tohono O'odham Indian Reservation Boundary and Indian Agency Road. On the west end of this floodwall, a partially lined concrete channel diverts a portion of the flood flows northward into the New West Branch channel. A partially lined concrete channel exists along the south edge of the development and diverts all remainder flood flows into the Santa Cruz River approximately opposite Hughes Wash.

New West Branch: The New West Branch diversion is an entrenched partially bank protected trapezoidal channel that extends 3.5 miles from Los Reales road to Irvington Road where it joins the river. The channel has a natural bottom with 3 on 1 concrete lined sideslopes. The base width varies from 100 to 120 ft. The average bank height is 8 ft. There is a large concrete drop structure at the confluence of the New West Branch and the Santa Cruz River. Vehicular bridges exist at Irvington and Valencia Roads and one (1) a pedestrian bridge exists south of Drexel Road.

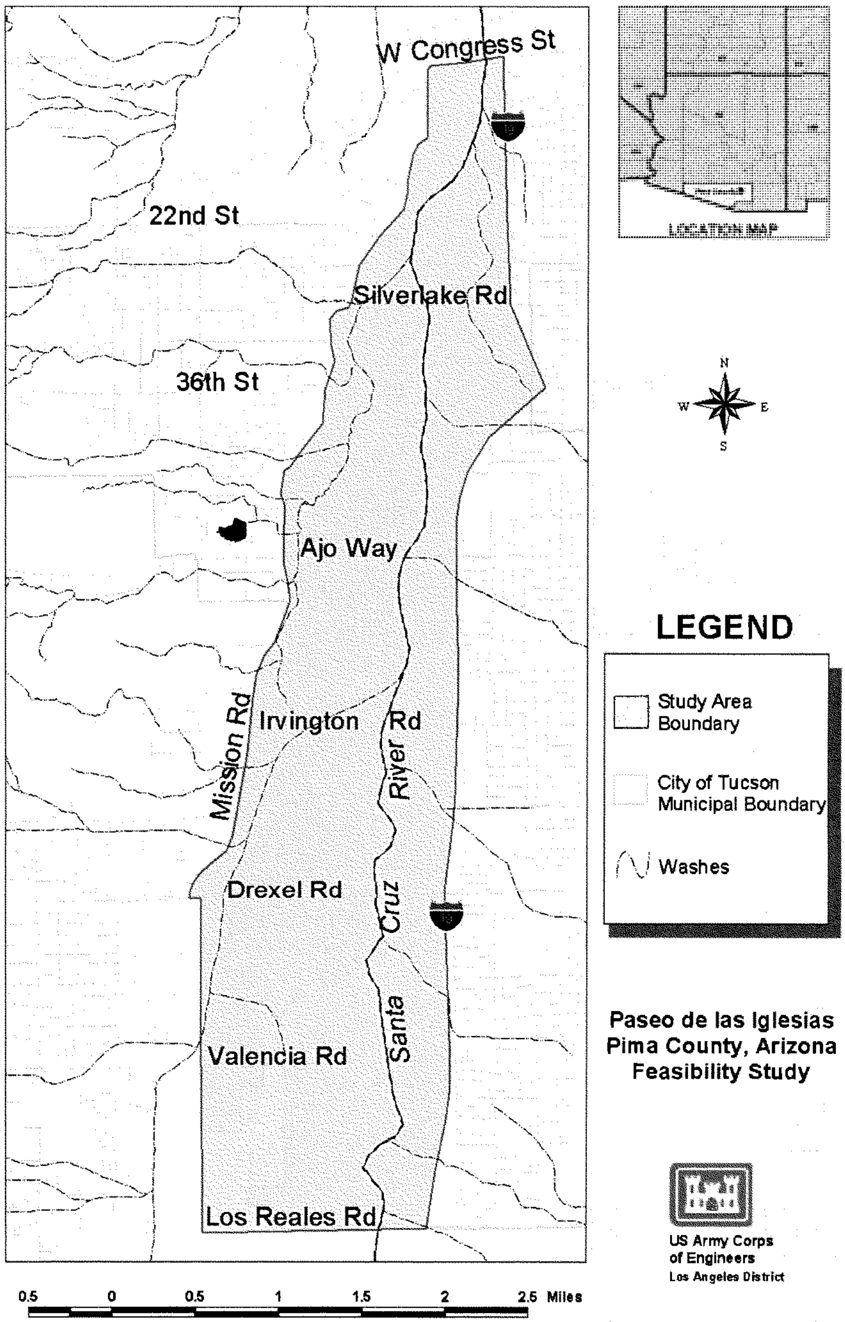

Figure 2: Paseo de las Iglesias Study Area

1.2 METHODOLOGY

1.2.1 GUIDANCE

The hydraulic analysis was prepared in accordance with EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", USACE 1994. EM 1110-2-1418, "Channel Stability Assessment for Flood Control Projects" (USACE, 1994), and EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies" (USACE, 1996) provided additional guidance.

1.2.2 ANALYSIS TOOLS

HEC-RAS (USACE 2001) was used for the Santa Cruz River with project conditions model(s). The ArcView (ESRI 1999) extension HEC-GeoRAS (HEC 2000) was used as a pre and post processor for HEC-RAS.

1.2.3 HYDROLOGY AND DESIGN DISCHARGES

Table 1 below summarizes the peak discharges that were used for the with project hydraulic analysis. Hydrologic methodologies and assumptions were used to develop the respective discharges are documented in Appendix A, Hydrology.

Table 1: Santa Cruz River (Drainage Area = 2,222 Sq. mi.)
Discharge – Frequency Relationships

Frequency (Year)	Discharge (cfs)
2	4,900
5	9,500
10	14,000
20	20,000
50	35,000
100	55,000
200	75,000
500	120,000

1.2.4 TOPOGRAPHIC MAPPING AND VERTICAL DATUM

The information used for this study is based on two vertical datums. The original Flood Insurance Study (FIS) models and workmaps that were based on the National Geodetic Vertical Datum of 1929 (NGVD 1929). The datum used for the current topography is the North American Vertical Datum of 1988 (NAVD 1988). The difference between these datums varies as a function of location.

However, within the study reach, a constant difference was determined to be appropriate and reasonable. The following equations were used to convert between the datums:

Elev(NAVD) = Elev(NGVD) + ♠Elev
Elev(NGVD) = Elev(NAVD) - ♠Elev

where: Elev(NAVD) = elevation in NAVD 1988 datum;
Elev(NGVD) = elevation in NGVD 1929 datum.
♠Elev = 2.2 ft.

The Pima County Flood Control District provided digital orthophotos (1998), digital terrain model (DTM) breakline data, DTM mass points, ArcInfo coverage of the existing mapped floodplains, and digital GIS layers for the County. Additional field survey data was provided by Pima County for the New West Branch diversion. Triangulated Irregular Networks (TIN) were then developed to obtain cross section data for the models. All topography provided by Pima County was based on NAVD 1988 datum.

1.2.4.1 New West Branch Survey Information

Field survey information for the New West Branch channel was provided by Pima County on 18 June 2003. The survey information consisted of a spreadsheet containing northing, easting, elevation data and an AutoCAD image of the points and breaklines. The data is on the same coordinate system as the topography that was used in the original hydraulic model. Pima County also provided some field drawing showing structure locations (e.g., bike paths, concrete channel locations, pipes).

1.3. HYDRAULIC ANALYSES

1.3.1 PREVIOUS MODELS AND DATA

The Pima County Department of Transportation and Flood Control District assembled a continuous HEC-2 water surface profile model for the Santa Cruz River that extended through Pima County, from the Santa Cruz County line to the Pinal County line. The original model was adapted from previously coded HEC-2 flood insurance study and County engineering study models.

In September 1998, the Corps of Engineers (USACE) converted the original Pima County HEC-2 model into a HEC-RAS model for the Gila River, Santa Cruz River Watershed, Pima County, Arizona, Final Feasibility Study, dated August 2001. Within Pima County, the Santa Cruz River was modeled under six contiguous reaches, which provided the modelers an efficient method to characterize the hydraulic differences along the river. The geometric data contained in the USACE model was updated at several locations along the Santa Cruz River from cross-section data provided by Pima County that was generated from detailed topography provided to the County by the U.S. Bureau of Reclamation.

The Paseo de las Iglesias study area is contained in the Tucson Urban reach, known as Reach 4 in the USACE Santa Cruz River Watershed Feasibility Study. The original cross-section geometric data within the stream valley in Reach 4 was not updated from the Bureau of Reclamation topography; however, some of the overbank areas (also known as the Historic Floodplain) have been updated using the GEO-RAS software program. The distinction for the age of the geometric data indicates that the station versus elevation data used to define the in-channel cross-sections (low flow area) is older than the historic floodplain (upland areas that receive flow only during major flood events) data, which was more recently updated with accurate topography. In short, the model's accuracy for predicting floodwater surface elevations is somewhat diminished "inside" the channel, whereas flood elevations "outside" the channel are more accurate.

Starting Water Surface Elevations

The starting water surface elevations were determined for each model based on stage-discharge curves from the FIS model at the downstream end of the Santa Cruz River model.

Bridge Modeling

All bridges on the Santa Cruz River were modeled using detailed bridge geometry developed for the Santa Cruz River Watershed Study (USACE 2001) HEC-RAS model. Contraction and expansion loss coefficients were set at 0.30 and 0.50, respectively in the cross sections upstream and downstream of bridges. Standard bridge pier loading was used.

Manning's Roughness Coefficients

Manning's roughness coefficients contained in the Pima County FIS model were used initially. These roughness coefficients were subsequently field checked and found to be reasonable. In general, roughness coefficients assigned to the channel, overbanks, and ineffective flow areas were 0.025 – 0.035, 0.035 – 0.070, and 1.00 respectively.

For with project conditions, the roughness coefficients will be increased to reflect the proposed establishment of vegetation along the channel where it does not currently exist.

1.3.1.1 Revised New West Branch Model

At the request of the non-federal sponsor, additional hydraulic analysis was performed subsequent to the Without Project investigation. Based on suspicions that the New West Branch Channel actually has a higher conveyance capacity, field survey data described in Section 2.4.1 was provided by the non-federal sponsor. The Without Project HEC-RAS model was then updated using this new survey information. However, there were two limitations with the new data: 1) the survey locations did not correspond with the original HEC-RAS cross-sections, and were subsequently incorporated into the original model as additional cross-sections; and 2) the new survey only included channel geometric information, i.e. there was no overbank information. Once the original HEC-RAS model was updated with new geometric information, another channel capacity-split flow analysis was performed to determine the amount of water overtopping the left bank. Finally, the left overbank was modeled separately using the flows determined from the split flow analysis to compute the more representative water surface elevations.

1.3.1.1.1 *<u>Revised New West Branch Model Results</u>*

1. The 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flood events were simulated for the New West Branch channel reach. There are no breakouts for the 50-year flood event. The New West Branch was determined to have a flood conveyance capacity of between a 50- and 100-year flood event within the channel system. The 100-, 200-, and 500-year flood events would overtop the channel banks, primarily the left overbank looking downstream.
2. For the 100-year flood event, approximately 1,120 cfs overtops the left bank. The breakout over the weir (left levee) extends approximately 760 ft with a depth of 1-2 ft. The overbank breakout flow then quickly spreads out onto the overbank where flood depths of approximately one foot are experienced.
3. The 200- and 500-year flood events would overtop the channel similar to the original HEC-RAS model results.
4. Plate 15 in the Without Project Hydraulics Appendix was updated to reflect the changes described above. Specifically, the 50-year floodplain was removed from the left overbank. The 100-year floodplain was redrawn, while the 200- and 500-year floodplains remained the same.
5. <u>Conclusions</u>: The revised without-project overflow analysis for the New West Branch of the Santa Cruz River indicated that the existing channel capacity and

amount of overflow is different from the original hydraulic model results. Applicable hydraulic data tables, overflow maps, and equivalent annual damage estimates were updated based on the results of this analysis.

1.3.2 SANTA CRUZ RIVER WITH PROJECT CONDITIONS ANALYSIS

As part of the project, ecosystem restoration measures are being proposed within the active channel, on the channel banks and the historic overbank floodplain. The predominant method for ecosystem restoration is the establishment of native vegetation species in areas that do not receive high frequency flows. These areas exist within the main channel but are located on terraces that are above low flow channel or 2-year recurrent event water surface elevation.

Stream banks along the Santa Cruz River are highly unstable and nearly vertical cliffs composed of weakly cemented sands, which are highly susceptible to instability from shear stresses during flood events, desiccation and wind erosion from the lack of vegetative cover that would normally provide stability from these erosive forces. Modifications to the present channel geometry important to the ability to construct, re-vegetate and sustain a restored riparian ecosystem include lowering the gradient of the steep channel banks, reducing instability from water and wind erosion. By altering the station versus elevation data on specific River Station cross-sections, the available flow area within the channel can be increased which would result in a lower water surface elevation.

The hydraulic investigation of the potential impacts of the proposed actions for the project can be analyzed by modeling the proposed conditions and comparing the results to the existing conditions. The two major changes to the existing model, adding vegetation for an increased Manning's roughness coefficient and decreasing the steepness of the channel banks through the alteration of station versus elevation data, will allow for the comparison of existing and proposed conditions.

1.3.3 SANTA CRUZ RIVER MODEL ALTERATION

The existing USACE Santa Cruz River Watershed Study HEC-RAS model was used to determine the hydraulic effects of proposed channel alterations on portions of the study area. The limits of the HEC-RAS model for the Santa Cruz River study are located upstream at River Station 40.11 (Los Reales Road) and downstream at River Station 32.62 (Congress Street bridge). River Stations within the model are defined and measured as river miles starting at zero at the mouth of the Santa Cruz and increasing in an upstream direction. There are 73 HEC-RAS River Station (RS) cross-sections and five bridge crossings within the study area model. Areas along the project reach that lacked soil cement bank protection and had sufficient width of adjacent vacant land were identified for the establishment of vegetation and laying back the over steep banks. Areas along the channel that are currently protected by soil cement or areas where development exists in close proximity to the historic floodplain were not altered in the model. Based on these parameters, two main reaches of the model were identified for channel alterations as shown in Table 2:

Table 2: Reach Alteration River Station Limits

Reach	Upstream RS in Reach	Downstream RS in Reach	No. of RS Altered
Upstream	RS 39.16 (Valencia Rd)	RS 36.93 (Irvington Rd)	23
Downstream	RS 35.66 (Ajo Way)	RS 34.34 (Silverlake Rd)	15

The cross-section geometric data for each River Station in these two reaches was examined to determine the existing slopes of the channel banks and the location and value of the Manning's roughness coefficient. Within the station versus elevation data that define the cross-sectional shape of the channel at that River Station, the channel banks that were steeper than a five-on-one vertical to horizontal (5:1 V:H) slope where altered to achieve a 5:1 slope. The station versus elevation data pairs that defined the steep slopes within the cross-section were replaced by proposed station versus elevation data pairs that were set on a 5:1 slope.

Alteration to the existing station versus elevation data pairs was limited to only those data pairs that define the channel geometry at elevations above the 2-year recurrent storm water surface elevation. By preserving geometric data pairs near the invert of the channel, the channel-forming discharge (also known as the bankfull discharge) was left in tact to prevent further instability within the low flow boundaries of the channel.

The location and value of the Manning's roughness coefficient was reviewed and altered for each of the River Stations identified in Table 2. The roughness coefficient is applied to each cross-section by indicating the location and value in the model. The overbank areas, either left overbank or right overbank, usually have higher roughness values than in the channel, which is attributed to the fact that larger vegetation and/or development (resulting in higher roughness values) is more readily able to grow in less flooded areas on the overbanks. Likewise, the channel roughness values are lower because frequent discharges presumably reduce the ability for vegetation to persist.

Manning's roughness values for floodplain (or overbank) areas in the project were set at 0.05, corresponding to the existing scattered brush and trees in the project area. The roughness values for channel areas in the project were set at 0.025; the appropriate value for the existing clean, straight, full stage channel, with no rifts or deep pools. The roughness values (0.05 in the floodplain and 0.025 in the channel) set for the project were unchanged in value, however, the location of where the roughness values were applied was changed in each of the 38 altered River Stations. The left overbank and right overbank areas (roughness set at 0.05) were expanded toward the centerline of the channel to account for the proposed establishment of vegetation on the banks and in the terraces. Likewise, the channel roughness value (set at 0.025) was applied to the reduced lateral extent of the 2-year recurrent storm water surface elevation, where dense vegetation typically does not exist, due to the higher frequency of flow.

1.3.4 SANTA CRUZ RIVER MODEL RESULTS

There was an increase in the 100-year recurrent floodwater surface elevation in 19 of the 38 altered cross-sections due to the change in roughness values within the channel (decreasing horizontal range of 0.025 to only include 2-year event discharges). A rise is defined in this investigation as any increase exceeding 0.1 feet in vertical elevation. The largest rise was 1.53 feet at River Station 37.4, which is located on a meander bend approximately halfway between Irvington Road bridge crossing and Drexel Road. The proposed 100-year recurrent flood event water surface elevation at this, and all other locations showing increases remains within the Santa Cruz River valley banks and would not induce flooding conditions in the historic floodplain.

Thirteen (13) altered cross-section River Stations showed a reduction in the 100-year recurrent flood water surface elevation due primarily to added available flow area from laying back the steep banks to a uniform 5:1 slope. A reduction is defined in this investigation as any decrease in water surface elevation greater than 0.09-feet. River Station 35.66, located immediately downstream from the Ajo Way bridge crossing, exhibited the largest reduction in water surface flood elevation at a minus 2.03 feet. The remaining six cross-section River Stations either exhibited no change in water surface elevation, exhibited an increase between 0 and 0.1 feet, or exhibited a reduction in water surface elevation between 0 and 0.1 feet.

These results are expected and would typically be observed in this type of project where both the roughness and channel geometry are altered for the purpose of ecosystem restoration and bank stability efforts. Table 3 provides a comparison of With and Without Project model results. River stations are measured from the confluence of the Santa Cruz River and Gila River, 35 miles downstream of the study area. Overflow maps are provided in Figures 2a and 2b following Table 3.

Table 3: Santa Cruz River Comparison – With Project

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
40.11	2YR	4900	2469.23	2469.23	0
40.11	100YR	55000	2475.79	2475.79	0
40.01	2YR	4900	2468.45	2468.45	0
40.01	100YR	55000	2472.89	2472.89	0
39.92	2YR	4900	2466.88	2466.88	0
39.92	100YR	55000	2470.83	2470.86	0.03
39.82	2YR	4900	2461.68	2461.68	0
39.82	100YR	55000	2470.64	2470.67	0.03
39.73	2YR	4900	2461.48	2461.48	0
39.73	100YR	55000	2469.91	2469.95	0.04

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
39.63	2YR	4900	2459.64	2459.65	0.01
39.63	100YR	55000	2466.77	2466.5	-0.27
39.54	2YR	4900	2452.28	2452.28	0
39.54	100YR	55000	2468.56	2468.44	-0.12
39.44	2YR	4900	2452.26	2452.25	-0.01
39.44	100YR	55000	2468.32	2468.19	-0.13
39.35	2YR	4900	2452.24	2452.24	0
39.35	100YR	55000	2468.33	2468.2	-0.13
39.25	2YR	4900	2452.24	2452.24	0
39.25	100YR	55000	2468.31	2468.18	-0.13
39.16	2YR	4900	2451.19	2451.19	0
39.16	100YR	55000	2461.3	2461.34	0.04
39.06	2YR	4900	2448.34	2448.36	0.02
39.06	100YR	55000	2460.92	2459.64	-1.28
38.97	2YR	4900	2445.32	2445.32	0
38.97	100YR	55000	2462.12	2461.85	-0.27
38.965	Bridge at Valencia Road				
38.96	2YR	4900	2444.58	2444.58	0
38.96	100YR	55000	2461.85	2461.56	-0.29
38.82	2YR	4900	2444.11	2444.11	0
38.82	100YR	55000	2461.97	2461.64	-0.33
38.73	2YR	4900	2443.98	2443.98	0
38.73	100YR	55000	2461.84	2461.42	-0.42
38.63	2YR	4900	2443.68	2443.68	0
38.63	100YR	55000	2461.52	2460.85	-0.67
38.54	2YR	4900	2441.46	2441.46	0
38.54	100YR	55000	2454.84	2454.7	-0.14
38.44	2YR	4900	2437.64	2437.64	0
38.44	100YR	55000	2448.7	2448.88	0.18
38.35	2YR	4900	2435.89	2435.89	0
38.35	100YR	55000	2449.1	2449.69	0.59

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
38.25	2YR	4900	2435.22	2435.23	0.01
38.25	100YR	55000	2449.04	2449.59	0.55
38.16	2YR	4900	2433.42	2433.42	0
38.16	100YR	55000	2443.53	2443.84	0.31
38.06	2YR	4900	2430.62	2430.61	-0.01
38.06	100YR	55000	2438.59	2439.12	0.53
37.97	2YR	4900	2429.4	2429.29	-0.11
37.97	100YR	55000	2438.19	2438.63	0.44
37.87	2YR	4900	2428.44	2428.34	-0.1
37.87	100YR	55000	2437.85	2438.17	0.32
37.78	2YR	4900	2427.53	2427.54	0.01
37.78	100YR	55000	2435.48	2436.56	1.08
37.69	2YR	4900	2425.24	2425.22	-0.02
37.69	100YR	55000	2432.52	2433.24	0.72
37.59	2YR	4900	2422.32	2422.43	0.11
37.59	100YR	55000	2431.07	2431.52	0.45
37.5	2YR	4900	2420.07	2420.06	-0.01
37.5	100YR	55000	2430.66	2430.6	-0.06
37.4	2YR	4900	2418.3	2418.25	-0.05
37.4	100YR	55000	2428.37	2429.9	1.53
37.31	2YR	4900	2416.32	2416.44	0.12
37.31	100YR	55000	2427.15	2426.74	-0.41
37.21	2YR	4900	2414.97	2415	0.03
37.21	100YR	55000	2426.71	2426.68	-0.03
37.12	2YR	4900	2413.64	2413.62	-0.02
37.12	100YR	55000	2426.35	2426.66	0.31
37.02	2YR	4900	2412.55	2412.53	-0.02
37.02	100YR	55000	2426.06	2426.58	0.52
36.93	2YR	4900	2409.84	2409.85	0.01
36.93	100YR	55000	2425.66	2424.93	-0.73

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
36.83	2YR	4900	2406.66	2406.66	0
36.83	100YR	55000	2425.72	2425.72	0
36.825	Bridge at Irvington				
36.82	2YR	4900	2405.23	2405.23	0
36.82	100YR	55000	2415.19	2415.19	0
36.72	2YR	4900	2403.34	2403.34	0
36.72	100YR	55000	2412.15	2412.15	0
36.63	2YR	4900	2400.53	2400.53	0
36.63	100YR	55000	2412.33	2412.33	0
36.54	2YR	4900	2399.42	2399.42	0
36.54	100YR	55000	2413.18	2413.18	0
36.44	2YR	4900	2398.23	2398.23	0
36.44	100YR	55000	2409.92	2409.92	0
36.35	2YR	4900	2396.84	2396.84	0
36.35	100YR	55000	2408.79	2408.79	0
36.25	2YR	4900	2395.84	2395.84	0
36.25	100YR	55000	2408.43	2408.43	0
36.16	2YR	4900	2394.47	2394.47	0
36.16	100YR	55000	2407.2	2407.2	0
36.06	2YR	4900	2392.93	2392.93	0
36.06	100YR	55000	2405.5	2405.5	0
35.97	2YR	4900	2390.12	2390.12	0
35.97	100YR	55000	2403.03	2403.04	0.01
35.87	2YR	4900	2389.79	2389.79	0
35.87	100YR	55000	2403.1	2403.11	0.01
35.78	2YR	4900	2388.67	2388.67	0
35.78	100YR	55000	2401.88	2401.88	0
35.775	Bridge at Ajo Way				
35.77	2YR	4900	2387.62	2387.62	0
35.77	100YR	55000	2398.6	2398.6	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
35.66	2YR	4900	2383.58	2383.58	0
35.66	100YR	55000	2395.78	2393.75	-2.03
35.57	2YR	4900	2382.74	2382.72	-0.02
35.57	100YR	55000	2391.2	2391.22	0.02
35.47	2YR	4900	2381.1	2381.09	-0.01
35.47	100YR	55000	2389.48	2389.98	0.5
35.38	2YR	4900	2379.67	2379.67	0
35.38	100YR	55000	2388.91	2389.75	0.84
35.29	2YR	4900	2377.91	2377.91	0
35.29	100YR	55000	2385.5	2385.78	0.28
35.19	2YR	4900	2376.5	2376.5	0
35.19	100YR	55000	2386.02	2386.06	0.04
35.1	2YR	4900	2375.33	2375.35	0.02
35.1	100YR	55000	2384.83	2384.02	-0.81
35	2YR	4900	2374.06	2373.85	-0.21
35	100YR	55000	2381.4	2381.41	0.01
34.91	2YR	4900	2372.47	2372.56	0.09
34.91	100YR	55000	2382.4	2382.9	0.5
34.81	2YR	4900	2369.62	2369.61	-0.01
34.81	100YR	55000	2379.88	2379.06	-0.82
34.72	2YR	4900	2367.01	2367.05	0.04
34.72	100YR	55000	2379.7	2378.3	-1.4
34.62	2YR	4900	2366.41	2366.45	0.04
34.62	100YR	55000	2377.82	2377.95	0.13
34.53	2YR	4900	2365.24	2365.24	0
34.53	100YR	55000	2378.49	2378.34	-0.15
34.43	2YR	4900	2362.4	2362.4	0
34.43	100YR	55000	2378.3	2377.98	-0.32
34.34	2YR	4900	2359.3	2359.31	0.01
34.34	100YR	55000	2377.32	2376.87	-0.45
34.25	2YR	4900	2357.34	2357.34	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
34.25	100YR	55000	2376.17	2376.17	0
34.245	Bridge at Silverlake				
34.24	2YR	4900	2356.23	2356.23	0
34.24	100YR	55000	2367.77	2367.77	0
34.14	2YR	4900	2352.86	2352.86	0
34.14	100YR	55000	2365.45	2365.45	0
34.05	2YR	4900	2350.55	2350.55	0
34.05	100YR	55000	2363.73	2363.73	0
33.95	2YR	4900	2350.35	2350.35	0
33.95	100YR	55000	2365.62	2365.62	0
33.86	2YR	4900	2349.38	2349.38	0
33.86	100YR	55000	2362.38	2362.38	0
33.76	2YR	4900	2348.08	2348.08	0
33.76	100YR	55000	2361.08	2361.08	0
33.755	Bridge at 22nd Street				
33.75	2YR	4900	2346.96	2346.96	0
33.75	100YR	55000	2359.02	2359.02	0
33.66	2YR	4900	2343.92	2343.92	0
33.66	100YR	55000	2359.21	2359.21	0
33.57	2YR	4900	2343	2343	0
33.57	100YR	55000	2359.18	2359.18	0
33.47	2YR	4900	2342.02	2342.02	0
33.47	100YR	55000	2356.6	2356.6	0
33.38	2YR	4900	2340.92	2340.92	0
33.38	100YR	55000	2354.7	2354.7	0
33.28	2YR	4900	2339.79	2339.79	0
33.28	100YR	55000	2352.68	2352.68	0
33.19	2YR	4900	2338.64	2338.64	0
33.19	100YR	55000	2350.77	2350.77	0
33.09	2YR	4900	2338.19	2338.19	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
33.09	100YR	55000	2352.45	2352.45	0
33	2YR	4900	2337.02	2337.02	0
33	100YR	55000	2351.65	2351.65	0
32.9	2YR	4900	2334.77	2334.77	0
32.9	100YR	55000	2350.15	2350.15	0
32.81	2YR	4900	2333.55	2333.55	0
32.81	100YR	55000	2350.13	2350.13	0
32.72	2YR	4900	2332.9	2332.9	0
32.72	100YR	55000	2350.07	2350.07	0
32.62	2YR	4900	2331.85	2331.85	0
32.62	100YR	55000	2347.46	2347.46	0
32.615	Bridge at Congress Street				
32.61	2YR	4900	2331.48	2331.48	0
32.61	100YR	55000	2343.46	2343.46	0
32.53	2YR	4900	2330.8	2330.8	0
32.53	100YR	55000	2343.5	2343.5	0
32.44	2YR	4900	2328.25	2328.25	0
32.44	100YR	55000	2340.82	2340.82	0
32.34	2YR	4900	2325.37	2325.37	0
32.34	100YR	55000	2341.27	2341.27	0
32.25	2YR	4900	2323	2323	0
32.25	100YR	55000	2340.48	2340.48	0
32.15	2YR	4900	2321.94	2321.94	0
32.15	100YR	55000	2341.06	2341.06	0
32.06	2YR	4900	2320.98	2320.98	0
32.06	100YR	55000	2340.87	2340.87	0
31.96	2YR	4900	2319.87	2319.87	0
31.96	100YR	55000	2339.73	2339.73	0
31.955	Bridge at St. Marys				
31.95	2YR	4900	2318.71	2318.71	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
31.95	100YR	55000	2332.88	2332.88	0
31.82	2YR	4900	2315.83	2315.83	0
31.82	100YR	55000	2328.3	2328.3	0
31.73	2YR	4900	2314.02	2314.02	0
31.73	100YR	55000	2328.03	2328.03	0
31.63	2YR	4900	2311.68	2311.68	0
31.63	100YR	55000	2327.63	2327.63	0
31.54	2YR	4900	2310.72	2310.72	0
31.54	100YR	55000	2328.56	2328.56	0
31.53		Bridge at Speedway			
31.52	2YR	4900	2310.13	2310.13	0
31.52	100YR	55000	2323.43	2323.43	0

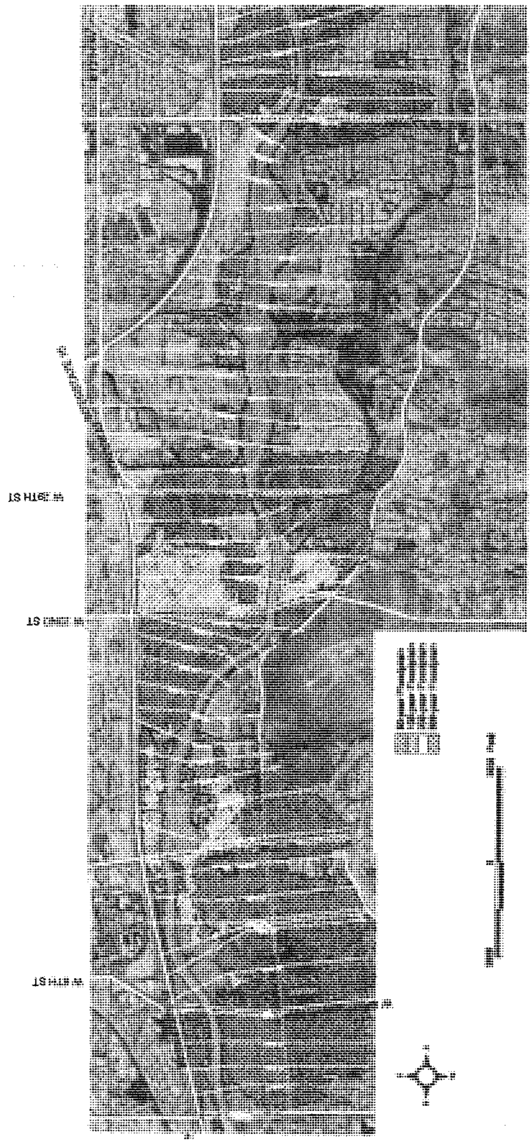

Figure 3 Santa Cruz River With Project Floodplain
Northern Portion of Study Area

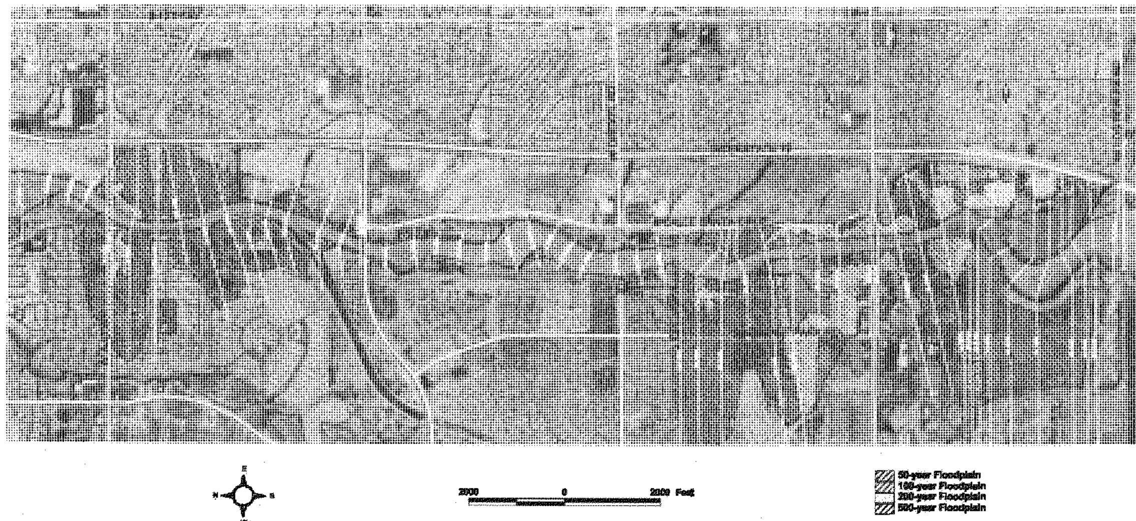

Figure 4 Santa Cruz River With Project Floodplain
Southern Portion of Study Area

1.3.5 SEDIMENT BUDGET ANALYSIS

To date, a sediment budget level of analysis was undertaken for the Without Project Condition only. The computer program SAM (WES, 1997) was used for the sediment budget analysis. More detailed analysis (e.g., HEC-6, HEC, 1993) program model approach will be utilized once a recommend plan is identified for design purposes.

In general, the previous analysis results indicate that there would be significant to moderate degradation at both the extreme upstream and downstream reaches and to a lesser extent within the middle reaches. In other words, almost all of the entire study reach was found to be subject to some overall degradation. However, a full comprehension of the results especially at the upstream and downstream limit of the study reach needs to be expanded upon. In the case of the upstream reach, the deep scour phenomenon may be the result of the equilibrium conditions that were assumed for this reach. Whereas, for the downstream reach, the obvious effects of the existing grade control structure downstream of Congress Street could not be incorporated in the sediment budget model. Hence, the application of a sediment budget analysis inherently suffers several notable shortcomings as a penalty for the simple and expedient nature of the calculations. Specifically, the analysis does not properly restrict the deposition of the wash load from the supply reach; it does not revise the hydraulic characteristics of the stream to reflect the changes in bed slope caused by scour and deposition; it does not account for the effect of changes in the bed material composition on the computed sediment transport capacities; and it does not account for armoring of the streambed that would limit degradation. Because of these simplifications, a sediment budget analysis typically overestimates aggradation and degradation. This overestimation is evident in the results for the upstream reach of the Santa Cruz River. In addition, a sediment budget analysis is extremely sensitive to the selection of subreaches and representative cross sections. Relatively minor differences in average hydraulic characteristics, particularly velocity, can translate into large differences in computed average bed changes. For these reasons, firm conclusions as to the stability of the study reach could not be drawn from the limited sedimentation computations. However, the reach did appear to exhibit a progression toward quasi-equilibrium by a lessening in the erosion rate.

Because of the inadequacies of the sediment budget analysis, the historical behavior of the existing stream was reviewed to add additional clarity in assessing the stability of this reach of the Santa Cruz River. The following excerpt was extracted from the Santa Cruz River Management Study (SLA, 1986):

"USGS data suggest that there may have been vertical stability during the early to mid 19th century, but that this reach has been degrading since the 1950's. There have been multiple references to degradation along specific reaches of the Santa Cruz River during the late 1950's to the mid 1960's. Ajo Way to Grant Road experienced 10 to 15 feet of degradation, while 6 to 8 feet of degradation occurred between Speedway Boulevard and Valencia Road. This change may be partially due to the extensive use of materials from the Santa Cruz River streambed during the construction of the I-10 highway during the late 1950's/early 1960's. While subsequent bed profiles show a slight recovery, the overall profile of the streambed has still degraded by one to four feet through the Tucson Urban Reach since

1947. Historic lateral changes are not easily identified through this reach of the river due to extensive fill and channelization. There is general agreement that this reach is well defined and incised; however, any documentation of the lateral changes may suffer due to the intensive channel work performed in the metropolitan area.

The floods of 1983 were a significant test of lateral and channel stability. During this event, the unstabilized embankments along two reach locations—one reach located just upstream of and within the southern end (i.e., between I-19 and Ajo Way), and the other reach located at the northern end of the Tucson Urban Reach (i.e., just downstream of Grant Road to the Silverbell Golf Course)—experienced significant erosion/lateral migration (i.e., from 200 feet to 500 feet)."

1.3.6 BANK EROSION

1.3.6.1 Background

The bank erosion study was limited to the Santa Cruz River. The New West Branch was not studied since its banks are lined with concrete/soil cement. This was the same case for the Los Reales Improvement District area. The Old West Branch was not studied due to plan formulation constrains that preclude structural channel modifications.

1.3.6.2 Geomorphic Relationships

Since there is no official guidance on determining bank erosion, several widely acceptable technical approaches within the hydraulic community were used in the study. The processes and methodologies were found in the following references:

a. EM 1110-2-1418, "Channel Stability Assessment for Flood Control Channels" (US Army Corps of Engineers, 1994). The section titled "Channel Evolution and Geomorphic Thresholds" has guidance on distinguishing braided from non-braided channels. The channel slope of the study area is approximately 0.003. In natural streams the channel-forming discharge can often be taken as equivalent to the bank-full discharge. In terms of flood frequency, a return period of around 2 years appears to be common in the eastern half of the United States. However, in the western United States area, a return period between 5 and 10 years is more appropriate (the latter for urban and channelized streams). The channel forming discharge is between 4900 cfs (2-year flood event) and 14000 cfs (10-year flood event). This range of data was plotted on Figure 2-24. The Leopold & Wolman 1957 braided vs. meandering separation line was used to distinguish between braided and meandering channels. According to this figure, this reach of the Santa Cruz River is of the braided type.

b. Rosgen Classification System (Rosgen, 1996). This reach of the Santa Cruz River has a slope of 0.003, sinuosity less than 1.2, has multiple channels, and consists of sands and gravels. According to the Rosgen Classification System, it can be classified as a D4 or D5 channel. Rosgen describes a D5 channel as follows: "The D5 stream types are multiple channel systems described as braided streams... The braided channel system is characterized by high bank erosion rates, excessive deposition occurring as both longitudinal and transverse bars, and annual shifts of the bed location. A combination of adverse conditions are responsible for channel braiding, including high sediment supply, high bank erodibility, moderately steep gradients, and very flashy runoff conditions which can vary rapidly from a base flow to an over-bank flow on a frequent basis (Rosgen, 1996)."

c. Restoring Streams in Cities (Riley, 1998). According to the book: "A braided stream channel is typically wide and shallow and contains a number of separated channels that flow in and around mid-channel sediment bars and islands. Braided channels usually indicate that a stream is supplied with more sediment than it can carry. Other conditions that can lead to braiding are steep slopes, coarse materials with low erosion resistance, sediments deposited at grade changes, and aggradation that allows the channel to shift course...A braided stream is unstable, changes its alignment rapidly, carries large amounts of sediment, is wide and shallow even at flood flows, and is in general unpredictable." This reach of the Santa Cruz River certainly fits this description.

d. USGS Water Supply Paper 2429, Channel Change on the Santa Cruz River, Pima County, Arizona, 1936-86 (USGS, 1995). This paper contained some historical and geomorphic information.

1.3.6.3 Existing Bank Protection

In response to historical flooding and lateral bank erosion, Pima Count and the City of Tucson initiated a program of bank stabilization. Many areas in the study reach were channelized and the banks lined with soil cement revetments. Soil cement grade control structures were also installed to prevent scour at selected bridges. Currently, the following areas of the Santa Cruz River are completely bank protected with soil cement and were excluded from this analysis:

- Upstream and downstream of the Valencia Road Bridge,
- Irvington Road to Ajo Way, and
- Silverlake Road to Congress Street.

There are three (3) remaining gaps that are currently unprotected:

- Los Reales Road to south of Valencia Road,
- North of Valencia Road to Irvington Road, and
- Ajo Way to Silverlake Road.

1.3.6.4 Historical Bank Erosion Information

The following excerpts from USGS Water Supply Paper 2429 (1995) pertain to this study reach:

"The Tucson reach has shown the least lateral instability during the period. Either much of the apparent stability is artificial—because of bank armoring, which has prevented channel change, or of artificial filling, which has obscured the record of change occurring between 1936 and 1986. Parts of the reach underwent about 15 ft of degradation between the 1950's and 1976."

"Arroyo change along other reaches of the Santa Cruz River is difficult to evaluate because the Tucson and Sahuarita reaches have been subject to extensive human alteration and much of the apparent lateral stability of the reaches is artificial. For example, according to bridge specifications prepared in 1916, the channel at Congress Street in the Tucson reach widened to 375 ft during the floods of 1914-15, but subsequent artificial filling reduced width at that location to less than 200 ft. Two motels now stand on landfill above the site of the migrating meander that destroyed the Congress Street bridge in 1915. In contrast to the San Xavier reach, most arroyo widening of the upper Tucson reach took place in the 1950's, and little widening occurred thereafter except locally as a result of the flood of 1983. Some of the arroyo widening that took place between Silverlake Road and Congress Street in the 1950's may have been associated with construction activity that is visible in aerial photographs of 1960...The most pronounced arroyo widening occurred from Silverlake Road to Grant Road during 1953-60 before degradation had begun at most locations in the Tucson reach. Between Silverlake Road and Congress Street, the rate of arroyo widening was constant from 1953 to 1971. From Congress Street to Grant Road, however, no significant arroyo widening occurred between 1960 and 1978 even though this was a period of maximum incision and subsequent vertical fluctuation. After the flood of 1983, only the part of the Tucson reach from Congress Street to Speedway Boulevard showed a significant increase in mean arroyo width."

"Between 1915 and 1929, extensive arroyo widening occurred during 1914-15 floods throughout the reach and the Congress Street bridge was destroyed. Between 1930 and 1959, extensive widening occurred between Speedway Boulevard and Grant Road and channel degradation begins during the later years. Between 1960 and 1986, the arroyo widths were generally stable. There was apparent narrowing at some locations caused by channelization and landfill operations. As much as 15 ft of arroyo incision occurred. There was substantial arroyo wall retreat along unprotected segments of the reach as a result of 1983 flood."

Table 4 summarizes the amount of bank movement between 1941 and 2002. Within the study reach, there was major arroyo widening throughout the study period. There was considerable degradation in the 1950's and 1960's. Artificial changes include extensive channelization and armoring; and landfill operations. There was sand-gravel mining at Valencia Road. There were some armoring, highway fill, and landfill at other locations.

At some locations, the banks generally did not move. This is expected in geologically confined reaches and reaches with bank protection. At other locations, the banks moved as much as 900 ft within the past 60 years. In addition, the migration rate per year for each bank was determined by dividing the migration amount by the number of years between the photographs, i.e. the migration rate was linearized from the historical data.

Table 4: Bank Erosion Between 1941-2002

Year	Bank Width	Lt. Bank Erosion	Rt. Bank Erosion	Lt. Bank Erosion Rate Per Year	Rt Bank Erosion Rate Per Year
Station 34.43					
1941	180				
1960	130	40	60	2	3
2002	650	350	170	8	4
Station 35.66					
1941	220				
1960	250	420	380	22	20
2002	330	380	460	9	11
Station 37.50					
1941	610				
1960	360	340	680	18	36
2002	890	380	850	9	20

1.3.6.5 Erosion Hazard Boundary Mapping

Erosion hazard boundary maps from the Santa Cruz River Management Study (SLA, 1986) were also considered in this study. The subject report developed a map identifying potential erosion-hazard areas based on lateral-migration measurements and a time-sequence series of historical photographs. They present the "worst-case" estimates of the potential bank erosion limits of the Santa Cruz River. The erosion limits within the study area were manually digitized and is illustrated in Plate 19.

The Pima County Flood Control District provided digitized historical aerial photographs of the Santa Cruz River study reach dated 1941 and 1969. The digitized photographs were not georeferenced or orthorectified. Using an ArcView extension, the photographs were georeferenced only. They were not orthorectified since this is a more involved process. The left and right banks were then digitized. Given the original conditions of the photographs, the historical bank locations are not exact but were determined to be adequate for this level of study.

Recent geologic banks were determined from reviewing the historical aerial photographs and viewing the shape of the topographic lines along the Santa Cruz River study reach. 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 0.5 mile in width at 22nd Street to approximately 1.5 miles in width at Valencia Road. Lateral migration would not be expected to exceed these limits.

1.3.6.6 Conclusions

The purpose of this erosion investigation was to determine the maximum bank erosion as well as the average annual bank erosion along the study reach of the Santa Cruz River. The references cited in this section contained numerous historical material for the Santa Cruz River and geomorphic relationships for natural streams. However, there was no information or guidance to calculate average annual bank erosion for braided type streams. To complicate matters, there were several artificial features that affected the bank stability of the study reach, i.e. bridge abutment fill, bank armoring, gravel mining, etc.

For the reasons stated above, it was determined that a simplified methodology would be used to determine the maximum bank erosion; it would be inappropriate at this time to determine an average annual erosion rate given all the uncertainties. Using a combination of all the methods and historical information described above, a maximum bank erosion set of limits was developed and is illustrated on Plate 19.

It is anticipated that the With Project Conditions bank erosion analysis will not significantly change from the Without Project analysis. The flattening of unprotected banks and introduction of vegetative habitat may prevent bank erosion and lateral head cutting during frequent storm events, however these measures are unlikely to provide sufficient bank stability infrequent (e.g., 50 to 500-year) storm events.

1.4 NEW WEST BRANCH WITH PROJECT CONDITIONS

1.4.1 ALTERNATIVES ANALYSES

The revised without project conditions HEC-RAS model for the New West Branch was modified to determine the impacts of two proposed alternatives. These alternatives are NWB-1 (Channel Invert Excavation), NWB-2 (raise Existing Levees), and NWB-3 (Floodwalls).

1.4.1.1 Alternative NWB-1 (Channel Dredging)

The without project hydraulic model was modified to determine the impacts of channel dredging. The following impacts or concerns were identified:

a) Excavation can increase the conveyance of the New West Branch up to the 100-yr flood event only. Up to two (2) ft of excavation is necessary.
b) Excavation alone would not contain the 200- and 500-yr flood events.
c) The existing grade control structure at Station 6.0 would need to be modified (i.e., lowered or reconstructed) as well as the key-in to the existing bank protection.
d) The existing footbridge upstream of Drexel Road would need to be removed or replaced.

e) Excavation may result in undermining of the existing soil cement bank protection. The toe down depth(s) of the existing soil cement bank protection is unknown and cannot be verified. Additional field exploration will be required to determine structural integrity, toe-down depths, and subsurface conditions behind and under the soil cement.

The results of this evaluation are presented in Figures 5 and 6 and Table 5.

1.4.1.2 Alternative NWB-2 and NWB-3

Low levees currently exist along both channel banks, however they do not contain the 100, 200, and 500-year flows. An alternative analysis was performed to determine effects of raising the existing levees to protect for the 100 through 500-year flood events. As built drawings for the existing levees and bank protection are not available therefore, for engineering design and cost estimating purposes, the existing levees were assumed to be structurally inadequate, therefore new engineered levees are assumed. Due to the high velocities and possibility of run-up at the curve, rigid armoring (i.e., soil cement) is recommended for the inside slopes of the levees.

The results of the evaluation and required levee heights for each respective design storm are presented in Table 6.

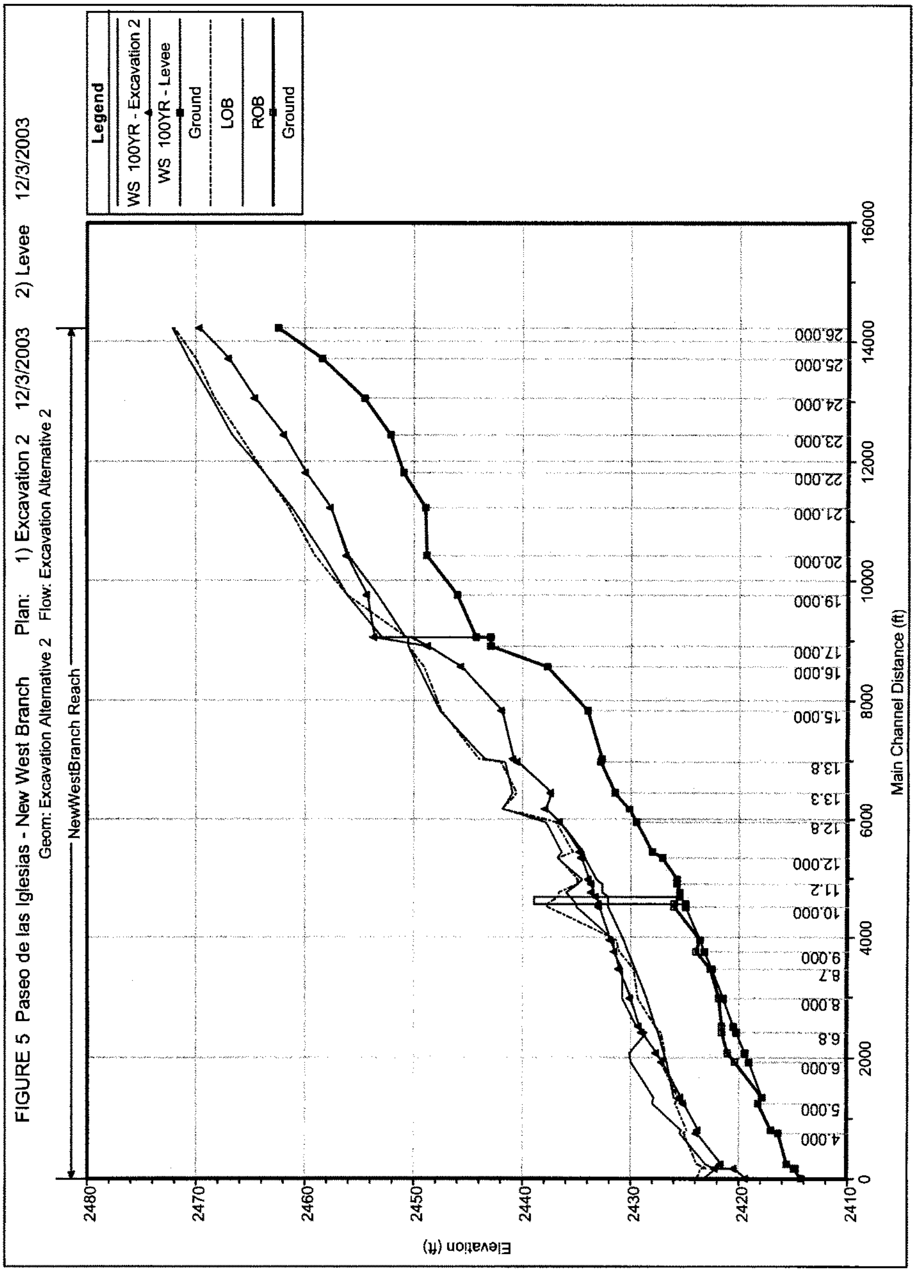
FIGURE 5 Paseo de las Iglesias - New West Branch Plan: 1) Excavation 2 12/3/2003 2) Levee 12/3/2003
Geom: Excavation Alternative 2 Flow: Excavation Alternative 2
NewWestBranch Reach
Legend
WS 100YR - Excavation 2
WS 100YR - Levee
Ground
LOB
ROB
Ground
Elevation (ft)
Main Channel Distance (ft)
2410
2420
2430
2440
2450
2460
2470
2480
0
2000
4000
6000
8000
10000
12000
14000
16000
4.000
5.000
6.000
6.8
8.000
8.7
9.000
10.000
11.2
12.000
12.8
13.3
13.8
15.000
16.000
17.000
19.000
20.000
21.000
22.000
23.000
24.000
25.000
26.000
1

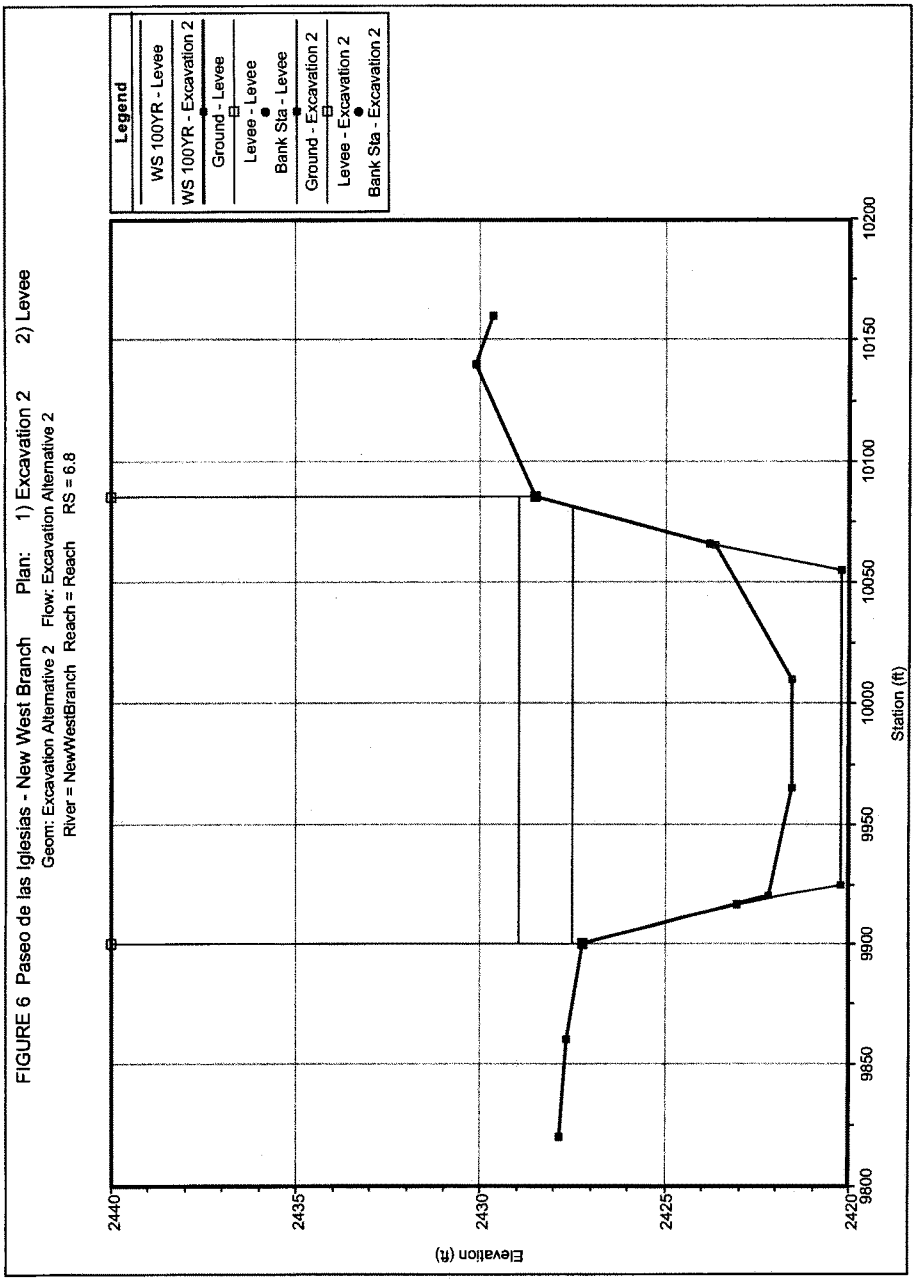
FIGURE 6 Paseo de las Iglesias - New West Branch Plan: 1) Excavation 2 2) Levee
Geom: Excavation Alternative 2 Flow: Excavation Alternative 2
River = NewWestBranch Reach = Reach RS = 6.8
Legend
WS 100YR - Levee
WS 100YR - Excavation 2
Ground - Levee
Levee - Levee
Bank Sta - Levee
Ground - Excavation 2
Levee - Excavation 2
Bank Sta - Excavation 2
Elevation (ft)
2440
2435
2430
2425
2420
Station (ft)
9800
9850
9900
9950
10000
10050
10100
10150
10200
1

TABLE 5 HEC-RAS Plan: Excavation 2 River: NewWestBranch Reach: Reach Profile: 100YR

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	1.000	100YR	9908.00	2414.25	2419.37	2419.37	2421.76	0.005646	12.42	797.89	165.90	1.00
Reach	1.9	100YR	9908.00	2415.00	2420.44	2420.44	2422.76	0.005491	12.24	809.58	173.32	1.00
Reach	2.000	100YR	9908.00	2414.78	2422.13	2420.63	2422.99	0.002886	7.43	1334.23	375.13	0.69
Reach	3.000	100YR	9908.00	2415.55	2421.54	2421.22	2423.58	0.004423	11.47	863.44	172.99	0.91
Reach	4.000	100YR	9908.00	2416.43	2423.87	2422.19	2425.14	0.002102	9.05	1095.26	179.15	0.64
Reach	4.2	100YR	9908.00	2417.00	2423.76	2422.80	2425.37	0.003119	10.19	972.70	179.52	0.77
Reach	5.000	100YR	9908.00	2418.25	2425.11	2423.96	2426.65	0.002776	9.96	994.70	173.40	0.73
Reach	5.2	100YR	9908.00	2417.80	2425.95	2423.17	2426.89	0.001285	7.80	1270.47	178.32	0.51
Reach	6.000	100YR	9908.00	2419.13	2426.71	2424.46	2427.77	0.001579	8.25	1201.48	181.41	0.56
Reach	6.3	100YR	9908.00	2419.46	2426.87	2424.86	2428.06	0.001803	8.73	1134.46	173.47	0.60
Reach	6.8	100YR	9908.00	2420.25	2427.51	2425.70	2428.73	0.001984	8.85	1119.35	180.83	0.63
Reach	7.000	100YR	9908.00	2420.47	2427.74	2425.87	2428.93	0.001920	8.75	1132.23	181.65	0.62
Reach	8.000	100YR	9908.00	2421.47	2428.57	2426.87	2429.84	0.002103	9.07	1092.72	177.93	0.64
Reach	8.7	100YR	9908.00	2422.59	2429.62	2428.01	2430.92	0.002189	9.14	1083.69	179.72	0.66
Reach	9.000	100YR	9908.00	2423.25	2430.28	2428.63	2431.57	0.002176	9.09	1089.89	181.53	0.65
Reach	9.2	100YR	9908.00	2423.57	2430.70	2429.14	2432.03	0.002275	9.23	1073.62	182.32	0.67
Reach	10.000	100YR	9908.00	2424.94	2432.07	2430.19	2433.17	0.001826	8.40	1178.98	193.51	0.60
Reach	10.5		Bridge									
Reach	11.000	100YR	9908.00	2425.48	2432.71	2430.83	2433.93	0.001926	8.86	1118.66	176.34	0.62
Reach	11.2	100YR	9908.00	2425.77	2432.63	2432.01	2434.52	0.003689	11.03	898.16	166.47	0.84
Reach	11.3	100YR	9908.00	2425.70	2433.16	2432.15	2434.78	0.003038	10.23	968.72	174.06	0.76
Reach	12.000	100YR	9908.00	2427.04	2434.22	2433.27	2435.94	0.003105	10.51	942.36	164.96	0.78
Reach	12.2	100YR	9908.00	2428.00	2434.39	2433.89	2436.37	0.004013	11.30	877.01	167.11	0.87
Reach	12.8	100YR	9908.00	2429.50	2436.56	2435.19	2437.98	0.002463	9.56	1036.35	175.69	0.69
Reach	13.000	100YR	9908.00	2430.08	2437.84	2435.69	2438.45	0.001304	6.24	1588.68	318.09	0.49
Reach	13.3	100YR	9908.00	2431.52	2437.35	2437.35	2439.86	0.005442	12.69	780.73	156.75	1.00
Reach	13.8	100YR	9908.00	2432.76	2440.45	2438.31	2441.27	0.001420	7.27	1362.91	229.94	0.53
Reach	14.000	100YR	9908.00	2432.60	2440.80	2437.68	2441.36	0.000842	6.04	1639.74	246.62	0.41
Reach	15.000	100YR	9908.00	2434.04	2441.82	2441.82	2444.26	0.005392	12.53	790.67	160.29	0.99
Reach	16.000	100YR	9908.00	2437.70	2445.60	2445.18	2447.75	0.004193	11.76	842.55	155.97	0.89
Reach	17.000	100YR	9908.00	2442.96	2448.67	2448.67	2451.07	0.005484	12.43	797.12	164.41	0.99
Reach	17.5		Bridge									
Reach	18.000	100YR	9908.00	2444.29	2450.86	2450.06	2452.71	0.003608	10.93	906.18	165.90	0.82
Reach	19.000	100YR	9908.00	2446.01	2453.32	2452.51	2455.22	0.003423	11.06	895.89	156.02	0.81
Reach	20.000	100YR	9908.00	2448.79	2456.03	2454.62	2457.06	0.002229	8.16	1213.53	242.86	0.64
Reach	21.000	100YR	9908.00	2448.97	2457.62	2456.96	2459.62	0.003657	11.34	874.07	154.39	0.84
Reach	22.000	100YR	9908.00	2450.92	2459.81	2458.95	2461.68	0.003281	10.97	903.34	154.56	0.80
Reach	23.000	100YR	9908.00	2452.07	2461.86	2461.64	2464.28	0.004654	12.48	793.62	144.70	0.94
Reach	24.000	100YR	9908.00	2454.54	2464.56	2463.77	2466.74	0.003502	11.84	837.13	133.33	0.83
Reach	25.000	100YR	9908.00	2458.40	2466.90	2466.65	2469.54	0.004559	13.04	759.86	127.70	0.94
Reach	26.000	100YR	9908.00	2462.46	2469.55	2469.48	2471.98	0.005118	12.53	790.64	154.60	0.98

HEC-RAS Standard Output Table for Proposed Excavation Alternative

Table 6. New West Branch of the Santa Cruz River Required Levee Elevations

Station[1]	WSEL[2] (ft) 100-yr	WSEL[2] (ft) 200-yr	WSEL[2] (ft) 500-yr	Existing Top of Levee (ft) Left Levee	Existing Top of Levee (ft) Right Levee	Minimum Top of Levee[3] (ft) 100-yr	Minimum Top of Levee[3] (ft) 200-yr	Minimum Top of Levee[3] (ft) 500-yr	Minimum Required Levee Raising[4] (ft) 100-yr Left Levee	100-yr Right Levee	200-yr Left Levee	200-yr Right Levee	500-yr Left Levee	500-yr Right Levee
1	2419.4	2420.0	2420.6	2423.8	2423.2	2421.4	2422.0	2422.6	-2.5	-1.8	-1.8	-1.2	-1.2	-0.6
1.9	2420.4	2421.1	2421.7	2423.5	2422.1	2422.4	2423.1	2423.7	-1.0	0.3	-0.3	1.0	0.3	1.6
2	2422.1	2423.3	2424.2	2423.0	2422.2	2424.1	2425.3	2426.2	1.2	1.9	2.3	3.1	3.2	4.0
3	2421.5	2422.4	2423.2	2423.9	2423.1	2423.5	2424.4	2425.2	-0.4	0.5	0.5	1.3	1.3	2.1
4	2423.9	2424.6	2425.3	2425.1	2425.4	2425.9	2426.6	2427.3	0.8	0.4	1.5	1.2	2.3	1.9
4.2	2423.8	2424.5	2425.2	2424.8	2425.3	2425.8	2426.5	2427.2	1.0	0.5	1.7	1.2	2.4	2.0
5	2425.1	2425.8	2426.5	2425.9	2428.1	2427.1	2427.8	2428.5	1.2	-0.9	1.9	-0.2	2.5	0.4
5.2	2425.3	2426.1	2426.7	2425.6	2427.9	2427.3	2428.1	2428.7	1.8	-0.6	2.5	0.2	3.1	0.8
6	2427.1	2427.9	2428.5	2427.3	2430.0	2429.1	2429.9	2430.5	1.9	-0.9	2.6	-0.1	3.3	0.5
6.3	2427.6	2428.3	2429.0	2426.8	2430.1	2429.6	2430.3	2431.0	2.8	-0.5	3.5	0.2	4.1	0.8
6.8	2429.0	2429.8	2430.5	2427.2	2428.5	2431.0	2431.8	2432.5	3.8	2.4	4.5	3.2	5.2	3.9
7	2429.3	2430.1	2430.8	2427.7	2429.5	2431.3	2432.1	2432.8	3.5	1.7	4.4	2.6	5.1	3.3
8	2430.0	2430.8	2431.5	2429.4	2430.8	2432.0	2432.8	2433.5	2.6	1.2	3.5	2.1	4.2	2.8
8.7	2431.1	2432.0	2432.7	2429.8	2430.8	2433.1	2434.0	2434.7	3.3	2.3	4.2	3.2	4.9	3.9
9	2431.5	2432.4	2433.1	2431.0	2431.6	2433.5	2434.4	2435.1	2.5	1.8	3.3	2.7	4.1	3.4
9.2	2431.9	2432.7	2433.4	2431.3	2431.7	2433.9	2434.7	2435.4	2.6	2.3	3.4	3.1	4.1	3.8
10	2432.9	2433.7	2434.5	2437.7	2435.0	2434.9	2435.7	2436.5	-2.8	-0.1	-2.0	0.7	-1.2	1.5
11	2433.6	2434.4	2435.3	2436.7	2436.0	2435.6	2436.4	2437.3	-1.1	-0.5	-0.2	0.4	0.6	1.3
11.2	2433.6	2434.5	2435.3	2435.0	2435.0	2435.6	2436.5	2437.3	0.6	0.6	1.4	1.4	2.3	2.3
11.3	2433.8	2434.7	2435.5	2435.0	2434.6	2435.8	2436.7	2437.5	0.8	1.2	1.7	2.1	2.5	2.9
12	2434.5	2435.3	2436.1	2436.7	2436.8	2436.5	2437.3	2438.1	-0.2	-0.3	0.6	0.6	1.4	1.3
12.2	2434.7	2435.5	2436.2	2435.3	2436.4	2436.7	2437.5	2438.2	1.3	0.3	2.1	1.1	2.9	1.9
12.8	2436.5	2437.3	2437.9	2436.9	2437.9	2438.5	2439.3	2439.9	1.6	0.6	2.4	1.3	3.1	2.0
13	2437.8	2438.8	2439.6	2441.9	2441.9	2439.8	2440.8	2441.6	-2.1	-2.1	-1.2	-1.2	-0.3	-0.3
13.3	2437.4	2438.1	2438.7	2440.6	2440.9	2439.4	2440.1	2440.7	-1.2	-1.6	-0.5	-0.8	0.1	-0.2
13.8	2440.5	2441.3	2442.1	2442.0	2441.7	2442.5	2443.3	2444.1	0.4	0.8	1.3	1.7	2.1	2.5
14	2440.8	2441.7	2442.5	2444.0	2443.5	2442.8	2443.7	2444.5	-1.2	-0.7	-0.4	0.2	0.4	1.0
15	2441.6	2442.5	2443.1	2447.5	2447.6	2443.8	2444.5	2445.1	-3.6	-3.8	-2.9	-3.1	-2.3	-2.5
16	2445.6	2446.3	2446.8	2449.1	2449.6	2447.6	2448.3	2448.8	-1.5	-2.0	-0.8	-1.3	-0.2	-0.8
17	2448.7	2449.4	2450.0	2450.5	2450.5	2450.7	2451.4	2452.0	0.2	0.2	0.9	0.8	1.5	1.5
18	2453.7	2453.9	2454.1	2450.7	2453.0	2455.7	2455.9	2456.1	4.9	2.7	5.2	3.0	5.4	3.2
19	2454.3	2454.8	2454.9	2456.1	2456.1	2456.3	2456.8	2456.9	0.2	0.2	0.7	0.6	0.8	0.8
20	2456.1	2456.9	2457.7	2459.1	2458.3	2458.1	2458.9	2459.7	-1.0	-0.2	-0.1	0.7	0.7	1.5
21	2457.6	2458.2	2458.7	2461.4	2461.2	2459.6	2460.2	2460.7	-1.8	-1.6	-1.2	-1.0	-0.7	-0.5
22	2459.8	2460.7	2461.4	2463.8	2463.7	2461.8	2462.7	2463.4	-2.0	-1.9	-1.1	-1.0	-0.4	-0.3
23	2461.9	2462.6	2463.2	2466.1	2466.6	2463.9	2464.6	2465.2	-2.2	-2.8	-1.5	-2.0	-0.8	-1.4
24	2464.6	2465.3	2466.0	2468.3	2468.5	2466.6	2467.3	2468.0	-1.7	-1.9	-0.9	-1.1	-0.3	-0.5
25	2466.9	2467.7	2468.5	2470.0	2470.7	2468.9	2469.7	2470.5	-1.1	-1.8	-0.3	-1.0	0.4	-0.2
26	2469.6	2470.5	2471.3	2472.1	2472.2	2471.6	2472.5	2473.3	-0.5	-0.6	0.4	0.3	1.2	1.1

Notes:

1. Station numbers with decimals are from additional Pima County survey data.
2. HEC-RAS computed water surface elevations.
3. 95% confidence levee elevation (computed water surface elevation + 2.0 ft).
4. Negative numbers indicate locations where levee raising is not necessary.

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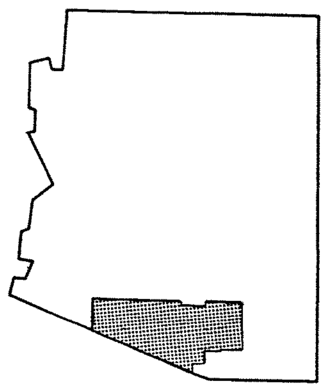
FLOOD INSURANCE STUDY

PIMA COUNTY, ARIZONA

AND INCORPORATED AREAS

VOLUME 1 OF 3

COMMUNITY NAME	COMMUNITY NUMBER
MARANA, TOWN OF	040118
ORO VALLEY, TOWN OF	040109
PIMA COUNTY, UNINCORPORATED AREAS	040073
SAHUARITA, TOWN OF	040137
SOUTH TUCSON, TOWN OF	040075
TUCSON, CITY OF	040076



REVISED: FEBRUARY 8, 1999

Federal Emergency Management Agency

Table 2. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Ruelas Canyon					
Downstream of confluence with Unnamed Canyon	56.6	--[1]	--[1]	6,562	--[1]
At Apex	3.58	1,800	4,460	5,990	10,470
Sabino Creek					
Above confluence with Tanque Verde Creek	66.4	4,900	12,000	18,000	36,000
Above confluence with Bear Creek	36.8	3,750	8,500	12,500	25,000
Sahuara Wash					
At Pima Street	0.4	--[1]	--[1]	622	--[1]
San Juan Wash					
At confluence with West Branch Santa Cruz River	1.2	--[1]	--[1]	2,165	--[1]
1,300 feet upstream of Mission Road	1.1	--[1]	--[1]	2,420	--[1]
At Greasewood Road	0.4	--[1]	--[1]	1,125	--[1]
Santa Clara Wash					
At Interstate Highway 19	0.3	--[1]	--[1]	705	--[1]
Santa Cruz River					
At Cortaro Road	3,503	21,800	48,000	70,000	107,400
Above confluence with Canada del Oro Wash	3,232	21,800	48,000	70,000	107,400
At Cortaro Farms Road	3,053	21,800	48,000	70,000	107,400
Above confluence with Rillito Creek	2,282	16,800	41,000	60,000	93,000
At Congress Street	2,222	16,800	41,000	60,000	93,000
At Drexel Road	2,101	16,800	41,000	60,000	93,000
At Continental Road	1,662	--[1]	--[1]	45,000	--[1]

See LOMR 7-24-00

[1]Data not computed

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T1       EMW-94-C-4542 (MMLA Job No. 92145-03)
T2       City of Tucson FIS (FEMA '94)
T3       West Branch SCR 100-yr Floodplain
J1       0       2       0       0   0.011       0     0.0  6621.0
J2      -1       1     0.0     0.0     0.0     0.0     0.0     0.0     0.0
J6       1       0     0.0
NC 0.045   0.045   0.035     0.1     0.3
X1     0.5       9    67.5   117.5     0.0     0.0     0.0     1.0     0.0
GR2366.0     0.0  2366.0    50.0  2365.5    60.0  2365.0    67.5  2347.5    84.0
GR2347.5   101.0  2365.0   117.5  2365.5   125.0  2370.0   130.0
NC 0.055   0.055   0.035     0.1     0.3
X1       1       9   140.0   180.0   505.0   505.0   505.0     1.0     0.0
GR2370.0     0.0  2370.0   125.0  2360.0   140.0  2353.0   155.0  2353.0   165.0
GR2360.0   180.0  2370.0   190.0  2372.0   240.0  2374.0   300.0
NC 0.055   0.055   0.035     0.1     0.3
X1       2      10   168.0   200.0   520.0   520.0   520.0     1.0     0.0
GR2372.0     0.0  2370.0   130.0  2360.0   168.0  2356.0   180.0  2356.0   190.0
GR2360.0   200.0  2370.0   220.0  2372.0   225.0  2374.0   270.0  2376.0   315.0
NC 0.055   0.055   0.035     0.1     0.3
X1       3      10   245.0   330.0   400.0   400.0   400.0     1.0     0.0
GR2373.0     0.0  2372.0   190.0  2370.0   245.0  2360.0   275.0  2358.0   285.0
GR2358.0   300.0  2360.0   305.0  2370.0   330.0  2374.0   335.0  2376.0   660.0
NC 0.055   0.055   0.035     0.3     0.5
QT       1  6220.0
X1       4       7   220.0   273.0   345.0   345.0   345.0     1.0     0.0
X3       0     0.0     0.0   220.0  2376.0   273.0  2376.0     0.0     0.0
GR2376.0     0.0  2374.0   150.0  2372.8   220.0  2360.4   221.0  2360.4   272.0
GR2372.8   273.0  2376.0   550.0
NC 0.055   0.055   0.035     0.3     0.5
SC 4.012     0.4     3.0   100.0    12.0    12.0    90.0    10.1  2360.8  2360.4
X1     4.1       7   220.0   273.0   100.0   100.0   100.0     1.0     0.0
X2     0.0     0.0       2     0.0  2373.3     0.0       0     0.0     0.0
X3       0     0.0     0.0   220.0  2376.0   273.0  2376.0     0.0     0.0
GR2376.0     0.0  2374.0   150.0  2372.8   220.0  2360.8   221.0  2360.8   272.0
GR2372.8   273.0  2376.0   550.0
NC 0.055   0.065   0.035     0.1     0.3
X1       5      15   620.0   685.0   440.0   620.0   510.0     1.0     0.0
GR2380.0     0.0  2378.0    50.0  2376.0   620.0  2370.0   640.0  2364.0   645.0
GR2364.0   655.0  2370.0   665.0  2376.0   685.0  2377.0   705.0  2377.0  1030.0
GR2376.0  1031.0  2376.0  1055.0  2377.0  1060.0  2377.0  1560.0  2378.5  1580.0
NC 0.055   0.065   0.035     0.1     0.3
X1       6      12   455.0   495.0   670.0   370.0   590.0     1.0     0.0
GR2380.0     0.0  2378.0   330.0  2376.0   440.0  2372.0   455.0  2366.0   470.0
GR2366.0   482.0  2372.0   495.0  2378.0   512.0  2380.0   600.0  2378.0   750.0
GR2378.0  1600.0  2379.5  1660.0
NC 0.055    0.06   0.035     0.1     0.3
QT       1  5722.0
X1       7       8   185.0   240.0   580.0   460.0   560.0     1.0     0.0
GR2382.0     0.0  2380.0    80.0  2380.0   185.0  2369.0   205.0  2369.0   225.0
GR2380.0   240.0  2380.0  1160.0  2381.5  1210.0
NC 0.055   0.065   0.035     0.1     0.3
X1       8      11   747.0   770.0   550.0   650.0   680.0     1.0     0.0
GR2384.0     0.0  2382.0   120.0  2380.0   220.0  2380.0   747.0  2372.0   750.0
GR2372.0   760.0  2380.0   770.0  2382.0   780.0  2382.0  1230.0  2383.2  1620.0
GR2383.5  1955.0
NC 0.055   0.065   0.035     0.1     0.3
X1       9      12  1035.0  1080.0   400.0   500.0   470.0     1.0     0.0
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GR2384.0     0.0  2383.5   130.0  2382.0   660.0  2382.0  1035.0  2380.0  1045.0
GR2373.5  1050.0  2373.5  1070.0  2380.0  1080.0  2382.0  1100.0  2382.0  1155.0
GR2383.0  1390.0  2384.0  1760.0
NC 0.055    0.06   0.035     0.1     0.3
X1    10       9  1090.0  1130.0   470.0   470.0   480.0     1.0     0.0
GR2386.0     0.0  2384.0   400.0  2383.5   805.0  2382.0  1090.0  2378.0  1110.0
GR2378.0  1120.0  2382.0  1130.0  2384.0  1220.0  2386.0  1700.0
NC 0.055    0.06   0.035     0.1     0.3
NH     3    0.05   410.0   0.035   455.0    0.05  1080.0
X1    11      10   410.0   455.0   600.0   650.0   800.0     1.0     0.0
GR2388.0     0.0  2386.0   370.0  2384.0   410.0  2380.0   425.0  2380.0   450.0
GR2384.0   455.0  2386.0   475.0  2385.5   700.0  2386.0   950.0  2388.0  1080.0
NC  0.05    0.05   0.035     0.1     0.3
X1    12      13   410.0   470.0   520.0   620.0   695.0     1.0     0.0
GR2392.0     0.0  2390.0   165.0  2390.0   360.0  2388.0   410.0  2384.0   440.0
GR2384.0   460.0  2390.0   470.0  2390.0   560.0  2388.0   710.0  2387.5   800.0
GR2388.0   890.0  2390.0   900.0  2391.0   950.0
NC 0.055   0.055   0.035     0.1     0.3
QT     1  3614.0
X1    13      10   300.0   350.0   475.0   475.0   475.0     1.0     0.0
GR2392.5     0.0  2391.0   190.0  2390.0   300.0  2385.5   320.0  2385.5   335.0
GR2390.0   350.0  2391.5   355.0  2390.0   600.0  2390.0   770.0  2393.0   800.0
NC 0.055   0.055   0.035     0.1     0.3
X1  13.5      11   280.0   335.0   270.0   360.0   310.0     1.0     0.0
GR2394.0     0.0  2392.0   220.0  2390.0   280.0  2387.0   290.0  2387.0   330.0
GR2390.0   335.0  2392.0   340.0  2392.0   550.0  2391.5   600.0  2392.0   670.0
GR2394.0   680.0
NC 0.055   0.055   0.035     0.1     0.3
NH     4   0.055   160.0   0.035   220.0   0.045   310.0    0.06   910.0
X1    14       9   170.0   210.0   450.0   560.0   480.0     1.0     0.0
GR2396.0     0.0  2394.0   130.0  2392.0   160.0  2389.0   170.0  2389.0   210.0
GR2394.0   220.0  2394.0   310.0  2394.0   460.0  2395.5   910.0
NC   0.0     0.0     0.0     0.1     0.3
NH     4   0.055   110.0   0.035   160.0    0.04   230.0    0.07   620.0
X1  14.5      10   110.0   140.0   390.0   390.0   390.0     1.0     0.0
X3     0     0.0     0.0     0.0     0.0   280.0  2396.5     0.0     0.0
GR2398.0     0.0  2396.0    63.0  2392.0    85.0  2390.0   110.0  2390.0   140.0
GR2396.0   160.0  2396.0   230.0  2396.5   280.0  2396.0   340.0  2398.0   620.0
NC 0.055   0.055   0.035     0.1     0.3
X1    15       9   130.0   180.0   360.0   405.0   380.0     1.0     0.0
GR2400.0     0.0  2398.0    60.0  2396.0   100.0  2394.0   130.0  2390.7   135.0
GR2390.7   162.0  2396.0   180.0  2398.0   235.0  2400.0   350.0
NC 0.055   0.055   0.035     0.1     0.3
NH     3    0.05    65.0   0.035   135.0   0.055   300.0
X1  15.5       8    65.0   135.0   375.0   375.0   375.0     1.0     0.0
GR2402.0     0.0  2400.0    40.0  2398.0    65.0  2391.5    75.0  2391.5    90.0
GR2398.0   135.0  2400.0   215.0  2401.0   300.0
NC 0.055    0.05   0.035     0.1     0.3
X1    16       7    70.0   120.0   580.0   580.0   580.0     1.0     0.0
X3     0     0.0     0.0     0.0     0.0   190.0     0.0     0.0     0.0
GR2404.0     0.0  2402.0    70.0  2394.5    80.0  2394.5   110.0  2402.0   120.0
GR2403.0   190.0  2404.0   240.0
NC 0.055   0.055   0.035     0.1     0.3
X1    17      11    57.0   100.0   445.0   445.0   445.0     1.0     0.0
X3     0     0.0     0.0     0.0     0.0   190.0  2405.5     0.0     0.0
GR2406.0     0.0  2404.0    30.0  2402.0    40.0  2400.0    55.0  2398.0    57.0
GR2395.0    70.0  2395.0    95.0  2398.0   100.0  2400.0   115.0  2404.0   130.0
```

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GR2405.5   435.0
NC  0.04   0.065   0.035     0.1     0.3
X1  17.5       8    30.0   140.0   570.0   570.0   570.0     1.0     0.0
GR2410.0     0.0  2410.0    30.0  2396.5    75.0  2396.5   100.0  2400.0   110.0
GR2402.0   122.0  2408.0   140.0  2408.5   200.0
NC 0.055   0.055   0.035     0.3     0.5
X1    18       8   370.0   430.0   415.0   415.0   415.0     1.0     0.0
X3     0     0.0     0.0   370.0  2415.0   430.0  2415.0     0.0     0.0
GR2418.0     0.0  2414.0   190.0  2412.0   230.0  2411.0   370.0  2399.0   381.0
GR2399.0   419.0  2410.5   430.0  2411.0  1200.0
NC 0.055   0.055   0.035     0.3     0.5
SC 3.012     0.4     3.0    90.0    10.0    12.0    77.0     8.1  2399.2  2399.0
X1  18.1       8   370.0   430.0    80.0    80.0    80.0     1.0     0.0
X2   0.0     0.0       2     0.0  2411.0     0.0       0     0.0     0.0
X3     0     0.0     0.0   370.0  2415.0   430.0  2415.0     0.0     0.0
GR2418.0     0.0  2414.0   190.0  2412.0   230.0  2411.0   370.0  2399.2   381.0
GR2399.2   419.0  2410.5   430.0  2411.0  1200.0
NC 0.040   0.060   0.035     0.1     0.3
X1  18.5      12   420.0   465.0   265.0   265.0   265.0     1.0     0.0
GR2418.0     0.0  2416.0    95.0  2414.0   145.0  2414.0   245.0  2412.0   340.0
GR2410.0   417.0  2408.0   420.0  2400.0   430.0  2400.0   460.0  2408.0   465.0
GR2410.0   473.0  2412.0   520.0
NC 0.050   0.075   0.035     0.1     0.3
X1    19       8   390.0   425.0   280.0   305.0   315.0     1.0     0.0
GR2414.0     0.0  2412.0   280.0  2410.0   390.0  2400.5   405.0  2400.5   420.0
GR2410.0   425.0  2412.0   525.0  2413.5   570.0
NC 0.045    0.06   0.035     0.1     0.3
QT     1  1657.0
X1  19.5       9   310.0   335.0   185.0   230.0   210.0     1.0     0.0
GR2416.0     0.0  2414.0   170.0  2412.0   295.0  2410.0   310.0  2401.0   315.0
GR2401.0   325.0  2410.0   335.0  2412.0   360.0  2414.0   430.0
NC  0.05    0.05   0.035     0.1     0.3
X1    20      10   280.0   310.0   395.0   380.0   395.0     1.0     0.0
GR2416.0     0.0  2414.0   220.0  2412.0   270.0  2410.0   280.0  2401.7   290.0
GR2401.7   300.0  2410.0   310.0  2412.0   327.0  2414.0   330.0  2414.5   390.0
NC  0.04   0.045   0.035     0.1     0.3
X1  20.5       9   275.0   315.0   330.0   390.0   390.0     1.0     0.0
GR2416.0     0.0  2414.0   250.0  2412.0   254.0  2410.0   275.0  2402.5   287.0
GR2402.5   297.0  2410.0   315.0  2414.5   327.0  2416.0   427.0
NC 0.055   0.055   0.035     0.1     0.3
X1    21      10   200.0   228.0   330.0   330.0   330.0     1.0     0.0
GR2416.0     0.0  2414.0   190.0  2408.0   200.0  2404.0   210.0  2404.0   220.0
GR2408.0   228.0  2410.0   240.0  2414.0   250.0  2416.0   265.0  2417.5   400.0
NC 0.055   0.055   0.035     0.1     0.3
X1  21.5      10    75.0   100.0   380.0   510.0   510.0     1.0     0.0
GR2418.0     0.0  2416.0    55.0  2410.0    75.0  2406.0    78.0  2406.0    95.0
GR2410.0   100.0  2412.0   110.0  2414.0   127.0  2416.0   133.0  2418.0   250.0
NC 0.055   0.055   0.035     0.1     0.3
X1    22      13    89.0   105.0   370.0   370.0   370.0     1.0     0.0
GR2420.0     0.0  2418.0    50.0  2414.0    60.0  2412.0    75.0  2410.0    89.0
GR2408.0    90.0  2408.0   100.0  2410.0   105.0  2412.0   110.0  2414.0   137.0
GR2416.0   160.0  2416.0   190.0  2417.0   400.0
NC 0.055   0.055   0.035     0.1     0.3
X1    23      11    70.0    95.0   580.0   580.0   580.0     1.0     0.0
GR2420.0     0.0  2418.0    60.0  2416.0    65.0  2414.0    70.0  2410.5    75.0
GR2410.5    95.0  2414.0    98.0  2416.0   104.0  2418.0   140.0  2419.0   250.0
GR2420.0   380.0
```

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NC 0.055    0.055   0.035     0.3      0.5
X1     24       6   150.0   220.0    215.0    215.0   215.0     1.0     0.0
X3      0     0.0     0.0   150.0   2422.0    220.0  2422.0     0.0     0.0
GR2422.0      0.0  2421.5   150.0   2411.7    184.0  2411.7   216.0  2421.5   220.0
GR2422.0    500.0
NC 0.055    0.055   0.035     0.3      0.5
SC 3.012      0.4     3.0    50.0      7.0     10.0    50.0    10.1  2412.0 2411.75
X1   24.1       6   170.0   240.0     75.0     75.0    75.0     1.0     0.0
X2    0.0     0.0       2     0.0   2421.5      0.0       0     0.0     0.0
X3      0     0.0     0.0   170.0   2422.0    240.0  2422.0     0.0     0.0
GR2422.0      0.0  2421.5   170.0   2412.0    184.0  2412.0   216.0  2421.5   240.0
GR2422.0    500.0
NC 0.055    0.055   0.035     0.1      0.3
QT      1   768.0
X1     25      10   157.0   181.0    325.0    325.0   325.0     1.0     0.0
GR2421.0      0.0  2420.0   145.0   2414.0    157.0  2412.5   160.0  2412.5   170.0
GR2414.0    181.0  2416.0   183.0   2418.0    200.0  2420.0   290.0  2421.0   350.0
NC 0.055    0.055   0.035     0.1      0.3
X1     26       9    40.0    57.0    490.0    500.0   490.0     1.0     0.0
GR2422.0      0.0  2420.0    27.0   2416.0     37.0  2415.0    40.0  2415.0    53.0
GR2416.0     57.0  2418.0   110.0   2420.0    120.0  2422.0   150.0
NC 0.055    0.055   0.035     0.1      0.3
X1     27      10    65.0    95.0    500.0    500.0   500.0     1.0     0.0
GR2424.0      0.0  2422.0    45.0   2420.0     50.0  2418.0    65.0  2416.0    70.0
GR2416.0     85.0  2418.0    95.0   2420.0    120.0  2422.0   150.0  2424.0   185.0
NC 0.055    0.055   0.035     0.1      0.3
X1     28       9    40.0    65.0    425.0    475.0   435.0     1.0     0.0
GR2424.0      0.0  2422.0    29.0   2420.0     40.0  2418.0    50.0  2418.0    65.0
GR2420.0     65.0  2421.0   145.0   2422.0    220.0  2424.0   240.0
NC 0.055    0.055   0.035     0.1      0.3
X1     29      10    90.0   140.0      350      350     350     1.0     0.0
GR2426.0      0.0  2424.0    85.0   2421.5    100.0  2421.5   120.0  2424.0   125.0
GR2426.0    150.0  2426.0   210.0   2425.0    240.0  2425.0   420.0  2426.0   480.0

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Appendix 2

Master Drainage Study, Tohono O□Odham Nation-San Xavier District Phase 1- Panhandle Area Existing Conditions: study boundaries, hydraulic analysis, HEC-RAS output printout, and maps (2) of HEC-RAS cross section locations

MASTER DRAINAGE STUDY
TOHONO O'ODHAM NATION - SAN XAVIER DISTRICT
PHASE I – PANHANDLE AREA
EXISTING CONDITIONS

Location:
The study area is located in portions of
Section 9, 16, 21&22, Township 15 South, Range 13 East

Prepared for:
Pima County Flood Control District
201 N. Stone Avenue
Tucson, Arizona 85701

July 31, 2001

Prepared by:

MMLA Inc.
800 E. Wetmore Road, Suite 110
Tucson, AZ 85719

MMLA 99024-04-45

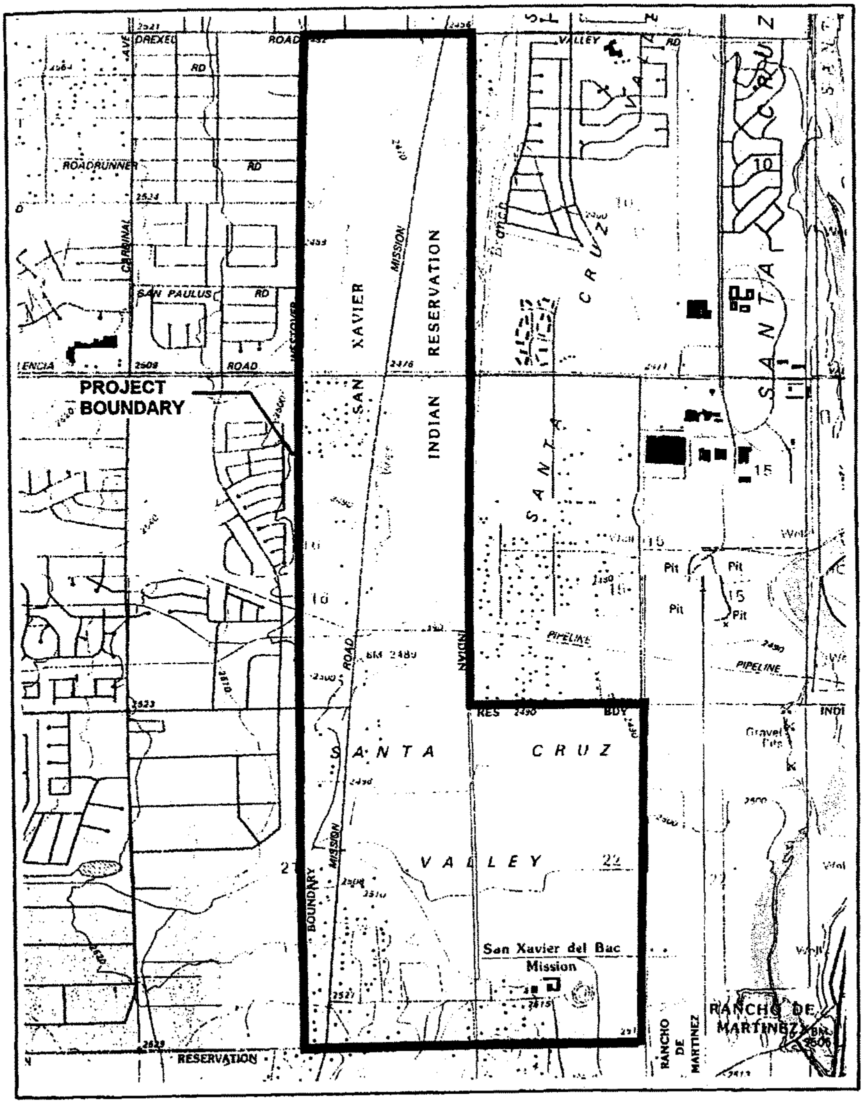

FIGURE 1
STUDY BOUNDARY MAP
Township 15S, Range 13E,
Portions of Sections 9,16, 21 & 22

MMLA
McGovern MacVittie Lodge & Associates, Inc.

3.3.3 Split Flow Analysis

In order to better quantify the peak discharges in Cemetery Wash at San Xavier Mission Road, a split flow analysis was completed on Black Mountain Wash (Watershed 21) using the HEC-2 split flow option. The analysis utilized the HEC-1 peak discharge calculated at Concentration Point (C.P.) 21, and it was assumed that breakout over Mission Road behaves as weir flow. The results of the split flow analysis were entered back into the HEC-1 model as a flow diversion.

Under existing conditions, conveyance in Black Mountain Wash is limited to approximately 1630 cfs upstream of Go:k Ka:wulk Wo:g. Excess flow breaks over Mission Road and enters Watershed 17. Downstream of Go:k Ka:wulk Wo:g, most of the remaining flow crosses Mission Road and enters the Cemetery Wash watershed. Flow that does not cross Mission Road, enters the Mission Wash watershed and causes problematic flooding along Su:dagi Wo:g, a local dirt road. A detailed analysis of this second flow split was not completed due to the lack of adequate topography, and all of the runoff downstream of Go:k Ka:wulk Wo:g was assumed to contribute to Cemetery Wash. A copy of the split flow output and a cross-section location map are provided in Appendix 8.8.

4.0 HYDRAULIC ANALYSIS

4.1 EXISTING DRAINAGE IMPROVEMENTS

4.1.1 CULVERT CROSSINGS

There are currently four culvert crossings that affect the study area, all of which are located along Valencia Road. The details and design capacities of the culverts were determined from as-built drawings obtained from Pima County Mapping and Records. The first crossing consists of a 7 cell, 10' x 6' RCBC which conveys flow in Valencia Wash under Valencia Road. The upstream channel and culvert have a design capacity of 5257 cfs, which will pass the calculated 100-year peak discharge without breakout over Valencia Road. The second crossing is located at the southwest corner of Mission Road and Valencia Road and consists of a single 10' x 4' RCBC. The crossing conveys flow at C.P. 5 (Figure 4a) under Valencia Road and into a concrete lined channel which conveys flow to WBCSR. The design capacity of the culvert is 360 cfs, which will pass the 100-year discharge if all flow can concentrate at the headwall of the culvert. The third crossing consists of a 3 cell, 71" x 47" CMPA which is located in the historic alignment of the WBSCR, approximately 900 feet west of the channel realignment. The design capacity of the crossing is 512 cfs and conveys low flows in the historic channel under Valencia Road. The final crossing consists of a 10 cell, 12' x 8' RCBC and upstream channel improvements that convey flow from the relocated WBSCR under Valencia Road. The upstream channel and culvert crossing have a design capacity of 8000 cfs, which assuming all flow is contained in the channel, could pass the calculated 100-year discharge without breakout over Valencia Road. However, the earthen berms near the improved WBSCR prevent runoff from entering the channel, contributing to the wide floodplain across the panhandle area and Co-op Farm. Table 2 provides a summary of culvert crossing details.

TABLE 2
SUMMARY OF CULVERT CROSSING DETAILS

LOCATION	TYPE	Q_{design} (cfs)	Q_{100}* (cfs)
Valencia Wash @ Valencia Road	10-12' x 8 RCBC	5257	3680
Mission Road @ Valencia Road	1-10' x 4' RCBC	360	251
900 ft. west of WBSCR	3-71" x 47" CMPA	512	N/A
WBSCR @ Valencia Road	7-10' x 6' RCBC	8000	6900

*As determined by this study

4.1.2 LOS REALES IMPROVEMENT DISTRICT

In order to mitigate flooding caused from Mission Wash, Cemetery Wash and the unnamed drainage located just east of San Xavier Mission, the residents of the Los Reales subdivision formed an improvement district with Pima County in 1986. The formation of the Los Reales Improvement District (LRID) resulted in the construction of collector and conveyance channels on the west and south boundaries of the subdivision. The channel on the west boundary ties into an existing channel improvement which was associated with the construction of the 10-12'x 8' RCBC under Valencia Road. The extent of the west LRID channel is shown on Figure 5 (Sheet 2). Along the southern boundary, a floodwall was constructed which diverts flow to the head of the southern conveyance channel. The floodwall extends approximately 1500' feet east from the southwest corner of the subdivision, and has a height of four feet. The southern channel conveys flow directly to the Santa Cruz River as shown on Figure 5 (Sheet 4).

Record drawings for the LRID were obtained from Pima County to estimate the conveyance capacity of the channels. The western channel consists of two distinct channel reaches. The first reach is fully lined with concrete and extends north from Los Reales Road for a distance of approximately 1100 feet. It has 1:1 side slopes, a depth that varies from 4.5 to 6 feet, and a bottom width of 34 feet with a slope of 0.32%. The channel then transitions into Reach 2 geometry, which extends north for a distance of approximately 1500 feet. The channel has a 26' bottom width with a slope of 0.35%. The sides are concrete lined with a 1:1 slope, and the channel depth ranges from 5.5 to 7.5 feet.

The southern channel consists of three distinct reaches, the first of which begins at the end of the flood wall. This reach extends approximately 2100' east and has a 30' to 40' bottom width, 1:1 concrete lined side slopes, and a depth ranging from 6 to 9 feet. The slope of the earthen bottom is 0.25%. The channel then transitions into Reach 2 geometry which extends approximately 2000 feet to the east. Reach 2 has an unlined bottom with a width of 15' to 30' feet and slope of 0.25%. The northern side of the channel is earthen with a 3:1 slope. The southern side of the channel is concrete lined with a 1:1 slope. The last segment of the channel (Reach 3) extends approximately 630 east where it discharges to the Santa Cruz River. The channel is completely unlined with 3:1 side slopes, a depth of 15 to 19 feet, and a 15' bottom width with a 1.2% slope.

A minimum and maximum capacity for each reach of the west and south channels was calculated using Manning's equation. A field inspection of channel integrity and more detailed backwater analysis may be completed on both channels as part of the Phase II study. Hydraulic calculation sheets and typical cross-sections for the channels taken from the record drawings are provided in Appendix 8.8. The approximate beginning and end for each channel reach is shown on Figure 5 (Sheets 2 & 4). The minimum full flow discharge for each segment is summarized in Table 3 below. The variances in full flow capacity are the results of both varying channel depth and bottom slope. As shown in the table, it does not appear the LRID channels were designed to convey the 100-year discharge. The capacity values calculated as part of this study correlate well with those presented in the *Letter of Map Revision for the Los Reales Improvement District*, completed by Arroyo Engineering in December 1994. The analysis presented in that document is the basis for the current FEMA floodplain mapping in the area of the collector channels.

TABLE 3
SUMMARY OF MANNING'S CALCULATIONS
LOS REALES IMPROVEMENT DISTRICT CONVEYANCE CHANNELS

CHANNEL	SEGMENT	ESTIMATED CAPACITY (cfs)		INFLOW (cfs)		
		Min.	Max.	Q_2	Q_{10}	Q_{100}
West	1	1938	2858	2241	4215	6901
West	2	1578	2389	2241	4215	6901
South	1	2723	2829	1056	2355	5128
South	2	3559	4498	1056	2355	5128
South	3	17010	18500	1056	2355	5128

Based on field observations and available topographic mapping, the channels are not effectively receiving the flows they were intended to convey. The presence of earthen berms, as shown on Figure 5 (Sheets 2 & 4), is severely impeding conveyance into both the western and southern channels. Consequently, the channels are not providing any appreciable level of flood control or mitigation for the Nation. The presence of the berms is shown on the record drawings. However, it is unknown whether they were present prior to construction, or placed as part of construction.

4.2 FLOODPLAIN ANALYSIS

The purpose of the floodplain analysis was to delineate the 100-year floodplains impacting the study area, and determine the 100-year water surface elevations for planning of future improvements. Floodplain delineation was completed using Manning's equation, the HEC-RAS computer program, as well as the results of aerial photograph analysis and field reconnaissance in areas where computational methods were considered inappropriate due to topography and limited conveyance. Floodplain mapping was completed on 1"= 200', 2' contour interval aerial topography dated November 15, 1994 (Figure 5). The topography was supplied to Pima County Flood Control District by the Natural Resource Conservation Service (NRCS), Phoenix office, and is based on the North American Vertical Datum of 1929. An attempt was made in a memorandum dated April 16, 1999, to obtain the more recent topography (April 1998) which is to be distributed by Pima Association of Governments. However, it was determined that this topography was not readily available at the time of this report, and that it did not extend far enough into the study area. Manning's calculation sheets and HEC-RAS output files are provided in Appendix 8.10.

The 100-year discharge of 6809 cfs used upstream of Valencia Road represents the hydrograph summation of the Mission Wash and Cemetery Wash watersheds. An additional 2440 cfs is contributed from the smaller watersheds to the west. However, this discharge was not added to the 6809 cfs due to the large difference in the time to peak discharge between the those smaller watersheds to the west, and the Cemetery Wash and Mission Wash watersheds which contribute the largest amount of flow. Mission Wash was modeled assuming an approximate 4:1 expansion from the point where flow crosses Mission Road. This approach was taken to ensure that water surface elevations on the west side of the floodplain were not underestimated as a result of the expansion of flows into the agricultural area east of Mission Road (see Figure 5, Sheet 3). The results of the floodplain analysis yielded the following conclusions:

- The agricultural area south of Valencia Road is **completely inundated** during the 100-year event because of flat topography and poor conveyance into the existing Los Reales Improvement District southern channel. Most existing residences in the panhandle area south of Valencia Road are not in the 100-year floodplain.

- Flow from Watershed 17 which enters the study area east of San Xavier Mission is conveyed east to the Santa Cruz River, either directly, or by way of the Los Reales Improvement District southern conveyance channel. This assumption is based on existing topography and the presence of a berm on both sides of Cemetery Wash that tends to promote conveyance to the east.

- For the purposes of future development, the entire panhandle area north of Valencia Road is considered as **completely inundated** during the 100-year event. This assumption is based on the results of the hydrologic analysis, and review of the existing topography which indicates flows in the various poorly defined drainages converge prior to reaching Mission Road creating large ponded areas. In addition, the actual location of discharge points across Westover Avenue is unpredictable due to poorly defined dip sections and periodic grading of the shoulder. Any "islands" which do exist in the panhandle area during the 100-year event would be inaccessible due to flooding in the surrounding areas.

- The 100-year discharge in the Santa Cruz River is contained within the existing channel banks as per FIRM Panel C2830K, dated February 8, 1999.

HEC-RAS September 1998 Version 2.2
U.S. Army Corp of Engineers
Hydrologic Engineering Center
609 Second Street, Suite D
Davis, California 95616-4687
(916) 756-1104

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X      XXX   XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
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PROJECT DATA
Project Title: San Xavier District Master Drainage Study
Project File : FSPNIR.prj
Run Date and Time: 11/22/99 2:21:08 PM

Project in English units

Project Description:
100-year Floodplain Mission Wash, Mission Road to Valencia Road

PLAN DATA

Plan Title: Plan 06
Plan File : e:\mike\98013-05\FSPNIR.p06

Geometry Title: Mission Wash - South of Valencia
Geometry File : e:\mike\98013-05\FSPNIR.g02

Flow Title : Mission Wash
Flow File : e:\mike\98013-05\FSPNIR.f04

Plan Summary Information:

Number of:	Cross Sections	= 11	Mulitple Openings	=	0
	Culverts	= 0	Inline Weirs	=	0
	Bridges	= 0			

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculaton tolerance = 0.01
Maximum number of interations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Mission Wash
Flow File : e:\mike\98013-05\FSPNIR.f04

Flow Data (cfs)

River	Reach	RS	PF#1
Mission Wash	1	11	6901

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Mission Wash	1	PF#1		Normal S = .003

GEOMETRY DATA

Geometry Title: Mission Wash - South of Valencia
Geometry File : e:\mike\98013-05\FSPNIR.g02

CROSS SECTION RIVER: Mission Wash

```
REACH: 1                  RS: 11

INPUT
Description:
Station Elevation Data     num=       9
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0   2504.9      240     2502      490     2500      590     2498      620     2498
     720     2500      990     2502     1050     2504     1150     2505

Manning's n Values         num=       3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     1150     .035

Bank Sta: Left    Right    Lengths: Left Channel    Right      Coeff Contr.    Expan.
             0     1150              720     720      720                .1        .3

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 10

INPUT
Description:
Station Elevation Data     num=      18
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2502      220     2500      420     2498      530     2498      640   2498.2
     660   2496.3      770   2496.3      790     2498      830     2498      840     2496
    1070   2495.5     1690   2494.5     1870   2494.2     2380     2496     2540     2496
    2640     2495     2720     2496     2730     2498

Manning's n Values         num=       3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     2730     .035

Bank Sta: Left    Right    Lengths: Left Channel    Right      Coeff Contr.    Expan.
             0     2730              640     640      640                .1        .3
Ineffective Flow      num=        1
   Sta L    Sta R    Elev
     820     2730    2502

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 9

INPUT
Description:
Station Elevation Data     num=      23
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2500      320     2498      370   2497.8      490     2497      590   2496.2
     650     2496      750     2495      810     2494      820     2495      850     2495
     900     2494      970     2493     1000   2492.4     1025   2491.9     1160     2492
    1270   2491.9     1470   2491.3     1800     2492     1835     2492     1960   2491.8
    1970   2491.7     2120     2492     2440     2494

Manning's n Values         num=       3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     2440     .035

Bank Sta: Left    Right    Lengths: Left Channel    Right      Coeff Contr.    Expan.
             0     2440              600     600      600                .1        .3
Ineffective Flow      num=        1
   Sta L    Sta R    Elev
     950     2440    2498

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 8

INPUT
Description: 0
Station Elevation Data     num=      15
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2496      150     2495      370     2494      470     2493      550     2492
     600   2492.5      610     2492      800   2491.1      900     2490     1200   2490.3
    1500   2490.5     1600   2490.4     1700   2490.5     1800   2490.7     2000   2492.3

Manning's n Values         num=       3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     2000     .035

Bank Sta: Left    Right    Lengths: Left Channel    Right      Coeff Contr.    Expan.
             0     2000              460     460      460                .1        .3
Ineffective Flow      num=        1
   Sta L    Sta R    Elev
    1050     2000    2498

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 7

INPUT
Description:
Station Elevation Data     num=      16
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2494      150     2492      207   2490.9      360   2490.5      500     2490
     510     2492      517     2492      650   2490.6      840     2490     1040   2489.6
    1110   2489.4     1300   2489.2     1570   2488.9     1740   2489.9     1800     2490
    1850     2491

Manning's n Values         num=       3
```

```
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .035        0    .035     1850    .035

Bank Sta: Left    Right     Lengths: Left Channel    Right       Coeff Contr.    Expan.
             0     1850               500     500      500                 .1        .3

CROSS SECTION            RIVER: Mission Wash
REACH: 1                     RS: 6

INPUT
Description:
Station Elevation Data      num=       14
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2492       25     2492      165     2490      400     2488      585   2488.3
    1340     2488     1760     2486     1772     2484     1800     2486     1810     2488
    1815   2490.5     1825   2481.2     1855   2481.2     1865     2491

Manning's n Values          num=        3
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .035        0    .035     1815    .025

Bank Sta: Left    Right     Lengths: Left Channel    Right       Coeff Contr.    Expan.
             0     1815               800     800      800                 .1        .3
Ineffective Flow       num=         1
   Sta L    Sta R     Elev
    1815     1865   2490.5

CROSS SECTION            RIVER: Mission Wash
REACH: 1                     RS: 5

INPUT
Description:
Station Elevation Data      num=       18
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2488       60     2488      180     2487      220     2486      260     2486
     620   2485.3     1045   2485.4     1255   2485.3     1625     2484     1720     2482
    1740     2481     1750     2482     1760     2484     1765     2486     1770     2488
    1780   2479.5     1810   2479.5     1820     2489

Manning's n Values          num=        3
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .035        0    .035     1770    .025

Bank Sta: Left    Right     Lengths: Left Channel    Right       Coeff Contr.    Expan.
             0     1770               800     800      800                 .1        .3
Ineffective Flow       num=         1
   Sta L    Sta R     Elev
    1770     1820     2488

CROSS SECTION            RIVER: Mission Wash
REACH: 1                     RS: 4

INPUT
Description:
Station Elevation Data      num=       18
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2486       35     2486      100     2484      260     2482      750     2481
    1050   2480.2     1404   2481.4     1535     2480     1650     2478     1660     2476
    1670     2474     1680     2478     1690     2480     1700     2478     1710     2483
    1720     2475     1750     2475     1760     2484

Manning's n Values          num=        3
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .035        0    .035     1710    .035

Bank Sta: Left    Right     Lengths: Left Channel    Right       Coeff Contr.    Expan.
             0     1710               800     800      800                 .1        .3
Ineffective Flow       num=         1
   Sta L    Sta R     Elev
    1710     1760     2484

CROSS SECTION            RIVER: Mission Wash
REACH: 1                     RS: 3

INPUT
Description:
Station Elevation Data      num=       19
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2486       20     2485       40     2486       75     2484      120     2482
     179     2482      300     2483      370     2482      410     2480      900   2479.5
    1250   2479.7     1560     2478     1575     2477     1590     2478     1615     2480
    1630     2480     1645     2472     1665     2472     1675     2481

Manning's n Values          num=        3
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .035        0    .035     1675    .035

Bank Sta: Left    Right     Lengths: Left Channel    Right       Coeff Contr.    Expan.
             0     1675               780     780      780                 .1        .3
Ineffective Flow       num=         1
   Sta L    Sta R     Elev
    1630     1675     2482

CROSS SECTION            RIVER: Mission Wash
REACH: 1                     RS: 2
```

```
INPUT
Description:                              :
Station Elevation Data     num=       12
     Sta      Elev      Sta      Elev      Sta      Elev      Sta      Elev      Sta      Elev
       0      2481       20      2480      150      2478      430    2477.6      700      2478
    1220      2478     1330    2477.6     1490      2478     1580      2480     1615    2467.5
    1635    2467.5     1645      2481

Manning's n Values         num=       3
     Sta     n Val      Sta     n Val      Sta     n Val
       0      .035        0      .035     1645      .035

Bank Sta: Left     Right     Lengths: Left Channel     Right        Coeff Contr.     Expan.
             0      1645              800      600       800                  .1         .3
Ineffective Flow       num=        1
   Sta L    Sta R     Elev
    1580     1645     2480

CROSS SECTION             RIVER: Mission Wash
REACH: 1                  RS: 1

INPUT
Description:
Station Elevation Data     num=       27
     Sta      Elev      Sta      Elev      Sta      Elev      Sta      Elev      Sta      Elev
       0      2479       50    2478.5       70      2478      130      2476      145      2476
     160      2476      320      2474      505      2472      560      2472      650      2474
    1150      2474     1312      2474     1370      2474     1440      2472     1460      2474
    1471      2476     1485      2478     1500      2478     1508      2476     1512      2474
    1520      2470     1530      2468     1550      2466     1580      2464     1590      2463
    1600      2464     1630      2470

Manning's n Values         num=       3
     Sta     n Val      Sta     n Val      Sta     n Val
       0      .035        0      .035     1630      .035

Bank Sta: Left     Right     Lengths: Left Channel     Right        Coeff Contr.     Expan.
             0      1630              800      800       800                  .1         .3
Ineffective Flow       num=        1
   Sta L    Sta R     Elev
    1485     1630     2478
```

SUMMARY OF REACH LENGTHS

River: Mission Wash

Reach	River Sta.	Left	Channel	Right
1	11	720	720	720
1	10	640	640	640
1	9	600	600	600
1	8	460	460	460
1	7	500	500	500
1	6	800	800	800
1	5	800	800	800
1	4	800	800	800
1	3	780	780	780
1	2	800	800	800
1	1	800	800	800

Profile Output Table - Standard Table 1

Reach Froude # Chl	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
1 0.45	11	6901.00	2498.00	2502.75		2502.97	0.002764	3.77	1830.75	834.10
1 0.43	10	6901.00	2494.20	2500.85	2499.53	2501.09	0.002462	3.92	1761.19	2604.05
1 0.84	9	6901.00	2491.30	2497.54	2497.26	2498.22	0.010125	6.62	1043.21	2031.29
1 0.61	8	6901.00	2490.00	2493.52	2492.81	2493.92	0.005165	5.08	1357.99	1581.78
1 0.62	7	6901.00	2488.90	2490.97		2491.20	0.006484	3.81	1809.73	1536.06
1 0.34	6	6901.00	2484.00	2489.53	2488.58	2489.63	0.001777	2.55	2708.14	1640.44
1 0.99	5	6901.00	2481.00	2485.87	2485.87	2486.31	0.018049	5.33	1295.82	1479.79
1 0.31	4	6901.00	2474.00	2482.68	2481.44	2482.77	0.001369	2.41	2863.17	1551.81
1 0.32	3	6901.00	2472.00	2481.52	2480.40	2481.63	0.001474	2.65	2599.29	1295.44
1 0.70	2	6901.00	2467.50	2479.05	2478.80	2479.33	0.008439	4.22	1636.64	1516.79
1 0.45	1	6901.00	2463.00	2475.36	2474.63	2475.53	0.003002	3.28	2103.99	1376.97

Profile Output Table - Standard Table 2

Reach	River Sta	E.G. Elev (ft)	W.S. Elev (ft)	Vel Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
1	11	2502.97	2502.75	0.22	1.87	0.00		6901.00		834.10
1	10	2501.09	2500.85	0.24	2.83	0.04		6901.00		2604.05
1	9	2498.22	2497.54	0.68	4.22	0.08		6901.00		2031.29
1	8	2493.92	2493.52	0.40	2.67	0.05		6901.00		1581.78
1	7	2491.20	2490.97	0.23	1.53	0.04		6901.00		1536.06
1	6	2489.63	2489.53	0.10	3.29	0.03		6901.00		1640.44
1	5	2486.31	2485.87	0.44	2.69	0.11		6901.00		1479.79
1	4	2482.77	2482.68	0.09	1.14	0.00		6901.00		1551.81
1	3	2481.63	2481.52	0.11	2.29	0.02		6901.00		1295.44
1	2	2479.33	2479.05	0.28	3.77	0.03		6901.00		1516.79
1	1	2475.53	2475.36	0.17				6901.00		1376.97

Appendix 3

Request for a Letter of Map Revision for the Los Reales Improvement District Located in Pima County, Arizona, and the City of Tucson, Arizona: study boundaries, HEC-2 input and output printout for the West Branch of the Santa Cruz River from Valencia Road to the Reservation Boundary, HEC-2 input and output printout for the South Channel

REQUEST FOR A LETTER OF MAP REVISION FOR THE LOS REALES IMPROVEMENT DISTRICT LOCATED IN PIMA COUNTY, ARIZONA, AND IN THE CITY OF TUCSON, ARIZONA

Submitted to:
PIMA COUNTY DEPARTMENT OF TRANSPORTATION
AND FLOOD CONTROL DISTRICT
Floodplain Planning Section
Fourth Floor, Public Works Building
201 North Stone Avenue
Tucson, Arizona 85701-1207
(602) 740-6350

and to:
CITY OF TUCSON DEPARTMENT OF TRANSPORTATION
Engineering Division, Floodplain Section
P.O. Box 27210
Tucson, Arizona 85726-7210
(602) 791-4914

Prepared By:
ARROYO ENGINEERING, INC.
P.O.Box 2668
Tucson, Arizona 85702
(602) 882-0206

Registered Professional Engineer (Civil)
CERTIFICATE NO. 18683
ROBERT J. SMOLINSKY
DATE SIGNED 1-10-95
ARIZONA, U.S.A.

December, 1994

ARROYO ENGINEERING, INC.

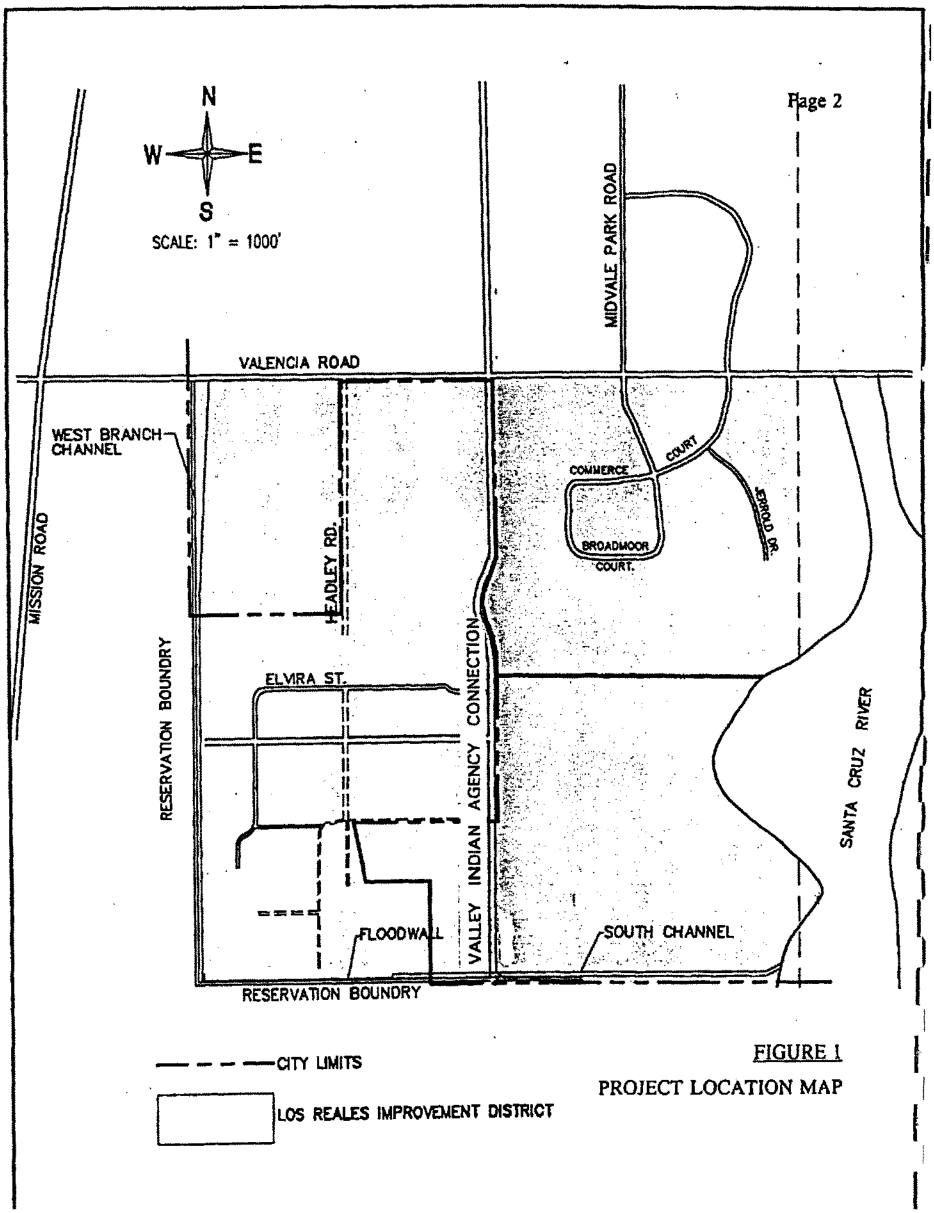

FIGURE 1

PROJECT LOCATION MAP

Appendix C

HEC-2 Input and Output Files for the West Branch of the Santa Cruz River from Valencia Rd to the Reservation Boundary

ARROYO ENGINEERING, INC.

```
SF  Splitflow Analysis of the Los Reales Floodwall and Diversion Channels
JC  Splitflow Analysis
JP     0       0     100       0       0
TN  Normal depth split flow  - Sections 11 to 12
NS     2      11      12      -1    0.06   0.004
NG     0  2477.2     200  2478.0
TN  Normal depth split flow - Sections 12 to 13
NS     2      12      13      -1    0.06   0.004
NG     0  2478.0     200  2478.5
TN  Normal depth split flow - Section 13 to 14
NS     2      13      14      -1    0.06   0.004
NG     0  2478.5     112  2478.6
TN  Normal depth split flow - Sections 14 to 15
NS     2      14      15      -1    0.06   0.004
NG     0  2478.6     100  2479.5
TN  Normal depth split flow - Sections 21 to 22
NS     2      21      22      -1    0.06   0.003
NG     0  2484.3      44  2484.4
TN  Normal depth split flow - Sections 22 to 23
NS     2      22      23      -1    0.06   0.003
NG     0  2484.4     231  2484.5
TC  Rating curve outflow data set for Splitflow into South Diversion Channel
CS     3      28    28.1      -1
CR  3250 2489.90    3300 2489.93    3350 2489.97
TW  Splitflow #28 to #28.1 (Splitflow goes directly into the Santa Cruz River)
WS     9      28    28.1      -1     2.6
WC6750.0  2491.3  6760.0  2488.3  6950.0  2489.1  7150.0  2489.2  7350.0  2490.0
WC7550.0  2491.6  7750.0  2491.8  7850.0  2492.5  7950.0  2494.1
EE
T1      Los Reales Improvement District, Letter of Map Revision
T2      Arroyo Job #PDOT01.1, HEC2 File: WEST.H2I
T3      West Branch Santa Cruz  River
T4      West Branch Santa Cruz River, from Valencia Rd. to Los Reales Rd.

J1     0       2       0       0       0       0       0       0  2466.7
J2     1       0      -1       0       0       0       0       0       0
J3    38      43      13      14      15       1       2       3       8      53
J3     4      54      61              150
NC  .030    .030   .0275     0.1     0.3
QT     1    7638

X1     1      15    1390    2002       0       0       0
*  X-Sec  1: Same as Sta 448+00 on West Branch Bank Protection Plan 4BVALE
GR  2474    1300    2474    1390    2472    1520    2470    1695    2468    1780
GR  2466    1810    2465    1836  2463.7  1861.5    2463    1864    2463    1995
GR  2470    2002  2470.3    2022    2470    2172    2472    2860    2472    3020

X1     2      23    1800    2002     100     100     100
*  X-Sec  2: Same as Sta 447+00 on West Branch Bank Protection Plan 4BVALE
GR  2475    1250    2474    1430    2472    1560    2470    1710    2470    1778
GR  2472    1785    2472    1794    2474    1800    2472    1805    2470    1810
GR  2468    1825    2466  1835.5  2464.9    1841  2465.2    1852    2464    1864
GR2463.5  1865.5  2463.5    1995  2470.5    2002  2470.8    2022  2471.4    2024
GR2471.7    2074    2472    2164    2472    3050

X1     3      18    1820    2002     200     200     200
*  X-Sec  3: Same as Sta 445+00 on West Branch Bank Protection Plan 4BVALE
GR2475.5    1200    2474    1470    2472    1565    2470    1650    2472    1680
GR  2472    1750    2472    1790    2476    1805    2476    1820  2471.5  1836.5
GR2465.8    1858  2464.5    1878  2464.3  1879.5  2464.4    1995  2471.2    2002
GR2471.5    2022  2471.8    2023    2473    3050

X1     4      16    1838    2002     200     200     200
*  X-Sec  4: Same as Sta 443+00 on West Branch Bank Protection Plan 4BVALE
GR  2476    1260    2474    1515    2472    1600    2472    1660    2474    1820
GR  2476    1830    2479    1838    2474    1848  2466.8    1873  2464.7    1939
GR  2465  1945.5    2465    1995    2472    2002  2472.3    2022  2472.5    2023
GR2473.5    3100

X1     5      15    1841    2002     200     200     200
*  X-Sec  5: Same as Sta 441+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    3090
GR2476.0    1250    2476    1530    2474    1790    2474    1820    2476    1830
GR2479.5    1841  2465.5    1901  2464.8    1918  2465.6  1925.5  2465.6    1995
GR2472.6    2002    2473    2022  2473.8    2023    2472    2720  2472.5    3100

X1     6      15    1868    2002     200     200     200
*  X-Sec  6: Same as Sta 439+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    3040
GR  2476    1300    2476    1840    2480    1850    2480    1868    2474    1879
GR  2467    1913    2465    1913  2466.5  1965.5  2466.5    1995  2473.5    2002
```

```
GR2473.7  2026.5    2474    2028    2472    2100    2473    2800  2474.0    3100

X1     7      14    1886    2002     200     200     200
* X-Sec  7: Same as Sta 437+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    3000
GR  2477    1300    2476    1870    2478    1875    2480    1880    2481    1886
GR2475.3    1894  2469.5    1922  2466.7    1930  2467.1  1982.5  2467.1    1995
GR  2474    2002  2474.4    2022  2472.5    2400    2474    3000

X1     8      12    1880    2000     200     200     200
* X-Sec  8: Same as Sta 435+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2970
GR  2477    1300    2478    1880    2480    1890  2480.0    1895  2476.5    1905
GR  2470    1930    2467    1948    2468    1992  2474.8    2000    2475    2020
GR  2474    2400  2475.5    3150

X1     9      17    1920    1998     164     164     164
* X-Sec  9: Same as Sta 433+36 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2930
GR  2478    1500    2478    1900    2480    1905    2480    1920  2476.8    1934
GR2467.7    1953  2467.5    1978    2469  1982.6    2469  1991.3  2475.5    1998
GR2475.6    2018    2476    2019    2476  2043.5  2474.5  2230.0  2475.0    2550
GR2476.0    2900    2476    3150

NC  .030    .030    .029     0.1     0.3
X1    10      18    1946  2004.5     136     136     136
* X-Sec 10: Same as Sta 432+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2920
GR  2482     400    2480     420    2478     540    2478     780    2478    1730
GR  2477    1850  2478.0    1920    2480    1940  2482.8    1946  2477.5    1955
GR2469.5    1977    2469    1980    2469    1998  2475.9  2004.5  2476.1    2064
GR  2475    2300  2476.0    2700  2476.5    3200
NC  .030    .060    .029     0.1     0.3

X1    11      18    1960    2003     200     200     200
* X-Sec 11: Same as Sta 430+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2860
GR  2480     580    2478     660    2478    1840  2477.0    1880    2480    1935
GR  2480    1960  2478.4    1965  2477.4    1972  2472.8    1972  2469.8    1978
GR2469.6  1979.5  2469.6    1996  2476.6    2003  2476.8    2015  2476.0    2040
GR2475.8    2200  2476.0    2520  2477.2    3350

X1    12      17    1955    2003     200     200     200
* X-Sec 12: Same as Sta 428+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2810
GR  2482     680    2480     720  2478.4    1600    2478    1875  2477.5    1900
GR  2478    1925    2480    1950  2483.1    1955    2477    1965  2470.8    1979
GR2470.3  1982.8  2470.3    1995  2478.4    2003  2478.7    2015    2476    2300
GR2477.5  2850.0  2478.0    3320

X1    13      19    1955    2003     200     200     200
* X-Sec 13: Same as Sta 426+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2765
GR  2482     680    2480     770  2479.1    1300    2478    1870  2477.7    1885
GR  2478    1920    2480    1932    2480    1945    2484    1955    2479    1965
GR  2478    1971    2473    1971    2471  1976.5    2471  1995.5  2478.5    2003
GR2478.5    2015  2477.5    2280    2478    2700  2478.5    3450

NC  .030    .060    .020     0.1     0.3
X1    14      16    1960    2000     112     112     112       0
* X-Sec 14: Same as Sta 52+66 on Los Reales Improvement District Plan ID-101
*                   and Sta 424+88 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2740
GR  2482     720    2480     800    2479    1200    2479    1800    2478    1870
GR2477.8    1900    2478    1920    2480    1950  2480.0    1960  2476.3    1966
GR2471.9    1970  2471.9    1996  2479.2    2000  2477.5    2400  2478.0    2650
GR2478.6    3500

NC  .030    .060   .0235     0.1     0.3
X1    15      16    2000    2040     100     100     100       0
* X-Sec 15: Same as Sta 51+66 on Los Reales Improvement District Plan ID-101
X3     0       0       0       0       0    2765
GR  2482     760    2480     820    2480    1180  2479.5    1820  2478.0    1895
GR  2476    1908    2474    1930    2474    1990  2478.8    2000  2472.2    2007
GR2472.2    2033  2479.7    2040    2478    2420    2478    2420    2479    2900
GR2479.5    3500

X1    16      20    1993    2040     250     250     250       0
* X-Sec 16: Same as Sta 49+16 on Los Reales Improvement District Plan ID-101
X3     0       0       0       0       0    2680
GR  2484     510    2482     890    2480    1310  2479.8    1750    2480    1870
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```
GR 2480     1920    2478    1927    2476    1932    2476    1940    2478    1948
GR 2480     1960    2482    1967    2482    1993  2480.3    2000 2473.11    2007
GR2473.1    2033  2480.5    2040  2478.5    2160  2480.0    2590  2481.5    3350

X1   17       14    1995    2040     250     250     250       0
*  X-Sec 17: Same as Sta 46+66 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2620
GR 2484      490    2482    1190    2480    1740    2481    1900    2480    1940
GR 2482     1970    2482    1995  2480.7    2000 2474.02    2007 2474.02    2033
GR2481.1    2040  2480.5    2250  2481.0    2900  2481.8    3300

X1   18       18    1990    2040     250     250     250       0    2000
*  X-Sec 18: Same as Sta 44+16 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2550
GR  486      450     484     580     482    1300   481.6    1530     482    1740
GR 482.2    1830     482    1910     480    1950     477    1970     480    1980
GR  483     1990   481.1    2000  474.92    2007  474.92    2033   481.7    2040
GR 481.5    2480     482    3300   482.2    3450

X1   19       17    1995    2040     250     250     250       0    2000
*  X-Sec 19: Same as Sta 41+66 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2480
GR  488      500     486     520     484     830   482.2    1500     482    1940
GR  480     1960     479    1980     480    1990     487    1995   481.6    2000
GR475.80    2007  475.80    2033   482.3    2040   481.8    2250     482    2500
GR  482     3000     483    3680

X1   20       18    1995    2040     250     250     250       0    2000
*  X-Sec 20: Same as Sta 39+16 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2420
GR  488      445     486     695     484     810   482.9    1065   482.2    1860
GR  478     1950     480    1960     482    1970     484    1980     486    1990
GR  487     1995   482.3    2000  476.67    2007  476.67    2033   483.0    2040
GR 482.2    2280     483    2930     484    3310

NC  .030    .060    .020
X1   21       16    1990    2048     197     197     197       0    2000
*  X-Sec 21: Same as Sta 37+19 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2375
GR  488      410     486     670     484    1060     484    1930     482    1949
GR  482     1962     484    1972     486    1980     487    1990   483.0    2000
GR477.37    2015  477.37    2041   484.0    2048   483.3    2300     484    2595
GR 484.3    3330

X1   22       19    1990    2046      44      44      44       0    2000
*  X-Sec 22: Same as Sta 36+75 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2365
GR  488      390     488     650     486     720     484     780     484    1600
GR  482     1660     482    1910     482    1965     484    1975     486    1982
GR  487     1990   483.2    2000  478.87    2006  478.87    2040   484.2    2046
GR  484     2080   483.4    2300     484    2640   484.4    3335

X1   23       15    1980    2046     231     231     231       0    2000
*  X-Sec 23: Same as Sta 34+44 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2310
GR  490      450     488     470     486    1230   484.3    1800     484    1910
GR  482     1935   481.5    1940     487    1980   484.2    2000   479.6    2006
GR 479.6    2040   485.2    2046   484.1    2140   484.5    3000   484.5    3400

X1   24       13    1985    2046     231     231     231       0    2000
*  X-Sec 24: Same as Sta 32+13 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2250
GR  488      370   487.4     820     486    1380     484    1950   482.2    1960
GR  488     1985     486    1995   485.8    2000   480.4    2006   480.4    2040
GR 485.4    2046   485.5    2400     486    3150

X1   25       15    2000    2046     300     300     300       0    2000
*  X-Sec 25: Same as Sta 29+13 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2170
GR  488      410     486    1850     484    1950   483.5    1955     484    1970
GR  486     1982     488    1995   488.3    2000   481.3    2006   481.3    2040
GR 488.3    2046   486.5    2430     487    3040   486.2    3450   487.5    4100

X1   26       13    2000    2046     235     235     235       0    2000
*  X-Sec 26: Same as Sta 26+78 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2100
GR  490      420     488     650     487    1200     486    1940     485    1950
GR  486     1975     488    1990   488.5    2000   482.1    2006   482.1    2040
GR 488.5    2046     487    2500     488    3400

X1   27       16    2000    2046     234     234     234       0
```

```
* X-Sec 2444  Located at u/s end of channel
GR2494.0      50  2492.0     200  2490.0     490  2488.0    1900  2487.4  1931.5
GR2485.6  1957.5  2488.5  1961.5  2488.8  1967.5  2488.2  1975.5  2489.1  1984.5
GR2488.8  1998.9  2488.8    2000  2482.8    2006  2482.8    2040  2488.8  2045.5
GR2493.4  2046.0

NC 0.030   0.060   0.022      .1      .3
X1    28      44    2000    3340      52      52      52       0
* X-Sec 2392  Located at u/s end of channel and 31 ft u/s from Floodwall
* Ground-profile data along upstream side of floodwall were determined by
* field survey (NGVD-1929 datum).
GR2494.0       0  2492.0     150  2491.0     400  2489.5     650  2489.5     800
GR2490.0    1000  2490.0    1200  2490.0    1400  2490.0    1600  2490.0  1746.5
GR2490.3    1800  2490.2  1846.5  2490.0  1889.5  2488.6    1903  2488.6  1912.5
GR2487.4  1931.5  2485.6  1957.5  2488.5  1961.5  2488.8  1967.5  2488.2  1975.5
GR2489.1  1984.5  2488.8  1998.9  2488.7  2000.0  2488.9  2042.3  2489.4  2046.4
GR2488.7  2046.5  2489.3  2260.0  2489.2  2520.0  2489.0  2770.0  2489.2  3020.0
GR2489.3  3340.0  2488.9    3470  2488.9  3546.5  2488.2  4046.5  2488.7  4346.5
GR2487.9  4546.5  2489.5  4633.5  2489.5    4650  2489.5    5200  2488.7    5500
GR2488.6  5800.5  2488.7    6100  2488.3    6400  2491.3    6750

NC 0.030   0.060   0.022      .1      .3
X1  28.1      52    2000    3340       2       2       2       0
* X-Sec 2390  Located at u/s end of channel and 33 ft u/s from Floodwall
* Ground-profile data along upstream side of floodwall were determined by
* field survey (NGVD-1929 datum).
GR2494.0       0  2492.0     150  2491.0     400  2489.5     650  2489.5     800
GR2490.0    1000  2490.0    1200  2490.0    1400  2490.0    1600  2490.0  1746.5
GR2490.3    1800  2490.2  1846.5  2490.0  1889.5  2488.6    1903  2488.6  1912.5
GR2487.4  1931.5  2485.6  1957.5  2488.5  1961.5  2488.8  1967.5  2488.2  1975.5
GR2489.1  1984.5  2488.8  1998.9  2488.7  2000.0  2488.9  2042.3  2489.4  2046.4
GR2488.7  2046.5  2489.3  2260.0  2489.2  2520.0  2489.0  2770.0  2489.2  3020.0
GR2489.3  3340.0  2488.9    3470  2488.9  3546.5  2488.2  4046.5  2488.7  4346.5
GR2487.9  4546.5  2489.5  4633.5  2489.5    4650  2489.5    5200  2488.7    5500
GR2488.6  5800.5  2488.7    6100  2488.3    6400  2491.3    6750  2488.3    6760
GR2489.1    6950  2489.2    7150    2490    7350  2491.6    7550  2491.8    7750
GR2492.5    7850  2494.1    7950
EJ
ER
```

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*******************************************
* HEC-2 WATER SURFACE PROFILES            *
*                                         *
* Version   4.6.2;  May 1991              *
*                                         *
* RUN DATE   30NOV94    TIME   11:37:31   *
*******************************************
```

```
**************************************
* U.S. ARMY CORPS OF ENGINEERS       *
* HYDROLOGIC ENGINEERING CENTER      *
* 609 SECOND STREET, SUITE D         *
* DAVIS, CALIFORNIA 95616-4687       *
*          (916) 756-1104            *
**************************************
```

```
X     X  XXXXXXX   XXXXX               XXXXX
X     X  X        X     X             X     X
X     X  X        X                         X
XXXXXXX  XXXX     X           XXXXX    XXXXX
X     X  X        X                   X
X     X  X        X     X             X
X     X  XXXXXXX   XXXXX              XXXXXXX
```

WEST BRANCH SANTA CRUZ RIVER

EXISTING CONDITIONS

REVISED 12-1-94

INCLUDES SPLIT FLOWS TO EAST

```
                                                    THIS RUN EXECUTED 30NOV94    11:37:31
**************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.2:  May 1991
**************************************


SPLIT FLOW BEING PERFORMED

SF  Splitflow Analysis of the Los Reales Floodwall and Diversion Channels

JC  Splitflow Analysis
JP     0       0     100      0       0

TN  Normal depth split flow  - Sections 11 to 12
NS     2      11      12     -1    0.06   0.004
NG     0  2477.2     200  2478.0

TN  Normal depth split flow - Sections 12 to 13
NS     2      12      13     -1    0.06   0.004
NG     0  2478.0     200  2478.5

TN  Normal depth split flow - Section 13 to 14
NS     2      13      14     -1    0.06   0.004
NG     0  2478.5     112  2478.6

TN  Normal depth split flow - Sections 14 to 15
NS     2      14      15     -1    0.06   0.004
NG     0  2478.6     100  2479.5

TN  Normal depth split flow - Sections 21 to 22
NS     2      21      22     -1    0.06   0.003
NG     0  2484.3      44  2484.4

TN  Normal depth split flow - Sections 22 to 23
NS     2      22      23     -1    0.06   0.003
NG     0  2484.4     231  2484.5

TC  Rating curve outflow data set for Splitflow into South Diversion Channel
CS     3      28    28.1     -1
CR  3250 2489.90    3300 2489.93    3350 2489.97

TW  Splitflow #28 to #28.1 (Splitflow goes directly into the Santa Cruz River)
WS     9      28    28.1     -1     2.6
WC6750.0  2491.3  6760.0  2488.3  6950.0  2489.1  7150.0  2489.2  7350.0  2490.0
WC7550.0  2491.6  7750.0  2491.8  7850.0  2492.5  7950.0  2494.1
```

```
T1      Los Reales Improvement District, Letter of Map Revision
T2      Arroyo Job #PDOT01.1, HEC2 File: WEST.H2I
T3      West Branch Santa Cruz  River
T4      West Branch Santa Cruz River, from Valencia Rd. to Los Reales Rd.

J1  ICHECK    INQ     NINV    IDIR    STRT    METRIC   HVINS    Q      WSEL     FQ

       0        2       0       0       0       0        0       0    2466.7

J2  NPROF    IPLOT   PRFVS   XSECV   XSECH    FN      ALLDC    IBW    CHNIM    ITRACE

      1        0      -1       0       0       0        0       0       0

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

     38       43      13      14      15       1        2       3       8       53
      4       54      61              150

NC    .030     .030    .0275    0.1     0.3
QT       1     7638

X1       1       15     1390    2002       0       0        0
   X-Sec  1: Same as Sta 448+00 on West Branch Bank Protection Plan 4BVALE
GR    2474     1300     2474    1390    2472     1520     2470     1695     2468     1780
GR    2466     1810     2465    1836  2463.7   1861.5     2463     1864     2463     1995
GR    2470     2002   2470.3    2022    2470     2172     2472     2860     2472     3020

X1       2       23     1800    2002     100      100      100
   X-Sec  2: Same as Sta 447+00 on West Branch Bank Protection Plan 4BVALE
GR    2475     1250     2474    1430    2472     1560     2470     1710     2470     1778
GR    2472     1785     2472    1794    2474     1800     2472     1805     2470     1810
GR    2468     1825     2466  1835.5  2464.9     1841   2465.2     1852     2464     1864
GR  2463.5   1865.5   2463.5    1995  2470.5     2002   2470.8     2022   2471.4     2024
GR  2471.7     2074     2472    2164    2472     3050

X1       3       18     1820    2002     200      200      200
   X-Sec  3: Same as Sta 445+00 on West Branch Bank Protection Plan 4BVALE
GR  2475.5     1200     2474    1470    2472     1565     2470     1650     2472     1680
GR    2472     1750     2472    1790    2476     1805     2476     1820   2471.5   1836.5
GR  2465.8     1858   2464.5    1878  2464.3   1879.5   2464.4     1995   2471.2     2002
GR  2471.5     2022   2471.8    2023    2473     3050

X1       4       16     1838    2002     200      200      200
   X-Sec  4: Same as Sta 443+00 on West Branch Bank Protection Plan 4BVALE
GR    2476     1260     2474    1515    2472     1600     2472     1660     2474     1820
GR    2476     1830     2479    1838    2474     1848   2466.8     1873   2464.7     1939
GR    2465   1945.5     2465    1995    2472     2002   2472.3     2022   2472.5     2023
GR  2473.5     3100
```

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X1       5        15      1841      2002       200       200       200
  X-Sec  5: Same as Sta 441+00 on West Branch Bank Protection Plan 4BVALE
X3       0         0         0         0         0      3090
GR  2476.0      1250      2476      1530      2474      1790      2474      1820      2476      1830
GR  2479.5      1841    2465.5      1901    2464.8      1918    2465.6    1925.5    2465.6      1995
GR  2472.6      2002      2473      2022    2473.8      2023      2472      2720    2472.5      3100

X1       6        15      1868      2002       200       200       200
  X-Sec  6: Same as Sta 439+00 on West Branch Bank Protection Plan 4BVALE
X3       0         0         0         0         0      3040
GR    2476      1300      2476      1840      2480      1850      2480      1868      2474      1879
GR    2467      1913      2465      1913    2466.5    1965.5    2466.5      1995    2473.5      2002
GR  2473.7    2026.5      2474      2028      2472      2100      2473      2800    2474.0      3100

X1       7        14      1886      2002       200       200       200
  X-Sec  7: Same as Sta 437+00 on West Branch Bank Protection Plan 4BVALE
X3       0         0         0         0         0      3000
GR    2477      1300      2476      1870      2478      1875      2480      1880      2481      1886
GR  2475.3      1894    2469.5      1922    2466.7      1930    2467.1    1982.5    2467.1      1995
GR    2474      2002    2474.4      2022    2472.5      2400      2474      3000

X1       8        12      1880      2000       200       200       200
  X-Sec  8: Same as Sta 435+00 on West Branch Bank Protection Plan 4BVALE
X3       0         0         0         0         0      2970
GR    2477      1300      2478      1880      2480      1890    2480.0      1895    2476.5      1905
GR    2470      1930      2467      1948      2468      1992    2474.8      2000      2475      2020
GR    2474      2400    2475.5      3150

X1       9        17      1920      1998       164       164       164
  X-Sec  9: Same as Sta 433+36 on West Branch Bank Protection Plan 4BVALE
X3       0         0         0         0         0      2930
GR    2478      1500      2478      1900      2480      1905      2480      1920    2476.8      1934
GR  2467.7      1953    2467.5      1978      2469    1982.6      2469    1991.3    2475.5      1998
GR  2475.6      2018      2476      2019      2476    2043.5    2474.5    2230.0    2475.0      2550
GR  2476.0      2900      2476      3150

NC    .030      .030      .029       0.1       0.3
X1      10        18      1946    2004.5       136       136       136
  X-Sec 10: Same as Sta 432+00 on West Branch Bank Protection Plan 4BVALE
X3       0         0         0         0         0      2920
GR    2482       400      2480       420      2478       540      2478       780      2478      1730
GR    2477      1850    2478.0      1920      2480      1940    2482.8      1946    2477.5      1955
GR  2469.5      1977      2469      1980      2469      1998    2475.9    2004.5    2476.1      2064
GR    2475      2300    2476.0      2700    2476.5      3200
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NC     .030      .060      .029      0.1       0.3

X1       11        18      1960      2003       200       200       200
  X-Sec 11: Same as Sta 430+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2860
GR     2480       580      2478       660      2478      1840    2477.0      1880      2480      1935
GR     2480      1960    2478.4      1965    2477.4      1972    2472.8      1972    2469.8      1978
GR   2469.6    1979.5    2469.6      1996    2476.6      2003    2476.8      2015    2476.0      2040
GR   2475.8      2200    2476.0      2520    2477.2      3350

X1       12        17      1955      2003       200       200       200
  X-Sec 12: Same as Sta 428+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2810
GR     2482       680      2480       720    2478.4      1600      2478      1875    2477.5      1900
GR     2478      1925      2480      1950    2483.1      1955      2477      1965    2470.8      1979
GR   2470.3    1982.8    2470.3      1995    2478.4      2003    2478.7      2015      2476      2300
GR   2477.5    2850.0    2478.0      3320

X1       13        19      1955      2003       200       200       200
  X-Sec 13: Same as Sta 426+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2765
GR     2482       680      2480       770    2479.1      1300      2478      1870    2477.7      1885
GR     2478      1920      2480      1932      2480      1945      2484      1955      2479      1965
GR     2478      1971      2473      1971      2471    1976.5      2471    1995.5    2478.5      2003
GR   2478.5      2015    2477.5      2280      2478      2700    2478.5      3450

NC     .030      .060      .020      0.1       0.3
X1       14        16      1960      2000       112       112       112         0
  X-Sec 14: Same as Sta 52+66 on Los Reales Improvement District Plan ID-101
            and Sta 424+88 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2740
GR     2482       720      2480       800      2479      1200      2479      1800      2478      1870
GR   2477.8      1900      2478      1920      2480      1950    2480.0      1960    2476.3      1966
GR   2471.9      1970    2471.9      1996    2479.2      2000    2477.5      2400    2478.0      2650
GR   2478.6      3500

NC     .030      .060     .0235      0.1       0.3
X1       15        16      2000      2040       100       100       100         0
  X-Sec 15: Same as Sta 51+66 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2765
GR     2482       760      2480       820      2480      1180    2479.5      1820    2478.0      1895
GR     2476      1908      2474      1930      2474      1990    2478.8      2000    2472.2      2007
GR   2472.2      2033    2479.7      2040      2478      2420      2478      2420      2479      2900
GR   2479.5      3500
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X1      16       20     1993     2040      250      250      250        0
   X-Sec 16: Same as Sta 49+16 on Los Reales Improvement District Plan ID-101
X3       0        0        0        0        0     2680
GR    2484      510     2482      890     2480     1310   2479.8     1750     2480     1870
GR    2480     1920     2478     1927     2476     1932     2476     1940     2478     1948
GR    2480     1960     2482     1967     2482     1993   2480.3     2000  2473.11     2007
GR  2473.1     2033   2480.5     2040   2478.5     2160   2480.0     2590   2481.5     3350

X1      17       14     1995     2040      250      250      250        0
   X-Sec 17: Same as Sta 46+66 on Los Reales Improvement District Plan ID-101
X3       0        0        0        0        0     2620
GR    2484      490     2482     1190     2480     1740     2481     1900     2480     1940
GR    2482     1970     2482     1995   2480.7     2000  2474.02     2007  2474.02     2033
GR  2481.1     2040   2480.5     2250   2481.0     2900   2481.8     3300

X1      18       18     1990     2040      250      250      250        0     2000
   X-Sec 18: Same as Sta 44+16 on Los Reales Improvement District Plan ID-101
X3       0        0        0        0        0     2550
GR     486      450      484      580      482     1300    481.6     1530      482     1740
GR   482.2     1830      482     1910      480     1950      477     1970      480     1980
GR     483     1990    481.1     2000   474.92     2007   474.92     2033    481.7     2040
GR   481.5     2480      482     3300    482.2     3450

X1      19       17     1995     2040      250      250      250        0     2000
   X-Sec 19: Same as Sta 41+66 on Los Reales Improvement District Plan ID-101
X3       0        0        0        0        0     2480
GR     488      500      486      520      484      830    482.2     1500      482     1940
GR     480     1960      479     1980      480     1990      487     1995    481.6     2000
GR  475.80     2007   475.80     2033    482.3     2040    481.8     2250      482     2500
GR     482     3000      483     3680

X1      20       18     1995     2040      250      250      250        0     2000
   X-Sec 20: Same as Sta 39+16 on Los Reales Improvement District Plan ID-101
X3       0        0        0        0        0     2420
GR     488      445      486      695      484      810    482.9     1065    482.2     1860
GR     478     1950      480     1960      482     1970      484     1980      486     1990
GR     487     1995    482.3     2000   476.67     2007   476.67     2033    483.0     2040
GR   482.2     2280      483     2930      484     3310

NC    .030     .060     .020
X1      21       16     1990     2048      197      197      197        0     2000
   X-Sec 21: Same as Sta 37+19 on Los Reales Improvement District Plan ID-101
X3       0        0        0        0        0     2375
GR     488      410      486      670      484     1060      484     1930      482     1949
GR     482     1962      484     1972      486     1980      487     1990    483.0     2000
GR  477.37     2015   477.37     2041    484.0     2048    483.3     2300      484     2595
GR   484.3     3330
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X1      22      19    1990    2046      44      44      44       0    2000
  X-Sec 22: Same as Sta 36+75 on Los Reales Improvement District Plan ID-101
X3       0       0       0       0       0    2365
GR     488     390     488     650     486     720     484     780     484    1600
GR     482    1660     482    1910     482    1965     484    1975     486    1982
GR     487    1990   483.2    2000  478.87    2006  478.87    2040   484.2    2046
GR     484    2080   483.4    2300     484    2640   484.4    3335

X1      23      15    1980    2046     231     231     231       0    2000
  X-Sec 23: Same as Sta 34+44 on Los Reales Improvement District Plan ID-101
X3       0       0       0       0       0    2310
GR     490     450     488     470     486    1230   484.3    1800     484    1910
GR     482    1935   481.5    1940     487    1980   484.2    2000   479.6    2006
GR   479.6    2040   485.2    2046   484.1    2140   484.5    3000   484.5    3400

X1      24      13    1985    2046     231     231     231       0    2000
  X-Sec 24: Same as Sta 32+13 on Los Reales Improvement District Plan ID-101
X3       0       0       0       0       0    2250
GR     488     370   487.4     820     486    1380     484    1950   482.2    1960
GR     488    1985     486    1995   485.8    2000   480.4    2006   480.4    2040
GR   485.4    2046   485.5    2400     486    3150

X1      25      15    2000    2046     300     300     300       0    2000
  X-Sec 25: Same as Sta 29+13 on Los Reales Improvement District Plan ID-101
X3       0       0       0       0       0    2170
GR     488     410     486    1850     484    1950   483.5    1955     484    1970
GR     486    1982     488    1995   488.3    2000   481.3    2006   481.3    2040
GR   488.3    2046   486.5    2430     487    3040   486.2    3450   487.5    4100

X1      26      13    2000    2046     235     235     235       0    2000
  X-Sec 26: Same as Sta 26+78 on Los Reales Improvement District Plan ID-101
X3       0       0       0       0       0    2100
GR     490     420     488     650     487    1200     486    1940     485    1950
GR     486    1975     488    1990   488.5    2000   482.1    2006   482.1    2040
GR   488.5    2046     487    2500     488    3400

X1      27      16    2000    2046     234     234     234       0
  X-Sec 2444  Located at u/s end of channel
GR  2494.0      50  2492.0     200  2490.0     490  2488.0    1900  2487.4  1931.5
GR  2485.6  1957.5  2488.5  1961.5  2488.8  1967.5  2488.2  1975.5  2489.1  1984.5
GR  2488.8  1998.9  2488.8    2000  2482.8    2006  2482.8    2040  2488.8  2045.5
GR  2493.4  2046.0
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NC    0.030     0.060     0.022        .1        .3
X1       28        44      2000      3340        52        52        52         0
   X-Sec 2392  Located at u/s end of channel and 31 ft u/s from Floodwall
   Ground-profile data along upstream side of floodwall were determined by
   field survey (NGVD-1929 datum).
GR   2494.0         0    2492.0       150    2491.0       400    2489.5       650    2489.5       800
GR   2490.0      1000    2490.0      1200    2490.0      1400    2490.0      1600    2490.0    1746.5
GR   2490.3      1800    2490.2    1846.5    2490.0    1889.5    2488.6      1903    2488.6    1912.5
GR   2487.4    1931.5    2485.6    1957.5    2488.5    1961.5    2488.8    1967.5    2488.2    1975.5
GR   2489.1    1984.5    2488.8    1998.9    2488.7    2000.0    2488.9    2042.3    2489.4    2046.4
GR   2488.7    2046.5    2489.3    2260.0    2489.2    2520.0    2489.0    2770.0    2489.2    3020.0
GR   2489.3    3340.0    2488.9      3470    2488.9    3546.5    2488.2    4046.5    2488.7    4346.5
GR   2487.9    4546.5    2489.5    4633.5    2489.5      4650    2489.5      5200    2488.7      5500
GR   2488.6    5800.5    2488.7      6100    2488.3      6400    2491.3      6750

NC    0.030     0.060     0.022        .1        .3
X1     28.1        52      2000      3340         2         2         2         0
   X-Sec 2390  Located at u/s end of channel and 33 ft u/s from Floodwall
   Ground-profile data along upstream side of floodwall were determined by
   field survey (NGVD-1929 datum).
GR   2494.0         0    2492.0       150    2491.0       400    2489.5       650    2489.5       800
GR   2490.0      1000    2490.0      1200    2490.0      1400    2490.0      1600    2490.0    1746.5
GR   2490.3      1800    2490.2    1846.5    2490.0    1889.5    2488.6      1903    2488.6    1912.5
GR   2487.4    1931.5    2485.6    1957.5    2488.5    1961.5    2488.8    1967.5    2488.2    1975.5
GR   2489.1    1984.5    2488.8    1998.9    2488.7    2000.0    2488.9    2042.3    2489.4    2046.4
GR   2488.7    2046.5    2489.3    2260.0    2489.2    2520.0    2489.0    2770.0    2489.2    3020.0
GR   2489.3    3340.0    2488.9      3470    2488.9    3546.5    2488.2    4046.5    2488.7    4346.5
GR   2487.9    4546.5    2489.5    4633.5    2489.5      4650    2489.5      5200    2488.7      5500
GR   2488.6    5800.5    2488.7      6100    2488.3      6400    2491.3      6750    2488.3      6760
GR   2489.1      6950    2489.2      7150      2490      7350    2491.6      7550    2491.8      7750
GR   2492.5      7850    2494.1      7950
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 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

*PROF 1
0

CCHV=     .100 CEHV=      .300
*SECNO 1.000
    1.000      3.70   2466.70       .00   2466.70   2467.04       .34       .00       .00   2474.00
   2786.7        .0    2786.7        .0        .0     594.7        .0        .0        .0   2470.00
      .00       .00      4.69       .00      .000      .027      .000      .000   2463.00   1799.50
  .001769        0.        0.        0.         0         0         0       .00    199.20   1998.70

*SECNO 2.000
    2.000      3.31   2466.81       .00       .00   2467.30       .49       .21       .05   2474.00
   2786.7        .0    2786.7        .0        .0     494.0        .0       1.2        .4   2470.50
      .00       .00      5.64       .00      .000      .027      .000      .000   2463.50   1831.24
  .002603      100.      100.      100.         2         0         0       .00    167.07   1998.31

*SECNO 3.000
    3.000      2.99   2467.29       .00       .00   2468.06       .77       .68       .08   2476.00
   2786.7        .0    2786.7        .0        .0     395.3        .0       3.3       1.1   2471.20
      .01       .00      7.05       .00      .000      .027      .000      .000   2464.30   1852.38
  .004552      200.      200.      200.         2         0         0       .00    145.60   1997.98

*SECNO 4.000
    4.000      3.47   2468.17       .00       .00   2469.18      1.00      1.05       .07   2479.00
   2786.7        .0    2786.7        .0        .0     346.4        .0       5.0       1.8   2472.00
      .02       .00      8.04       .00      .000      .027      .000      .000   2464.70   1868.25
  .006089      200.      200.      200.         3         0         0       .00    129.92   1998.17

*SECNO 5.000

3470 ENCROACHMENT STATIONS=        .0    3090.0  TYPE=       1  TARGET=     3089.999
    5.000      4.51   2469.31       .00       .00   2470.07       .77       .87       .02   2479.50
   2786.7        .0    2786.7        .0        .0     397.0        .0       6.7       2.3   2472.60
      .03       .00      7.02       .00      .000      .027      .000      .000   2464.80   1884.69
  .003274      200.      200.      200.         3         0         0       .00    114.02   1998.71

*SECNO 6.000
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 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    L-BANK ELEV
 Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA      R-BANK ELEV
 TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN    SSTA
 SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID   ENDST


3470 ENCROACHMENT STATIONS=        .0    3040.0  TYPE=     1  TARGET=    3039.999
    6.000     4.89  2469.89      .00       .00  2470.91     1.02      .77      .08  2480.00
   2786.7       .0   2786.7       .0        .0    343.5       .0      8.4      2.8  2473.50
      .03      .00     8.11      .00      .000     .027     .000     .000  2465.00  1898.96
  .004534     200.     200.     200.         3        0        0      .00    99.43  1998.39

*SECNO 7.000

3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    3000.0  TYPE=     1  TARGET=    2999.999
    7.000     3.92  2470.62  2470.62       .00  2472.29     1.66     1.17      .19  2481.00
   2786.7       .0   2786.7       .0        .0    269.1       .0      9.8      3.2  2474.00
      .04      .00    10.35      .00      .000     .027     .000     .000  2466.70  1916.57
  .007778     200.     200.     200.         3       15        0      .00    82.00  1998.58

*SECNO 8.000

3470 ENCROACHMENT STATIONS=        .0    2970.0  TYPE=     1  TARGET=    2969.999
    8.000     5.17  2472.17      .00       .00  2473.59     1.42     1.28      .02  2478.00
   2786.7       .0   2786.7       .0        .0    291.6       .0     11.1      3.6  2474.80
      .05      .00     9.56      .00      .000     .027     .000     .000  2467.00  1921.61
  .005332     200.     200.     200.         3        0        0      .00    75.31  1996.92

*SECNO 9.000

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    2930.0  TYPE=     1  TARGET=    2929.999
    9.000     5.59  2473.09  2473.09       .00  2475.29     2.21     1.02      .24  2480.00
   2786.7       .0   2786.7       .0        .0    233.8       .0     12.1      3.8  2475.50
      .05      .00    11.92      .00      .000     .027     .000     .000  2467.50  1941.75
  .007384     164.     164..    164.        20        8        0      .00    53.76  1995.51
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SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST

CCHV=     .100 CEHV=     .300
*SECNO 10.000

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=          .0    2920.0  TYPE=     1  TARGET=     2919.999
   10.000     7.35   2476.35   2476.35       .00   2476.79       .44       .49       .18   2482.80
   2786.7       .0    1647.8    1138.9        .0     243.4     600.5      13.8       5.4   2475.90
      .06      .00      6.77      1.90      .000      .029      .030      .000   2469.00   1958.17
  .002148     136.      136.      136.        20        12         0       .00    961.83   2920.00

CCHV=     .100 CEHV=     .300
*SECNO 11.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=          .0    2860.0  TYPE=     1  TARGET=     2859.999
   11.000     7.53   2477.13   2477.13       .00   2477.67       .54       .48       .03   2480.00
   2786.7       .2    1549.3    1237.3        .5     198.6     914.3      18.3       9.7   2476.60
      .07      .41      7.80      1.35      .030      .029      .060      .000   2469.60   1874.80
  .002642     200.      200.      200.        20         9         0       .00    895.58   2860.00

*SECNO 12.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=          .0    2810.0  TYPE=     1  TARGET=     2809.999
   12.000     7.54   2477.84   2477.84       .00   2478.46       .61       .58       .02   2483.10
   2786.7      5.1    1647.0    1134.6       5.9     203.6     764.9      23.1      13.5   2478.40
      .08      .86      8.09      1.48      .030      .029      .060      .000   2470.30   1882.82
  .003187     200.      200.      200.        20         5         0       .00    777.78   2810.00
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 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    L-BANK ELEV
 Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA      R-BANK ELEV
 TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN    SSTA
 SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID   ENDST

*SECNO 13.000

3265 DIVIDED FLOW

3280 CROSS SECTION    13.00 EXTENDED      .35 FEET

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    2765.0  TYPE=     1  TARGET=     2764.999
   13.000     7.85  2478.85  2478.85      .00  2479.28      .43      .54      .02  2484.00
   2798.7    374.6   1538.9    885.3    240.4    219.8    746.9     28.1     18.3  2478.50
      .09     1.56     7.00     1.19     .030     .029     .060     .000  2471.00  1428.52
  .002295     200.     200.     200.       20        9        0      .00  1295.70  2765.00


CCHV=    .100 CEHV=     .300
*SECNO 14.000

3265 DIVIDED FLOW

3280 CROSS SECTION    14.00 EXTENDED      .74 FEET

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    2740.0  TYPE=     1  TARGET=     2739.999
   14.000     7.44  2479.34  2479.34      .00  2479.77      .43      .16      .00  2480.00
   2863.0    403.1   1631.8    828.1    372.5    237.1    912.2     31.6     22.1  2479.20
      .10     1.08     6.88      .91     .030     .020     .060     .000  2471.90  1063.48
  .000965     112.     112.     112.       20        9        0      .00  1655.57  2740.00


CCHV=    .100 CEHV=     .300
*SECNO 15.000
3280 CROSS SECTION    15.00 EXTENDED      .23 FEET

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE.  KRATIO =  1.64
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 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    L-BANK ELEV
 Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA      R-BANK ELEV
 TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN    SSTA
 SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID   ENDST


3470 ENCROACHMENT STATIONS=         .0    2765.0  TYPE=     1  TARGET=    2764.999
   15.000     7.53  2479.73      .00      .00  2479.85      .12      .06      .03  2478.80
   2910.1   1534.3    952.3    423.5    624.2    251.9    807.6     35.2     25.4  2479.70
      .11     2.46     3.78      .52     .030     .023     .060     .000  2472.20  1525.00
  .000369     100.     100.     100.        2        0        0      .00  1240.00  2765.00

*SECNO 16.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=         .0    2680.0  TYPE=     1  TARGET=    2679.999
   16.000     7.19  2480.29  2480.29      .00  2480.80      .51      .17      .12  2482.00
   2910.1    648.1   1728.1    534.0    344.7    236.4    562.5     43.4     32.9  2480.50
      .12     1.88     7.31      .95     .030     .023     .060     .000  2473.10  1248.73
  .001503     250.     250.     250.       20        9        0      .00  1379.59  2680.00

*SECNO 17.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=         .0    2620.0  TYPE=     1  TARGET=    2619.999
   17.000     7.44  2481.46  2481.46      .00  2481.94      .48      .36      .00  2482.00
   2910.1    804.7   1766.3    339.1    498.5    250.4    438.7     50.1     40.5  2481.10
      .14     1.61     7.05      .77     .030     .023     .060     .000  2474.02  1339.65
  .001400     250.     250.     250.       20        9        0      .00  1245.09  2620.00

*SECNO 18.000

3265 DIVIDED FLOW

7185 MINIMUM SPECIFIC ENERGY
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 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=       .0    2550.0  TYPE=     1  TARGET=     2549.999
    18.000      7.36   2482.28   2482.28       .00   2482.75       .46       .35       .00   2483.00
    2910.1     907.9    1743.4     258.9     431.5     252.8     353.8      56.4      47.9   2481.70
       .15      2.10      6.90       .73      .030      .023      .060      .000   2474.92   1198.13
   .001422      250.      250.      250.         3         6         0       .00   1345.70   2550.00

*SECNO 19.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL.CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=       .0    2480.0  TYPE=     1  TARGET=     2479.999
    19.000      6.92   2482.72   2482.72       .00   2483.23       .50       .37       .01   2487.00
    2910.1     934.1    1707.9     268.1     459.4     234.5     332.8      62.4      55.1   2482.30
       .17      2.03      7.28       .81      .030      .023      .060      .000   2475.80   1304.99
   .001520      250.      250.      250.        20         9         0       .00   1168.00   2480.00

*SECNO 20.000

3265 DIVIDED FLOW

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE.  KRATIO =  1.57

3470 ENCROACHMENT STATIONS=       .0    2420.0  TYPE=     1  TARGET=     2419.999
    20.000      6.69   2483.36       .00       .00   2483.50       .14       .23       .04   2487.00
    2910.1    1691.2    1028.6     190.4    1035.4     226.4     333.3      69.9      62.6   2483.00
       .19      1.63      4.54       .57      .030      .023      .060      .000   2476.67    957.99
   .000616      250.      250.      250.         2         0         0       .00   1439.95   2420.00

*SECNO 21.000

3265 DIVIDED FLOW
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SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=       .0    2375.0  TYPE=     1  TARGET=     2374.999
   21.000      7.21   2484.58   2484.58       .00   2485.05       .47       .15       .10   2487.00
   2910.1     747.2    1917.0     245.9     617.0     283.7     323.5      76.3      69.0   2484.00
      .20      1.21      6.76       .76      .030      .020      .060      .000   2477.37    946.98
  .000948      197.      197.      197.        20         9         0       .00   1406.29   2375.00

*SECNO 22.000

3265 DIVIDED FLOW

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE.  KRATIO =  2.39

3470 ENCROACHMENT STATIONS=       .0    2365.0  TYPE=     1  TARGET=     2364.999
   22.000      6.20   2485.07       .00       .00   2485.11       .04       .01       .04   2487.00
   2927.5    2036.2     713.8     177.5    1990.5     261.3     442.5      78.2      70.5   2484.20
      .21      1.02      2.73       .40      .030      .020      .060      .000   2478.87    747.59
  .000168       44.       44.       44.         2         0         0       .00   1601.14   2365.00

*SECNO 23.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=       .0    2310.0  TYPE=     1  TARGET=     2309.999
   23.000      5.76   2485.36   2485.36       .00   2485.92       .56       .09       .16   2487.00
   3129.9    1007.9    1833.4     288.7     454.4     239.3     275.1      88.0      77.0   2485.20
      .22      2.22      7.66      1.05      .030      .020      .060      .000   2479.60   1443.49
  .001612      231.      231.      231.        20        10         0       .00    842.91   2310.00
```

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SECNO     DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    L-BANK ELEV
Q         QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA      R-BANK ELEV
TIME      VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN    SSTA
SLOPE     XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID   ENDST

*SECNO 24.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    2250.0  TYPE=     1  TARGET=     2249.999
  24.000      5.65  2486.05  2486.05      .00  2486.52      .48      .35      .01  2488.00
  3129.9    1364.6   1679.4     86.0    657.9    229.3    125.9     93.2     81.6  2485.40
     .24      2.07     7.33      .68     .030     .020     .060     .000  2480.40  1361.64
 .001453      231.     231.     231.       20        6        0      .00   870.17  2250.00

*SECNO 25.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    2170.0  TYPE=     1  TARGET=     2169.999
  25.000      5.67  2486.97  2486.97      .00  2487.56      .59      .45      .03  2488.30
  3129.9    1366.4   1763.5       .0    627.6    220.4       .0     99.6     87.6  2488.30
     .25      2.18     8.00      .00     .030     .020     .000     .000  2481.30  1150.92
 .001560      300.     300.     300.       20        5        0      .00   881.11  2044.86

*SECNO 26.000

3265 DIVIDED FLOW

3470 ENCROACHMENT STATIONS=        .0    2100.0  TYPE=     1  TARGET=     2099.999
  26.000      5.42  2487.52      .00      .00  2487.91      .40      .33      .02  2488.50
  3129.9    1631.4   1498.6       .0    912.5    212.0       .0    104.9     93.0  2488.50
     .27      1.79     7.07      .00     .030     .020     .000     .000  2482.10   911.98
 .001280      235.     235.     235.        3        0        0      .00  1118.62  2045.08
```

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 27.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

27.000	6.45	2489.25	2489.25	.00	2489.87	.62	.30	.07	2488.80
3129.9	1111.0	2019.0	.0	695.7	258.8	.0	110.5	98.7	2493.40
.28	1.60	7.80	.00	.030	.020	.000	.000	2482.80	1021.68
.001267	234.	234.	234.	20	12	0	.00	1023.87	2045.55

CCHV= .100 CEHV= .300
*SECNO 28.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE. KRATIO = 2.15

28.000	4.35	2489.95	.00	.00	2489.96	.01	.03	.06	2488.70
3129.9	343.6	1052.1	1734.3	331.3	1084.8	3660.8	114.1	102.4	2489.30
.30	1.04	.97	.47	.030	.022	.060	.000	2485.60	575.13
.000273	52.	52.	52.	3	0	0	.00	5106.97	6592.40

CCHV= .100 CEHV= .300
*SECNO 28.100

3265 DIVIDED FLOW

28.100	4.32	2489.92	.00	.00	2489.97	.05	.00	.01	2488.70
7638.0	798.0	2394.2	4445.8	318.5	1051.1	4036.4	114.4	102.7	2489.30
.30	2.51	2.28	1.10	.030	.022	.060	.000	2485.60	579.32
.001573	2.	2.	2.	2	0	0	.00	5665.98	7331.02

TN Normal depth split flow - Sections 11 to 12

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
.0	.00	.00	.00	200.0	.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	10	2477.130	2477.844	11.000	12.000

TN Normal depth split flow - Sections 12 to 13

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
24.4	.49	.35	.18	200.0	138.5

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
12.00	11.99	.10	12.00	11.99	.10	10	2477.844	2478.852	12.000	13.000

TN Normal depth split flow - Section 13 to 14

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
61.2	1.05	.74	.55	112.0	112.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
64.27	64.11	.25	76.27	76.10	.22	10	2478.852	2479.341	13.000	14.000

TN Normal depth split flow - Sections 14 to 15

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
48.6	.97	.74	.49	100.0	100.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
47.12	47.03	.19	123.39	123.13	.21	10	2479.341	2479.730	14.000	15.000

TN Normal depth split flow - Sections 21 to 22

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
20.9	.83	.67	.48	44.0	44.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
17.34	17.29	.32	140.73	140.42	.22	10	2484.580	2485.071	21.000	22.000

TN Normal depth split flow - Sections 22 to 23

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
177.3	1.14	.86	.77	231.0	231.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
202.49	201.53	.48	343.23	341.95	.37	10	2485.071	2485.363	22.000	23.000

TC Rating curve outflow data set for Splitflow into South Diversion Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
3308.07	3308.22	.00	3651.30	3650.17	.03	10	2489.949	2489.924	28.000	28.100

TW Splitflow #28 to #28.1 (Splitflow goes directly into the Santa Cruz River)

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
1199.98	1197.65	.19	4851.28	4847.82	.07	10	2489.949	2489.924	28.000	28.100

THIS RUN EXECUTED 30NOV94 11:41:02

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

West Branch Santa Cruz

SUMMARY PRINTOUT

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
	1.000	2786.72	.00	2786.72	.00	2466.70	.00	2467.04	3.70	1799.50	199.20	1998.70	.00
	2.000	2786.72	.00	2786.72	.00	2466.81	.00	2467.30	3.31	1831.24	167.07	1998.31	.00
	3.000	2786.72	.00	2786.72	.00	2467.29	.00	2468.06	2.99	1852.38	145.60	1997.98	.00
	4.000	2786.72	.00	2786.72	.00	2468.17	.00	2469.18	3.47	1868.25	129.92	1998.17	.00
	5.000	2786.72	.00	2786.72	.00	2469.31	.00	2470.07	4.51	1884.69	114.02	1998.71	.00
	6.000	2786.72	.00	2786.72	.00	2469.89	.00	2470.91	4.89	1898.96	99.43	1998.39	.00
*	7.000	2786.72	.00	2786.72	.00	2470.62	2470.62	2472.29	3.92	1916.57	82.00	1998.58	.00
	8.000	2786.72	.00	2786.72	.00	2472.17	.00	2473.59	5.17	1921.61	75.31	1996.92	.00
*	9.000	2786.72	.00	2786.72	.00	2473.09	2473.09	2475.29	5.59	1941.75	53.76	1995.51	.00
*	10.000	2786.72	.00	1647.79	1138.94	2476.35	2476.35	2476.79	7.35	1958.17	961.83	2920.00	.00
*	11.000	2786.72	.20	1549.26	1237.26	2477.13	2477.13	2477.67	7.53	1874.80	895.58	2860.00	.00
*	12.000	2786.72	5.10	1646.98	1134.64	2477.84	2477.84	2478.46	7.54	1882.82	777.78	2810.00	.00
*	13.000	2798.72	374.61	1538.86	885.25	2478.85	2478.85	2479.28	7.85	1428.52	1295.70	2765.00	.00
*	14.000	2862.99	403.09	1631.77	828.13	2479.34	2479.34	2479.77	7.44	1063.48	1655.57	2740.00	.00
*	15.000	2910.11	1534.34	952.28	423.49	2479.73	.00	2479.85	7.53	1525.00	1240.00	2765.00	.00
*	16.000	2910.11	648.07	1728.09	533.95	2480.29	2480.29	2480.80	7.19	1248.73	1379.59	2680.00	.00
*	17.000	2910.11	804.66	1766.34	339.11	2481.46	2481.46	2481.94	7.44	1339.65	1245.09	2620.00	.00

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
*	18.000	2910.11	907.86	1743.38	258.88	2482.28	2482.28	2482.75	7.36	1198.13	1345.70	2550.00	.00
*	19.000	2910.11	934.13	1707.91	268.07	2482.72	2482.72	2483.23	6.92	1304.99	1168.00	2480.00	.00
*	20.000	2910.11	1691.17	1028.56	190.38	2483.36	.00	2483.50	6.69	957.99	1439.95	2420.00	.00
*	21.000	2910.11	747.23	1916.99	245.89	2484.58	2484.58	2485.05	7.21	946.98	1406.29	2375.00	.00
*	22.000	2927.46	2036.17	713.84	177.45	2485.07	.00	2485.11	6.20	747.59	1601.14	2365.00	.00
*	23.000	3129.95	1007.85	1833.37	288.72	2485.36	2485.36	2485.92	5.76	1443.49	842.91	2310.00	.00
*	24.000	3129.95	1364.55	1679.39	86.00	2486.05	2486.05	2486.52	5.65	1361.64	870.17	2250.00	.00
*	25.000	3129.95	1366.44	1763.51	.00	2486.97	2486.97	2487.56	5.67	1150.92	881.11	2044.86	.00
	26.000	3129.95	1631.36	1498.59	.00	2487.52	.00	2487.91	5.42	911.98	1118.62	2045.08	.00
*	27.000	3129.95	1110.97	2018.97	.00	2489.25	2489.25	2489.87	6.45	1021.68	1023.87	2045.55	.00
*	28.000	3129.95	343.55	1052.07	1734.33	2489.95	.00	2489.96	4.35	575.13	5106.97	6592.40	.00
	28.100	7638.00	797.98	2394.20	4445.82	2489.92	.00	2489.97	4.32	579.32	5665.98	7331.02	.00

West Branch Santa Cruz

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	1.000	.00	.00	.00	2463.00	2786.72	2466.70	.00	2467.04	17.69	4.69	594.71	662.55
	2.000	100.00	.00	.00	2463.50	2786.72	2466.81	.00	2467.30	26.03	5.64	493.97	546.18
	3.000	200.00	.00	.00	2464.30	2786.72	2467.29	.00	2468.06	45.52	7.05	395.31	413.05
	4.000	200.00	.00	.00	2464.70	2786.72	2468.17	.00	2469.18	60.89	8.04	346.42	357.13
	5.000	200.00	.00	.00	2464.80	2786.72	2469.31	.00	2470.07	32.74	7.02	396.99	487.04
	6.000	200.00	.00	.00	2465.00	2786.72	2469.89	.00	2470.91	45.34	8.11	343.47	413.87
*	7.000	200.00	.00	.00	2466.70	2786.72	2470.62	2470.62	2472.29	77.78	10.35	269.14	315.99
	8.000	200.00	.00	.00	2467.00	2786.72	2472.17	.00	2473.59	53.32	9.56	291.63	381.65
*	9.000	164.00	.00	.00	2467.50	2786.72	2473.09	2473.09	2475.29	73.84	11.92	233.84	324.31
*	10.000	136.00	.00	.00	2469.00	2786.72	2476.35	2476.35	2476.79	21.48	6.77	843.87	601.30
*	11.000	200.00	.00	.00	2469.60	2786.72	2477.13	2477.13	2477.67	26.42	7.80	1113.41	542.18
*	12.000	200.00	.00	.00	2470.30	2786.72	2477.84	2477.84	2478.46	31.87	8.09	974.42	493.60
*	13.000	200.00	.00	.00	2471.00	2798.72	2478.85	2478.85	2479.28	22.95	7.00	1207.04	584.25
*	14.000	112.00	.00	.00	2471.90	2862.99	2479.34	2479.34	2479.77	9.65	6.88	1521.86	921.51
*	15.000	100.00	.00	.00	2472.20	2910.11	2479.73	.00	2479.85	3.69	3.78	1683.71	1514.73
*	16.000	250.00	.00	.00	2473.10	2910.11	2480.29	2480.29	2480.80	15.03	7.31	1143.65	750.67
*	17.000	250.00	.00	.00	2474.02	2910.11	2481.46	2481.46	2481.94	14.00	7.05	1187.54	777.70
*	18.000	250.00	.00	.00	2474.92	2910.11	2482.28	2482.28	2482.75	14.22	6.90	1038.16	771.77
*	19.000	250.00	.00	.00	2475.80	2910.11	2482.72	2482.72	2483.23	15.20	7.28	1026.78	746.48
*	20.000	250.00	.00	.00	2476.67	2910.11	2483.36	.00	2483.50	6.16	4.54	1595.12	1172.58
*	21.000	197.00	.00	.00	2477.37	2910.11	2484.58	2484.58	2485.05	9.48	6.76	1224.30	945.13
*	22.000	44.00	.00	.00	2478.87	2927.46	2485.07	.00	2485.11	1.68	2.73	2694.39	2258.57
*	23.000	231.00	.00	.00	2479.60	3129.95	2485.36	2485.36	2485.92	16.12	7.66	968.81	779.68
*	24.000	231.00	.00	.00	2480.40	3129.95	2486.05	2486.05	2486.52	14.53	7.33	1013.08	821.05

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	25.000	300.00	.00	.00	2481.30	3129.95	2486.97	2486.97	2487.56	15.60	8.00	847.99	792.52
	26.000	235.00	.00	.00	2482.10	3129.95	2487.52	.00	2487.91	12.80	7.07	1124.46	874.98
*	27.000	234.00	.00	.00	2482.80	3129.95	2489.25	2489.25	2489.87	12.67	7.80	954.45	879.46
*	28.000	52.00	.00	.00	2485.60	3129.95	2489.95	.00	2489.96	2.73	.97	5076.90	1892.93
	28.100	2.00	.00	.00	2485.60	7638.00	2489.92	.00	2489.97	15.73	2.28	5406.00	1925.84

West Branch Santa Cruz

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	1.000	2786.72	2466.70	.00	.00	.00	199.20	.00
	2.000	2786.72	2466.81	.00	.11	.00	167.07	100.00
	3.000	2786.72	2467.29	.00	.48	.00	145.60	200.00
	4.000	2786.72	2468.17	.00	.88	.00	129.92	200.00
	5.000	2786.72	2469.31	.00	1.14	.00	114.02	200.00
	6.000	2786.72	2469.89	.00	.59	.00	99.43	200.00
*	7.000	2786.72	2470.62	.00	.73	.00	82.00	200.00
	8.000	2786.72	2472.17	.00	1.55	.00	75.31	200.00
*	9.000	2786.72	2473.09	.00	.91	.00	53.76	164.00
*	10.000	2786.72	2476.35	.00	3.26	.00	961.83	136.00
*	11.000	2786.72	2477.13	.00	.78	.00	895.58	200.00
*	12.000	2786.72	2477.84	.00	.71	.00	777.78	200.00
*	13.000	2798.72	2478.85	.00	1.01	.00	1295.70	200.00
*	14.000	2862.99	2479.34	.00	.49	.00	1655.57	112.00
*	15.000	2910.11	2479.73	.00	.39	.00	1240.00	100.00
*	16.000	2910.11	2480.29	.00	.56	.00	1379.59	250.00
*	17.000	2910.11	2481.46	.00	1.16	.00	1245.09	250.00
*	18.000	2910.11	2482.28	.00	.83	.00	1345.70	250.00
*	19.000	2910.11	2482.72	.00	.44	.00	1168.00	250.00
*	20.000	2910.11	2483.36	.00	.63	.00	1439.95	250.00
*	21.000	2910.11	2484.58	.00	1.22	.00	1406.29	197.00
*	22.000	2927.46	2485.07	.00	.49	.00	1601.14	44.00
*	23.000	3129.95	2485.36	.00	.29	.00	842.91	231.00
*	24.000	3129.95	2486.05	.00	.68	.00	870.17	231.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	25.000	3129.95	2486.97	.00	.93	.00	881.11	300.00
	26.000	3129.95	2487.52	.00	.55	.00	1118.62	235.00
*	27.000	3129.95	2489.25	.00	1.73	.00	1023.87	234.00
*	28.000	3129.95	2489.95	.00	.70	.00	5106.97	52.00
	28.100	7638.00	2489.92	.00	-.02	.00	5665.98	2.00

SUMMARY OF ERRORS AND SPECIAL NOTES

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CAUTION SECNO=     7.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     7.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=     9.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     9.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     9.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    10.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    10.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    10.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    11.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    11.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    11.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    12.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    12.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    12.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    13.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    13.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    13.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    14.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    14.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    14.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=    15.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=    16.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    16.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    16.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    17.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    17.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    17.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    18.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    18.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=    19.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    19.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    19.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=    20.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=    21.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    21.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    21.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=    22.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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CAUTION SECNO=    23.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    23.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    24.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    24.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    24.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    25.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    25.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    25.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=    27.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=    27.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=    27.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=    28.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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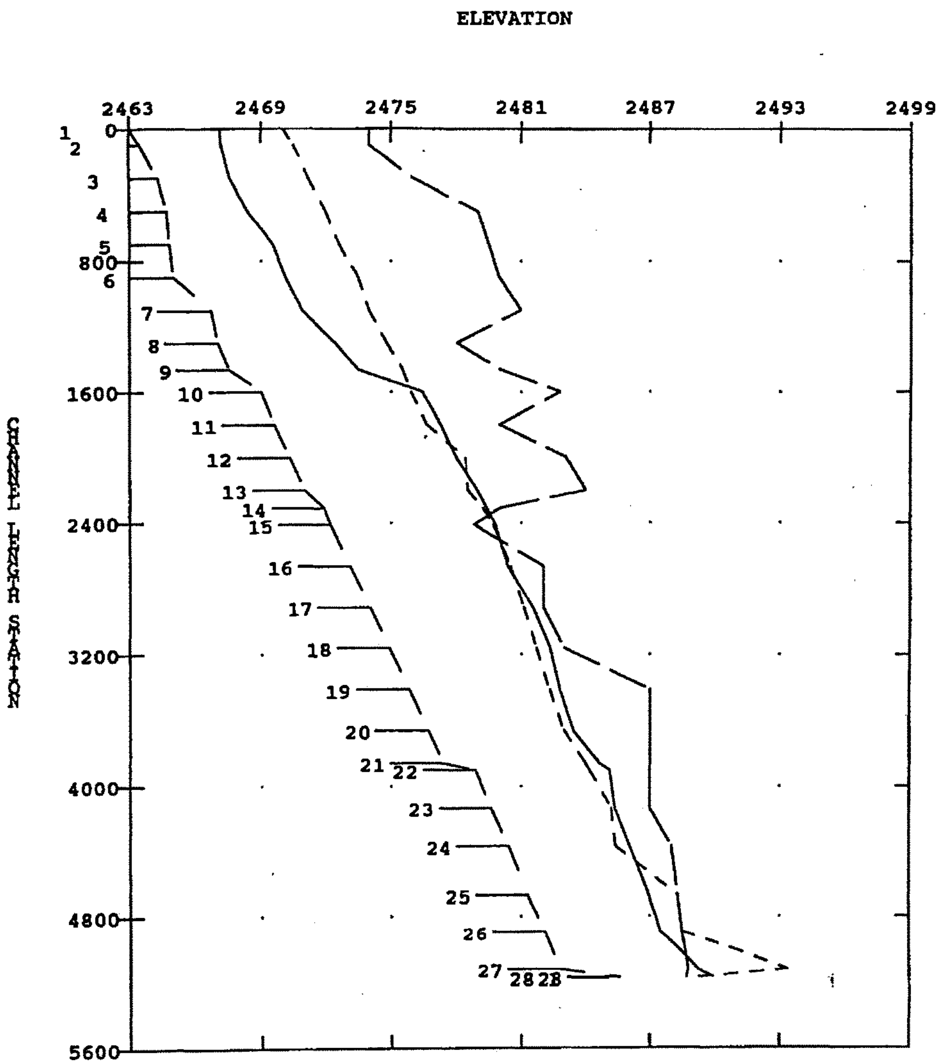
ELEVATION
2463
2469
2475
2481
2487
2493
2499
CHANNEL LENGTH STATION
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800
1600
2400
3200
4000
4800
5600
1
2
3
4
5
6
7
8
9
10
11
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22
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24
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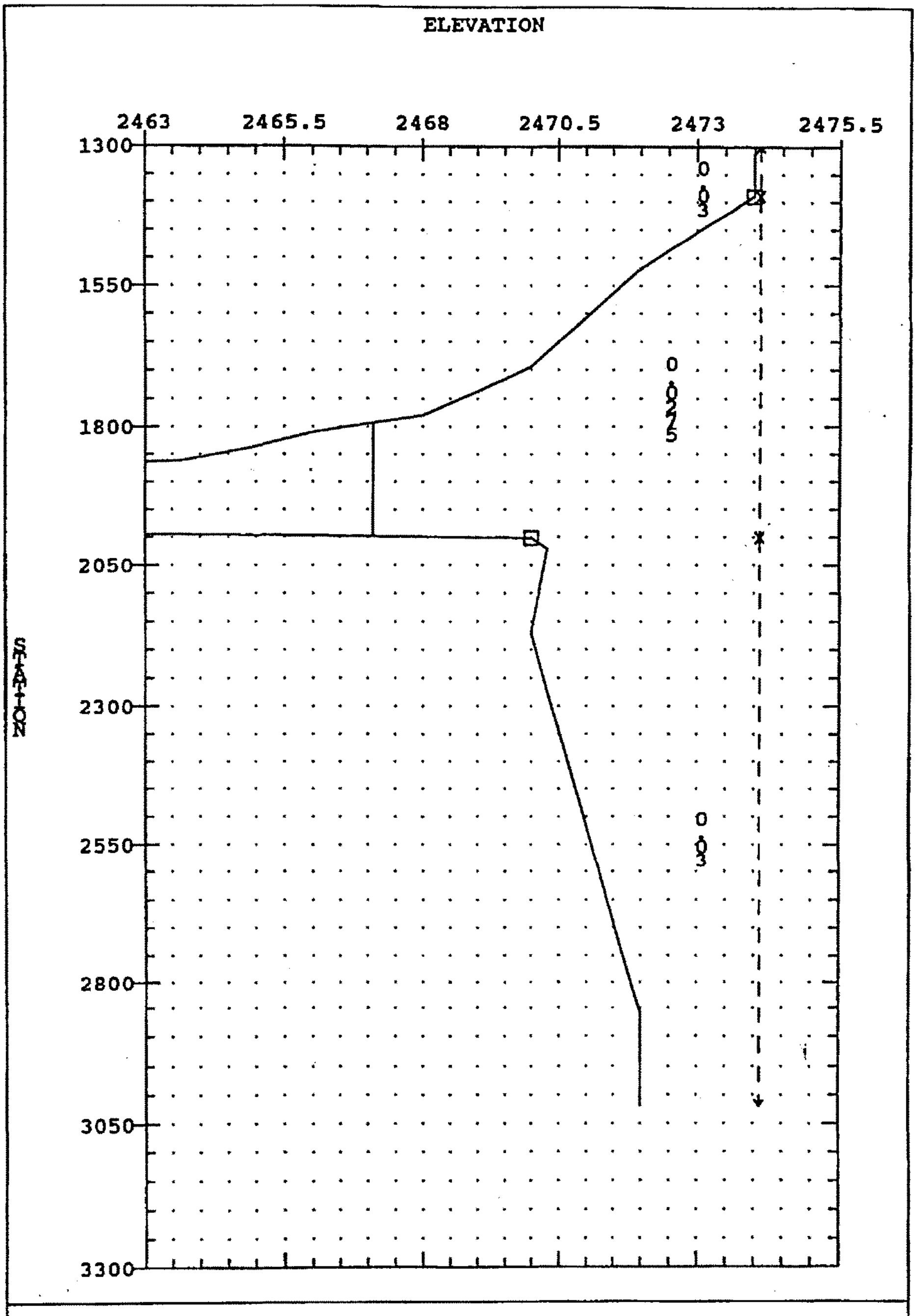
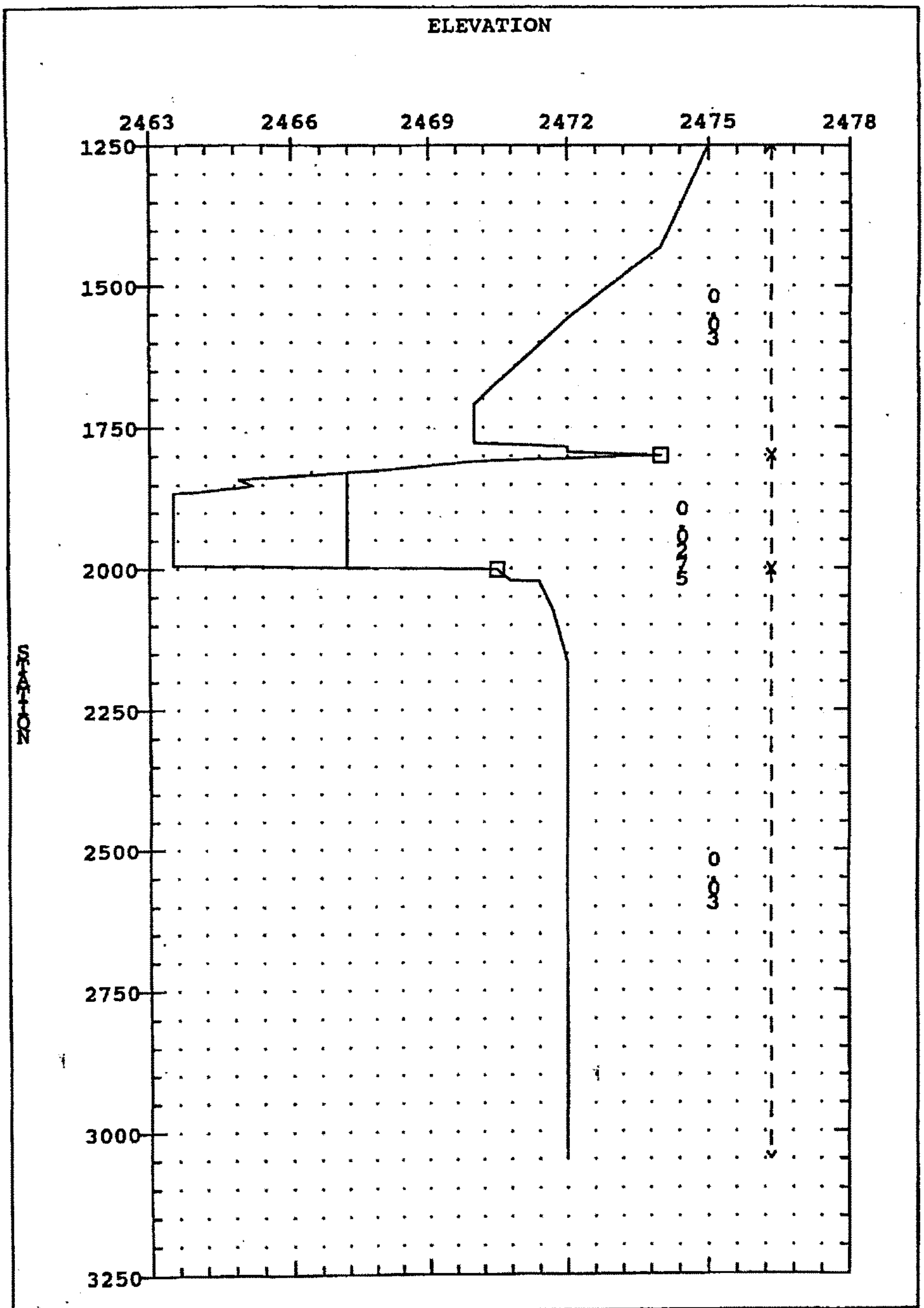
27
28
28



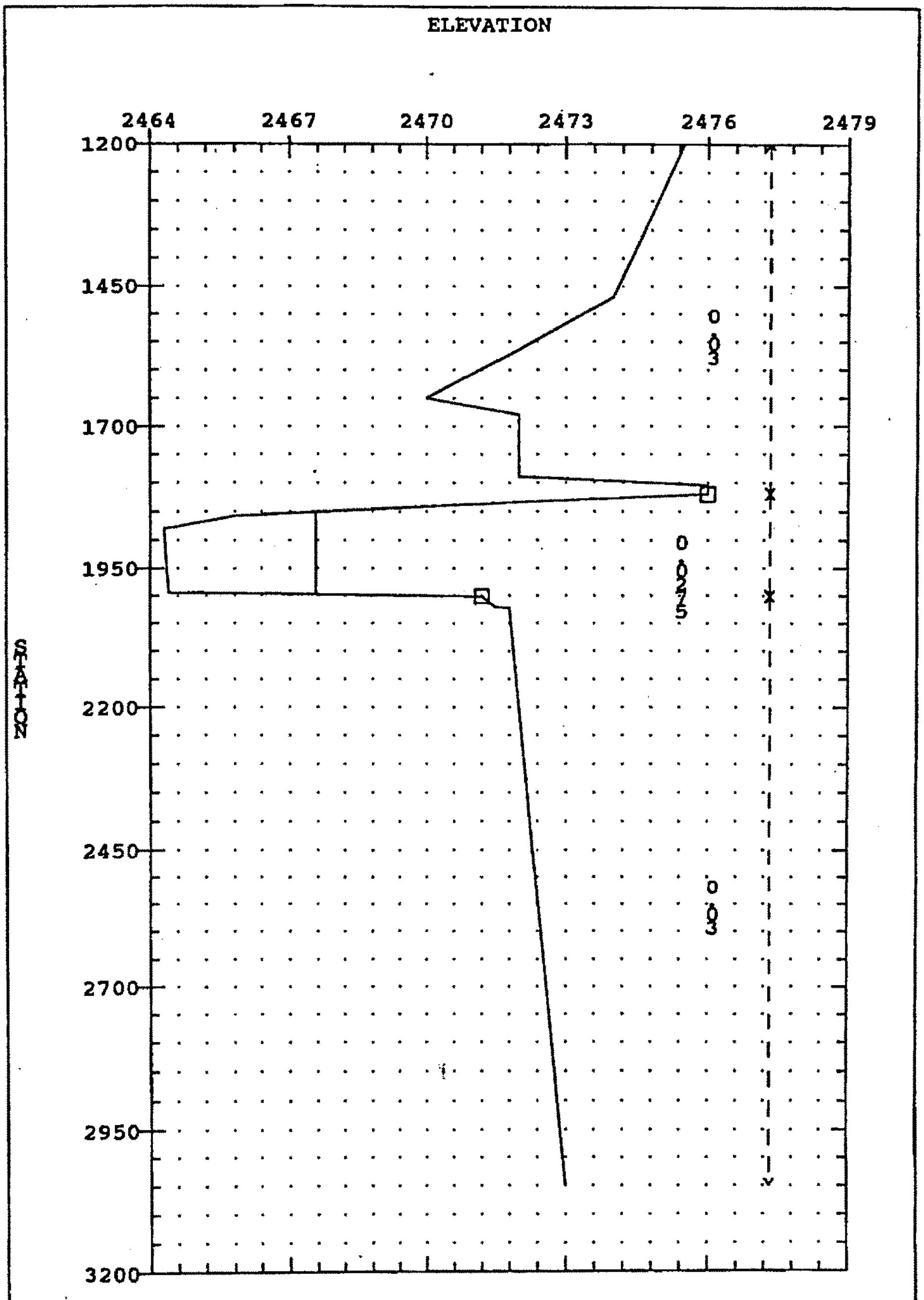
SECTION : 1

West Branch Santa Cruz River



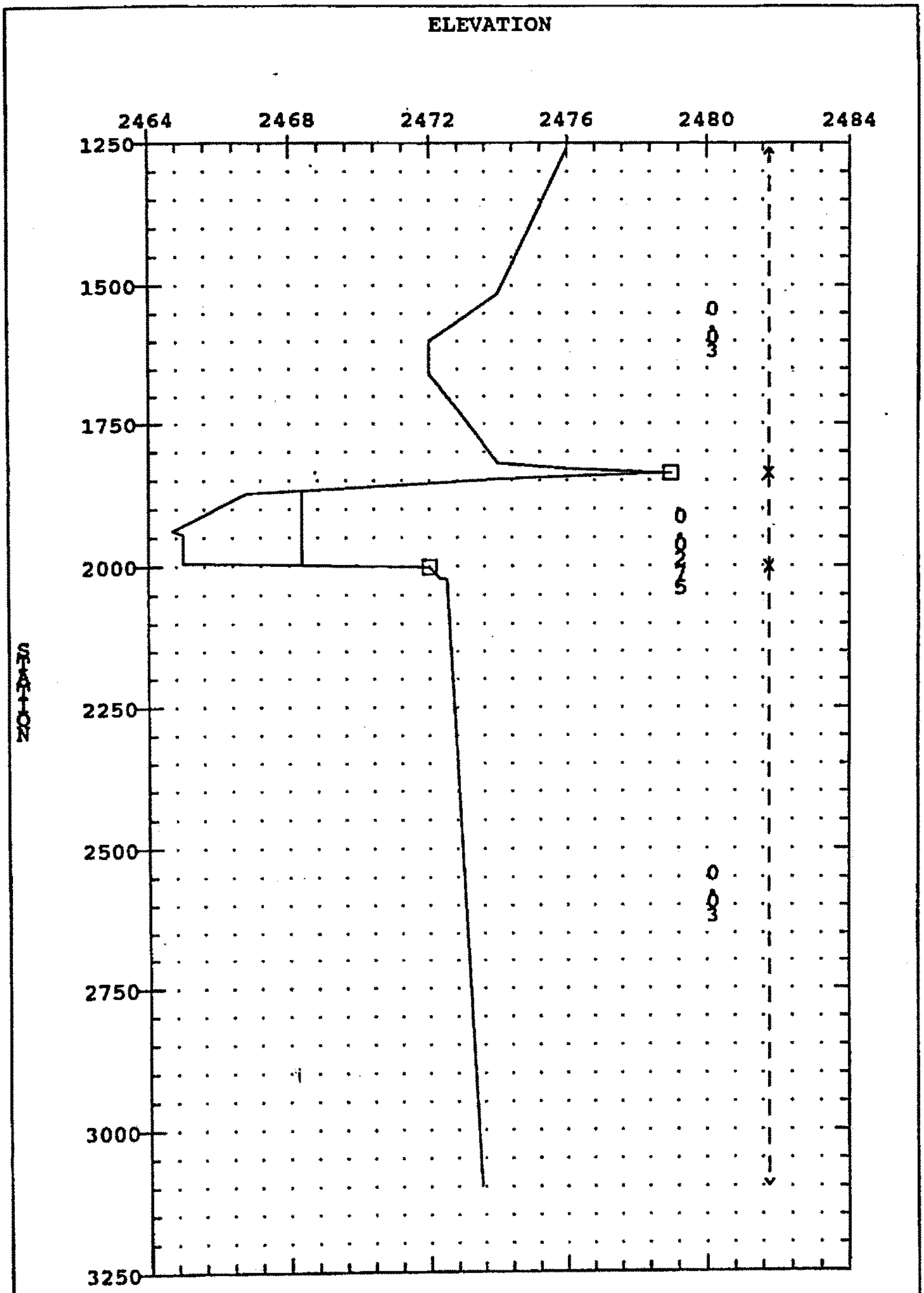
SECTION : 2

West Branch Santa Cruz River



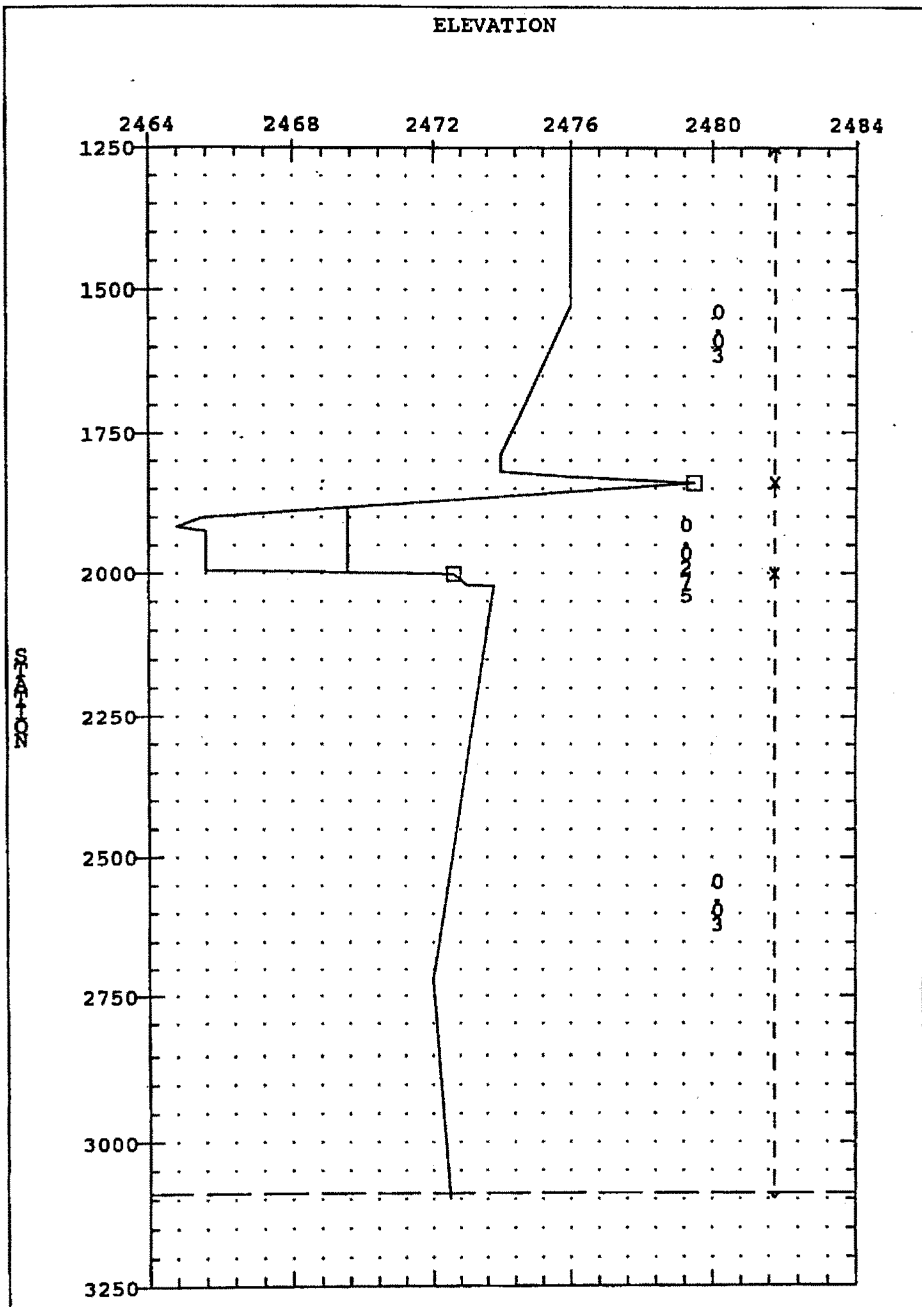
SECTION : 3

West Branch Santa Cruz River



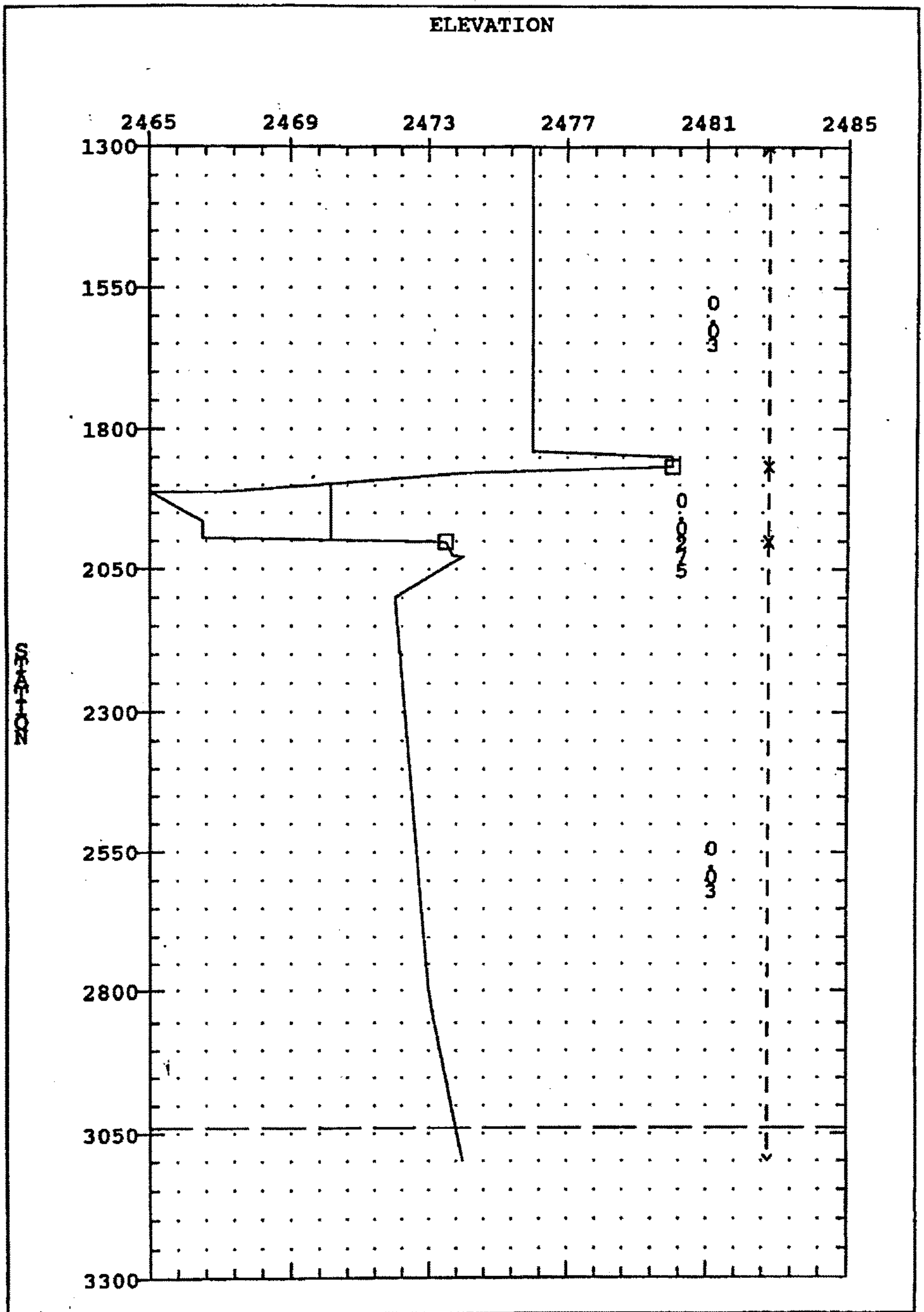
SECTION : 4

West Branch Santa Cruz River



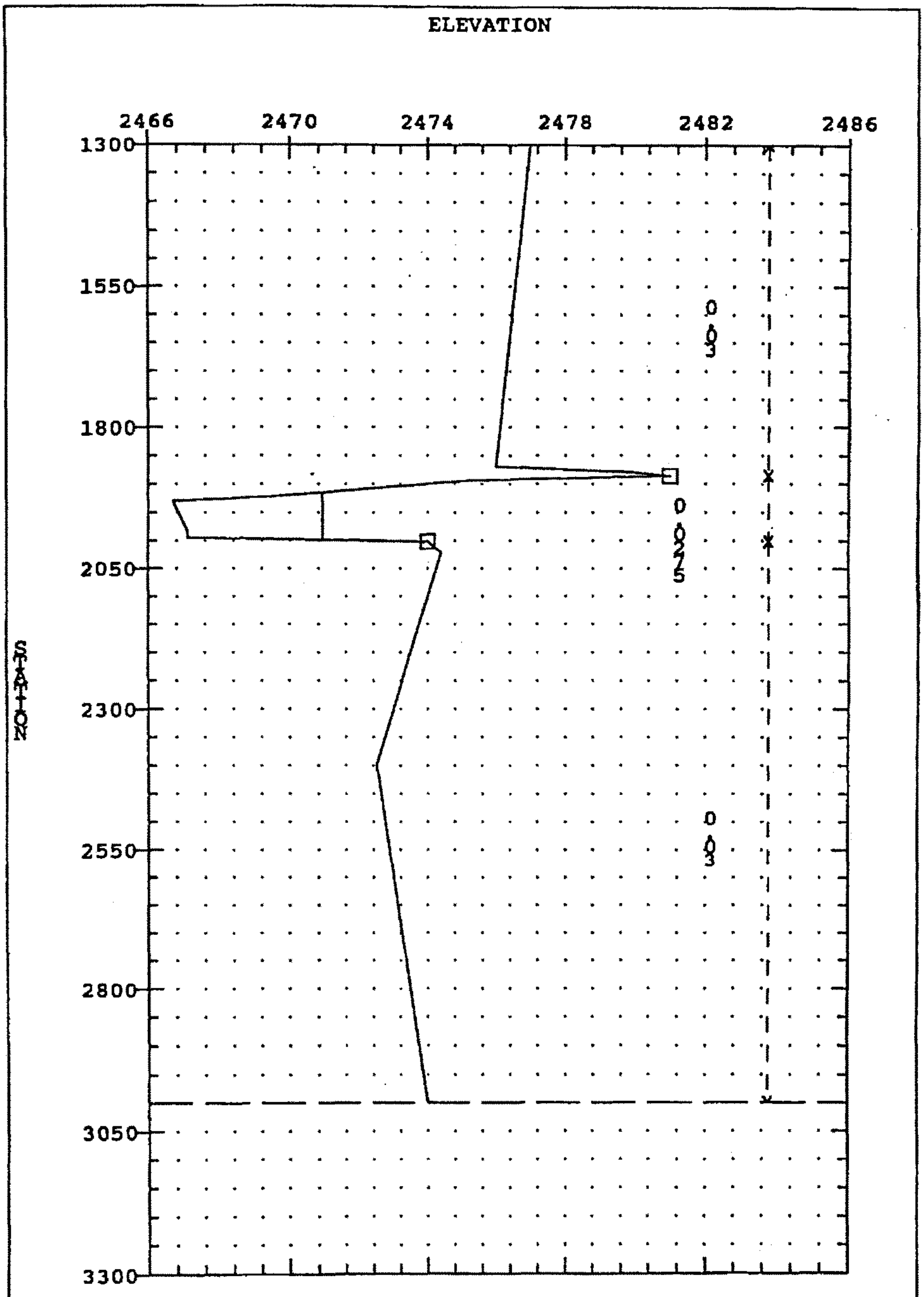
SECTION : 5

West Branch Santa Cruz River



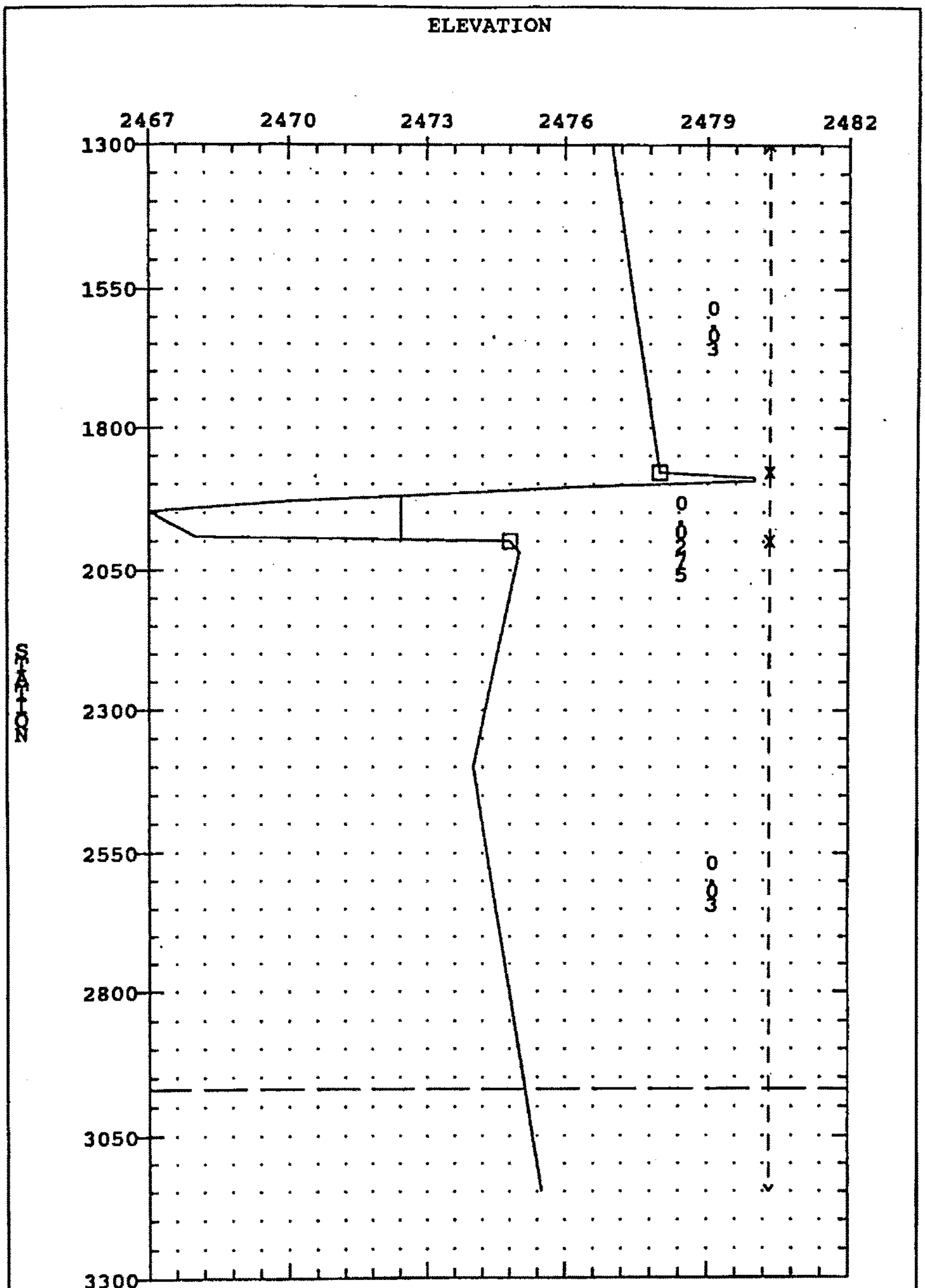
SECTION : 6

West Branch Santa Cruz River



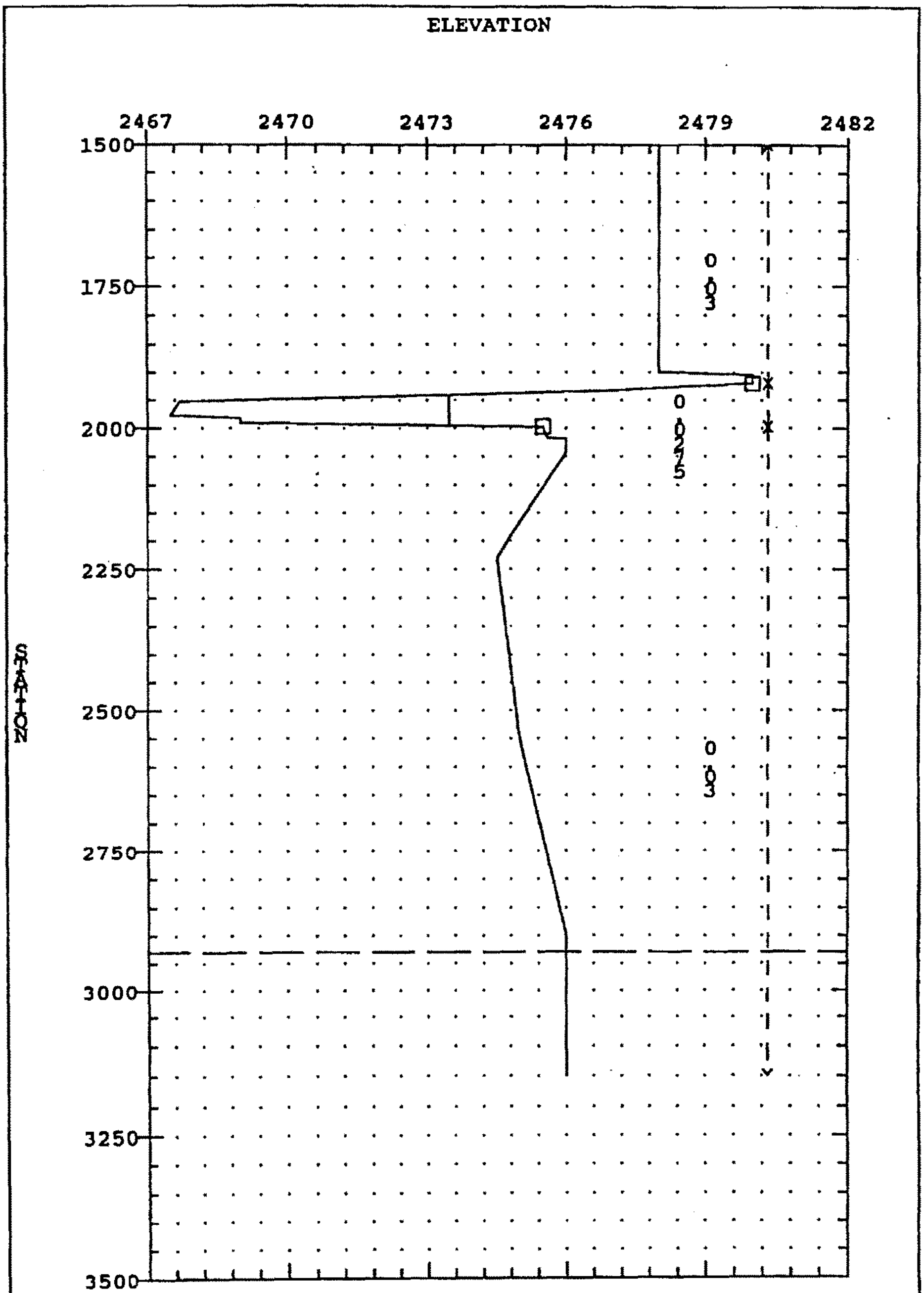
SECTION : 7

West Branch Santa Cruz River



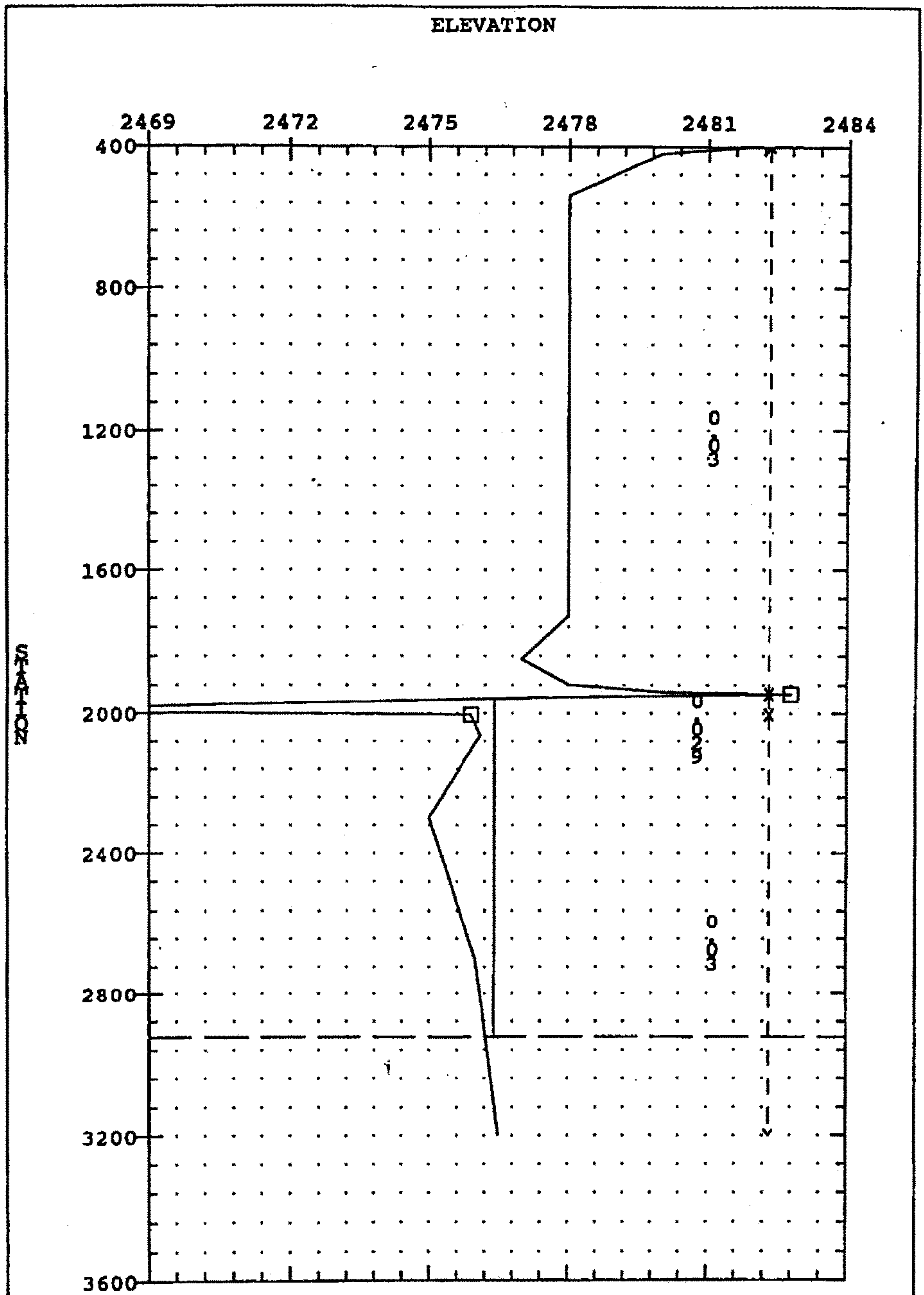
SECTION : 8

West Branch Santa Cruz River



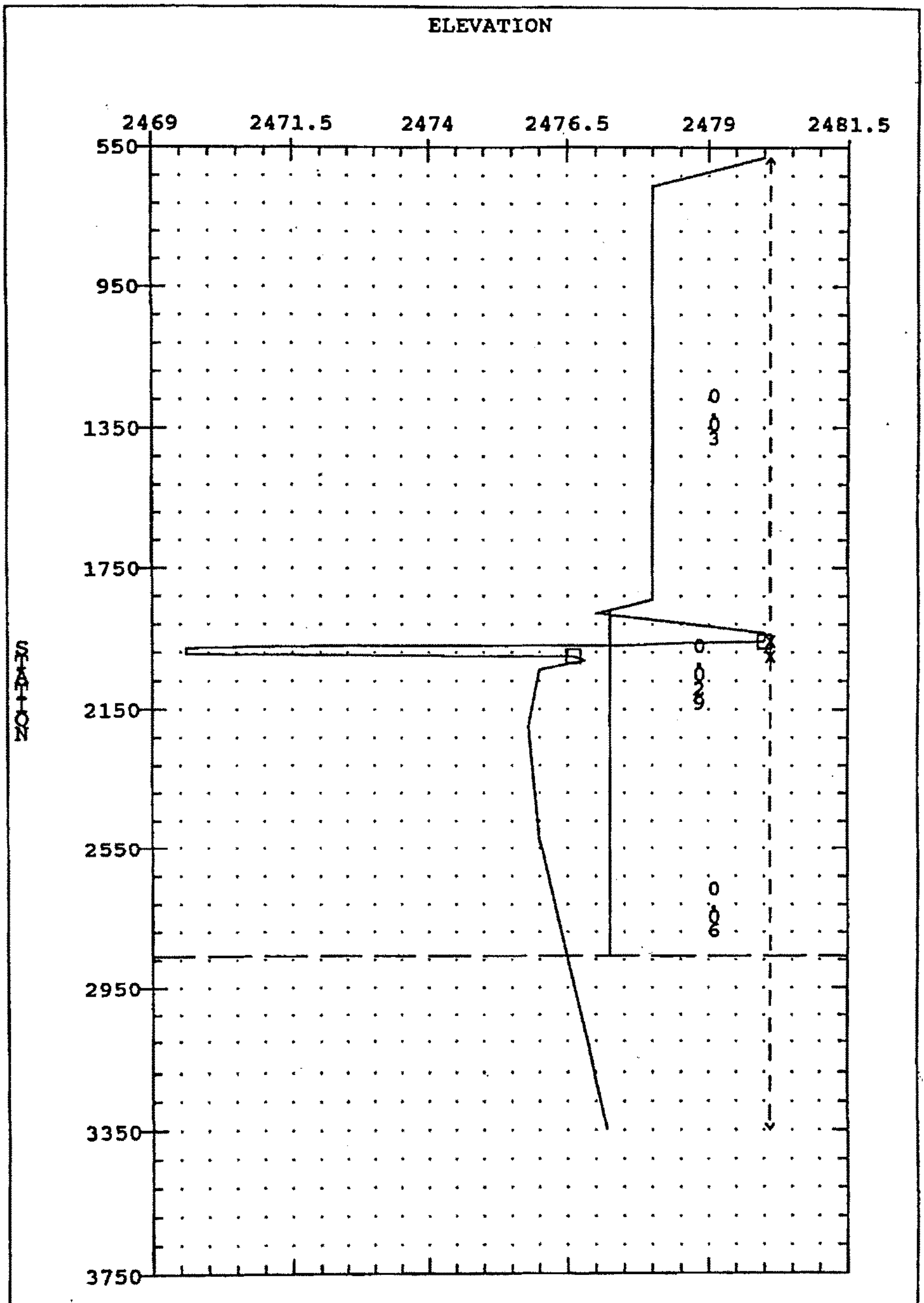
SECTION : 9

West Branch Santa Cruz River



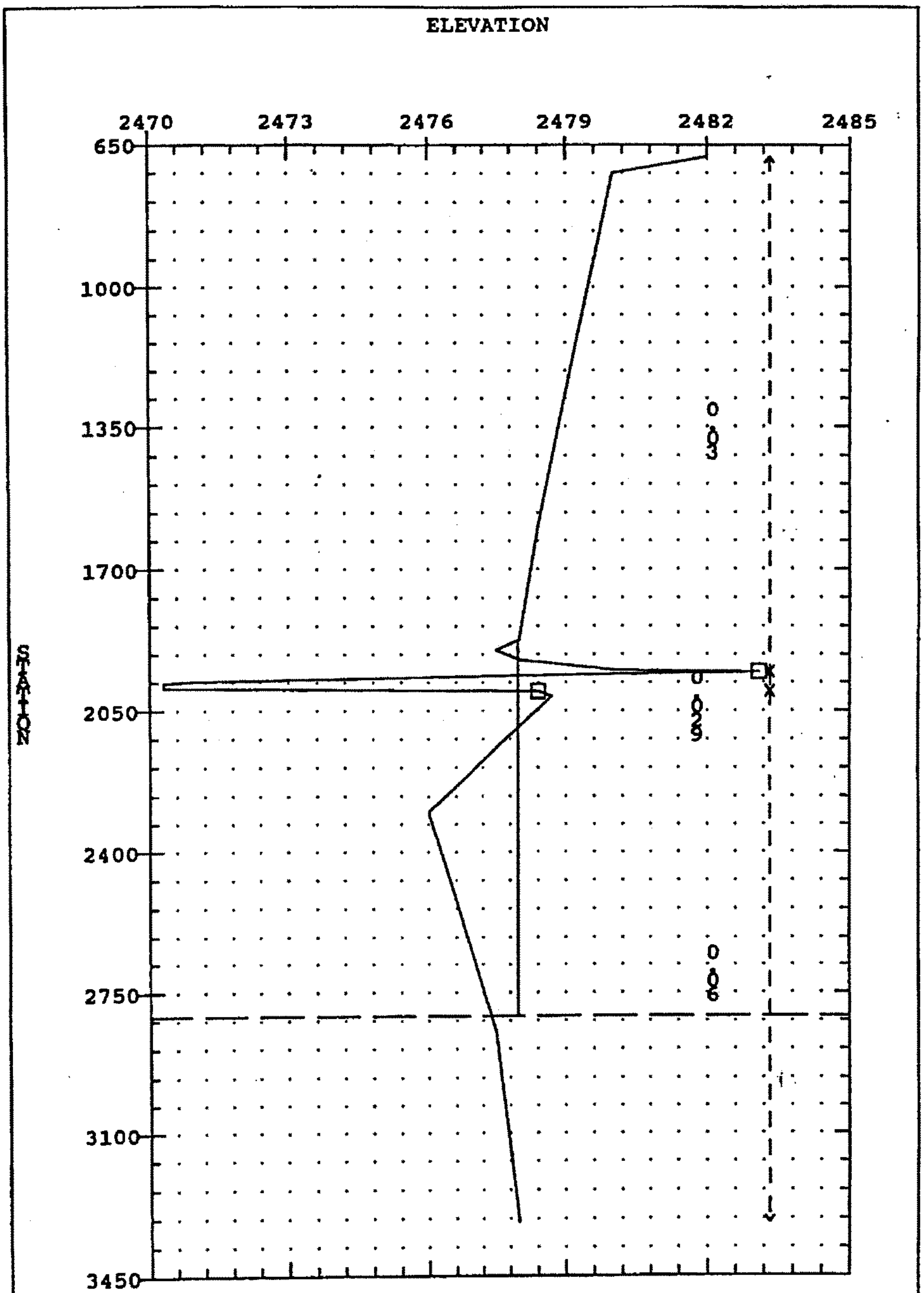
SECTION : 10

West Branch Santa Cruz River



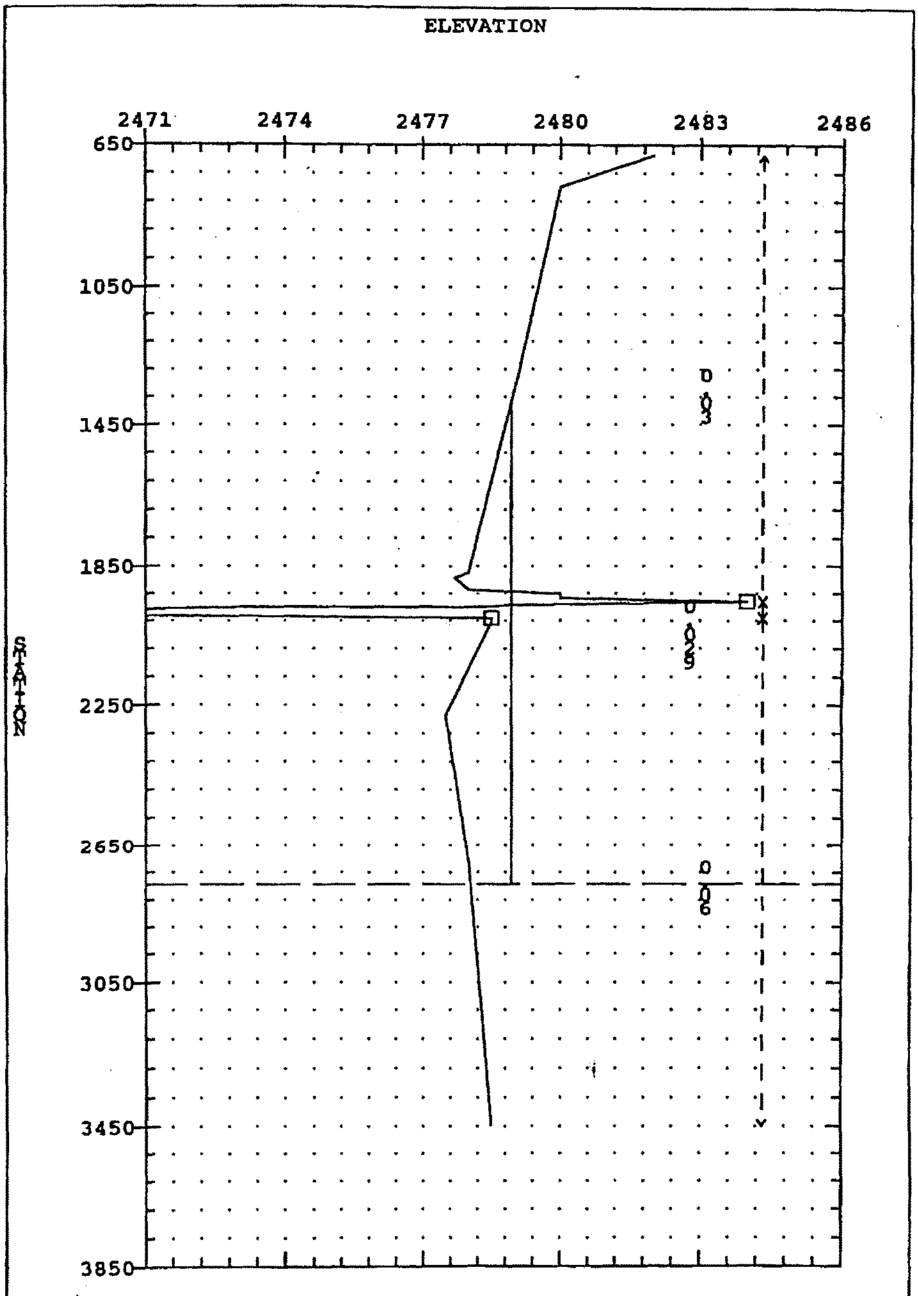
SECTION : 11

West Branch Santa Cruz River



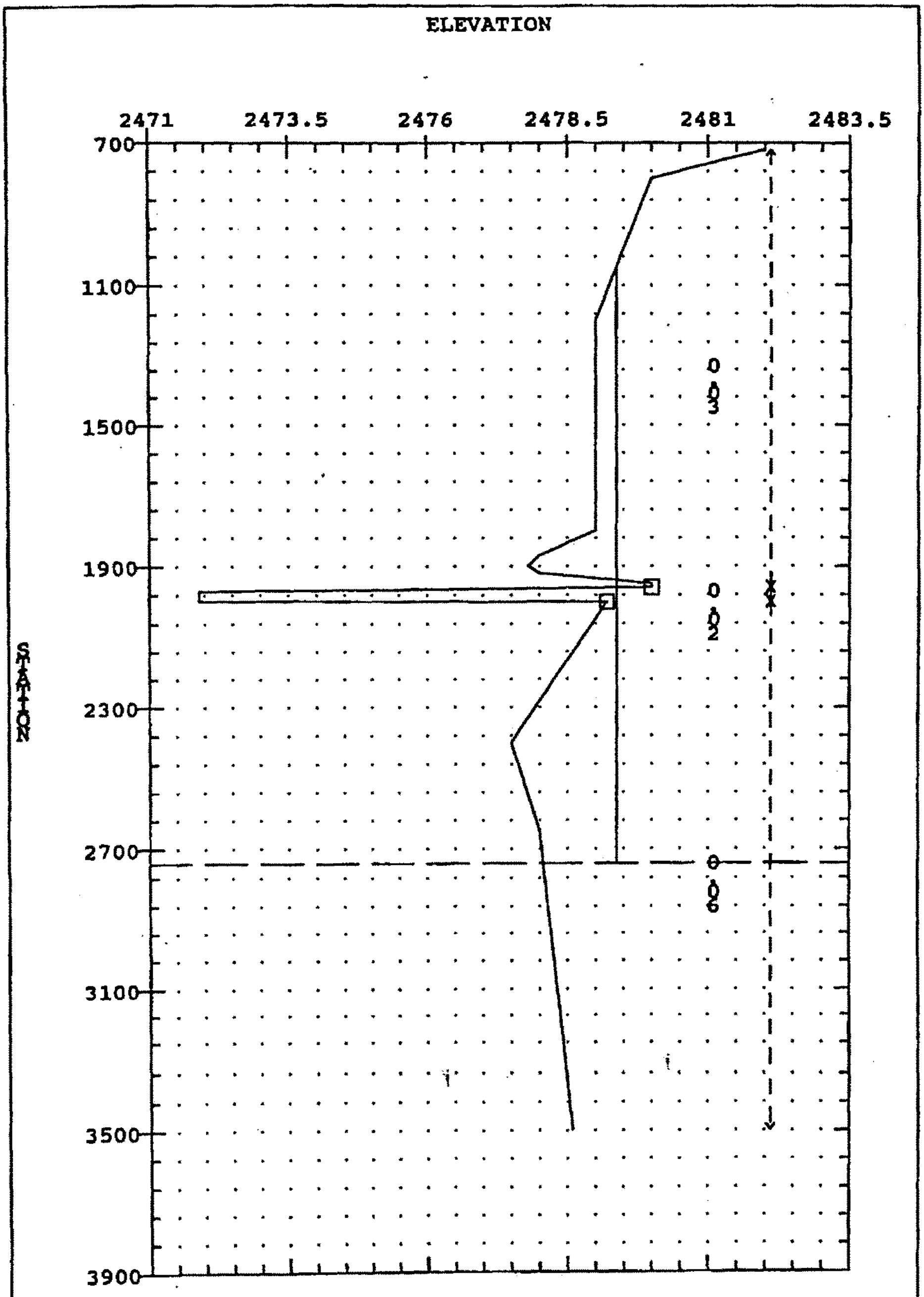
SECTION : 12

West Branch Santa Cruz River



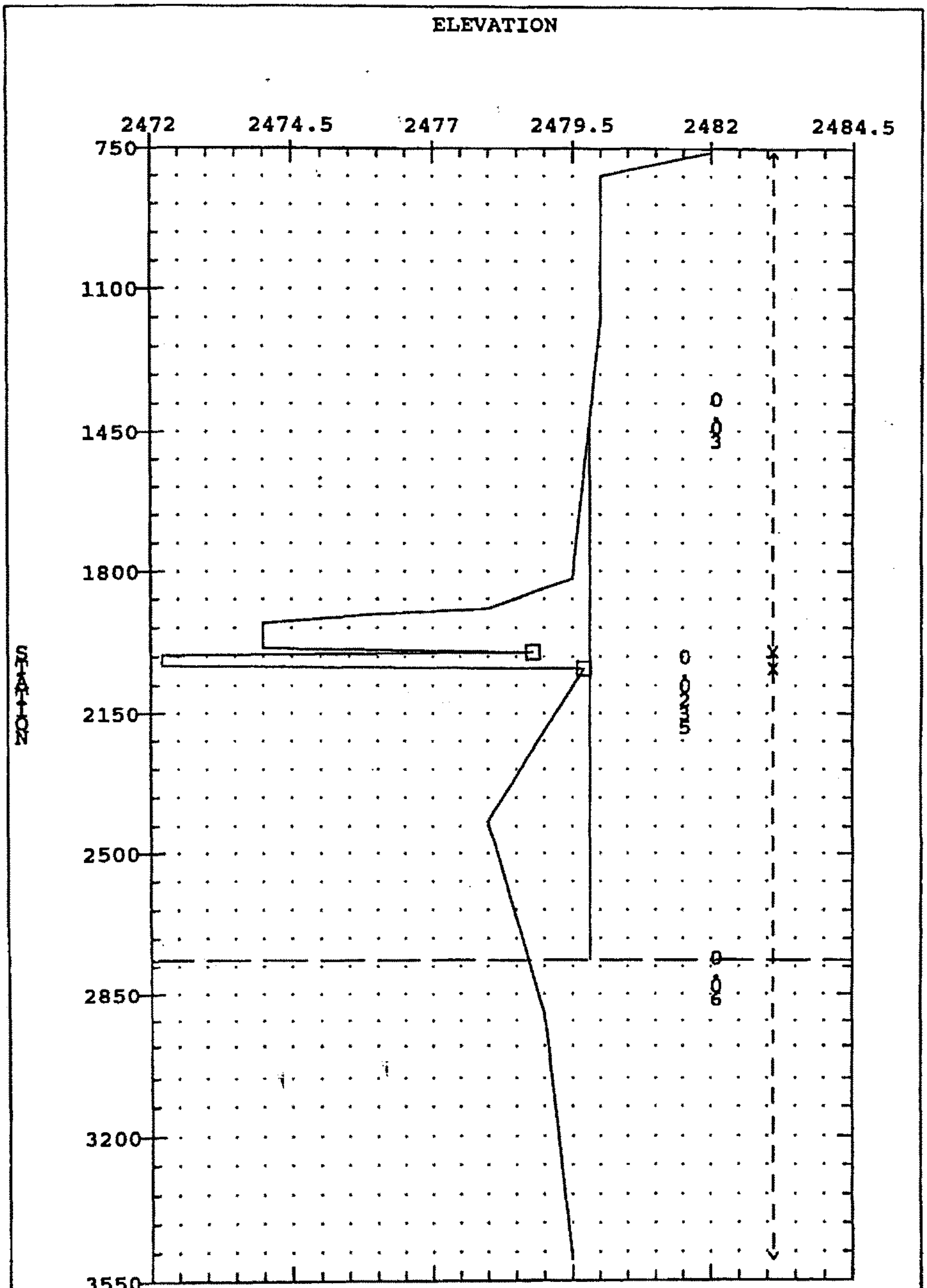
SECTION : 13

West Branch Santa Cruz River



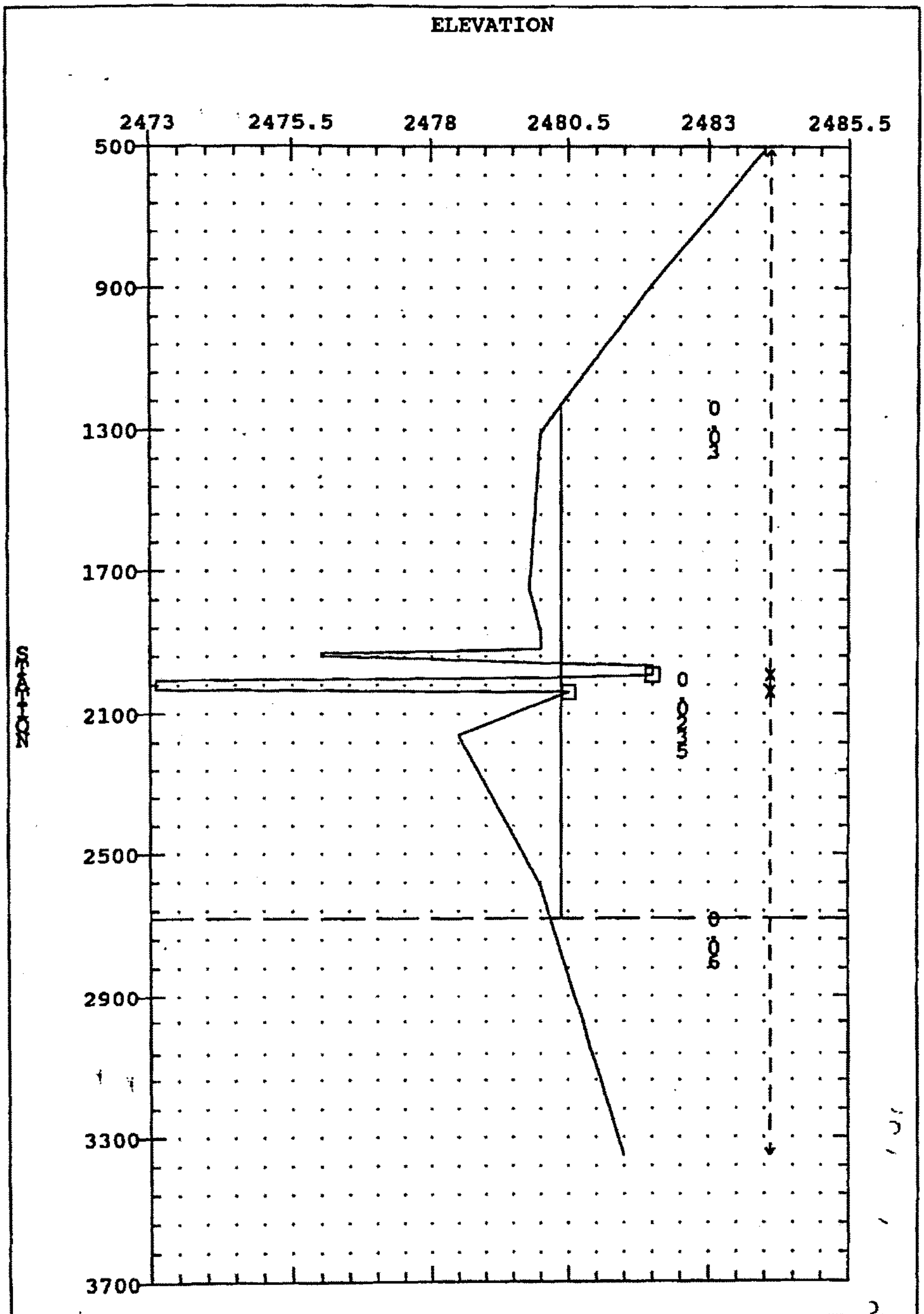
SECTION : 14

West Branch Santa Cruz River



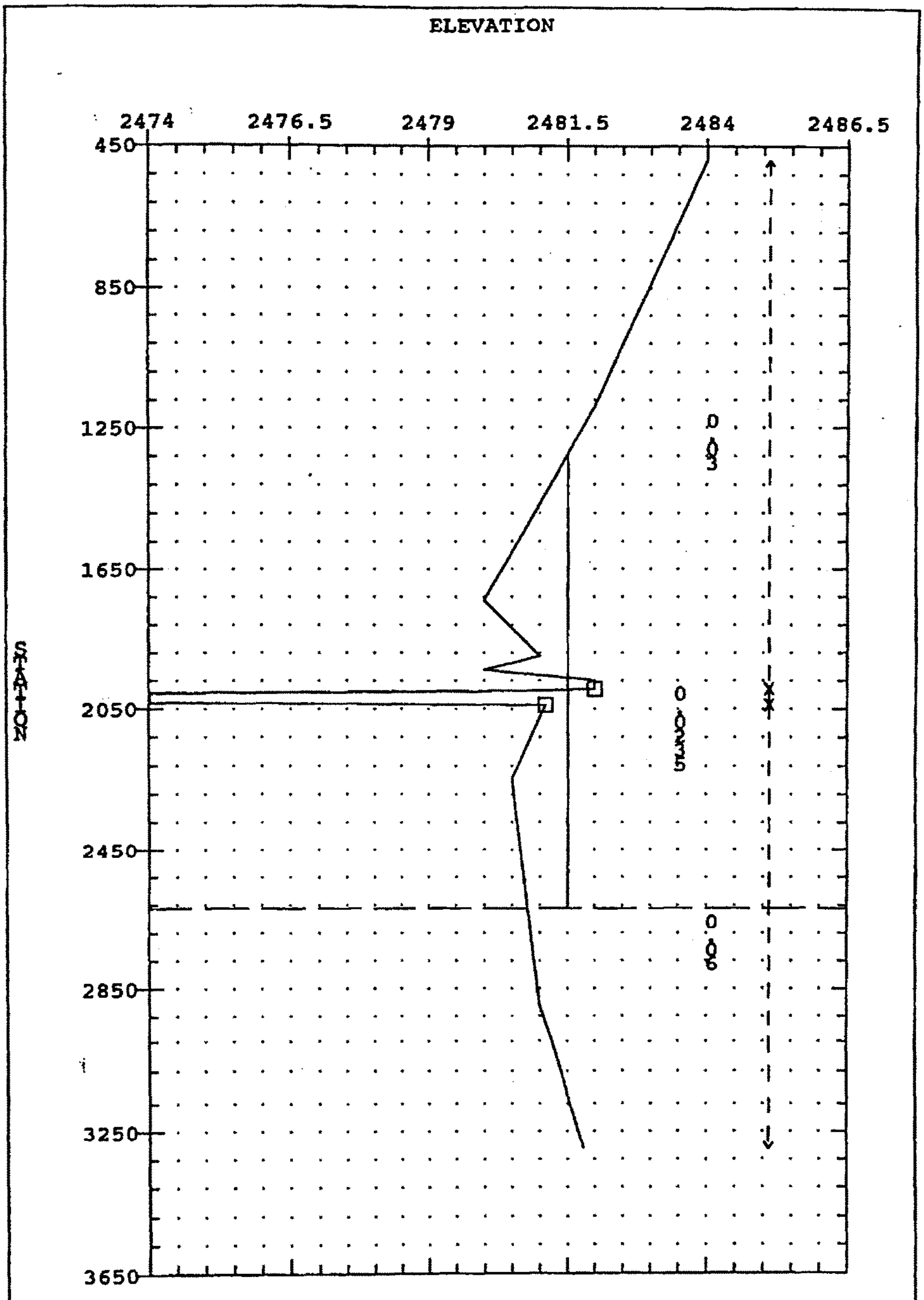
SECTION : 15

West Branch Santa Cruz River



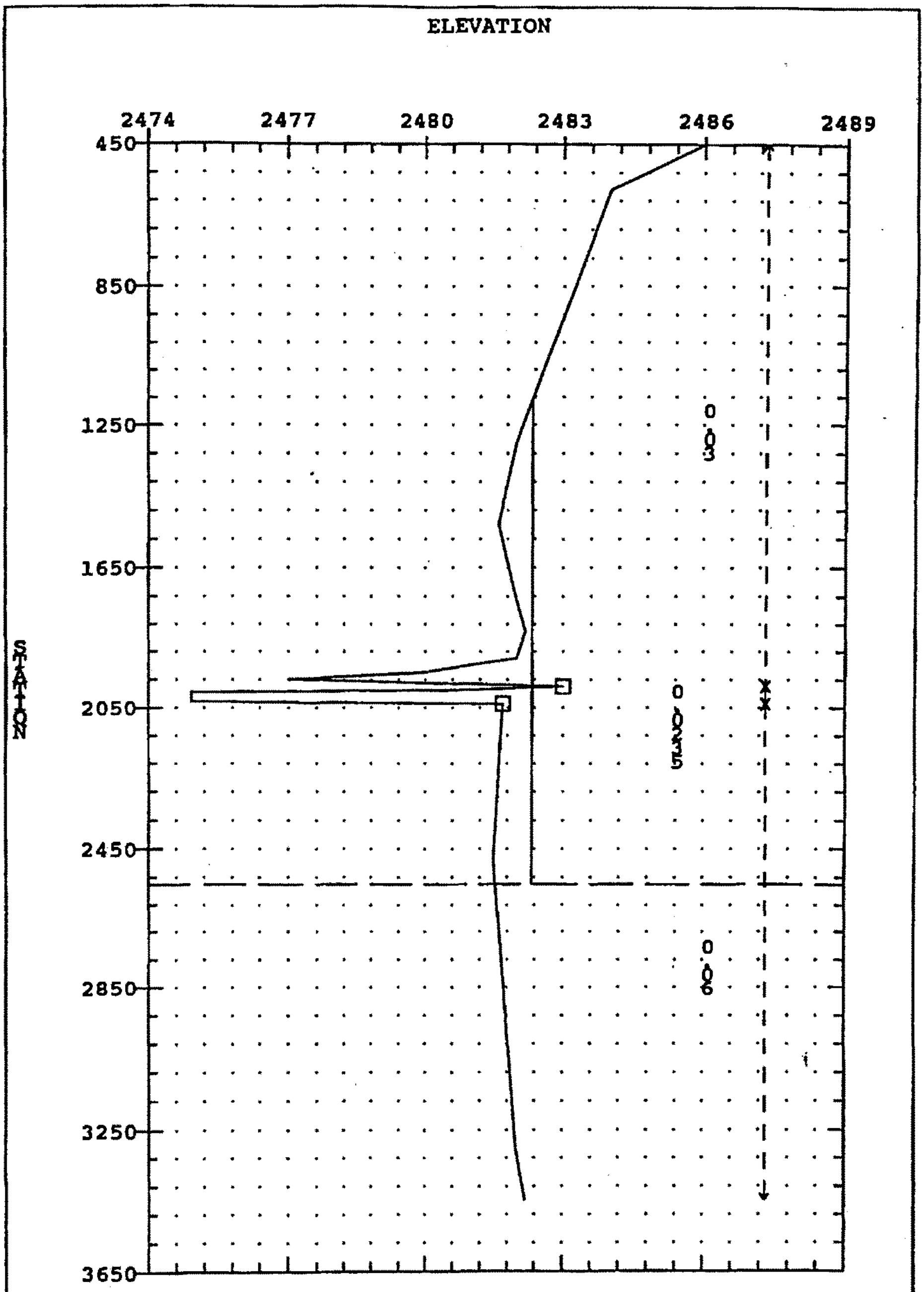
SECTION : 16

West Branch Santa Cruz River



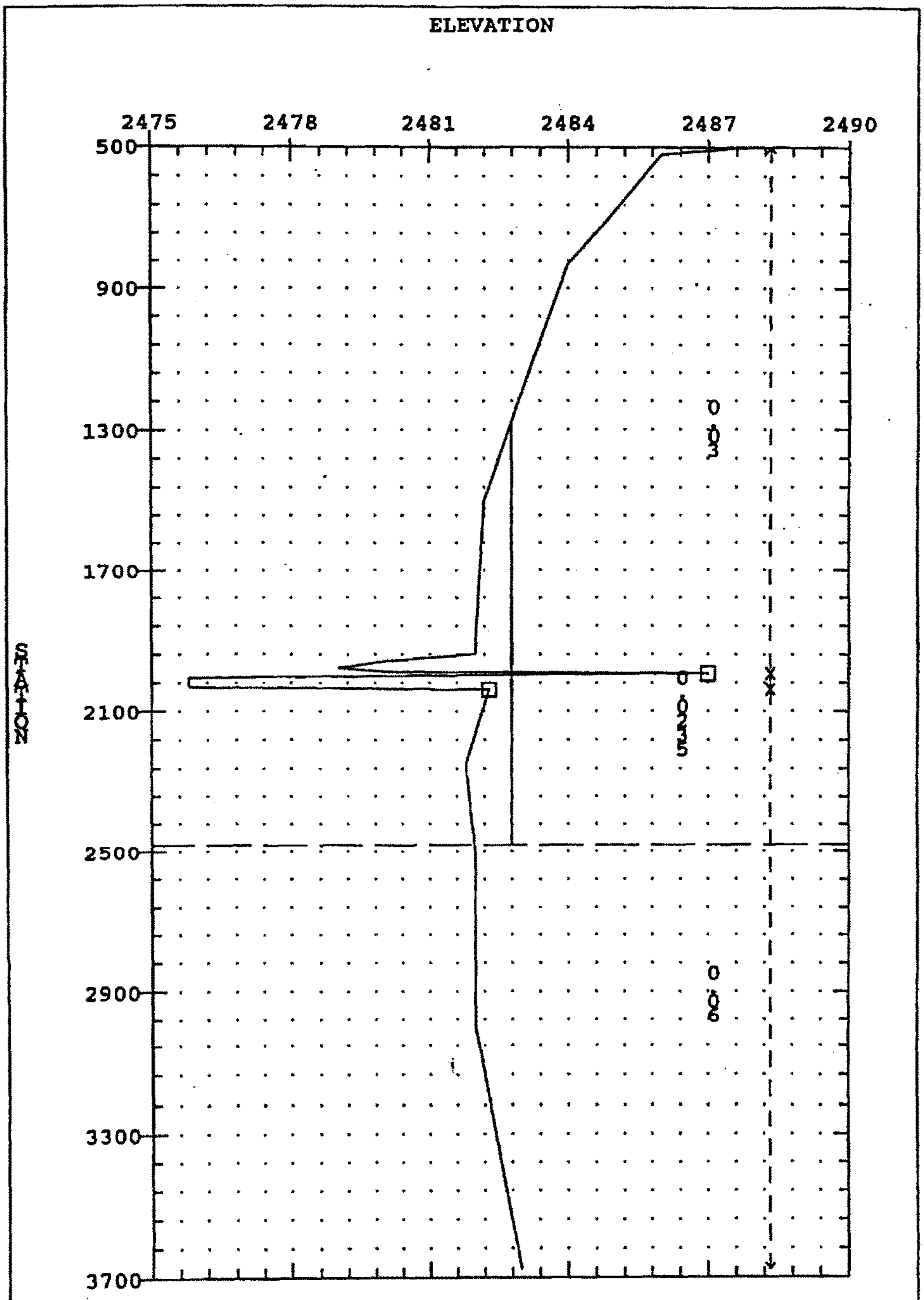
SECTION : 17

West Branch Santa Cruz River



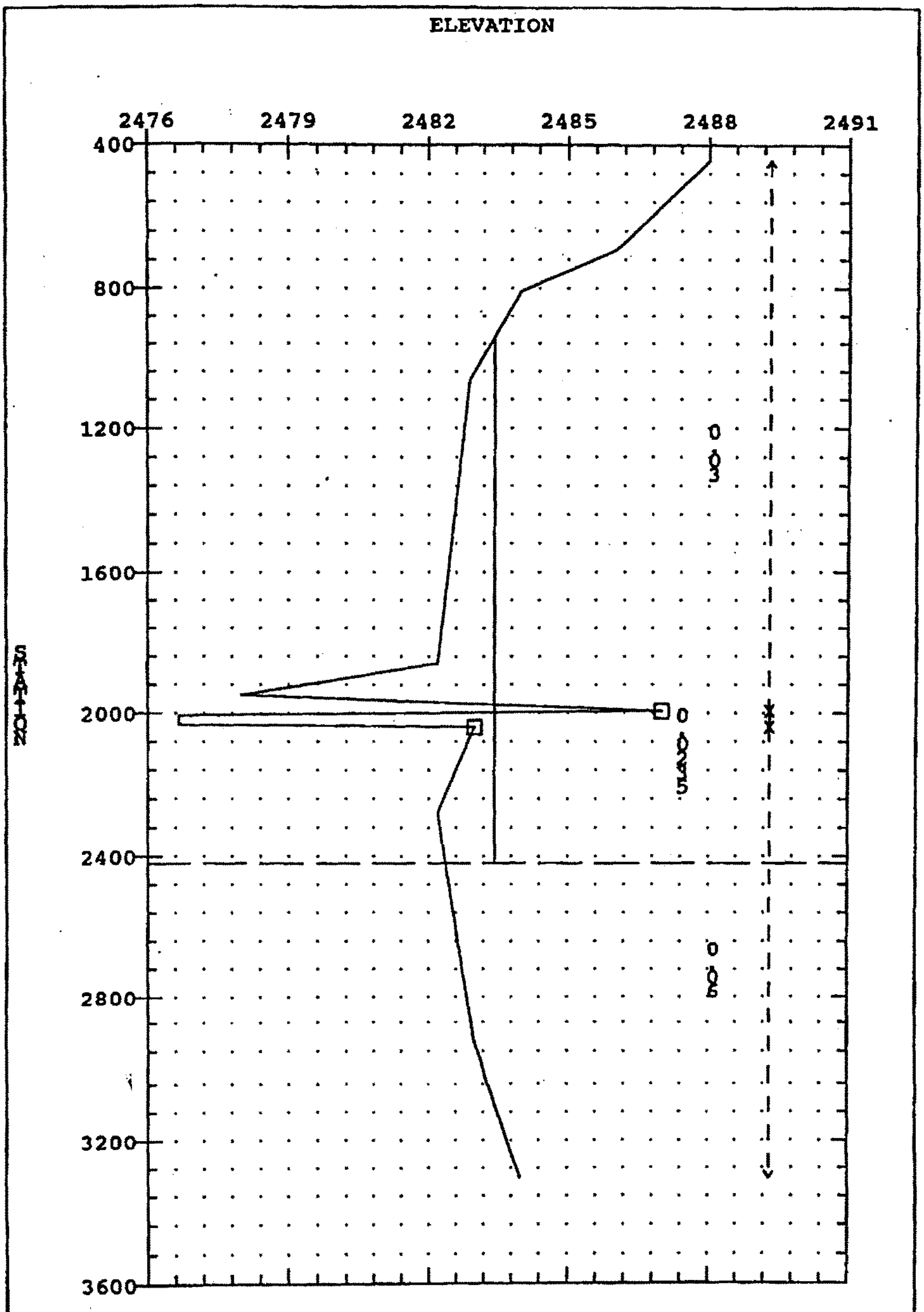
SECTION : 18

West Branch Santa Cruz River



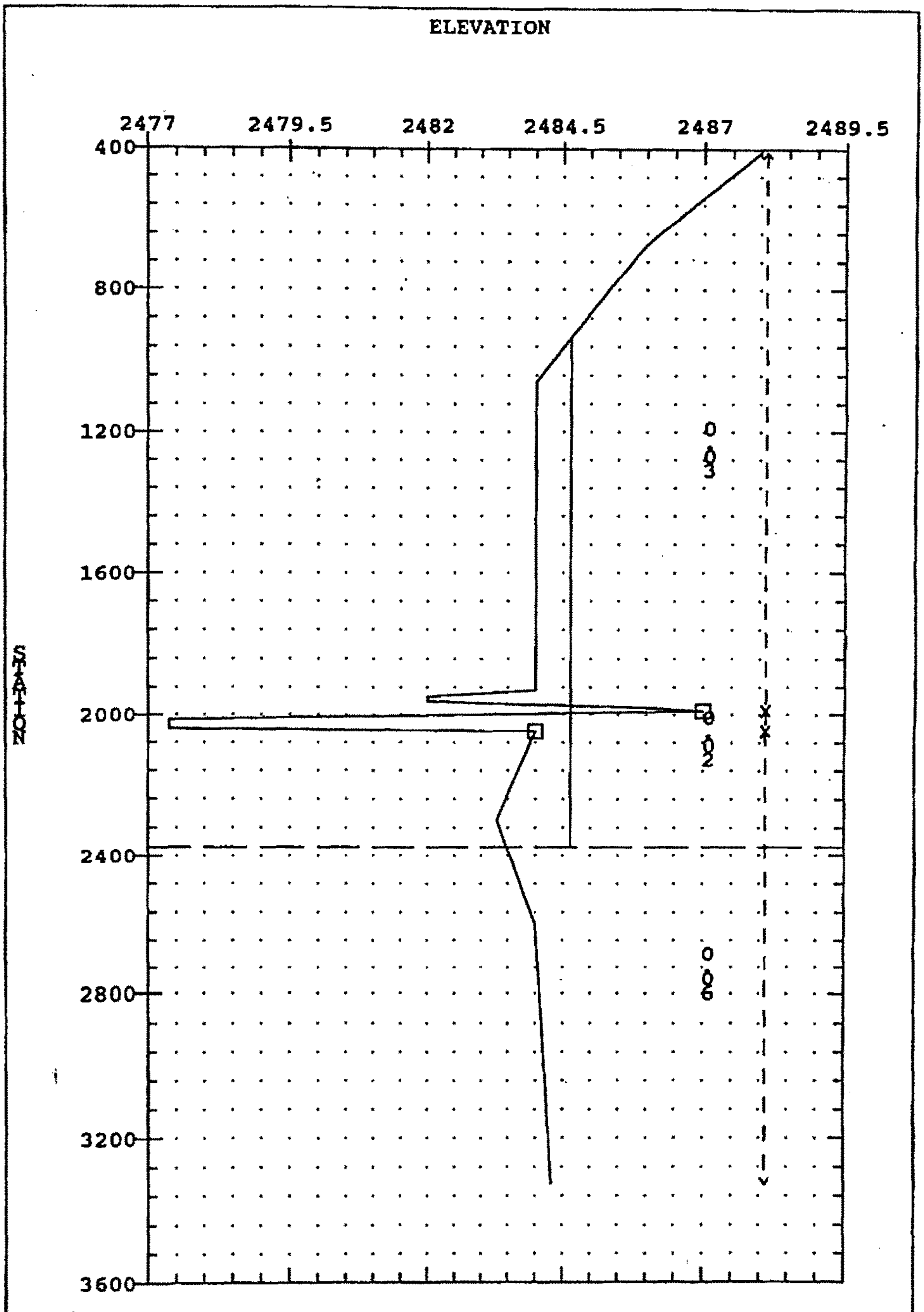
SECTION : 19

West Branch Santa Cruz River



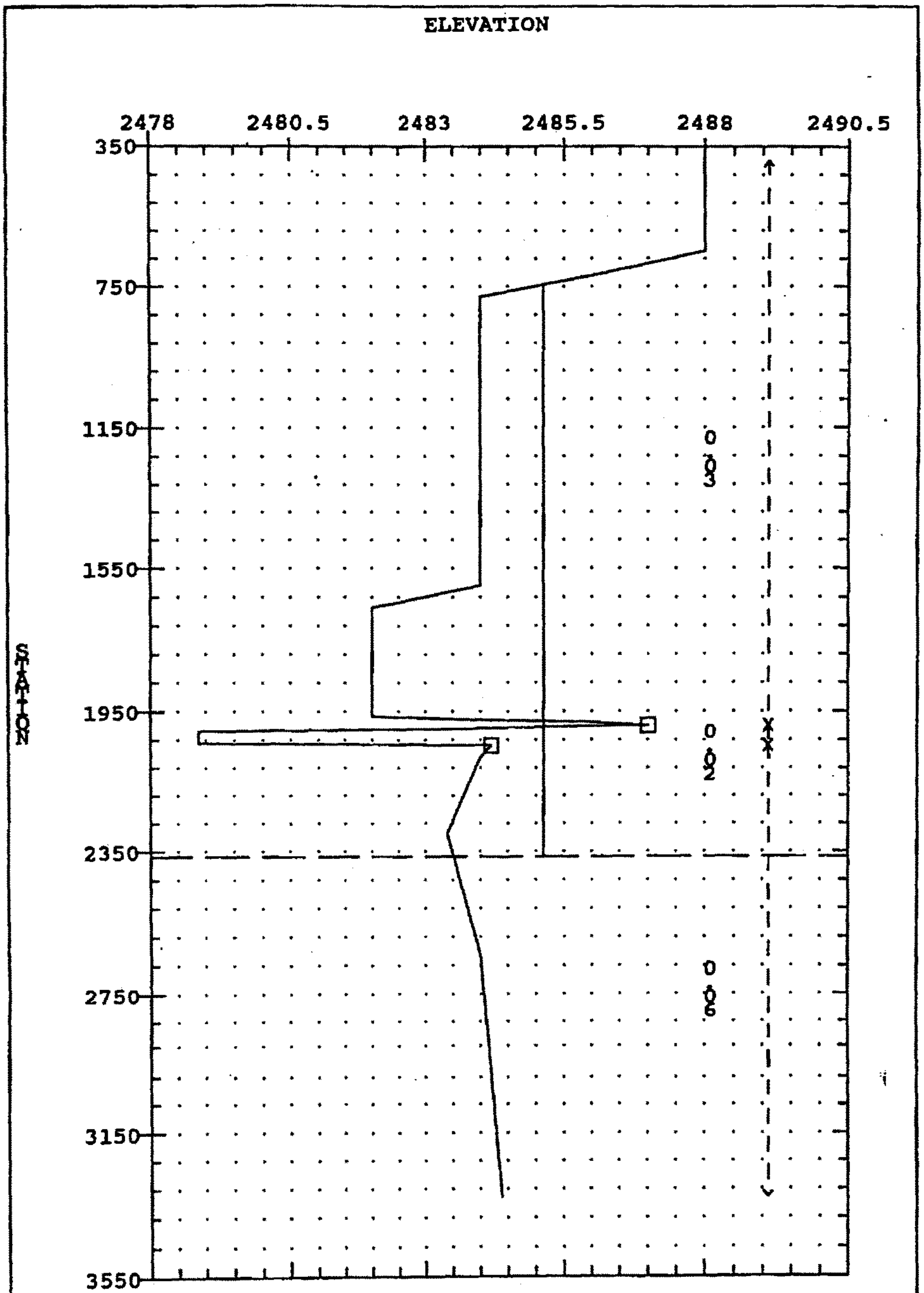
SECTION : 20

West Branch Santa Cruz River



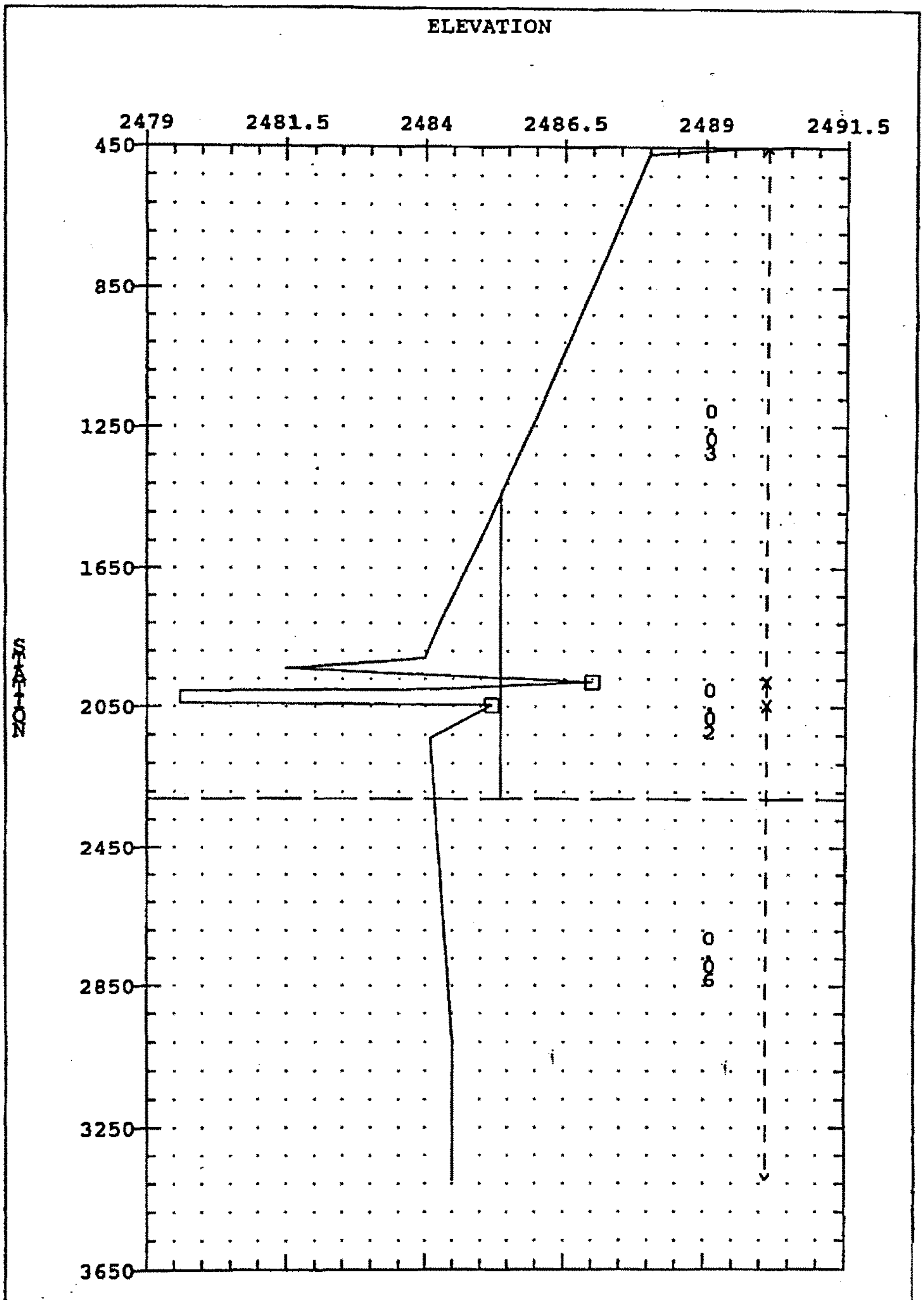
SECTION : 21

West Branch Santa Cruz River



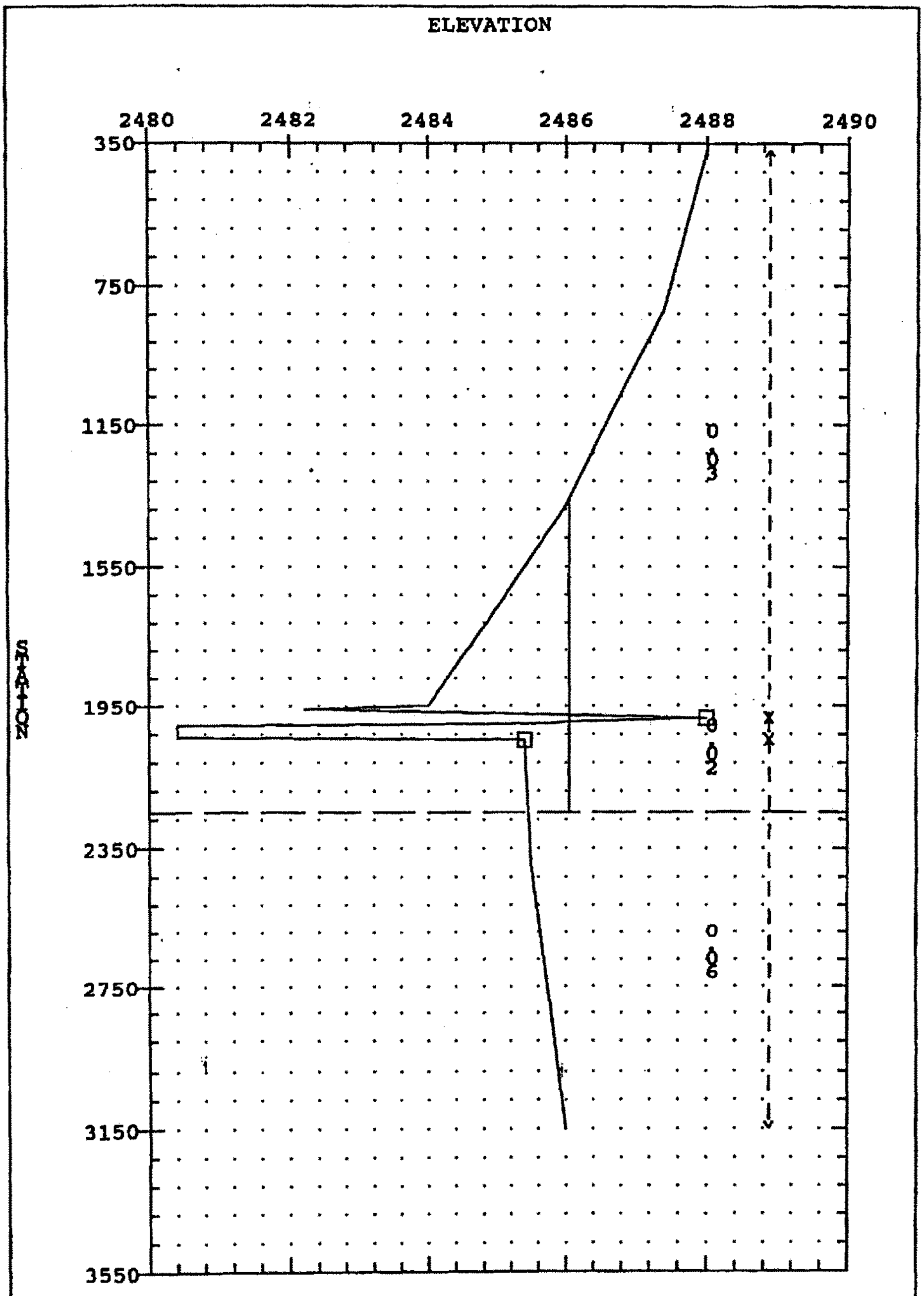
SECTION : 22

West Branch Santa Cruz River



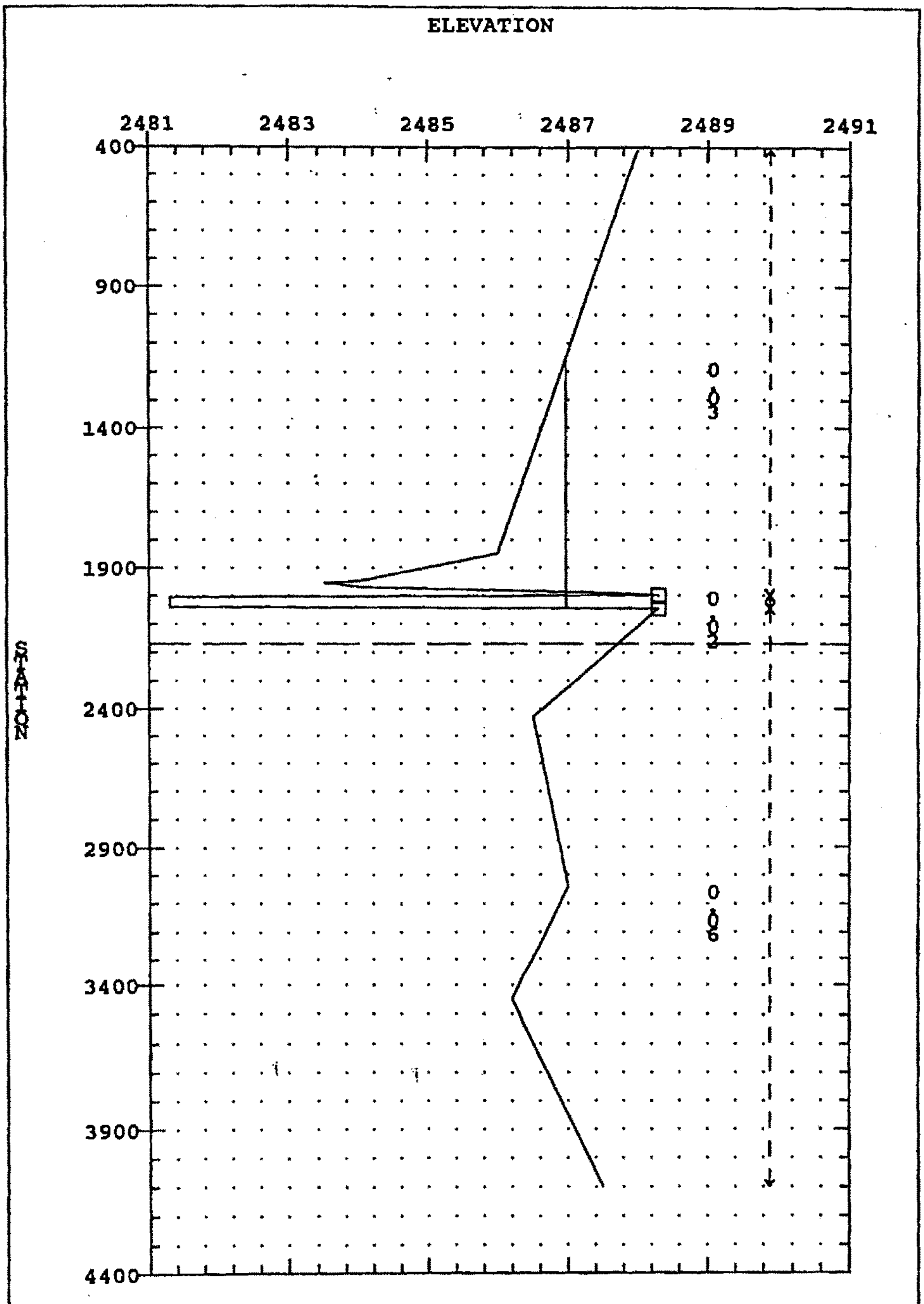
SECTION : 23

West Branch Santa Cruz River



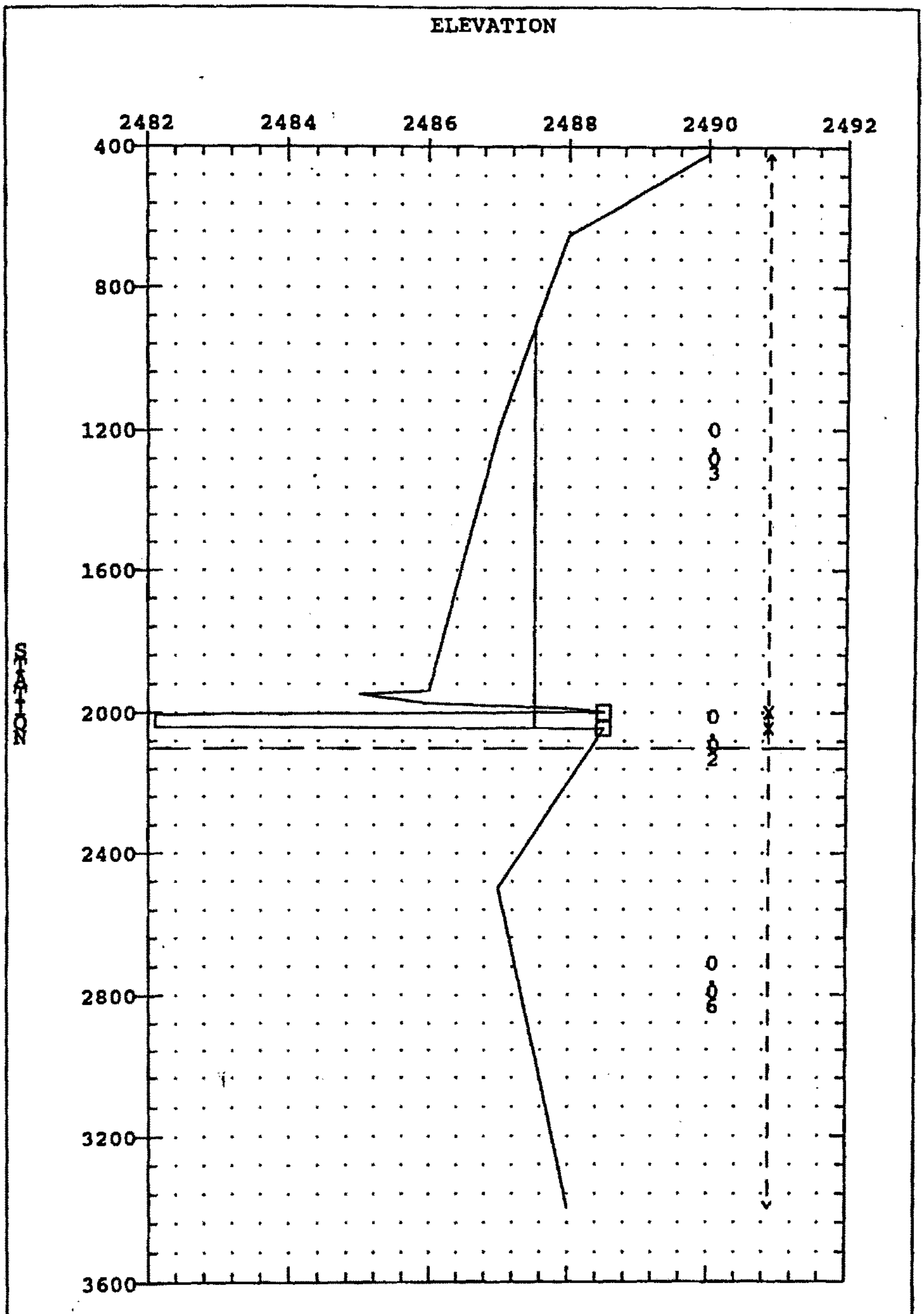
SECTION : 24

West Branch Santa Cruz River



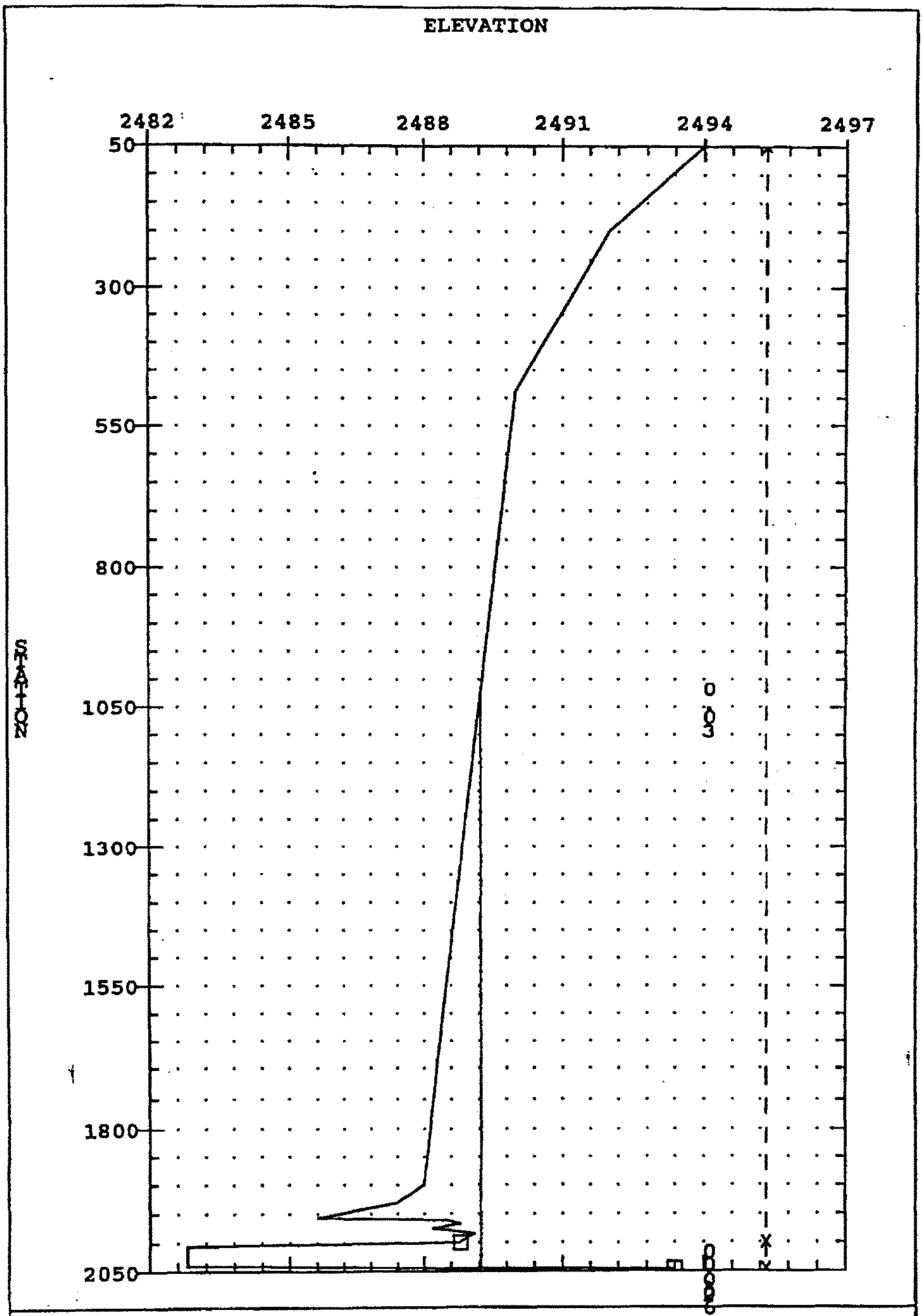
SECTION : 25

West Branch Santa Cruz River



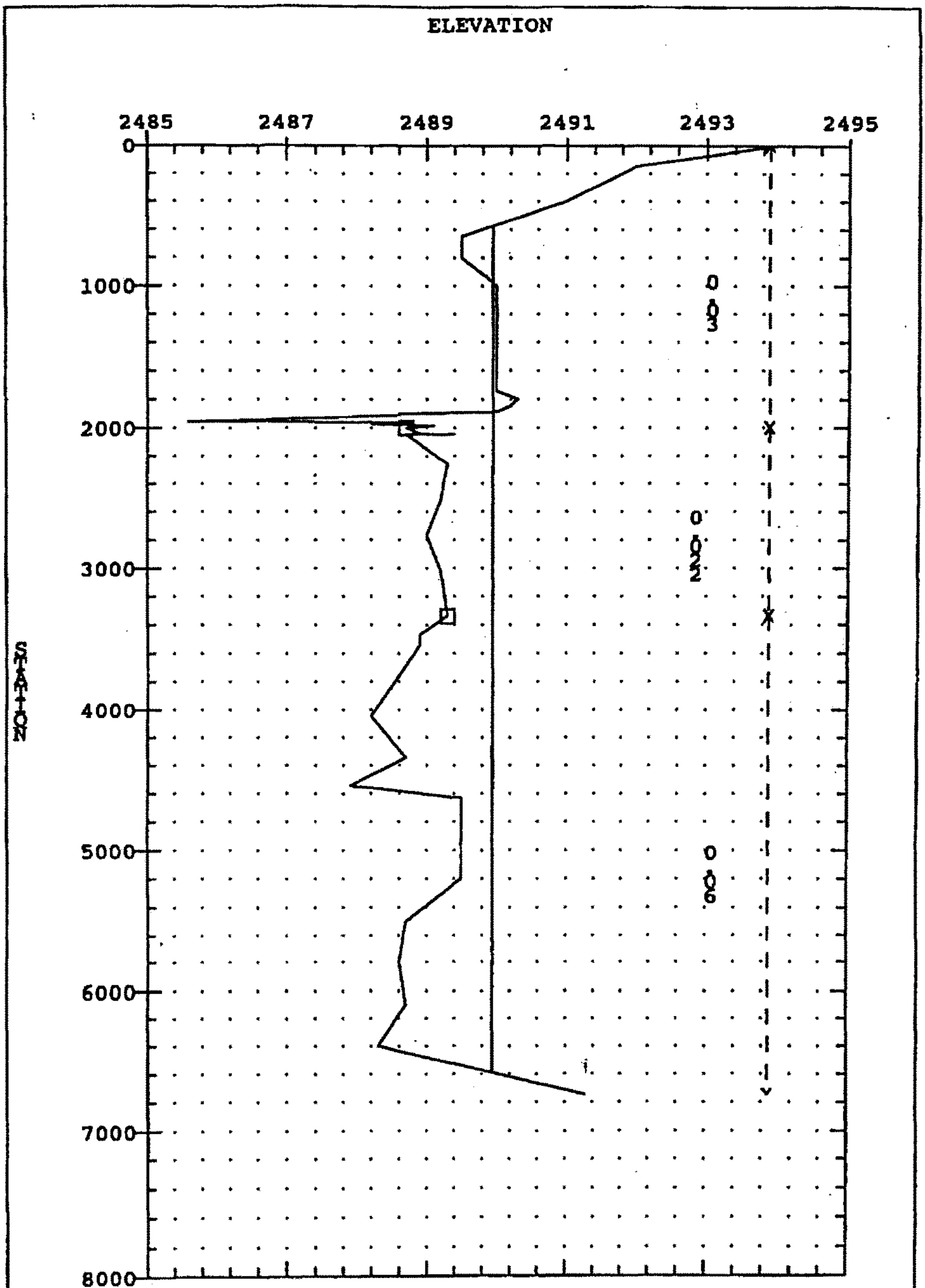
SECTION : 26

West Branch Santa Cruz River



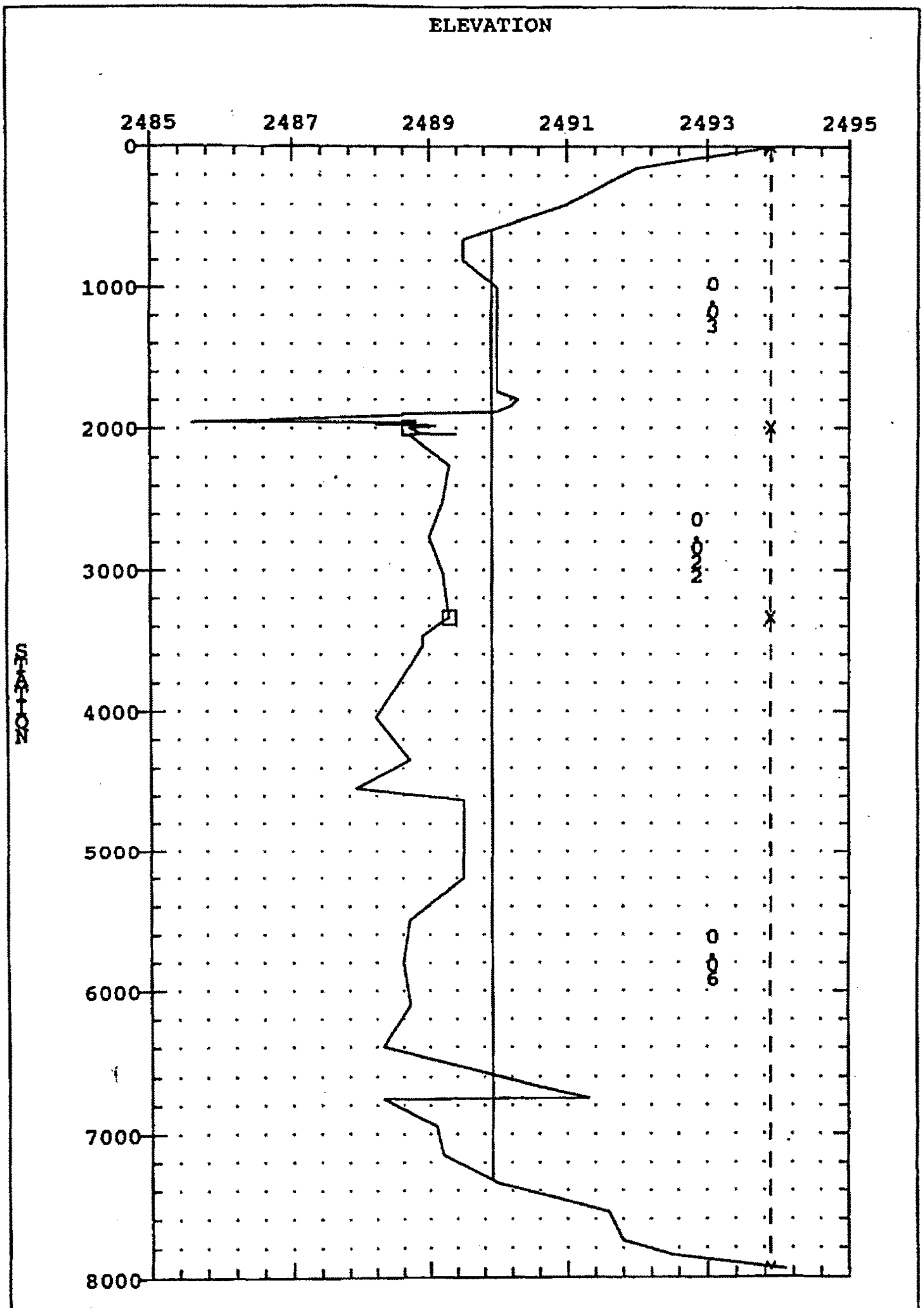
SECTION : 27

West Branch Santa Cruz River



SECTION : 28

West Branch Santa Cruz River



SECTION : 28.1

West Branch Santa Cruz River

Appendix D

HEC-2 Input And Output Files For The South Channel Of The Los Reales Improvement District

```
SF Splitflow Analysis of the South Channel
TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel
WS     7      9      10     -1     2.6
WC     0  2493.1      1  2489.8    530  2489.4    730  2489.7   1080  2492.5
WC  1280  2492.5   1450  2492.5
EE
T1       Los Reales Improvement District, Letter of Map Revision
T2       Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3       South Channel
J1     0      2      0      0     -1      0      0      0   2472
J2     1      0     -1      0      0      0      0      0      0
J3    38     43     13     14     15      1      2      3      8     53
J3     4     54     61            150
NC  .025   .025   .025    0.1    0.3
QT     3   3250   3300   3350

*  Note that 3 flood discharges were used in this multi-profile run.  These
*  discharges were used to develop the stage-discharge curve for use in the
*  HEC-2 model of the West Branch (see TC cards in HEC-2 file WEST.H2I), as well
*  as to predict water-surface elevations within and along the South Channel.
*  In addition, the water-surface elevation given in field J1.9 is equal to the
*  10-year water-surface elevation within the Santa Cruz River at the channel outlet.

*  Cross Section #62+50 from Sheet 12 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     1      4      0    128      0      0      0
GR2486.6      0  2468.9     57  2468.9     73  2486.4    128

*  Cross Section #60+00 from Sheet 12 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     2      4      0    112    250    250    250
GR2487.4      0  2471.8     48  2471.8     64  2487.6    112

*  Cross Section #57+00 from Sheet 11 of 15 of Los Reales Improvement District
*  Job No. 85-074
NC  .024   .024   .024    0.1    0.3
X1     3      6      0   86.9    300    300    300      0   2400
GR 87.78      0  75.20   27.1  75.20   56.0  88.19   66.5  91.31   75.9
GR 91.31   86.9

*  Cross Section #54+00 from Sheet 11 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     4      6      0   86.9    300    300    300      0   2400
GR 87.95      0  75.67   27.1  75.67   56.0  88.15   66.5  91.51   75.9
GR 91.51   86.9

*  Cross Section #51+00 from Sheet 11 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     5      6      0   86.9    300    300    300      0   2400
GR 88.11      0  76.64   27.1  76.64   56.0  88.35   66.5  91.59   75.9
GR 91.59   86.9

*  Cross Section #48+00 from Sheet 10 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     6      6      0   86.9    300    300    300      0   2400
GR 87.47      0  77.44   27.1  77.44   56.0  88.30   66.5   92.2   75.9
GR  92.2   86.9

*  Cross Section #45+00 from Sheet 10 of 15 of Los Reales Improvement District
*  Job No. 85-074
```

```
X1    7     6     0    86.9   300    300    300     0    2400
GR 87.99    0   78.16  27.1  78.16   56.0  88.50  66.5  92.03   75.9
GR 92.03  86.9

*  Cross Section #42+00 from sheet 10 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1    8     6     0    86.9   300    300    300     0    2400
GR 88.28    0   78.70  27.1  78.70   56.0  88.71  66.5  92.55   75.9
GR 92.55  86.9

*  Cross Section #39+20 from sheet  9 of 15 of Los Reales Improvement District
*  Job No. 85-074
NC  .022  .022   .022   0.1    0.3
X1    9     4     0     67    280    280    280     0    2400
GR  88.0    0   79.4    28   79.4     57   89.0    67

*  Cross Section runs along south top of bank protection between sta.
*  #24+70 and #39+20 from sheets 8 & 9 of 15 of Los Reales Improvement District
*  Job No. 85-074

X1   10     7     0    730   1450    720   1085     0    2400
GR  93.1    0   89.8     1   88.6    530   88.9   730   88.0   1130
GR  89.3  1310  92.5  1450

EJ

T1     Los Reales Improvement District, Letter of Map Revision
T2     Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3     South Channel
J1    0     3     0     0     -1     0      0      0    2472
J2    2     0    -1     0      0     0      0      0      0

T1     Los Reales Improvement District, Letter of Map Revision
T2     Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3     South Channel
J1    0     4     0     0     -1     0      0      0    2472
J2    3     0    -1     0      0     0      0      0      0

ER
```

```
*********************************************
* HEC-2 WATER SURFACE PROFILES              *
*                                           *
* Version   4.6.2;  May 1991                *
*                                           *
* RUN DATE    03OCT94    TIME    15:32:21   *
*********************************************
```

```
*****************************************
* U.S. ARMY CORPS OF ENGINEERS          *
* HYDROLOGIC ENGINEERING CENTER         *
* 609 SECOND STREET, SUITE D            *
* DAVIS, CALIFORNIA 95616-4687          *
*         (916) 756-1104                *
*****************************************
```

```
X     X XXXXXXX  XXXXX           XXXXX
X     X X       X     X         X     X
X     X X       X                     X
XXXXXXX XXXX    X         XXXXX  XXXXX
X     X X       X               X
X     X X       X     X         X
X     X XXXXXXX  XXXXX          XXXXXXX
```

THIS RUN EXECUTED 03OCT94 15:32:21

```
*************************************
HEC-2 WATER SURFACE PROFILES

Version  4.6.2;  May 1991
*************************************
```

SPLIT FLOW BEING PERFORMED

SF Splitflow Analysis of the South Channel

```
TW Splitflow #9 to #10, Weir flow across Los Reeles Rd. on No.Side of So.Channel
WS     7       9       10      -1     2.6
WC     0  2493.1        1  2489.8     530  2489.4     730  2489.7    1080  2492.5
WC  1280  2492.5     1450  2492.5
```

```
T1      Los Reales Improvement District, Letter of Map Revision
T2      Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3      South Channel

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ

      0        2        0        0       -1        0        0        0      2472

J2  NPROF    IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE

      1        0       -1        0        0        0        0        0        0


J3  VARIABLE CODES FOR SUMMARY PRINTOUT

     38       43       13       14       15        1        2        3        8       53
      4       54       61                150

NC     .025     .025     .025      0.1      0.3
QT        3     3250     3300     3350

   Note that 3 flood discharges were used in this multi-profile run.  These
   discharges were used to develop the stage-discharge curve for use in the
   HEC-2 model of the West Branch (see TC cards in HEC-2 file WEST.H2I), as well
   as to predict water-surface elevations within and along the South Channel.
   In addition, the water-surface elevation given in field J1.9 is equal to the
   10-year water-surface elevation within the Santa Cruz River at the channel ou

   Cross Section #62+50 from Sheet 12 of 15 of Los Reales Improvement District
   Job No. 85-074
X1        1        4        0      128        0        0        0
GR   2486.6        0   2468.9       57   2468.9       73   2486.4      128

   Cross Section #60+00 from Sheet 12 of 15 of Los Reales Improvement District
   Job No. 85-074

X1        2        4        0      112      250      250      250
GR   2487.4        0   2471.8       48   2471.8       64   2487.6      112

   Cross Section #57+00 from Sheet 11 of 15 of Los Reales Improvement District
   Job No. 85-074

NC     .024     .024     .024      0.1      0.3
X1        3        6        0     86.9      300      300      300        0     2400
GR    87.78        0    75.20     27.1    75.20     56.0    88.19     66.5    91.31     75.9
GR    91.31     86.9

   Cross Section #54+00 from Sheet 11 of 15 of Los Reales Improvement District
   Job No. 85-074
```

X1	4	6	0	86.9	300	300	300	0	2400	
GR	87.95	0	75.67	27.1	75.67	56.0	88.15	66.5	91.51	75.9
GR	91.51	86.9								

Cross Section #51+00 from Sheet 11 of 15 of Los Reales Improvement District
Job No. 85-074

X1	5	6	0	86.9	300	300	300	0	2400	
GR	88.11	0	76.64	27.1	76.64	56.0	88.35	66.5	91.59	75.9
GR	91.59	86.9								

Cross Section #48+00 from Sheet 10 of 15 of Los Reales Improvement District
Job No. 85-074

X1	6	6	0	86.9	300	300	300	0	2400	
GR	87.47	0	77.44	27.1	77.44	56.0	88.30	66.5	92.2	75.9
GR	92.2	86.9								

Cross Section #45+00 from Sheet 10 of 15 of Los Reales Improvement District
Job No. 85-074

X1	7	6	0	86.9	300	300	300	0	2400	
GR	87.99	0	78.16	27.1	78.16	56.0	88.50	66.5	92.03	75.9
GR	92.03	86.9								

Cross Section #42+00 from sheet 10 of 15 of Los Reales Improvement District
Job No. 85-074

X1	8	6	0	86.9	300	300	300	0	2400	
GR	88.28	0	78.70	27.1	78.70	56.0	88.71	66.5	92.55	75.9
GR	92.55	86.9								

Cross Section #39+20 from sheet 9 of 15 of Los Reales Improvement District
Job No. 85-074

NC	.022	.022	.022	0.1	0.3				
X1	9	4	0	67	280	280	280	0	2400
GR	88.0	0	79.4	28	79.4	57	89.0	67	

Cross Section runs along south top of bank protection between sta.
#24+70 and #39+20 from sheets 8 & 9 of 15 of Los Reales Improvement District
Job No. 85-074

X1	10	7	0	730	1450	720	1085	0	2400	
GR	93.1	0	89.8	1	88.6	530	88.9	730	88.0	1130
GR	89.3	1310	92.5	1450						

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

*PROF 1

CCHV=     .100 CEHV=      .300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
    1.000      7.03   2475.93   2475.93   2472.00   2478.18      2.26       .00       .00   2486.60
   3250.0        .0    3250.0        .0        .0     269.7        .0        .0        .0   2486.40
      .00       .00     12.05       .00      .000      .025      .000      .000   2468.90     34.36
  .005899        0.        0.        0.         0        16         0       .00     60.73     95.09

*SECNO 2.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    2.000      7.12   2478.92   2478.92       .00   2481.19      2.27      1.46       .00   2487.40
   3250.0        .0    3250.0        .0        .0     269.0        .0       1.5        .3   2487.60
      .01       .00     12.08       .00      .000      .025      .000      .000   2471.80     26.09
  .005818      250.      250.      250.        20         5         0       .00     59.54     85.63

CCHV=     .100 CEHV=      .300
*SECNO 3.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    3.000      6.48   2481.68   2481.68       .00   2484.32      2.63      1.70       .11   2487.78
   3250.0        .0    3250.0        .0        .0     249.7        .0       3.3        .7   2491.31
      .01       .00     13.02       .00      .000      .024      .000      .000   2475.20     13.13
  .005544      300.      300.      300.        20        11         0       .00     48.11     61.24

*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.61

    4.000      8.42   2484.09       .00       .00   2485.42      1.33       .97       .13   2487.95
   3250.0        .0    3250.0        .0        .0     351.3        .0       5.4       1.1   2491.51
      .02       .00      9.25       .00      .000      .024      .000      .000   2475.67      8.52
  .002130      300.      300.      300.         4         0         0       .00     54.56     63.08
```

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 5.000

5.000	8.06	2484.70	.00	.00	2486.13	1.43	.68	.03	2488.11
3250.0	.0	3250.0	.0	.0	338.7	.0	7.8	1.4	2491.59
.03	.00	9.59	.00	.000	.024	.000	.000	2476.64	8.06
.002410	300.	300.	300.	3	0	0	.00	55.17	63.23

*SECNO 6.000

6.000	8.08	2485.52	.00	.00	2486.84	1.31	.70	.01	2487.47
3250.0	.0	3250.0	.0	.0	353.3	.0	10.2	1.8	2492.20
.04	.00	9.20	.00	.000	.024	.000	.000	2477.44	5.27
.002234	300.	300.	300.	2	0	0	.00	58.55	63.81

*SECNO 7.000

7.000	8.04	2486.20	.00	.00	2487.51	1.31	.67	.00	2487.99
3250.0	.0	3250.0	.0	.0	354.4	.0	12.6	2.2	2492.03
.05	.00	9.17	.00	.000	.024	.000	.000	2478.16	4.93
.002237	300.	300.	300.	2	0	0	.00	59.24	64.17

*SECNO 8.000

8.000	8.26	2486.96	.00	.00	2488.15	1.19	.63	.01	2488.28
3250.0	.0	3250.0	.0	.0	371.2	.0	15.1	2.7	2492.55
.06	.00	8.76	.00	.000	.024	.000	.000	2478.70	3.73
.001986	300.	300.	300.	2	0	0	.00	60.94	64.67

CCHV= .100 CEHV= .300

*SECNO 9.000

9.000	8.11	2487.51	.00	.00	2488.66	1.16	.51	.00	2488.00
3250.0	.0	3250.0	.0	.0	376.4	.0	17.5	3.1	2489.00
.07	.00	8.63	.00	.000	.022	.000	.000	2479.40	1.60
.001679	280.	280.	280.	2	0	0	.00	63.85	65.45

*SECNO 10.000

3301 HV CHANGED MORE THAN HVINS

10.000	1.90	2489.90	.00	.00	2489.99	.09	1.22	.11	2493.10
3250.0	.0	1116.4	2133.6	.0	600.2	812.8	36.4	17.9	2488.90
.18	.00	1.86	2.62	.000	.022	.022	.000	2488.00	.97
.000983	1450.	1085.	720.	6	0	0	.00	1335.27	1336.24

TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	2	2487.507	2489.900	9.000	10.000

T1 Los Reales Improvement District, Letter of Map Revision
T2 Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3 South Channel

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	3	0	0	-1	0	0	0	2472	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2	0	-1	0	0	0	0	0	0	

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*PROF 2

CCHV= .100 CEHV= .300

*SECNO 1.000

3720 CRITICAL DEPTH ASSUMED

1.000	7.09	2475.99	2475.99	2472.00	2478.25	2.27	.00	.00	2486.60
3300.0	.0	3300.0	.0	.0	273.2	.0	.0	.0	2486.40
.00	.00	12.08	.00	.000	.025	.000	.000	2468.90	34.18
.005873	0.	0.	0.	0	16	0	.00	61.10	95.27

*SECNO 2.000

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

2.000	7.17	2478.97	2478.97	.00	2481.26	2.28	1.46	.01	2487.40
3300.0	.0	3300.0	.0	.0	272.1	.0	1.6	.3	2487.60
.01	.00	12.13	.00	.000	.025	.000	.000	2471.80	25.93
.005811	250.	250.	250.	20	5	0	.00	59.87	85.79

CCHV= .100 CEHV= .300

*SECNO 3.000

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

3.000	6.54	2481.74	2481.74	.00	2484.40	2.65	1.70	.11	2487.78
3300.0	.0	3300.0	.0	.0	252.6	.0	3.4	.7	2491.31
.01	.00	13.07	.00	.000	.024	.000	.000	2475.20	13.00
.005532	300.	300.	300.	20	11	0	.00	48.29	61.29

*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.61

4.000	8.49	2484.16	.00	.00	2485.50	1.34	.97	.13	2487.95
3300.0	.0	3300.0	.0	.0	355.0	.0	5.5	1.1	2491.51
.02	.00	9.30	.00	.000	.024	.000	.000	2475.67	8.37
.002132	300.	300.	300.	4	0	0	.00	54.76	63.14

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST
*SECNO 5.000									
5.000	8.13	2484.77	.00	.00	2486.21	1.44	.68	.03	2488.11
3300.0	.0	3300.0	.0	.0	342.5	.0	7.9	1.5	2491.59
.03	.00	9.63	.00	.000	.024	.000	.000	2476.64	7.90
.002408	300.	300.	300.	3	0	0	.00	55.39	63.29
*SECNO 6.000									
6.000	8.15	2485.59	.00	.00	2486.92	1.32	.69	.01	2487.47
3300.0	.0	3300.0	.0	.0	357.5	.0	10.3	1.8	2492.20
.04	.00	9.23	.00	.000	.024	.000	.000	2477.44	5.07
.002230	300.	300.	300.	2	0	0	.00	58.81	63.88
*SECNO 7.000									
7.000	8.11	2486.27	.00	.00	2487.59	1.32	.67	.00	2487.99
3300.0	.0	3300.0	.0	.0	358.5	.0	12.7	2.3	2492.03
.05	.00	9.21	.00	.000	.024	.000	.000	2478.16	4.74
.002233	300.	300.	300.	2	0	0	.00	59.50	64.24
*SECNO 8.000									
8.000	8.33	2487.03	.00	.00	2488.23	1.20	.63	.01	2488.28
3300.0	.0	3300.0	.0	.0	375.4	.0	15.3	2.7	2492.55
.06	.00	8.79	.00	.000	.024	.000	.000	2478.70	3.53
.001984	300.	300.	300.	2	0	0	.00	61.21	64.74
CCHV= .100	CEHV= .300								
*SECNO 9.000									
9.000	8.18	2487.58	.00	.00	2488.74	1.17	.51	.00	2488.00
3300.0	.0	3300.0	.0	.0	380.7	.0	17.7	3.1	2489.00
.07	.00	8.67	.00	.000	.022	.000	.000	2479.40	1.38
.001677	280.	280.	280.	2	0	0	.00	64.13	65.52
*SECNO 10.000									
3301 HV CHANGED MORE THAN HVINS									
10.000	1.93	2489.93	.00	.00	2490.02	.09	1.17	.11	2493.10
3300.0	.0	1153.9	2146.1	.0	625.5	833.9	37.1	18.0	2488.90
.18	.00	1.84	2.57	.000	.022	.022	.000	2488.00	.96
.000915	1450.	1085.	720.	6	0	0	.00	1336.80	1337.76

TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	2	2487.575	2489.935	9.000	10.000

T1 Los Reales Improvement District, Letter of Map Revision
T2 Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3 South Channel

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	4	0	0	-1	0	0	0	2472	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	3	0	-1	0	0	0	0	0	0	

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*PROF 3

CCHV= .100 CEHV= .300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED

1.000	7.14	2476.04	2476.04	2472.00	2478.32	2.28	.00	.00	2486.60
3350.0	.0	3350.0	.0	.0	276.6	.0	.0	.0	2486.40
.00	.00	12.11	.00	.000	.025	.000	.000	2468.90	34.00
.005855	0.	0.	0.	0	16	0	.00	61.45	95.45

*SECNO 2.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

2.000	7.23	2479.03	2479.03	.00	2481.33	2.30	1.46	.01	2487.40
3350.0	.0	3350.0	.0	.0	275.3	.0	1.6	.3	2487.60
.01	.00	12.17	.00	.000	.025	.000	.000	2471.80	25.76
.005802	250.	250.	250.	20	5	0	.00	60.19	85.96

CCHV= .100 CEHV= .300
*SECNO 3.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3.000	6.60	2481.80	2481.80	.00	2484.47	2.67	1.70	.11	2487.78
3350.0	.0	3350.0	.0	.0	255.3	.0	3.4	.7	2491.31
.01	.00	13.12	.00	.000	.024	.000	.000	2475.20	12.88
.005528	300.	300.	300.	20	11	0	.00	48.46	61.34

*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.61

4.000	8.56	2484.23	.00	.00	2485.58	1.35	.97	.13	2487.95
3350.0	.0	3350.0	.0	.0	358.7	.0	5.5	1.1	2491.51
.02	.00	9.34	.00	.000	.024	.000	.000	2475.67	8.22
.002134	300.	300.	300.	4	0	0	.00	54.97	63.20

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 5.000

5.000	8.20	2484.84	.00	.00	2486.29	1.45	.68	.03	2488.11
3350.0	.0	3350.0	.0	.0	346.3	.0	8.0	1.5	2491.59
.03	.00	9.67	.00	.000	.024	.000	.000	2476.64	7.74
.002406	300.	300.	300.	3	0	0	.00	55.61	63.35

*SECNO 6.000

6.000	8.22	2485.66	.00	.00	2487.00	1.33	.69	.01	2487.47
3350.0	.0	3350.0	.0	.0	361.6	.0	10.4	1.9	2492.20
.04	.00	9.26	.00	.000	.024	.000	.000	2477.44	4.88
.002225	300.	300.	300.	2	0	0	.00	59.06	63.95

*SECNO 7.000

7.000	8.18	2486.34	.00	.00	2487.66	1.33	.67	.00	2487.99
3350.0	.0	3350.0	.0	.0	362.5	.0	12.9	2.3	2492.03
.05	.00	9.24	.00	.000	.024	.000	.000	2478.16	4.55
.002231	300.	300.	300.	2	0	0	.00	59.75	64.30

*SECNO 8.000

8.000	8.40	2487.10	.00	.00	2488.31	1.21	.63	.01	2488.28
3350.0	.0	3350.0	.0	.0	379.5	.0	15.4	2.7	2492.55
.06	.00	8.83	.00	.000	.024	.000	.000	2478.70	3.34
.001984	300.	300.	300.	2	0	0	.00	61.47	64.81

CCHV= .100 CEHV= .300

*SECNO 9.000

9.000	8.25	2487.65	.00	.00	2488.82	1.17	.51	.00	2488.00
3350.0	.0	3350.0	.0	.0	385.3	.0	17.9	3.1	2489.00
.07	.00	8.70	.00	.000	.022	.000	.000	2479.40	1.15
.001673	280.	280.	280.	2	0	0	.00	64.44	65.59

*SECNO 10.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.40

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST
10.000	1.97	2489.97	.00	.00	2490.05	.08	1.12	.11	2493.10
3350.0	.0	1191.2	2158.8	.0	651.1	855.3	37.9	18.0	2488.90
.18	.00	1.83	2.52	.000	.022	.022	.000	2488.00	.95
.000853	1450.	1085.	720.	6	0	0	.00	1338.35	1339.30

TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	2	2487.645	2489.970	9.000	10.000

THIS RUN EXECUTED 03OCT94 15:34:10

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

South Channel

SUMMARY PRINTOUT

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
*	1.000	3250.00	.00	3250.00	.00	2475.93	2475.93	2478.18	7.03	34.36	60.73	95.09	.00
*	1.000	3300.00	.00	3300.00	.00	2475.99	2475.99	2478.25	7.09	34.18	61.10	95.27	.07
*	1.000	3350.00	.00	3350.00	.00	2476.04	2476.04	2478.32	7.14	34.00	61.45	95.45	.14
*	2.000	3250.00	.00	3250.00	.00	2478.92	2478.92	2481.19	7.12	26.09	59.54	85.63	.00
*	2.000	3300.00	.00	3300.00	.00	2478.97	2478.97	2481.26	7.17	25.93	59.87	85.79	.07
*	2.000	3350.00	.00	3350.00	.00	2479.03	2479.03	2481.33	7.23	25.76	60.19	85.96	.14
*	3.000	3250.00	.00	3250.00	.00	2481.68	2481.68	2484.32	6.48	13.13	48.11	61.24	.00
*	3.000	3300.00	.00	3300.00	.00	2481.74	2481.74	2484.40	6.54	13.00	48.29	61.29	.08
*	3.000	3350.00	.00	3350.00	.00	2481.80	2481.80	2484.47	6.60	12.88	48.46	61.34	.16
*	4.000	3250.00	.00	3250.00	.00	2484.09	.00	2485.42	8.42	8.52	54.56	63.08	.00
*	4.000	3300.00	.00	3300.00	.00	2484.16	.00	2485.50	8.49	8.37	54.76	63.14	.08
*	4.000	3350.00	.00	3350.00	.00	2484.23	.00	2485.58	8.56	8.22	54.97	63.20	.16
	5.000	3250.00	.00	3250.00	.00	2484.70	.00	2486.13	8.06	8.06	55.17	63.23	.00
	5.000	3300.00	.00	3300.00	.00	2484.77	.00	2486.21	8.13	7.90	55.39	63.29	.08
	5.000	3350.00	.00	3350.00	.00	2484.84	.00	2486.29	8.20	7.74	55.61	63.35	.16
	6.000	3250.00	.00	3250.00	.00	2485.52	.00	2486.84	8.08	5.27	58.55	63.81	.00
	6.000	3300.00	.00	3300.00	.00	2485.59	.00	2486.92	8.15	5.07	58.81	63.88	.08
	6.000	3350.00	.00	3350.00	.00	2485.66	.00	2487.00	8.22	4.88	59.06	63.95	.16
	7.000	3250.00	.00	3250.00	.00	2486.20	.00	2487.51	8.04	4.93	59.24	64.17	.00
	7.000	3300.00	.00	3300.00	.00	2486.27	.00	2487.59	8.11	4.74	59.50	64.24	.08
	7.000	3350.00	.00	3350.00	.00	2486.34	.00	2487.66	8.18	4.55	59.75	64.30	.16
	8.000	3250.00	.00	3250.00	.00	2486.96	.00	2488.15	8.26	3.73	60.94	64.67	.00
	8.000	3300.00	.00	3300.00	.00	2487.03	.00	2488.23	8.33	3.53	61.21	64.74	.08
	8.000	3350.00	.00	3350.00	.00	2487.10	.00	2488.31	8.40	3.34	61.47	64.81	.16

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
	9.000	3250.00	.00	3250.00	.00	2487.51	.00	2488.66	8.11	1.60	63.85	65.45	.00
	9.000	3300.00	.00	3300.00	.00	2487.58	.00	2488.74	8.18	1.38	64.13	65.52	.08
	9.000	3350.00	.00	3350.00	.00	2487.65	.00	2488.82	8.25	1.15	64.44	65.59	.15
	10.000	3250.00	.00	1116.35	2133.65	2489.90	.00	2489.99	1.90	.97	1335.27	1336.24	.00
	10.000	3300.00	.00	1153.94	2146.06	2489.93	.00	2490.02	1.93	.96	1336.80	1337.76	.03
*	10.000	3350.00	.00	1191.23	2158.77	2489.97	.00	2490.05	1.97	.95	1338.35	1339.30	.06

South Channel

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	1.000	.00	.00	.00	2468.90	3250.00	2475.93	2475.93	2478.18	58.99	12.05	269.69	423.15
*	1.000	.00	.00	.00	2468.90	3300.00	2475.99	2475.99	2478.25	58.73	12.08	273.20	430.61
*	1.000	.00	.00	.00	2468.90	3350.00	2476.04	2476.04	2478.32	58.55	12.11	276.56	437.80
*	2.000	250.00	.00	.00	2471.80	3250.00	2478.92	2478.92	2481.19	58.18	12.08	268.95	426.10
*	2.000	250.00	.00	.00	2471.80	3300.00	2478.97	2478.97	2481.26	58.11	12.13	272.12	432.89
*	2.000	250.00	.00	.00	2471.80	3350.00	2479.03	2479.03	2481.33	58.02	12.17	275.32	439.82
*	3.000	300.00	.00	.00	2475.20	3250.00	2481.68	2481.68	2484.32	55.44	13.02	249.69	436.48
*	3.000	300.00	.00	.00	2475.20	3300.00	2481.74	2481.74	2484.40	55.32	13.07	252.58	443.69
*	3.000	300.00	.00	.00	2475.20	3350.00	2481.80	2481.80	2484.47	55.28	13.12	255.33	450.59
*	4.000	300.00	.00	.00	2475.67	3250.00	2484.09	.00	2485.42	21.30	9.25	351.27	704.21
*	4.000	300.00	.00	.00	2475.67	3300.00	2484.16	.00	2485.50	21.32	9.30	354.96	714.62
*	4.000	300.00	.00	.00	2475.67	3350.00	2484.23	.00	2485.58	21.34	9.34	358.69	725.14
	5.000	300.00	.00	.00	2476.64	3250.00	2484.70	.00	2486.13	24.10	9.59	338.72	662.05
	5.000	300.00	.00	.00	2476.64	3300.00	2484.77	.00	2486.21	24.08	9.63	342.52	672.46
	5.000	300.00	.00	.00	2476.64	3350.00	2484.84	.00	2486.29	24.06	9.67	346.34	682.99
	6.000	300.00	.00	.00	2477.44	3250.00	2485.52	.00	2486.84	22.34	9.20	353.35	687.60
	6.000	300.00	.00	.00	2477.44	3300.00	2485.59	.00	2486.92	22.30	9.23	357.49	698.87
	6.000	300.00	.00	.00	2477.44	3350.00	2485.66	.00	2487.00	22.25	9.26	361.63	710.19
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	7.000	300.00	.00	.00	2478.16	3300.00	2486.27	.00	2487.59	22.33	9.21	358.50	698.36
	7.000	300.00	.00	.00	2478.16	3350.00	2486.34	.00	2487.66	22.31	9.24	362.49	709.22
	8.000	300.00	.00	.00	2478.70	3250.00	2486.96	.00	2488.15	19.86	8.76	371.16	729.26
	8.000	300.00	.00	.00	2478.70	3300.00	2487.03	.00	2488.23	19.84	8.79	375.38	740.82
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	9.000	280.00	.00	.00	2479.40	3350.00	2487.65	.00	2488.82	16.73	8.70	385.26	819.11
	10.000	1085.00	.00	.00	2488.00	3250.00	2489.90	.00	2489.99	9.83	1.86	1413.02	1036.65
	10.000	1085.00	.00	.00	2488.00	3300.00	2489.93	.00	2490.02	9.15	1.84	1459.34	1090.75
*	10.000	1085.00	.00	.00	2488.00	3350.00	2489.97	.00	2490.05	8.53	1.83	1506.36	1146.82

South Channel

SUMMARY PRINTOUT TABLE 150

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*	1.000	3350.00	2476.04	.05	.00	4.04	61.45	.00
*	2.000	3250.00	2478.92	.00	2.99	.00	59.54	250.00
*	2.000	3300.00	2478.97	.05	2.99	.00	59.87	250.00
*	2.000	3350.00	2479.03	.05	2.99	.00	60.19	250.00
*	3.000	3250.00	2481.68	.00	2.76	.00	48.11	300.00
*	3.000	3300.00	2481.74	.06	2.77	.00	48.29	300.00
*	3.000	3350.00	2481.80	.06	2.77	.00	48.46	300.00
*	4.000	3250.00	2484.09	.00	2.41	.00	54.56	300.00
*	4.000	3300.00	2484.16	.07	2.41	.00	54.76	300.00
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	5.000	3250.00	2484.70	.00	.61	.00	55.17	300.00
	5.000	3300.00	2484.77	.07	.61	.00	55.39	300.00
	5.000	3350.00	2484.84	.07	.61	.00	55.61	300.00
	6.000	3250.00	2485.52	.00	.82	.00	58.55	300.00
	6.000	3300.00	2485.59	.07	.82	.00	58.81	300.00
	6.000	3350.00	2485.66	.07	.83	.00	59.06	300.00
	7.000	3250.00	2486.20	.00	.68	.00	59.24	300.00
	7.000	3300.00	2486.27	.07	.68	.00	59.50	300.00
	7.000	3350.00	2486.34	.07	.68	.00	59.75	300.00
	8.000	3250.00	2486.96	.00	.76	.00	60.94	300.00
	8.000	3300.00	2487.03	.07	.76	.00	61.21	300.00
	8.000	3350.00	2487.10	.07	.76	.00	61.47	300.00
	9.000	3250.00	2487.51	.00	.55	.00	63.85	280.00
	9.000	3300.00	2487.58	.07	.55	.00	64.13	280.00
	9.000	3350.00	2487.65	.07	.55	.00	64.44	280.00
	10.000	3250.00	2489.90	.00	2.39	.00	1335.27	1085.00
	10.000	3300.00	2489.93	.03	2.36	.00	1336.80	1085.00
*	10.000	3350.00	2489.97	.04	2.32	.00	1338.35	1085.00

SUMMARY OF ERRORS AND SPECIAL NOTES

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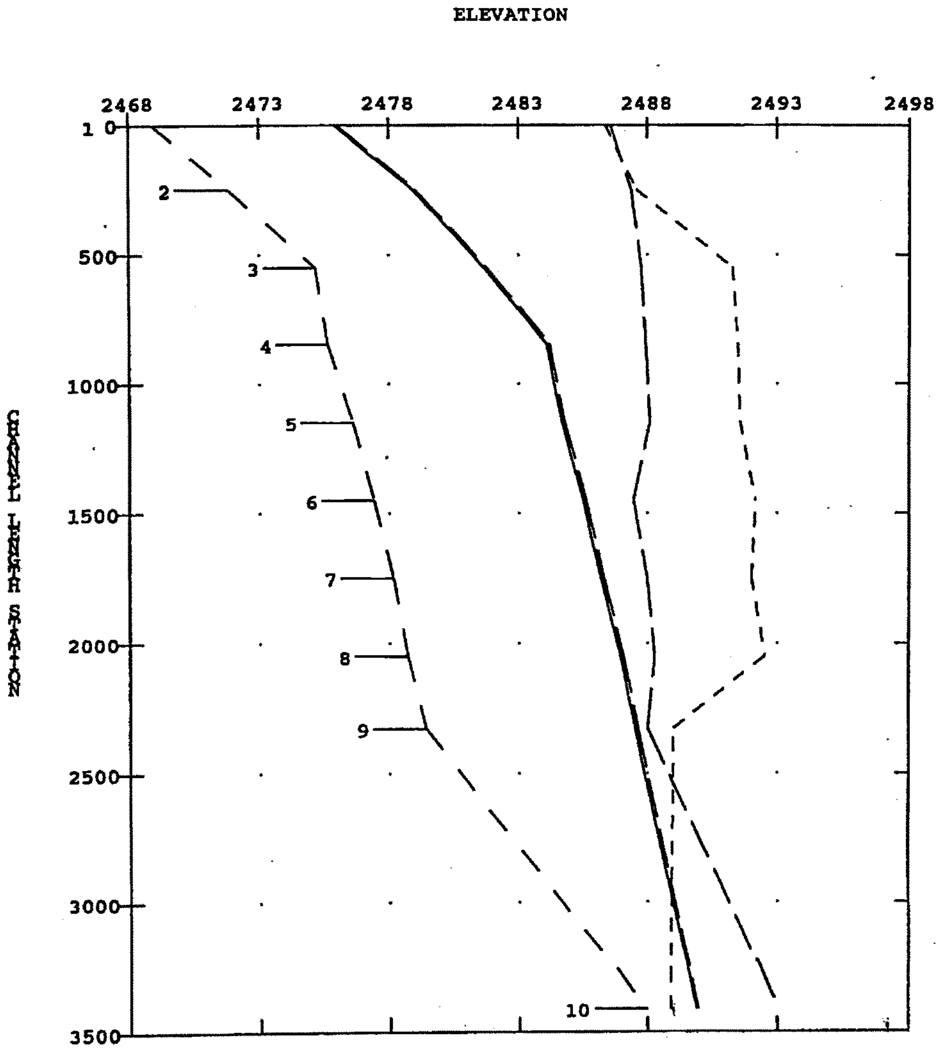
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2478
2483
2488
2493
2498
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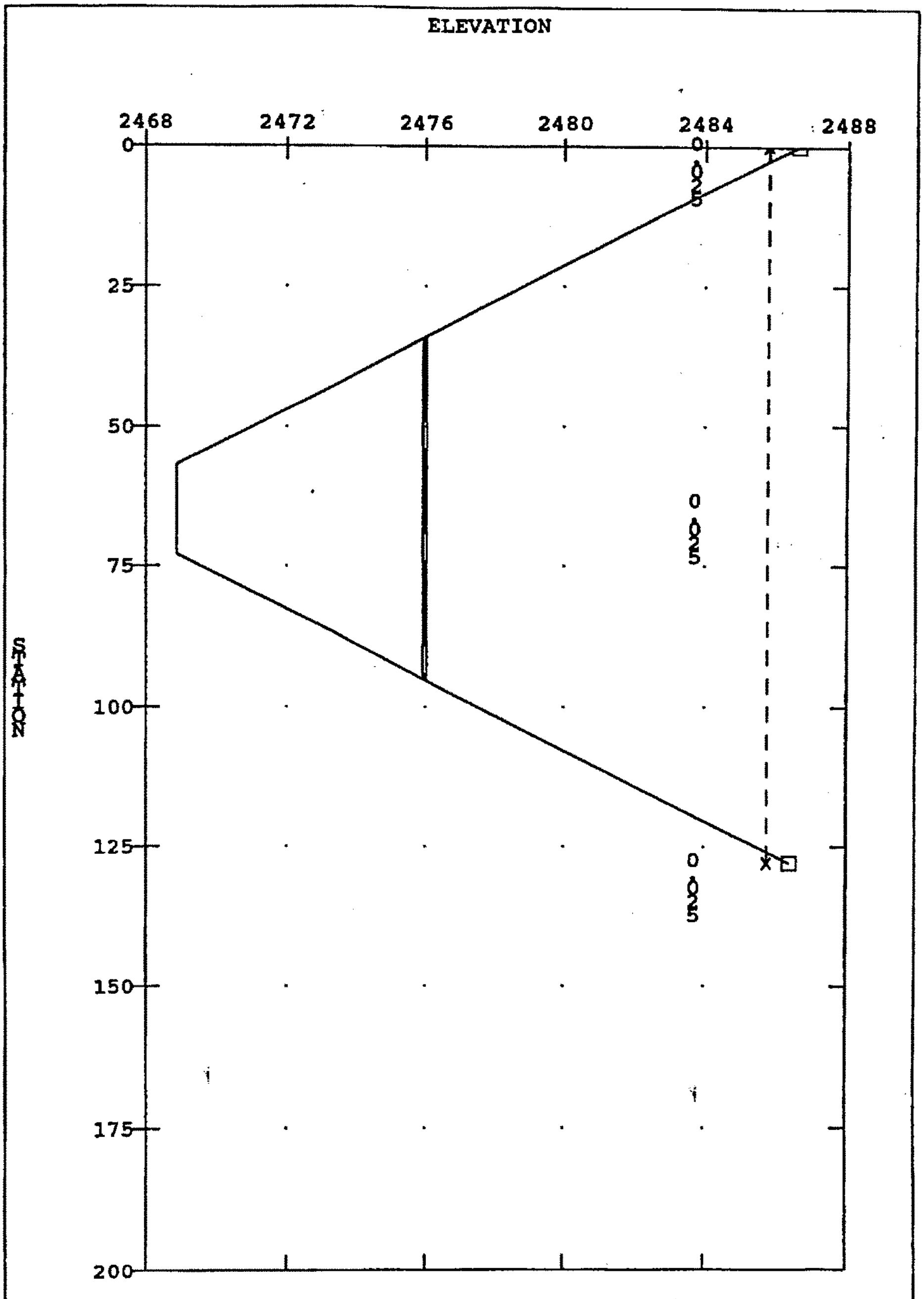

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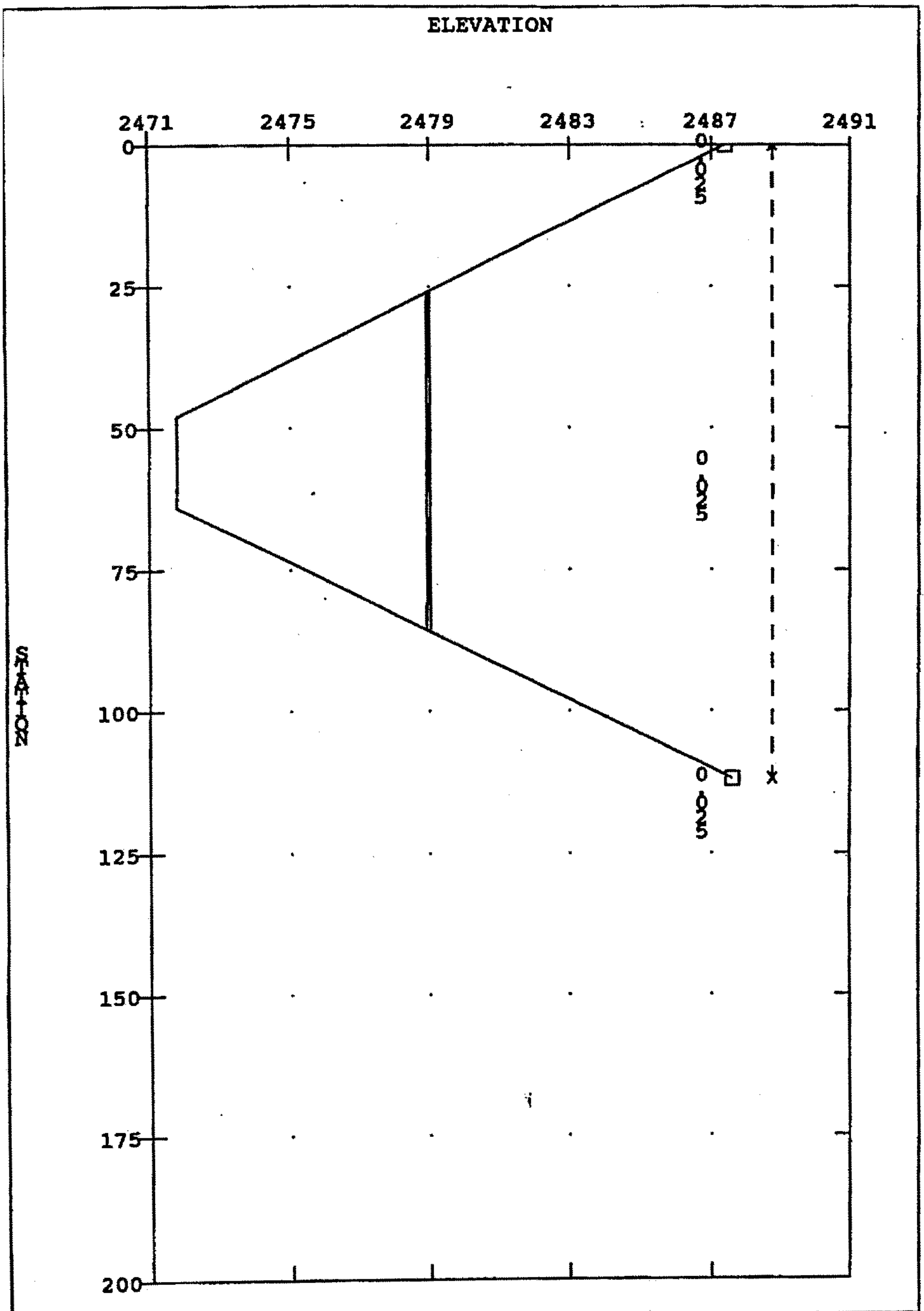
South Channel



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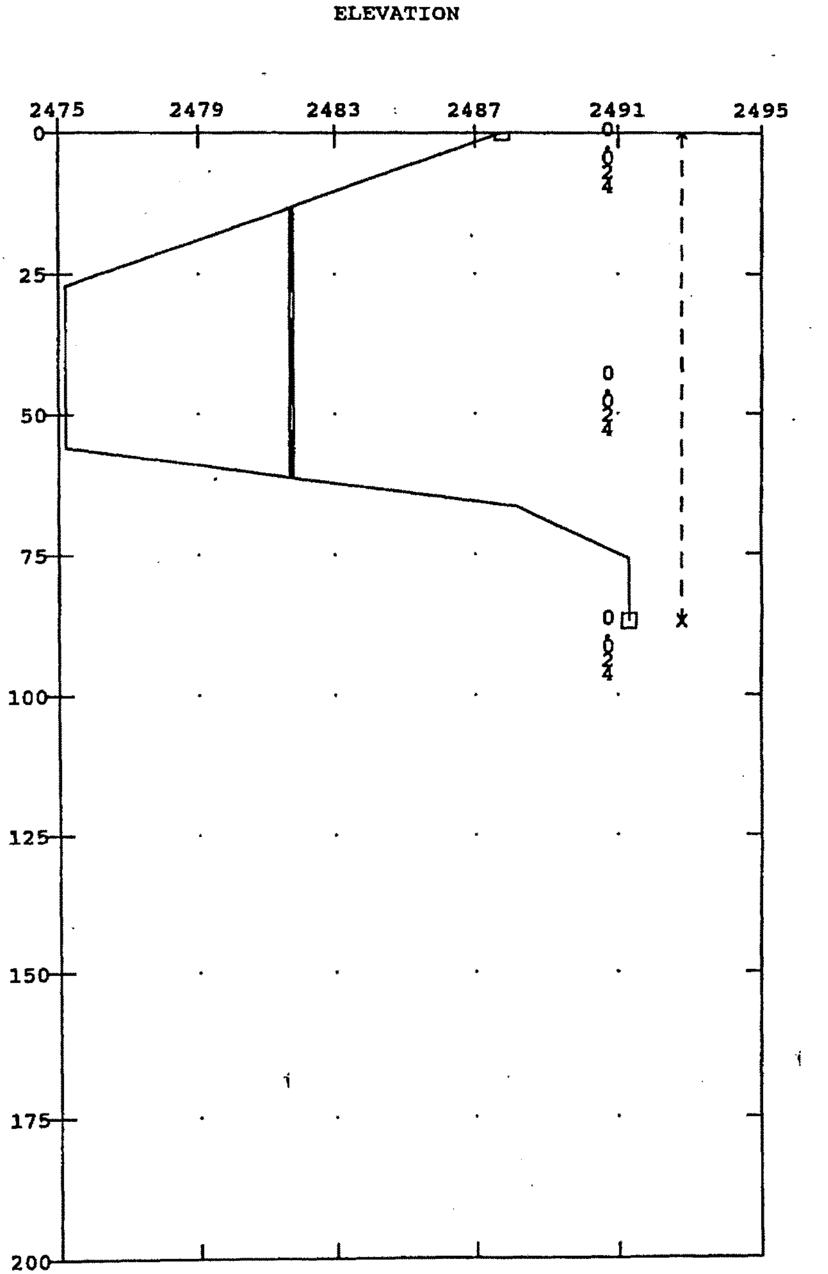

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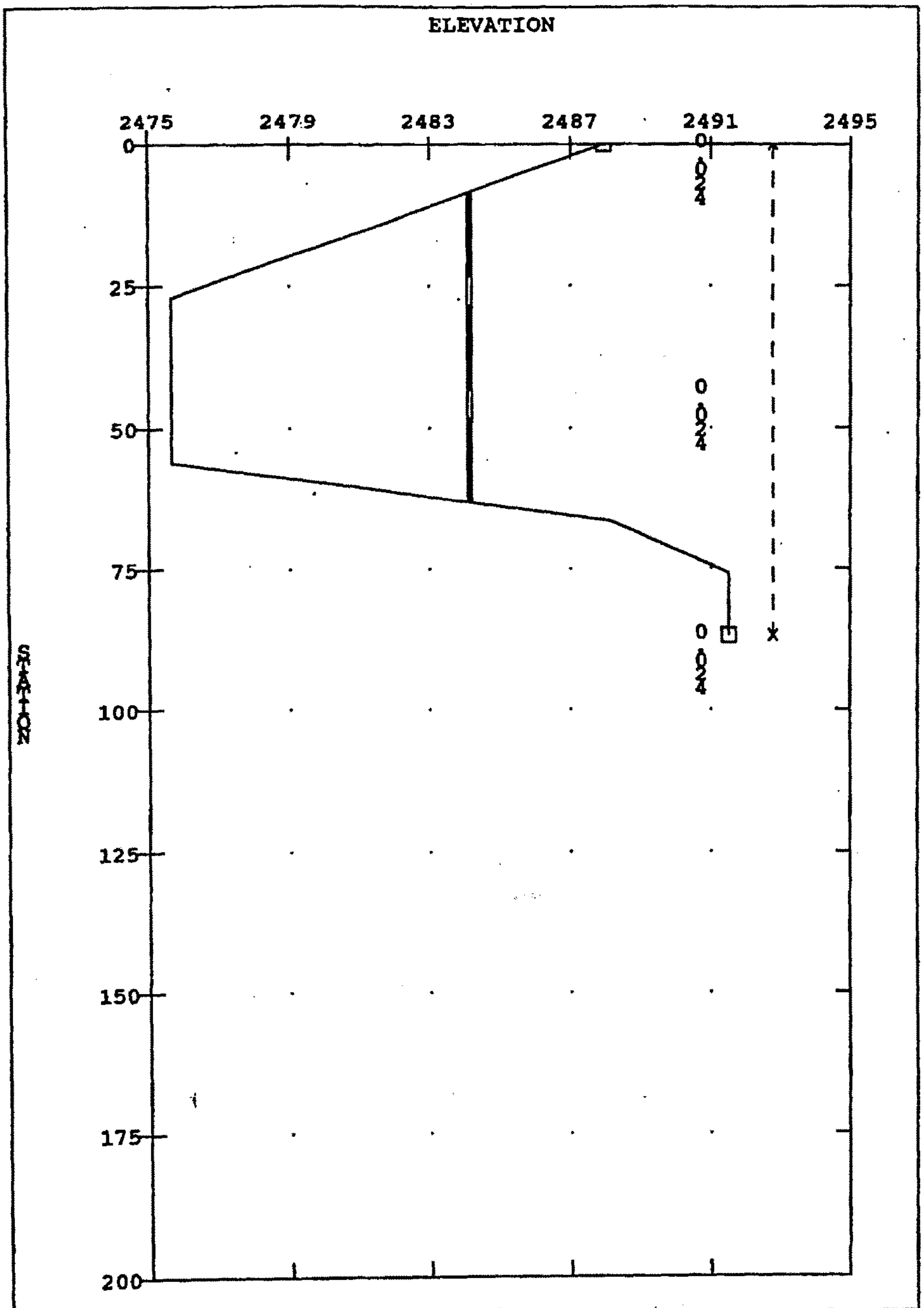

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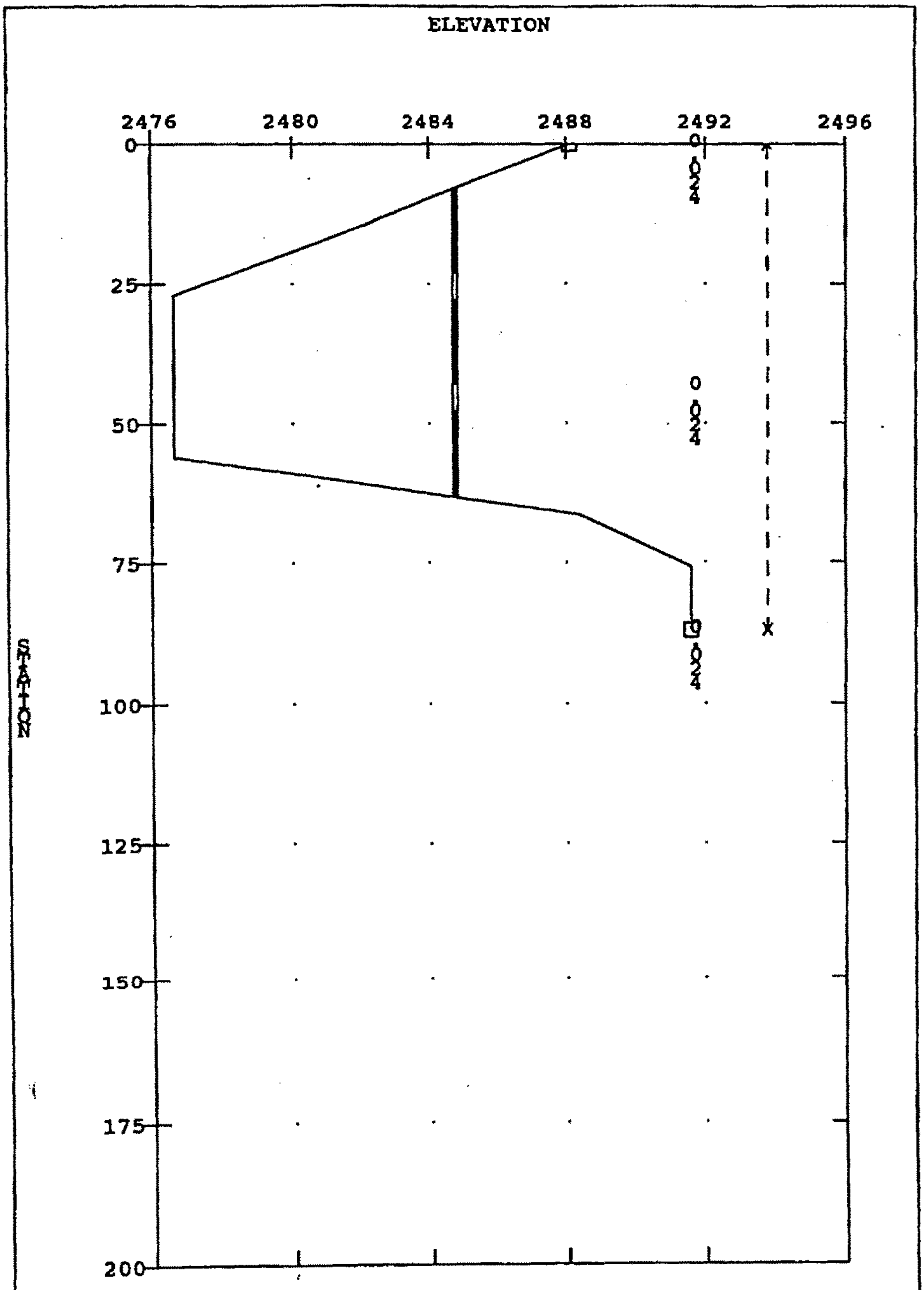

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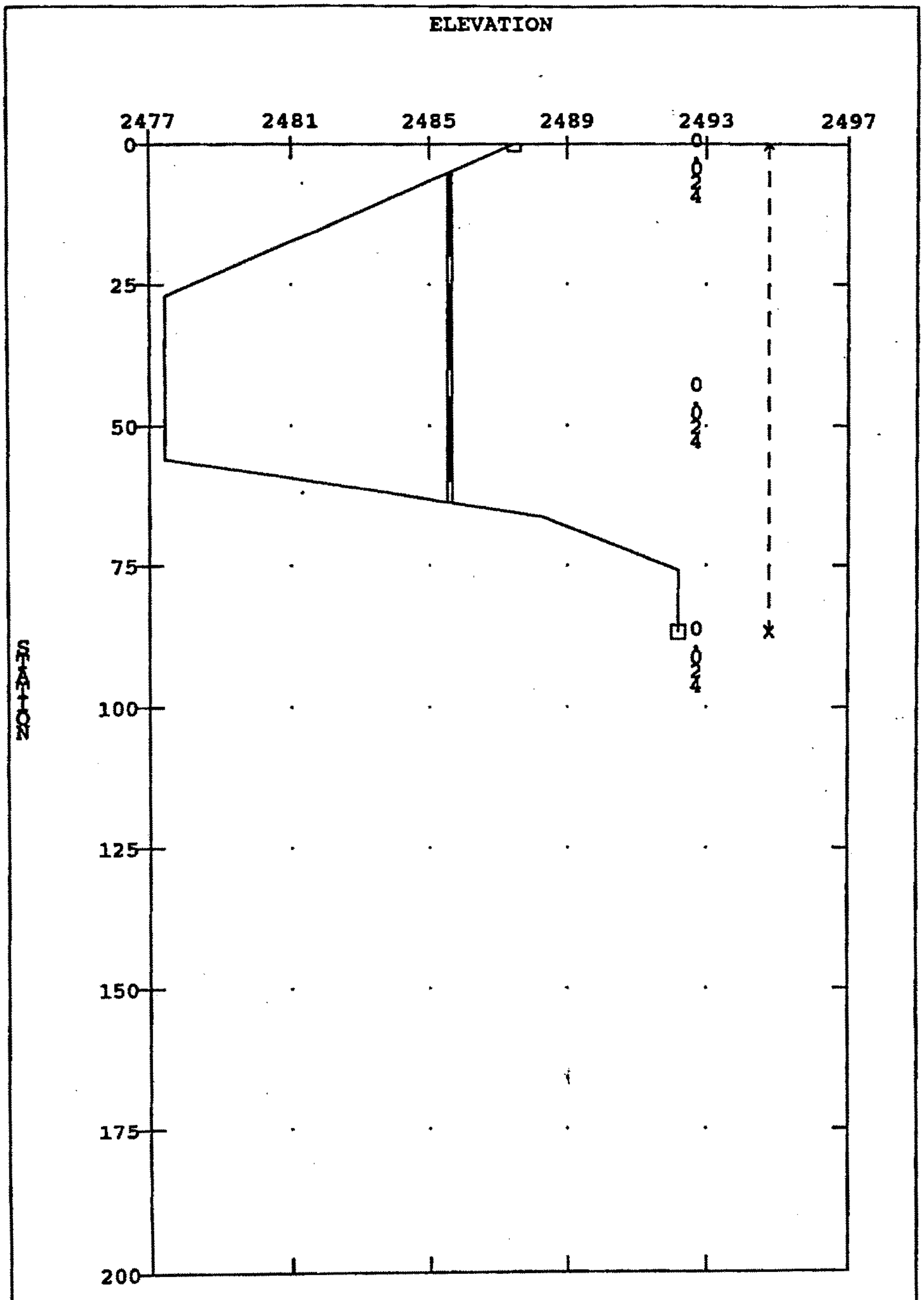

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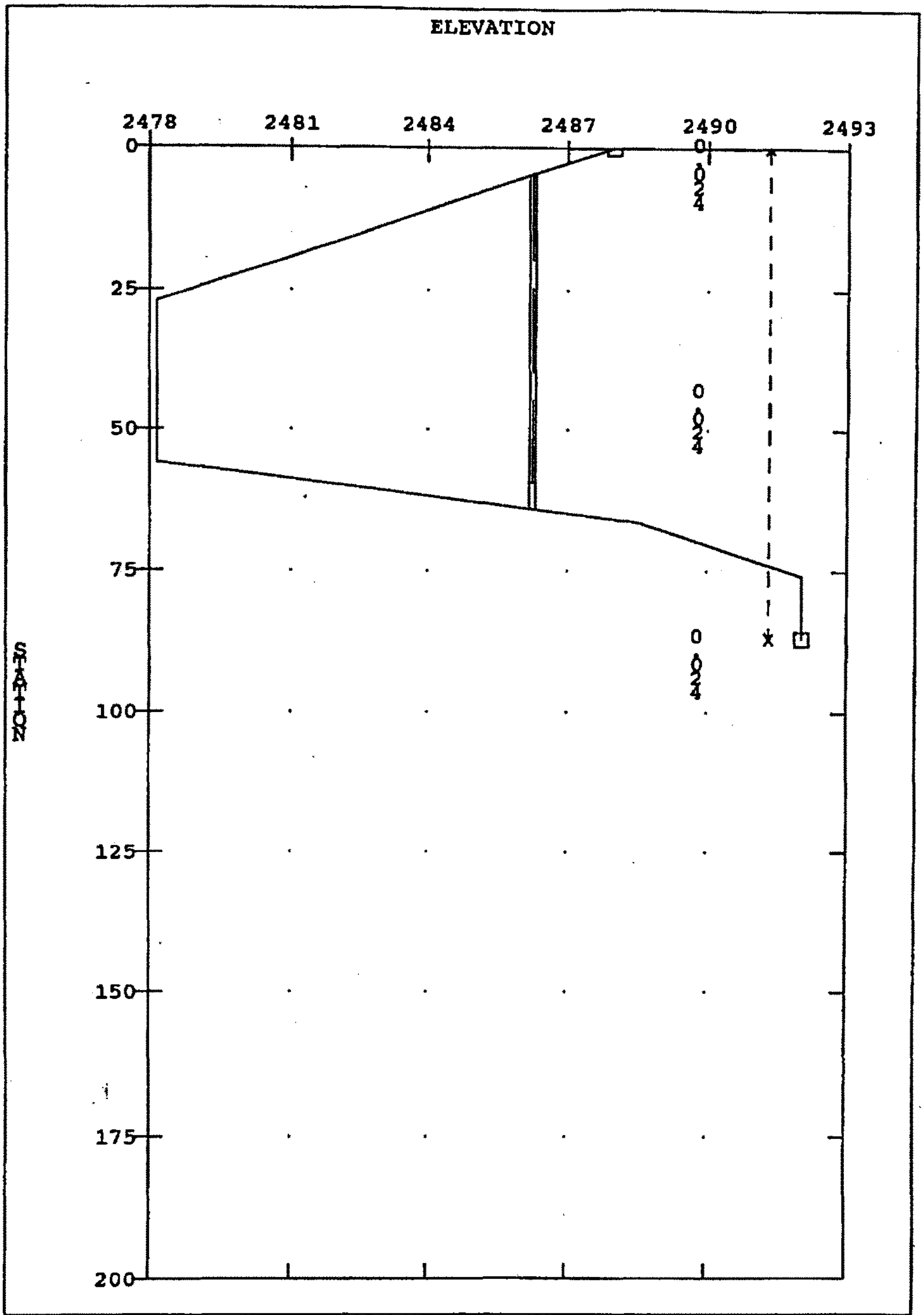

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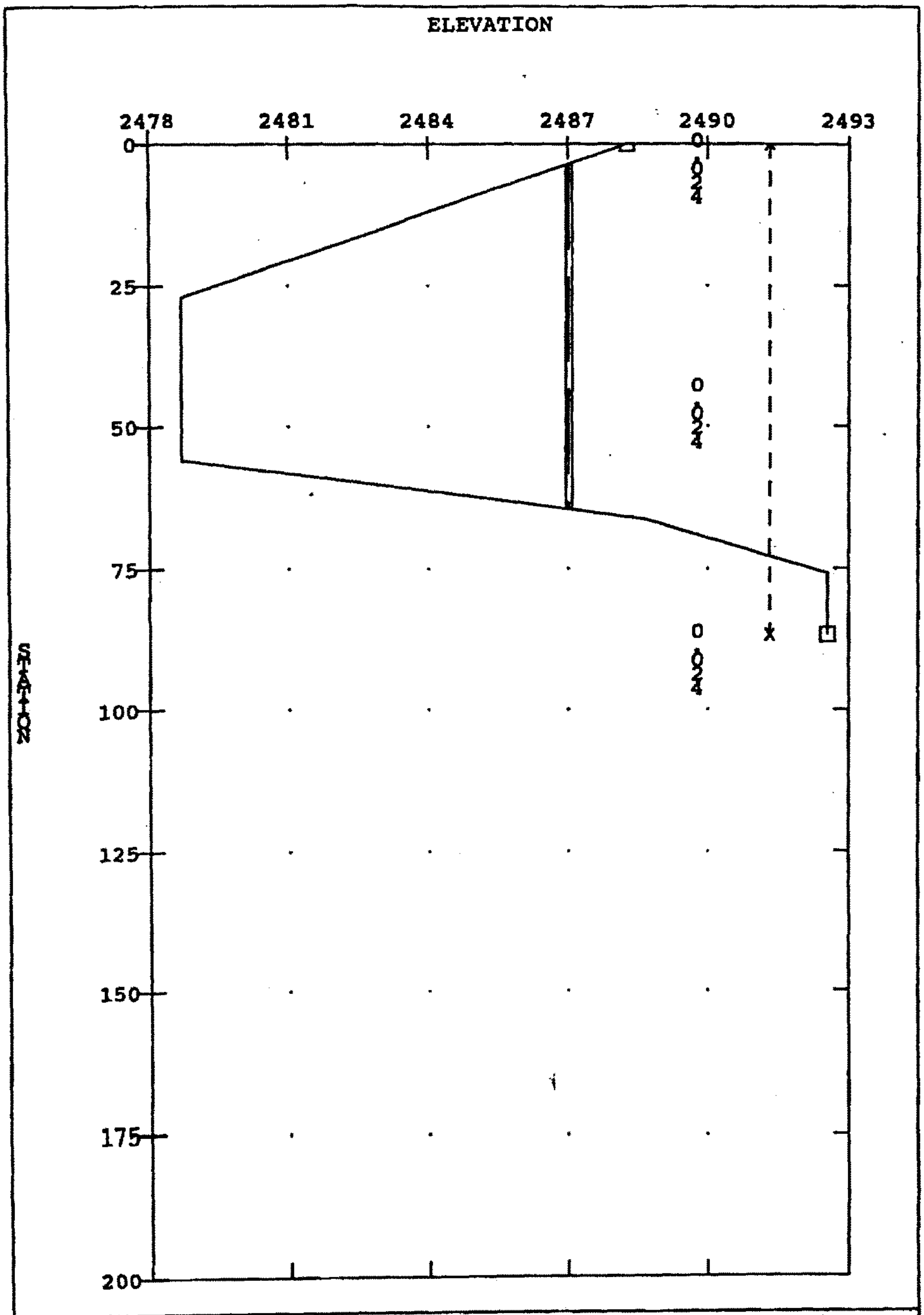

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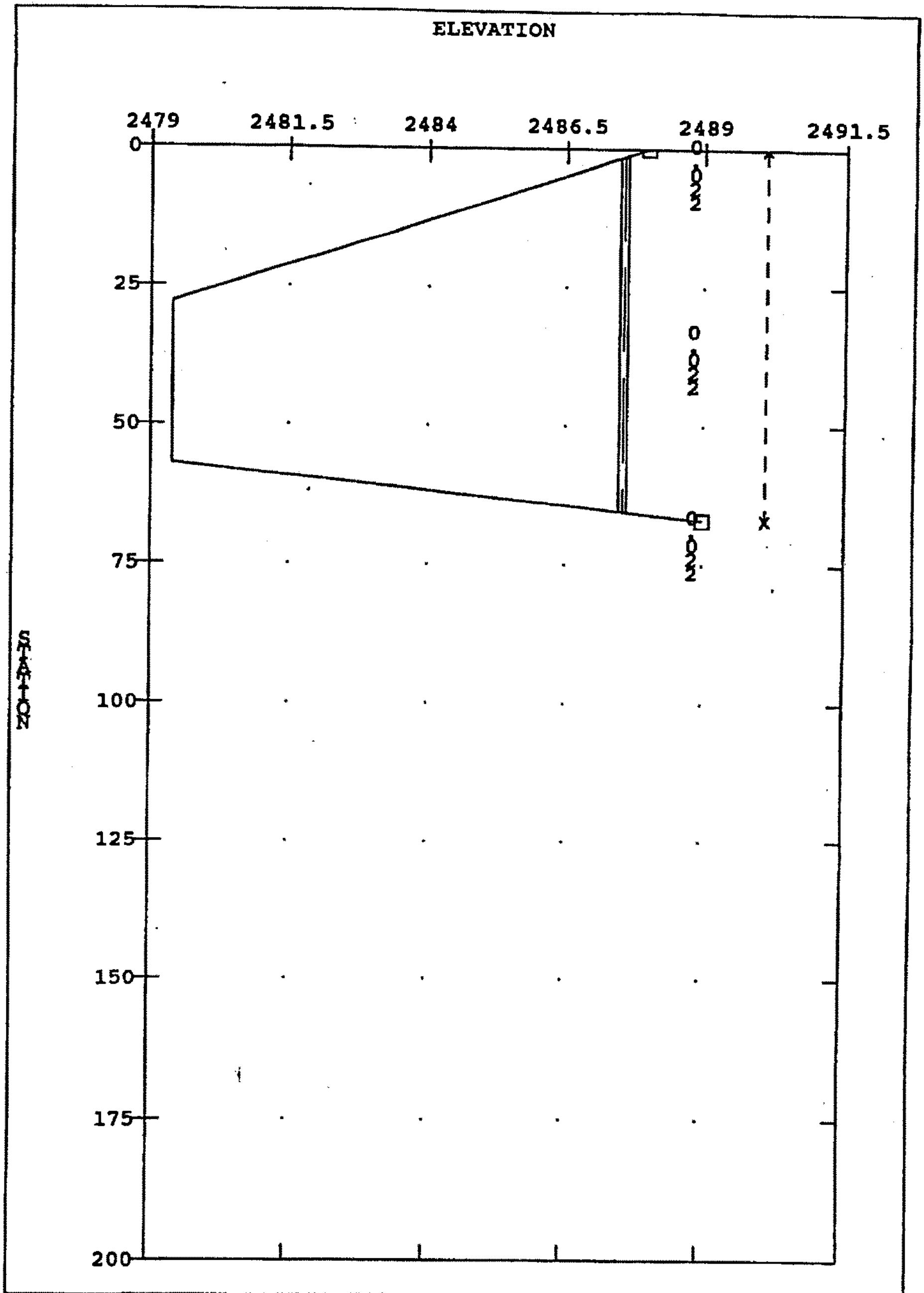
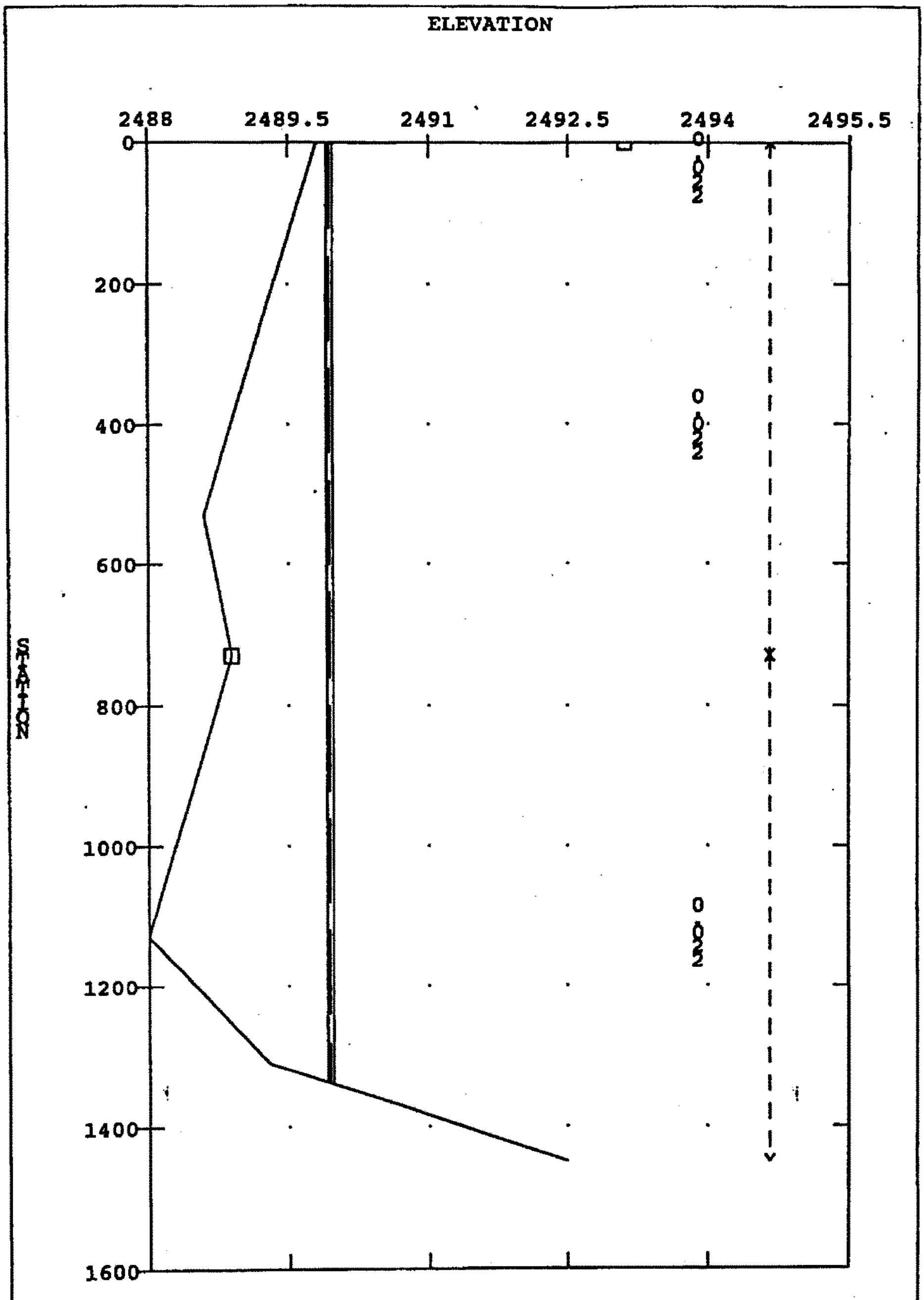
South Channel



SECTION : 9

South Channel



SECTION : 10

South Channel

Appendix 4

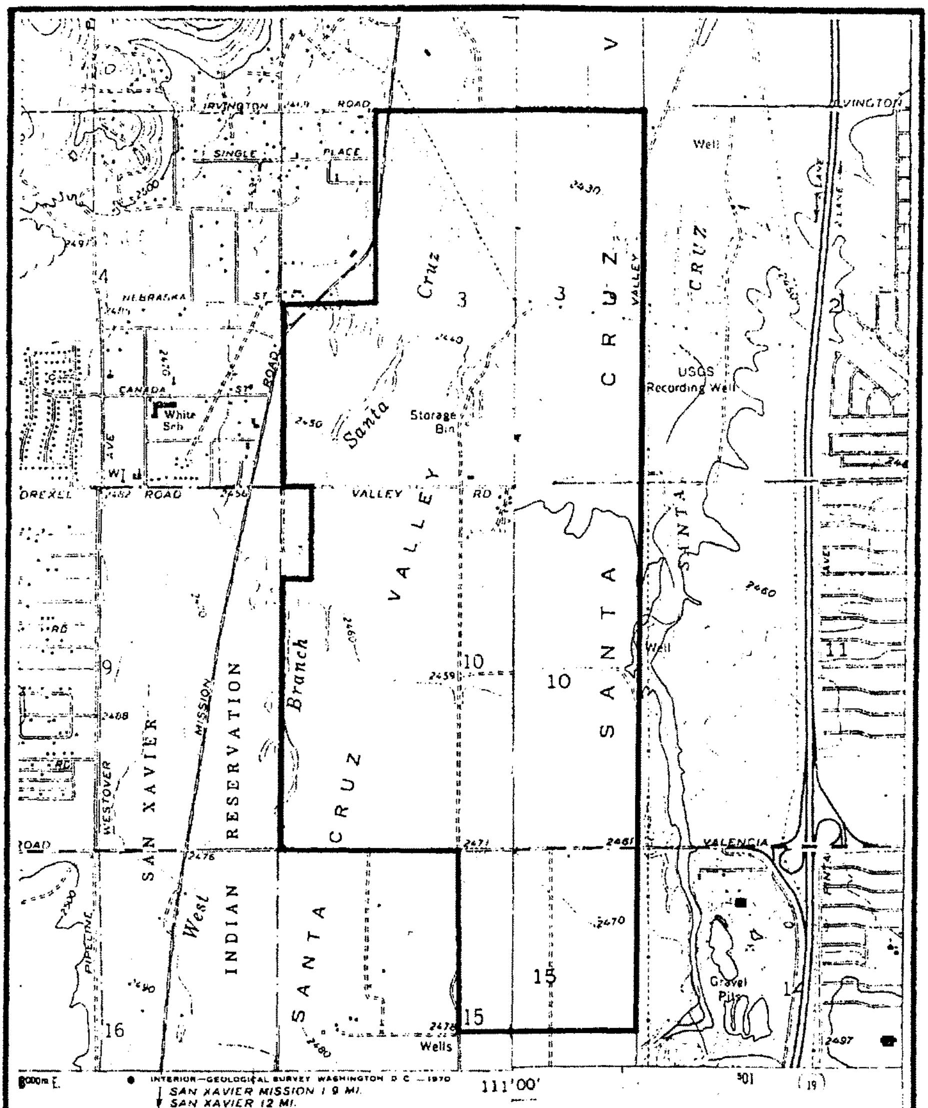
Midvale Park Master Drainage Report: study boundaries, West Branch Channel typical cross sections

Dooley-Jones & Associates, Inc.

CONSULTING ENGINEERS / PLANNERS

MIDVALE PARK
MASTER DRAINAGE REPORT

... EAST TOOLE AVENUE • P.O. BOX 1830, TUCSON, ARIZONA 85702 • (602) 624-2391



MIDVALE PARK

SCALE: 1" - 2000'

LOCATION PLAN

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX C

GROUNDWATER AND WATER BUDGET

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
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APPENDIX C

GROUNDWATER AND WATER BUDGET

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

**US Army Corps
of Engineers**
Los Angeles District

Paseo de las Iglesias Environmental Restoration Study
Tucson, Arizona

Groundwater and Water Budget Analysis
(Future With Project Conditions)

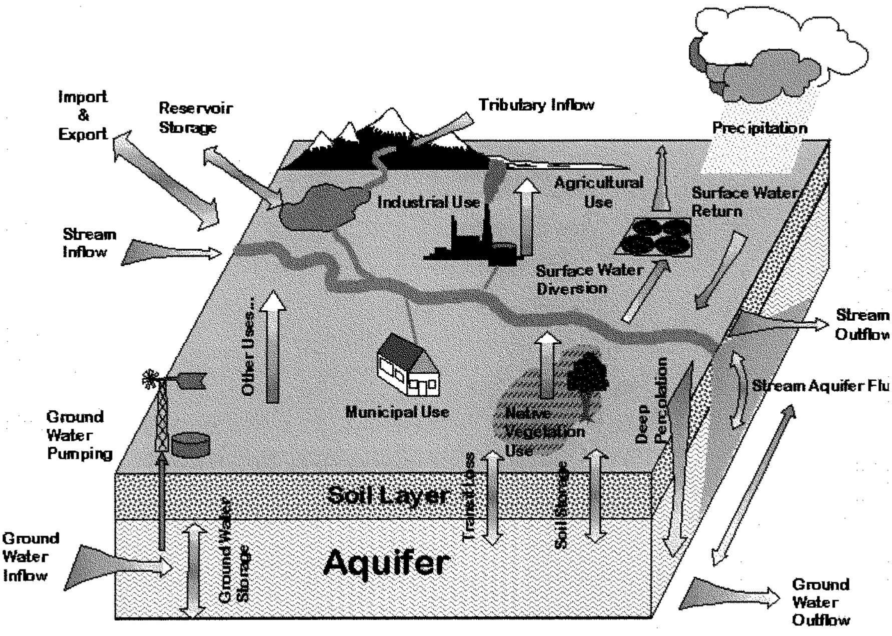

Illustration courtesy of: Colorado Division of Water Resources, Office of the State Engineer

July 2005

**LOS ANGELES DISTRICT, CORPS OF ENGINEERS
HYDROLOGY AND HYDRAULICS SECTION**

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Appendix B Groundwater Quality Data (Seven Wells)

Appendix C Tributaries Analysis

Appendix D Terminology of Monthly Statistics

1.0 INTRODUCTION

1.1 Purpose and Scope

The Feasibility Study and Environmental Impact Statement for Paseo de las Iglesias, Tucson, Arizona is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the Pima County Flood Control District. The purposes of this report are to present water resources with project conditions and to analyze a water budget in support of feasibility study for Santa Cruz River Environmental Restoration Project in the City of Tucson and Pima County, Arizona.

Specific objectives of this report are:

1. Collection and analyses of existing groundwater data including groundwater elevations, aquifer characteristics, and review of previous studies for Santa Cruz River basin.

2. Collection of water quality data under existing conditions.

3. Water budget analysis under future with project conditions, including mass balance calculations based on inflow (infiltration and reclaimed water/effluent), outflow (pumping at well exempt and non-exempt well locations), and plant consumptions (evapotranspiration).

4. Water budget for the proposed alternative plans.

Brief discussions on the hydrogeologic setting, geology, and aquifer characteristics based on previous studies for Santa Cruz River basin were also included in the report.

1.2 Project Area

The Paseo de las Iglesias study area consists of a 7-mile reach of the Santa Cruz River and its tributary washes beginning where Congress Street crosses the river in downtown Tucson and extending upstream to the south along the river to the boundary of the San Xavier District of the Tohono O'Odham Nation (**Figure 1-1**).

The study area was defined in coordination with the Pima County Flood Control District and the City of Tucson. The area comprises approximately 5,005 acres of urban and suburban Tucson. The main channel of the Santa Cruz River flows in a relatively straight northerly direction from the southern to the northern borders of the study area. The West Branch of the Santa Cruz River currently extends from the southern border of the study area north approximately 3.5 miles to where it flows into the mainstem Santa Cruz River just north of Irvington Road. The portion of this channel just north of Irvington Road has been re-routed. The former channel (before it was re-routed) extends from just north of Irvington to just south of 22nd Street where it joins the main branch of the Santa Cruz River. The climate in the Santa Cruz River Basin is desert in character with short, dry winters and long, hot summers. High diurnal temperature variations are characteristic of the region due to the low humidity and general lack of cloud cover. Precipitation occurs in two distinct seasons of the year: summer and winter, and primarily occurs in the form of rainfall. Summer runs from June into October. Winter runs from December through February. The primary precipitation falls during the summer months as a result of thunderstorms caused by moist air flowing from the Gulf of Mexico.

The alluvial deposits in the study area consist mainly of recent stream channels and floodplain deposits. These alluvial basin sediments are generally gravel and gravelly sand. Locally, the sediments in the study area are sand to sandy silt of fluvial origin. Lithified sediments do not crop out along the Santa Cruz River and generally they should not be present within excavation depths of the channel for structure installation, though such formations do approach the riverbed elevation in the vicinity of 22nd Street.

1.3 Expected Future Without-Project Conditions

The assessment of existing conditions within the study area is described in detail in this report. The future without-project conditions include the base year, 2012, the earliest year that the project could be in operation; and year 2062, 50 years after the project operation begins. Assuming that the present regional trend in decline of groundwater table elevations will continue, availability of groundwater for riparian use is likely to decrease in the future as depths to the water table increase and water is allocated to municipal or other uses within the study area and vicinity. Availability of reclaimed water and secondary effluent are also likely to decrease in the future as water is allocated for other uses. Such changes in availability of groundwater, secondary effluent, or reclaimed water will be minimal at the base year (2012) but are likely to be significant by 2062. Availability of surface water in future (2012 or 2062) from the Santa Cruz River and tributaries, however, is likely to remain the same as in current conditions.

1.4 Summary

The potential water sources including groundwater, Santa Cruz River and its tributaries water, and wastewater treatment plant effluents (both secondary effluent and reclaimed water) were evaluated based on the quality, quantity, and seasonality of flow. The analysis of water sources shows that the wastewater treatment plant effluent is a reliable water source to the project. The Santa Cruz River and its tributaries water, and groundwater can serve as supplemental water sources.

Also, preliminary water demand estimates were calculated for each of the alternatives based on a 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

Water Supply Sources	Water Sources (acre-feet/yr)	Water Sources (mgd)
Reclaimed Water[1]	~64,000	~57.1
Surface Water[1]	~17,681	~15.78
Secondary Effluent[1]	~1,343 – 3,577 [2]	~1.2 – 3.2 [2]
Water Demands for Alternatives	**Water Demand (acre-feet/yr)**	**Water Demand (mgd)**
NMX	562.52	0.50
NMM	1889.12	1.69
XXX	252.73	0.23
MXN	55.11	0.05
MXX	261.73	0.23
MMN	474.71	0.42
MMX	681.33	0.61
MMM	1924.53	1.72
HNN	7394.19	6.60
HXN	7280.55	6.50
HXX	7296.35	6.51
HHN	7842.77	7.00
HHX	7963.37	7.11
HHM	8977.77	8.01

1- These water supply sources and volumes are provided for information purposes only. This should not be construed as meaning these respective water volumes are available for restoration purposes. See Table 9-1 for additional information.

2- Effluent projections from Avra Valley WWFT: Source: Avra Valley Basin Study, Pima County Wastewater Management Department (July 2002)

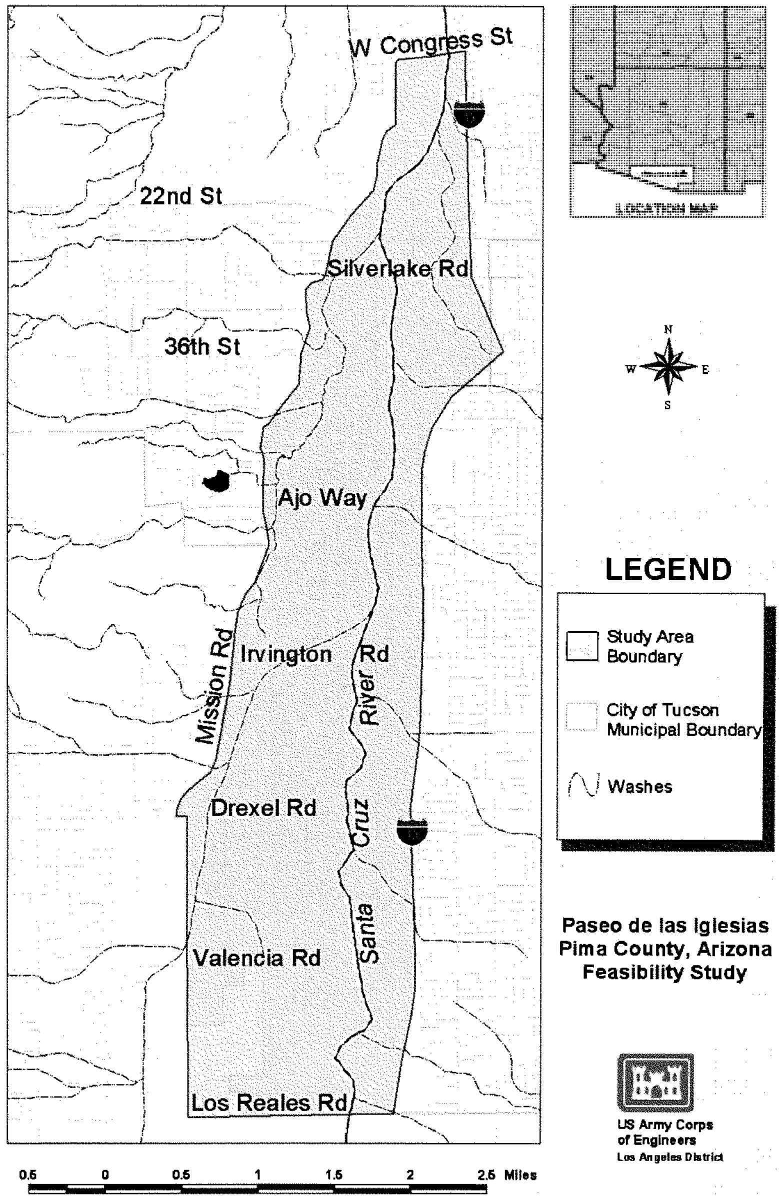


Figure 1-1 Location Map

2.0 HYDROGEOLOGIC CHARACTERISTICS

The complex geological history of Arizona has resulted in the formation of three geologic physiographical provinces. The three provinces consist of the Colorado Plateau (in the northern area of the state), the Basin and Range Province (encompassing southern and western Arizona), and the Central Highlands or Transitional Zone (encompassing the central part of the state). The Santa Cruz River Watershed lies within the Sonoran Desert of the Basin and Range Physiographic Province. The north to northwest trending alluvial basin is characterized by a semi-arid to arid broad valley.

The Santa Cruz River Basin is paralleled by steep mountain ranges composed of igneous, metamorphic, and sedimentary rocks of Precambrian (over 600 million years old) to Tertiary (63 to 2 million years ago) age (Anderson 1987). The mountains lie upon a Precambrian igneous and metamorphic basement complex that is composed predominantly of granite and diorite, schist and gneiss, and volcanic.

The alluvial sediments deposited within the basin have been divided into four geologic units that are, in descending order of depth: surficial or recent alluvial deposits, the Fort Lowell Formation, the Tinaja Beds, and the Pantano Formation (ADWR 1996). The extent of these layers in the study area is shown in **Table 2-1**. The surficial deposits occupy the streambed channels and are generally less than 100 feet thick. The coarse surficial deposits allow the infiltration of surface water to recharge the underlying units. The Fort Lowell Formation underlies the recent alluvial deposits and consists of unconsolidated to moderately consolidated sands and silts 300 to 400 feet thick throughout most of the basin (AMA 1998). The Tinaja Beds lie under the Fort Lowell Formation and are composed of sandstones and conglomerates with a total thickness of up to 5,000 feet at the center of the basin (AMA 1998). The Pantano Formation, which underlies the Tinaja Beds, is up to 6,400 feet thick near Davidson Canyon, which is about 20 miles southeast of Tucson along I-10. This formation consists of consolidated sandstones, conglomerates and mudstones. In addition to these sediments, as a result of intermittent periods of volcanism, there are areas of extrusive igneous rocks interbedded within the valley alluvium layers. Below the alluvial units and beds of volcanic rock, there is an impermeable basement complex, which extends to the surrounding mountainsides.

The main groundwater in the Tucson basin occurs in the sedimentary rocks and alluvium that form a single aquifer. The aquifer consists of the Pantano Formation, the Tinaja Beds, and the Fort Lowell Formation. The Pantano Formation yields small to moderate amounts of water to wells while the Tinaja beds yield small to large amounts of water to wells, frequently in excess of 1,000 gal/min. The water table for this main aquifer is within 350 ft. of the ground surface throughout most of the basin. Due to localized and/or perched water tables, the depth to groundwater ranges from less than 20 feet to about 170 feet below the ground surface along the Santa Cruz and Rillito Rivers.

Table 2-1 Stratigraphic Sediment Layers

Stratigraphic Sediment Layers (from Well Logs)	
At Marana	
Fort Lowell Formation and Recent Alluvium	73 m-thick (240 ft) layer
Upper Tinaja Beds	73 m-thick (240 ft) layer
Volcanic Bedrock	Top at -146m (-480 ft)
Near Grant Road Crossing	
Fort Lowell Formation and Recent Alluvium	24 m-thick (80 ft) layer
Upper Tinaja Beds	73 m-thick (240 ft) layer
Middle Tinaja Beds	49 m-thick (160 ft) layer
Volcanic Bedrock	Top at -146m (-480 ft)
1/2 Mile South of I-19/I-10 Interchange	
Fort Lowell Formation and Recent Alluvium	46 m-thick (150 ft) layer
Upper Tinaja Beds	46 m-thick (150 ft) layer
Volcanic Bedrock	Top at -91m (-300 ft)
1.5 Miles South of San Xavier Mission	
Fort Lowell Formation and Recent Alluvium	49 m-thick (160 ft) layer
Upper Tinaja Beds	37 m-thick (120 ft) layer
Lower Tinaja Beds	24 m, minimum (80 ft)
1.5 Miles North of Sahuarita/I-19 Interchange	
Fort Lowell Formation and Recent Alluvium	52 m-thick (170 ft) layer
Upper Tinaja Beds	43 m-thick (140 ft) layer
Lower Tinaja Beds	195 m, minimum (640 ft)
1 Mile North of Green Valley	
Fort Lowell Formation and Recent Alluvium	73 m-thick (240 ft) layer
Upper Tinaja Beds	37 m-thick (120 ft) layer
Lower Tinaja Beds	180 m, minimum (600 ft)
* logs adapted from Anderson 1987	

3.0 GROUNDWATER DATA INVENTORY

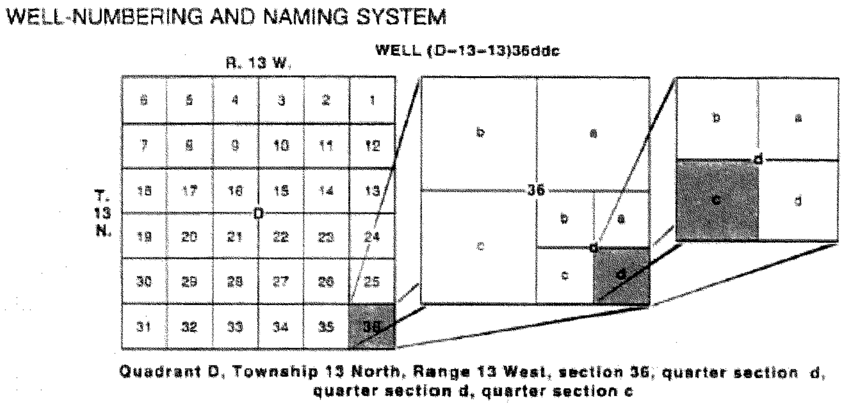
3.1 Well Inventory and Pumpage

Groundwater (perched) was encountered at depths ranging from about 5 to 35 feet at Congress St., Irvington Rd., and Valencia Road. No groundwater was encountered in the test borings for the 22nd St. Bridge where the borings were advanced to depths of 45 to 60 feet. Due to the perched and/or localized nature of the groundwater along the Santa Cruz channel, these groundwater conditions are expected to vary in relation to flows in the River, well pumping, subsurface stratification, and other factors.

Long-term groundwater withdrawal has resulted in a general decline in water levels in the Tucson area since the 1900's. This groundwater decline can be noted in the ADWR data for the depth to groundwater for the wells in this vicinity. Explanation of well numbering system used in Arizona is provided in **Figure 3-1**.

Large-scale pumping of groundwater in the Tucson basin began about 1900 and increased dramatically in the 1940's. Most of the groundwater pumped in 1940 was used for irrigation. Later, groundwater pumpage was approximately equally divided among irrigation, municipal, and industrial uses (Anderson et al. 1982). The centers of greatest water-level decline are along the Santa Cruz River near Sahuarita and in the City of Tucson. Declines exceeding 100 ft have occurred in Tucson and portions of the study area, while to the south along the river, the maximum decline has been about 150 ft (Schumann and Genualdi 1986). This difference has resulted in the formation of two distinct cones of depression in the groundwater table.

According to Arizona Department of Water Resources (ADWR), some exempt wells are associated with groundwater rights. Historic situations sometimes allow these small wells to be attached to groundwater rights, however, according to ADWR this is not currently allowed. If new wells are needed to pump groundwater, the Community could allow the wells to be drilled on their land. The wells should be located to produce minimal interference to existing wells. The well sitting would involve a hydrogeologic investigation, but state permits are not required. However, drilling new wells to pumped groundwater is not being considered as a viable water source for irrigation purposes, as this conflicts with ADWR policy.



The well numbers used by the U.S. Geological Survey in Arizona are in accordance with the Bureau of and Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the state into four quadrants and are designated by capital letters A, B, C, and D in a counterclockwise direction, beginning in the northeast quarter. The first digit of a well number indicates the township, second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d after the section number indicates the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northwest quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (D-13-13) 36ddc designates the well as being in the SE1/4, SE1/4, SW1/4, section 36, Township 13 North, and Range 13 West. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

Figure 3-1 Well-numbering and Naming System

3.2 Depth to Groundwater

Due to excessive groundwater withdrawals, Santa Cruz River in the project area flows in response to storm events. The Santa Cruz at one time flowed perennially and supported a variety of native species. However, because of extensive groundwater withdrawals along the river corridor for municipal, agricultural, and industrial uses, this is no longer the case. Groundwater levels continue to drop as water withdrawals exceed recharge.

Information was obtained from the Arizona Department of Water Resources (ADWR) regarding depth of groundwater in wells in this study area. This information is delineated on the graph for each well in **Appendix A**. These well locations are noted as ADWR Well Locations A through K on the aerial photo of the study region included with **Appendix A**.

The current well information indicates that depths to groundwater in the wells generally ranged from about 100 to 200 feet below ground surface in areas close to the Santa Cruz channel in Township 14 South, Range 13 East and Township 15 South, Range 13 East (**Figure 3-2**). Groundwater data was also obtained from soil borings made for bridges along the Santa Cruz River.

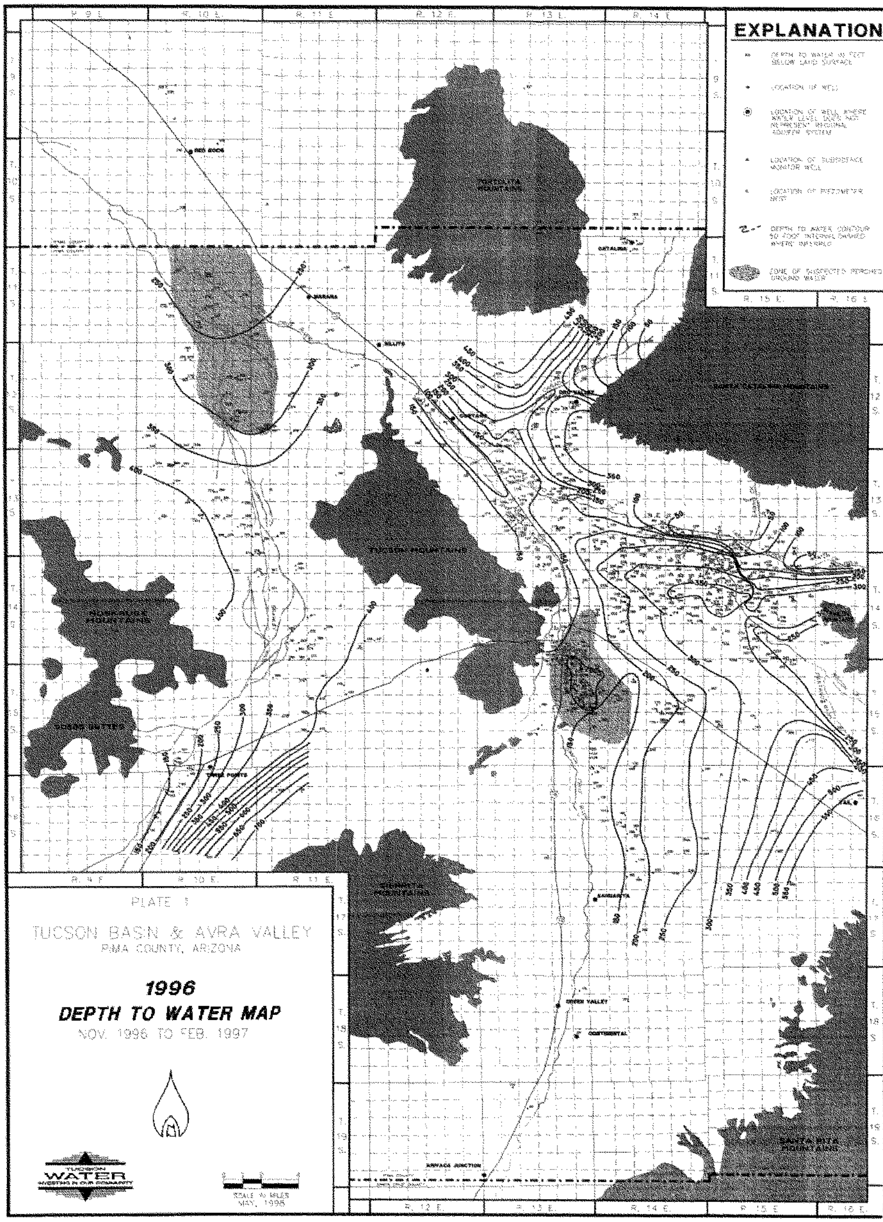


Figure 3-2 Depth to Water Map

3.3 Groundwater Quality

The groundwater delivered by Tucson Water meets all drinking water standards without treatment, with the exception of the water supplied from the Tucson Airport Area Remediation Project (TARP) wells. The TARP program was developed in order to clean and make beneficial use of water contaminated with the industrial solvent, primarily trichloroethylene (TCE). Tucson Water operates TARP under an agreement with the U.S. Environmental Protection Agency (EPA) and other industrial and governmental agencies, which pay for operation of the TARP program.

All drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. Tucson's groundwater contains dissolved minerals and organic compounds, which have been leached from the rock, sediments, and plant materials through which the water traveled. One would expect to find beneficial minerals such as calcium and magnesium, harmless minerals such as chloride, bicarbonate, and sulfate, and metals such as iron, copper, arsenic, and lead, which may be either beneficial or harmless at low concentrations, but harmful at high concentrations. In addition to these naturally occurring contaminants, our groundwater may contain contaminants resulting from human, industrial, or domestic activities. For this reason, water utilities must currently monitor for approximately 90 regulated and 12 unregulated contaminants.

Three inorganic contaminants of special interest are arsenic, fluoride, and nitrate. Fluoride and arsenic are naturally occurring and tend to increase as water is drawn from greater depths. Nitrate, on the other hand, is typically found in higher concentrations near the surface of the groundwater table because it is frequently associated with fertilizer use, septic tanks and other human activities.

Groundwater quality data was obtained from seven Tucson Water Wells. Noteworthy constituent concentrations are given in **Appendix B**. Concentration of pH is larger in sample from well (D-14-13 26ACC) than in sample from any other wells. Concentrations of Total Dissolved Solids (TDS), Chloride, Nitrate as N, Sulfate, Calcium, and Magnesium are relatively larger values in sample from wells (D-14-13 35CAC and D-14-13 35CAD) than in sample from any other wells. Concentration of Sodium is larger value from well (D-14-13 14ABC) than other wells. Consequently both of wells (D-14-13 35CAC and D-14-13 35CAD) have the larger values of contaminant among the seven wells. Tucson well data ranges between year 2000 and 2002.

Table 3-1 provides National Primary and Secondary Drinking Water Standards established by the EPA. Primary standards are legally enforceable standards that apply to public water systems. Secondary standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (skin or tooth discoloration) or aesthetic effects (taste, odor, or color).

Table 3-1 Drinking Water Standards (Primary and Secondary)

Constituent	Primary Standards		Secondary Standards
	Maximum Contaminant Level (MCL)	Maximum Contaminant Level Goal (MCLG)	
Nitrate (mg/l as N)	10	10	-
Sulphate (mg/l)	-	-	250
Chloride (mg/l)	-	-	250
Fluoride (mg/l)	4.0	4.0	-
Total Dissolved Solids (mg/l)	-	-	500
Arsenic (mg/l)	0.05	0	-
Barium (mg/l)	2.0	2.0	-
Copper (mg/l)	-	-	1.0
PH	-	-	6.5-8.5
Total Coliforms	5%*	0	-
Nitrite (mg/l as N)	1.0	1.0	-
Antimony (mg/l)	0.006	0.006	-
Beryllium (mg/l)	0.004	0.004	-
Cadmium (mg/l)	0.005	0.005	-
Chromium (total mg/l)	0.10	0.10	-
Cyanide (mg/l)	0.2	0.2	-
Mercury (inorganic) (mg/l)	0.002	0.002	-
Tetrachloroethyene (mg/l)	0.005	0.0	-
Trichloroethylene (mg/l)	0.005	0.0	-
Aluminum (mg/l)	-	-	0.05-0.2
Iron (mg/l)	-	-	0.3
Manganese (mg/l)	-	-	0.05
Lead (mg/l)	0.015(action level)	0	-

*-More than 5% samples total coliform-positive in a month.
Note: Sodium, Calcium, Magnesium, Potassium, Silica, Hardness and Alkalinity have no drinking water standards set by EPA.

4.0 SANTA CRUZ RIVER WATER

4.1 General

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it reenters Arizona about six miles east of Nogales. The river continues northward to Tucson then northwest to its confluence with the Gila River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the study area. The Paseo de las Iglesias study area consists of a 7-mile reach of the Santa Cruz River and its tributary washes beginning where Congress Street crosses the river in downtown Tucson and extending upstream to the south along the river to the boundary of the San Xavier District of the Tohono O'Odham Nation.

In the Santa Cruz River basin, flood events are linked to at least three differing storm types, categorized as *cyclonic*, *monsoon*, and *frontal*. There is some interrelationship between the meteorological circumstances leading to these differing types of storms, but generally speaking they result from differing factors, occur at different times of the year, and have different precipitation and runoff characteristics, including magnitude (both intensity and depth) and duration.

Mean annual precipitation ranges from 11 inches in the valleys to over 37 inches at elevations greater than 8000 feet National Geodetic Vertical Datum (NGVD). Studies conducted in the Tucson vicinity show an extremely low percentage (about 1%) of the rainfall appears as runoff, generally evaporating, or returning to groundwater. Precipitation occurs in two distinct seasons of the year; summer - late June, July, August, September, and into October; and winter - December, January, February, and March.

In general, the 100-year peak discharges developed by the COE in **Table 4-1** to support the Pima County's regulatory discharges, which have been adopted by FEMA.

Table 4-1 Comparison Table: Floods of Record, COE/PIMA County 100-Year Discharges

LOCATION	D.A. (mi^2)	WATER Year, POR PEAK	DISCHARGE (ft^3/s)			
			POR PEAK	OCT 83 PEAK	COE 100-Year	PIMA 100-Year
Santa Cruz River at Continental	1662	1993	32,400	45,000	45,000	45,000
Santa Cruz River at Tucson	2222	1993	37,400	52,700	55,000	60,000

Period-of-Record peak discharges <u>excluding</u> event of 10-2-83
Water Year 1984, annual maximum peak on 10-2-83 or 10-3-83 in Santa Cruz River
Mixed population analysis results - 1999 to 2000 COE study.

The results presented herein are based upon a *regional* **mixed population** approach in order to provide *consistent* discharge-frequency values, which are in agreement with observed streamflow data, and based upon reasonable application of statistical analysis

Floods can occur from heavy thunderstorms, but are typically of short duration (lasting up to three hours). The frequently occurring 2-year, 6-hour event in Tucson is about 1.5 inches of rainfall. The extreme 100-year, 6-hour event is about 3.6 inches in Tucson. Occasionally, longer-term summer storms occur, associated with tropical storms from the Gulf of Mexico or the Pacific Ocean. These storms may provide heavy precipitation for up to 24 hours, causing longer lasting flood events (24 hours or more). The 2-year, 24-hour event is about 1.8 inches in Tucson. The more extreme 100-year, 24-hour event is about 4.6 inches in Tucson. The mountainous areas may receive up to 5.5 inches during a 100-year event. Winter storms provide lesser amounts of precipitation and are associated with frontal storm systems from the Pacific Ocean.

The City of Tucson Report "Existing Conditions Hydrologic Modeling for the Tucson Stormwater Management Study (TSMS), Phase II, Stormwater Master Plan, Task 7, Subtask 7A3" provided most of the hydrologic data for existing (baseline) storm water quantity conditions for tributaries along the Santa Cruz River within the City limits.
The results of that analysis are presented in **Table 4-2**.

Table 4-2 Santa Cruz River Tributary Washes: Discharge Frequency Data at the Confluence with the Santa Cruz River (cubic feet per second)

Tributary Names South to North	WS Acres	100-yr	50-yr	25-yr	10-yr	5-yr	2-yr
Hughes Wash	5338	2376	1875	1258	738	334	93
Santa Clara Wash	250	389	314	221	143	86	47
El Vado Wash	1466	1558	1327	1003	716	474	287
Valencia Wash	1050	1510	1292	1026	721	441	230
Airport Wash	14547	5164	3981	2691	1549	7740	346
Wyoming Wash	448	877	719	519	335	184	82
Irvington Wash	160	427	343	237	145	75	40
Rodeo Wash	5370	3453	2839	2448	1340	744	321
Julian Wash	27859	5962	4767	3202	1901	945	389
Mission View Wash	1037	1802	1538	1201	885	599	355
18th Street Wash	2342	3085	2503	1921	1363	886	523
Cushing Street Wash	320	1165	993	770	562	375	221
Ajo Wash	1222	3465	2817	2007	1286	689	242
Enchanted Hills Wash	1990	3968	3270	2386	1540	801	256
San Juan wash	730	1757	1470	1104	757	423	152
Cholla Wash	832	2273	1882	1379	920	529	224
Old West Branch at Confluence with SCR	6541	6621	5417	3818	2447	1352	397
New West Branch at Confluence with SCR	21248	9908	7925	5250	3665	2020	595
Los Reales Road	12198	7638	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Notes: ■ indicates peak discharge estimated by LAD; 7900 indicates peak discharge provided by Pima County for this study.

4.2 Monthly Statistics and Low Flow Analysis for SCR

The stream flow primarily occurs in the two distinct rainfall seasons: summer and winter. The monthly statistics analyses were calculated for two gaging stations, Santa Cruz River at Tucson (09482500) and at Continental (09482000) in **Table 4-3** and **Table 4-4**.

At Tucson station located in Congress Street bridge, average daily stream flow rates are 17 cfs to 90 cfs in summer (July-October) and 11 cfs to 42 cfs in winter (December-February) and the annual average daily stream flow rate is 24.4 cfs. Maximum monthly stream flow rates are 312 cfs to 682 cfs in summer (July-October) and 202 cfs to 895 cfs in winter (December-February) and the annual maximum stream flow is 112 cfs. For the Continental station located in the upstream from this study area, the statistical analysis is summarized in **Table 4-4**.

Most precipitation falls during the summer months as a result of thunderstorms caused by moist air "monsoon" flow from the Gulf of Mexico. Winter storms provide lesser amounts of precipitation and are associated with frontal storm systems from the Pacific Ocean.

The Monthly Statistics view displays a suite of summary statistics on a month-by-month basis. This suite summarizes data over the entire period of record, reporting three types of statistics: daily statistics, period statistics (monthly), and exceedences. Daily statistics are calculated against the daily observations. Period statistics are calculated against the population of valid monthly totals or means for each period (month). Exceedences are calculated against all non-missing daily observations. **Appendix D** indicated the meanings of all text of table to help understanding.

4.3 Average Annual/Monthly Stream Flow for SCR Tributaries

There are nineteen notable tributaries joining the SCR in the study reach. Twelve tributaries – Hughes Wash, Santa Clara Wash, El Vado Wash, Valencia Wash, Airport Wash, Wyoming Wash, Irvington Wash, Rodeo Wash, Julian Wash, Mission View Wash, 18th Street Wash, Cushing Street– join the East bank, while seven tributaries – Ajo Wash, Enchanted Hills Wash, San Juan Wash, Cholla Wash, Old West Branch at Confluence with SCR, New West Branch at Confluence with SCR, Los Reales Road – join the West bank of the Santa Cruz River. Streamflow data are generally not available for the tributaries mentioned above.

Appendix C presents results of tributary analysis performed in support of this study. Average annual/monthly streamflow data of tributaries will be used to analyze the future available water resources. As shown in **Table 4-5**, eleven of the tributaries are urban tributaries and eight tributaries are rural or natural tributaries. Most of east bank tributaries are relatively urban while west bank tributaries are relatively rural or natural. Average annual tributary runoff is 9,020 AF, 3,535 AF from urban watersheds, and 5,485 AF from natural watersheds, as indicated in **Table 4-5.**

To estimate average monthly runoff volume (**Table 4-6**), the percentage of annual runoff volumes from the available records of the gaged watersheds was used as indicated in **Appendix C.**

Based on the results, the runoff from urban watersheds is more available in July, August, and September, while the runoff from rural or natural watersheds is more available in December, January, February, and March.

Table 4-3 Monthly Statistics of Santa Cruz River at Tucson, AZ

Parameter: Stream Flow CFS
Year: 1905-2001
State: AZ
County: PIMA

ID: 09482500
Statistic: Mean
Latitude: 32:13:16
Longitude: 110:58:52
Elevation: 2317.82
Drainage Area: 2222.00

	Jan (cfs)	Feb (cfs)	Mar (cfs)	Apr (cfs)	May (cfs)	Jun (cfs)	Jul (cfs)	Aug (cfs)	Sep (cfs)	Oct (cfs)	Nov (cfs)	Dec (cfs)	Year (cfs)	Year (ac-ft/yr)
# Days	2,335	2,119	2,325	2,250	2,325	2,250	2,329	2,328	2,250	2,388	2,310	2,387	27,596	
Avg Day	41.7	10.7	4.7	0.6	0.1	1.5	51.8	90.3	31.3	17.1	7	32.8	24.4	17,681
Max Day	24,700	1,580	1,240	142	70	403	3,120	4,570	6,400	11,200	3,200	9,840	24,700	17,898,551
Min Day	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# Months	75	75	75	75	75	75	75	75	75	77	77	77	75	
SDev Month	78.4	35.8	16.9	3.8	0.3	4.6	68.9	111.3	57.9	84.9	28.4	138.4	22.4	16,232
Skew Month	5.2	4.2	4.7	8.4	5.3	3.9	3.2	2.8	3.5	6.6	6	4.9	2.1	
Min Month	0	0	0	0	0	0	0	0	0	0	0	0	1.3	942
Max Month	517.6	202.4	102.5	32.9	2.3	24.7	429.6	681.8	311.9	656.3	214.5	895	111.8	81,014
Exceedences														
1%	759.8	308.1	107.3	9.4	0.1	35.5	1,060.0	1,568.8	505.0	184.9	164.9	703.3	525.2	380,580
5%	20	17	5	0	0	0	266.2	483.8	123	2	4.3	15	49	35,507
10%	9.5	2.1	0.1	0	0	0	110.1	216.4	21	0	0	5	5.3	3,841
20%	0	0	0	0	0	0	18	56	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note- Refer to the appendix D for description of table.

Table 4-4 Monthly Statistics of Santa Cruz River at Continental, AZ

Parameter: Stream Flow CFS
Year: 1940-2001
State: AZ
County: PIMA

ID:09482000
Statistic:Mean
Latitude:31:51:12
Longitude:110:58:40
Elevation:2832.28
Drainage Area:1682.00

	Jan (cfs)	Feb (cfs)	Mar (cfs)	Apr (cfs)	May (cfs)	Jun (cfs)	Jul (cfs)	Aug (cfs)	Sep (cfs)	Oct (cfs)	Nov (cfs)	Dec (cfs)	Year (cfs)	Year (ac-ft/yr)
# Days	1,581	1,441	1,581	1,530	1,612	1,560	1,601	1,581	1,530	1,612	1,560	1,612	18,801	
Avg Day	49.6	15.9	10.5	0.7	0	0.5	29.3	80.4	18.7	51.9	5.3	40.8	25.5	18,478
Max Day	14,800	2,290	2,450	291	31	180	1,720	4,290	6,110	17,800	3,000	9,800	17,800	12,898,551
Min Day	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# Months	51	51	51	51	52	52	51	51	51	52	52	52	50	
SDev Month	210.5	45.8	35.2	4.4	0.2	1.4	43.3	152	42.7	235.5	25.4	136	39.8	28,841
Skew Month	5.6	3.4	3.9	7	6.2	3.1	2.8	3.2	5.2	5.5	4.9	3.5	2.7	
Min Month	0	0	0	0	0	0	0	0	0	0	0	0	0.3	217
Max Month	1,386.5	207	181	31.5	1.3	6.2	227	753	285	1,524.5	133	658	205.9	149,203
Exceedences														
1%	1,267.6	383	249	2	0.7	8.6	667	1656	388	645.1	101	802	536	388,406
5%	92.9	69.9	8	0	0	0	157	420	63	9.4	0	20	44	31,884
10%	8.2	1.3	0	0	0	0	54.8	145	8.5	0.3	0	0	2.5	1,812
20%	0	0	0	0	0	0	8.4	32	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4-5 Average Annual Runoff for Tributaries

Tributary Names	Drainage Area (mi^2)	Drainage Area (Acres)	Impervious Area (Acres)[1]	Impervious Area (%)	Basin Rainfall (inch)	Urban[2]	Natural or Rural[3]	Ave. Annual Runoff (AAR_u) for Urban (Acre-ft)	Ave. Annual Runoff (AAR_n) for Natural (Acre-ft)
Hughes Wash	8.3	5,337.5	320.3	6.0%	11.55		X		486.3
Santa Clara Wash	0.4	249.6	74.1	29.7%		X		77.6	
El Vado Wash	2.3	1,465.6	524.7	35.8%		X		150.7	
Valencia Wash	1.6	1,049.6	436.6	41.6%		X		135.1	
Airport Wash	22.7	14,547.0	1,265.6	8.7%	11.55		X		1,228.2
Wyoming Wash	0.7	448.0	109.3	24.4%		X		82.7	
Irvington Wash	0.3	160.0	38.9	24.3%		X		72.7	
Rodeo Wash	8.4	5,369.5	1,127.6	21.0%		X		275.2	
Julian Wash	43.5	27,858.9	5,627.5	20.2%		X		2,174.8	
Mission View Wash	1.6	1,036.8	500.8	48.3%		X		146.4	
18th Street Wash	3.7	2,342.4	958.0	40.9%		X		237.1	
Cushing Street Wash	0.5	320.0	183.4	57.3%		X		93.8	
Ajo Wash	1.9	1,222.4	55.0	4.5%	11.55		X		124.6
Enchanted Hills Wash	3.1	1,990.4	13.9	0.7%	11.55		X		195.5
San Juan wash	1.1	729.6	16.1	2.2%	11.55		X		77.3
Cholla Wash	1.3	832.0	151.4	18.2%		X		89.0	
Old West Branch at Confluence with SCR	10.2	6,540.7	529.8	8.1%	11.55		X		586.8
New West Branch at Confluence with SCR	33.2	21,247.8	2,124.8*	10.0%	11.55		X		1,743.0
Los Reales Road	19.1	12,198.3	731.9*	6.0%	11.55		X		1,043.8
Total	164.0	104,946.1	11,933.0					3,535.0	5,485.6

*-Assume based on Aerial Photo.

Impervious Area (Acres)[1]- Source is HEC-1 Brief Summary provided by PIMA County.

Urban[2]-Assume the urban if impervious area (%) is greater than 10%.

Natural or Rural[3]-Assume the natural or rural if impervious area (%) is equal or less than 10%.

Table 4-6 Average Monthly Runoff (Acre-ft) for Tributaries

Watershed	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
East Bank													
Hughes Wash	42.3	34.5	26.3	2.4	4.9	6.3	95.8	97.7	99.7	34.5	15.6	27.2	486.3
Santa Clara Wash	6.8	5.5	4.2	0.4	0.8	1.0	15.3	15.6	15.9	5.5	2.5	4.3	77.6
El Vado Wash	13.1	10.7	8.1	0.8	1.5	2.0	29.7	30.3	30.9	10.7	4.8	8.4	150.7
Valencia Wash	11.8	9.6	7.3	0.7	1.4	1.8	26.6	27.2	27.7	9.6	4.3	7.6	135.1
Airport Wash	106.9	87.2	66.3	6.1	12.3	16.0	242.0	246.9	251.8	87.2	39.3	68.8	1228.2
Wyoming Wash	7.2	5.9	4.5	0.4	0.8	1.1	16.3	16.6	17.0	5.9	2.6	4.6	82.7
Irvington Wash	6.3	5.2	3.9	0.4	0.7	0.9	14.3	14.6	14.9	5.2	2.3	4.1	72.7
Rodeo Wash	23.9	19.5	14.9	1.4	2.8	3.6	54.2	55.3	56.4	19.5	8.8	15.4	275.2
Julian Wash	189.2	154.4	117.4	10.9	21.7	28.3	428.4	437.1	445.8	154.4	69.6	121.8	2174.8
Mission View Wash	12.7	10.4	7.9	0.7	1.5	1.9	28.8	29.4	30.0	10.4	4.7	8.2	146.4
18th Street Wash	20.6	16.8	12.8	1.2	2.4	3.1	46.7	47.7	48.6	16.8	7.6	13.3	237.1
Cushing Street Wash	8.2	6.7	5.1	0.5	0.9	1.2	18.5	18.9	19.2	6.7	3.0	5.3	93.8
West Bank													
Ajo Wash	28.4	23.4	22.1	5.6	0.6	0.1	3.1	8.3	6.4	3.6	2.1	20.7	124.6
Enchanted Hills Wash	44.6	36.8	34.6	8.8	1.0	0.2	4.9	13.1	10.0	5.7	3.3	32.5	195.5
San Juan wash	17.6	14.5	13.7	3.5	0.4	0.1	1.9	5.2	3.9	2.2	1.3	12.8	77.3
Cholla Wash	20.3	16.7	15.8	4.0	0.4	0.1	2.2	6.0	4.5	2.6	1.5	14.8	89
Old West Branch at Confluence with SCR	133.8	110.3	103.9	26.4	2.9	0.6	14.7	39.3	29.9	17.0	10.0	97.4	586.8
New West Branch at Confluence with SCR	397.4	327.7	308.5	78.4	8.7	1.7	43.6	116.8	88.9	50.5	29.6	289.3	1743
Los Reales Road	238.0	196.2	184.8	47.0	5.2	1.0	26.1	69.9	53.2	30.3	17.7	173.3	1043.8

5.0 TREATED WASTEWATER

5.1 Reclaimed Water

Secondary effluents generated by the Pima County Wastewater Management Department (PCWMD) sewage system receive additional treatment. Subsequent filtration and disinfection of secondary effluent produces reclaimed water, which is suitable for irrigation, industrial uses, and groundwater recharge. The Pima County Flood Control District (PCFCD) provides the monthly operating statistical data (**Table 5-1** and **Table 5-2**) of the Avra Valley Wastewater Treatment Facility (WWTF), which is a of potential water resource for irrigation needs. A capacity of existing WWTF is 1.2 MGD (1,343 acre-ft/year) but it is going to be extended with additional capacity, 3.2 MGD (3,577 acre-ft/year) until 2007. There are currently three possible use/disposal methods: 1) The majority of the effluent is disposed in the on-site percolation beds; 2) up to 2,000 gallons per day is authorized to leases for on-site landscaping needs, which is far less than that is actually used (this use is expected to be unlimited under future permitting because of the addition of an NO_3 removal system since that authorization was granted); and, 3) the facility is currently authorized to release effluent to Waters of the US, but only does so as needed during testing, repairs, or upgrades. The release is done in the spray field adjacent to the percolation beds and water flows downstream into the Black Wash.

Tertiary treated reclaimed water can be considered as another potential water resource for this project. Tucson Water Department owns 90% of this reclaimed water and delivers it through the Tucson Water reclaimed water distribution system to the City of Tucson Department of Parks & Recreation and to private users for non-potable uses, primarily turf irrigation. The reclaimed water is also made available to recharge facilities. Tucson Water has one of the largest community reclaimed water systems in the United States. Tucson Water delivers reclaimed water to nearly 400 sites, including: 13 golf courses; 32 parks; 35 schools (the University of Arizona and Pima Community College included); and more than 300 single family homes. Our reclaimed water production facilities at Roger Road near I-10 have been filtering and disinfecting treated wastewater for 18 years. Using reclaimed water for irrigation saves groundwater for drinking. In 2001, reclaimed customers saved 3.4 billion gallons of drinking water: enough for 31,000 families for a year. Existing and proposed Tucson Water Reclaimed Water System under the fiscal year 2003-2007 Capital Improvement Program (CIP) is shown in **Figure 5-1**. The total volume of effluent water generated at the Ina Road and Roger Road treatment plants is estimated at 74,000 acre-ft /year, of which approximately a total amount of 10,000 acre-ft /year is currently used for various purposes and the remaining amount discharged into the Santa Cruz River. Tucson Water estimates projected use of reclaimed water in the year 2007 at 12,000 acre-ft/year. Three environmental restoration studies (Tres Rios Del Norte, El Rio Antiguo, and Paseo de las Iglesias) around the City of Tucson are considering the reclaimed water as a potential water resource. Currently there are no effluents from the existing Tucson Reclaimed Water System to this study area, but it will be considered a viable water resource for the future plans.

Table 5-1 Monthly Operating Statistical Data of Avra Valley WWTF, (Fiscal Year 2001-2002)

FISCAL YEAR 2001-2002	LIMITS	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
INFLUENT TOTAL FLOW MG	N/A	24.352	23.881	23.806	26.6	27.23	28.175	30.23	27.4	29.73	28.53	28.23	26.07
INFLUENT AVG MGD	APP 2.2	0.786	0.77	0.794	0.858	0.908	0.909	0.975	0.978	0.959	0.951	0.91	0.869
RAW INFLUENT (PREOXIDATION DITCH)													
BOD AVG (mg/l)	N/A	184	157	207	170	165	222	205	191	238	210	243	194
pH	N/A	7.48	7.41	7.39	7.54	7.58	7.5	7.53	7.49	7.47	7.43	7.45	7.39
TSS AVG (mg/l)	N/A	244	228	280	265	221	230	270	258	332	273	268	286
SLUDGE DISPOSAL													
AVG (%sol)	N/A	0.9	1.04	0.95	0.89	0.88	0.93	1.27	0.8	0.89	1.09	0.96	1
GALLONS (Hauled)	N/A	363,880	373,700	380,840	443,520	372,140	428,560	442,640	401,280	398,256	334,530	440,880	338,960
GALLONS (Drying Bed)	N/A	0	0	0	0	0	0	76,560	147,400	0	100,760	228,000	111,760
EFFLUENT													
BOD AVG (mg/l)	30	2	4	2	2	2	2	4	3	3	3	4	<2
pH	6.0/9.0	7.59	7.61	7.54	7.55	7.53	7.34	7.42	7.38	7.4	7.38	7.48	7.5
TN AVG (mg/l)	30	<5	<5	<5	<5	5	<5	5	<5	<5	<5	<5	<5
TSS AVG (mg/l)	<10	1.9	1.7	1.6	1.7	1.3	1.9	1.8	2	2.1	1.3	1.4	1.6
NO3 AVG (mg/l)	<10	0.7	1	0.6	0.6	0.7	0.6	0.6	0.5	<0.5	<0.2	<0.8	<0.7
EFFLUENT REUSE													
REUSE TOTAL MG	N/A	0.355	0.562	0.85	0.147	0.152	0.058	0.155	0.13	0.236	0.529	0.54	0.85
AVG T. CL2	N/A	3.74	3.72	2.06	2.44	2.75	3.94	3.56	2.62	2.82	2.24	0.94	0.8
AVG F. COLIFORM	200	<2	<2	2	2	<2	<2	<2	<2	2	<2	4	2
Ph (Avg)	4.5/9.0	8.83	8.37	8.47	8.04	8.72	8	8.23	8.25	8.56	8.5	8.1	8.47
GROUNDWATER DOWNGRADIENT: AV-3*													
TN	<10	4.7	4.7	4.7	4.9	5	5.2	5.9	5.4	4.9	5.3	6.1	7.4
NO3	<10	4.7	4.7	4.7	4.9	5	5.2	5.9	5.4	4.9	5.3	6.1	7.4
GROUNDWATER DOWNGRADIENT: AV-1													
TN	N/A	15	13.2	14	15.8	19.3	N/A	12.6	14.6	14.2	13.8	12.7	12.6
NO3	N/A	15	13.2	14	15.8	19.3	N/A	12.6	14.6	14.2	13.8	12.7	12.6
GROUNDWATER UPGRADIENT: AV-4													
TN	N/A	N/A	1.6	N/A	1.1	N/A	N/A	2.7	N/A	N/A	N/A	1.6	N/A
NO3	N/A	N/A	1.6	N/A	1.1	N/A	N/A	1.8	N/A	N/A	N/A	1.6	N/A
SODIUM HYPOCHLORITE APPLIED GAL		3300	2560	1875	2335	2740	2000	1545	790	1040	1395	1670	1158
ELECTRICITY KWH		841	846	876	1061	1090	1123	1144	1045	1222	1176	1209	1745

Table 5-2 Monthly Operating Statistical Data of Avra Valley WWTF, (Fiscal Year 2002-2003)

FISCAL YEAR 2002-2003	LIMITS	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
INFLUENT TOTAL FLOW MG	N/A	28.88	29.5	27.91	27.49	28	28	30.08	27	29	28.7	27.56	
INFLUENT AVG MGD	APP 2.2	0.931	0.95	0.93	0.886	0.926	0.92	0.97	0.966	0.975	0.956	0.918	
RAW INFLUENT (PREOXIDATION DITCH)													
BOD AVG (mg/l)	N/A	217	155	186	204	200	212	228	177	215	203	222	
pH	N/A	7.4	7.44	7.45	7.53	7.56	7.46	7.56	7.48	7.46	7.5	7.45	
TSS AVG (mg/l)	N/A	265	270	253	203	302	299	339	259	295	331	270	
SLUDGE DISPOSAL													
AVG (%sol)	N/A	0.72	0.81	1.37	1.67	1.14	1.03	1.19	1.06	0.73	1.19	1	
GALLONS (Hauled)	N/A	490,160	446,600	347,600	376,120	348,040	394,680	497,017	486,040	445,800	438,130	505,120	
GALLONS (Drying Bed)	N/A	0	0	0	0	0	0	44,440	105,160	0	0	50,600	
EFFLUENT													
BOD AVG (mg/l)	30	2	<2	2	3	3	3	3	3	4	4	4	
pH	6.0/9.0	7.51	7.54	7.53	7.5	7.48	8.4	7.37	8.4	7.4	7.45	7.53	
TN AVG (mg/l)	30	<5	<5	<5	6	6	5	6	11	12	6	5	
TSS AVG (mg/l)	<10	1.6	1.6	1.5	2	2.4	0.9	2	2.3	2.2	2.1	106	
NO3 AVG (mg/l)	<10	<0.6	0.5	0.6	0.6	1	0.9	0.5	0.5	0.5	0.5	0.5	
EFFLUENT REUSE													
REUSE TOTAL MG	N/A	0.314	0.636	0.204	0.55	0.742	0	0	0	0	0	0	
AVG T. CL2	N/A	2.55	1.86	2.18	3.7	1.32	N/A	N/A	N/A	N/A	N/A	N/A	
AVG F. COLIFORM	200	<2	18	3	2	<2	N/A	N/A	N/A	N/A	N/A	N/A	
Ph (Avg)	4.5/9.0	8.16	8.14	8.29	8.8	8.4	N/A	N/A	N/A	N/A	N/A	N/A	
GROUNDWATER DOWNGRADIENT: AV-3*													
TN	<10	9.4	11.3	1.36	11	8.6	9.9	8.8	6.6	6.4	5.6	5.2	
NO3	<10	9.4	11.3	13.6	11	8.6	9.9	8.8	6.6	6.4	5.6	5.2	
GROUNDWATER DOWNGRADIENT: AV-1													
TN	N/A	10.9	7.8	5.7	4.8	4.8	6.3	6	6.6	5.6	5.7	7	
NO3	N/A	10.9	7.8	5.7	4.8	4.8	6.3	6	6.6	5.6	5.7	7	
GROUNDWATER UPGRADIENT: AV-4													
TN	N/A	N/A	1.8	N/A	N/A	1.8	N/A	1.8	1.9	N/A	1.9	N/A	
NO3	N/A	N/A	1.8	N/A	N/A	1.8	N/A	1.8	1.9	N/A	1.9	N/A	
SODIUM HYPOCHLORITE APPLIED GAL		2125	1475	2415	1310	2090	1070	1010	1200	1150	1900	1975	
ELECTRICITY KWH		1175	1157	1335	1150	1242	1337	1395	1364	1445	1425	1506	

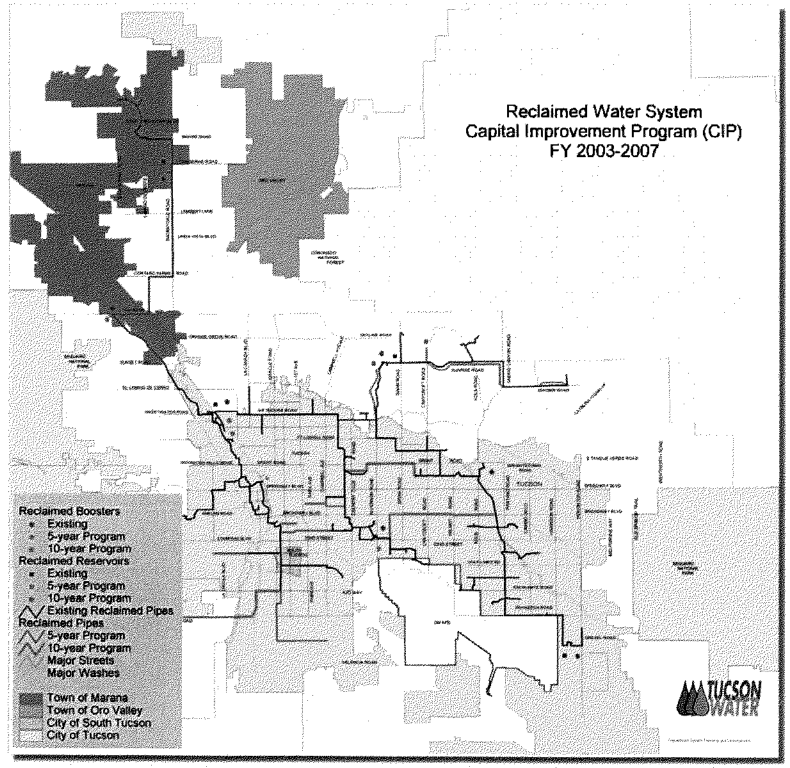


Figure 5-1 Reclaimed Water System Capital Improvement Program (CIP) FY 2003-2007

5.2 Reclaimed Water Quality

Reclaimed water ideally suited for turf irrigation and other commercial and industrial uses (Tucson Water, 2001; Pima Association of Governments (PAG), 1994a). Under a state wastewater reuse permit the reclaimed water is monitored for flow, turbidity, fecal coliform, pH, enteric virus, and *Ascaris lumbricoides* (Dotson, 2001). Water is sampled at a point that is representative of the quality of water received by the reclaimed water customers. The reclaimed water has a higher TDS concentration then secondary effluent. This is due in part to mixing with groundwater at the facility, where background TDS levels are higher than most Tucson Water wellfields (PAG, 1994a). **Tables 5-3** and **5-4** present data provided by Tucson Water for this sample point. All data is within permitted limits.

Table 5-3 Average Values, Water Quality Data, Tucson Water Reclaimed System, January-July 2001, Data from Tucson Water

Constituent	Average	No. of Samples
Total Dissolved Solids	657 mg/l	6
Total Kjeldahl Nitrogen	10.09 mg/l	6
Total Organic Carbon	7.35 mg/l	6
Total Suspended solids	1.6 mg/l *	7
Turbidity	3.28 NTU	6
Ammonia as N	6.29 mg/l	6
Nitrate as N	3.87 mg/l	7
Chloride	107.43 mg/l	7
pH	7.7 su	6
Conductivity	1012.66 umhos/cm	6
Fluoride	0.9	7
Potassium	8.2 mg/l	2
Phosphate as P	1.52 mg/l	6
Sulfate	120.8	7
Calcium	59.5	2
Total Alkalinity	247	3
Sodium	130 mg/l	2

*-This value calculated using a value of zero for one sample with a result of <1.

Samples collected on January 4, 2001, and April 12, 2001, were also analyzed for volatile organic compounds (VOCs) and metals. In general these constituents were only detected at levels less than the lowest standard or qualification limit of the method. Aluminum, Arsenic, Barium, Boron, Copper, Iron, Magnesium, Nickel, and Zinc were all present at detectable levels, but below permit limits. The results of the two samples are listed on **Table 5-4**.

Table 5-4 Analytical Results for Reclaimed Water, Sample Dates January 4, 2001 and April 12, 2001, Data provided by Tucson Water

Constituents (mg/l)	Sample Date 1/4/2001	Sample Data 4/12/2001
Aluminum, Total	<0.1	0.12
Arsenic, Total	0.0038	0.0055
Barium, Total	0.033	0.031
Boron, Total	0.3	0.29
Copper, Total	0.015	<0.01
Iron, Total	0.11	0.084
Magnesium, Total	10	9.9
Nickel, Total	0.013	<0.01
Zinc, Total	0.026	0.039

mg/l=milligrams per liter.

6.0 INFILTRATION

The infiltration of storm runoff in the stream channels during the rainy seasons is the major source of recharge to the groundwater basin (Davidson 1973). The seepage of runoff along the mountain fronts constitutes the second largest source of recharge. This natural system recharges about 100,000 ac-ft/yr; however, there is currently a demand for 300,000 to 400,000 ac-ft annually. The resulting deficit is causing the water table to decline at an approximate average annual rate of 2.7 ft (PCDOT 1986). For additional information regarding groundwater see the Geotechnical Appendix.

Several studies have been performed to evaluate the rate of recharge for both the Santa Cruz and Rillito Rivers (Wilson 1979; Katz 1987; Wilson and Newman 1987; Cluff et al. 1987; Galyean 1996). These studies attempted to evaluate the recharge rate using primarily empirical methods. The study by Katz indicated for the short-term loss that the infiltration rates, volumes of recharge per day, and volumes of recharge per day normalized to stream length were computed. For the Santa Cruz, these figures were roughly 1.37 ft/day, 551 ac-ft/day, and 18 ac-ft/day/mi, respectively. For the Rillito River, the same figures were roughly 1.67 ft/day, 479 ac-ft/day, and 41 ac-ft/day/mi, respectively. The study by Galyean indicated the infiltration of wastewater effluent in Santa Cruz River Channel, to simulate the effluent recharge volume with long-term rates. The average (1991-1993) volume of infiltration, 43733 acre-ft/yr, was divided by the average acreage of open-channel area, 136.83 acres, to get the infiltration rate, 320 ft/yr, or 0.88 ft/day. The studies by Cluff, et al., and Wilson and Newman, evaluate the effects of channel stabilization on infiltration and ground water recharge. These reports are available at the Pima County Flood Control in-house library.

Limited data is available on infiltration/recharge into the aquifer in the study area. Majority of the tests were performed locally, giving infiltration rate in ft/day at various location along the Santa Cruz River reach. These studies attempted to evaluate the recharge rate using primarily empirical methods. The Paseo de las Iglesias study area consists of a 7-mile reach of the Santa Cruz River. USGS streamflow data supports the ephemeral behavior of the Santa Cruz River. Data for water years 1995-2001 suggests that on the average, Santa Cruz River flows (above 30 cfs) 21 days per year. Based on this information, the infiltration rate was estimated as the 2,646 ac-ft/year [7 miles x (18 ac-ft/day/mi) x (21 day/year) = 2646 ac-ft/yr].

7.0 WATER DEMAND

Two different sources are available for the water demand from Environmental Restoration in Pima County (1999), and El Rio Antiguo feasibility study (2003). The water demand of an acre of habitat is different depending on whether the vegetation type is hydroriparian (such as cottonwood), mesoriparian (such as mature, dense mesquite), xeroriparian (such as less dense mesquite), or desert upland (such as native grass or cresotebush). Meso- and hydroriparian vegetation are groundwater dependent (i.e., they use water stored underground for their life cycles). **Table 7-1** quantifies the water needed (per unit area) to support various types of native vegetation, which could occur or might occur in or along our watercourses.

Table 7-1 Water Needs for Vegetation in Tucson Area

Type of Vegetation	Water Needs (acre-ft/acre/yr)
Desert Upland	
Saltbush	0.5 - 1.0
Cresotebush	0.8
Xeroriparian	
Less Dense Mesquite	1.6
Mesoriparian	
Mature, Dense Mesquite	3.0
Hydroriparian	
Mature Cottonwoods	5.0 – 5.8
Young Cottonwoods/Willows	8.3
Wetlands	
Cattails	6.9
Other Features	
Open Water	5.4
Park with turf and trees	2.9 - 4.0
Pecan Grove with Ground Cover	5.7
Golf Course with Water Features	4.7

Source: Pima County Administrator's Office

The following three groups of plant communities will be utilized: (1) Mesquite Communities include Mesquite, Desert Willow, Blue Palo Verde, Wolfberry, Graythorn, and Hackberry: (2) CW Forest Communities include Fremont Cottonwood, Gooding's Willow, Sycamore, Ash, Arizona Walnut, and Hackberry; and (3) Scrub/Shrub Communities include Wolfberry, Graythorn, Hackberry (upper edge), Seep Willow, Bursage, and Saltbrush. Secondly, water use requirements for the three groups (Mesquite, CW Forest and Scrub/Shrub Communities) are given in **Table 7-2**.

Table 7-2 Water Demand for Riparian Habitat Units

Type of Vegetation	Water Demands (ft/yr)*
Scrub Shrub	3.0
Mesquite	4.0
Cottonwood/Willow	8.5

Source: El Rio Antiguo AFB Feasibility Study Report
*- Includes infiltration loss

Sustaining xeroriparian scrub shrub and smaller less-dense mesquite in this manner without irrigation is consistent with the water demand research obtained Pima County, as well as ongoing restoration projects managed by the Audubon Society in the Tucson area. That research indicates xeroriparien mesquite requires 1.6 feet/year and the majority of the xeroriparian scrub shrub require 1.0 feet/year or less. The water demand values utilized in El Rio Antiguo were consistent with the highest or hydroriparian levels of evapotranspiration founded in the existing research. As such, the values of El Rio Antiguo are proposed for the hydroriparian. The new values are selected to provide estimates of the water demand that will be needed to sustain the vegetation communities for the alternatives based on the Pima County data and the El Rio Antiguo data in the **Table 7.3**. 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.

Table 7-3 Water Demand for Paseo de las Iglesias Project

Type of Vegetation	Xeroriparian Water Demands (ft/yr)	Mesoriparian Water Demands (ft/yr)	Hydroriparian Water Demands (ft/yr)
Scrub Shrub	1	2	3
Mesquite	<1.6	3	4
Cottonwood-Willow		7.5	8.5
Emergent Marsh	5	6	7

8.0 RESTORATION ALTERNATIVES

The specific objectives identified for this study are to:

- Restore wetland and riparian vegetative communities within the river corridor to a more natural state
- Increase the acreage of functional wetland habitat within the resource
- Minimize disturbance-type impacts to restored wetlands
- Minimize potential for sediment and organic matter accumulation in restored wetlands (low maintenance design)
- Increase habitat diversity by providing a mix of habitats within the river corridor including the riparian fringe
- Reduce flood damages in specified areas

Prior to developing restoration alternatives constraints were also 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
- Landfills and HTRW Sites

The principal limiting constraint for ecosystem restoration in an arid environment is the availability of water; however this formulation process initially assumed that unlimited volumes of water could be made available. The kinds of restoration techniques and measures to be implemented were also used to define alternatives. Land was presumed to be available within the study area, particularly near the larger stream channels within the study area. Alternatives were developed by varying the volumes of water that could be supplied, the area of land utilized and the restoration measures that might be constructed within a carefully selected area of land adjacent to the Santa Cruz River and its major tributaries. This approach allows decision makers to weigh the relative cost of the biologic outputs resulting from commitment of large volumes of water when evaluating plans for implementation of ecosystem restoration measures within a fixed area of land.

The plan formulation process began with three broad concepts for restoration that were characterized by high, medium and low water demand. These became the starting point for development of an initial array of alternatives.

The initial restoration concept included introducing periodic releases of water into washes in the western portion of the study area that are tributaries of both the old and new West Branches of the Santa Cruz River. The land at the southern end of the study area would have been acquired to maintain and expand the existing artificial wetland areas and altering those areas to permit periodic releases from the pools into the Santa Cruz River. The concept also included modifications to the Santa Cruz River to create ponding of low flows; widening of the Santa Cruz River channel between Valencia Road and Irvington Road and between Los Reales Road and Valencia Road in order to expand riparian areas; and modification of tributary confluences to facilitate habitat restoration throughout the study area.

Another concept relied entirely on storm water harvesting to provide water to support habitat restoration. Water to support restored habitat would have come from eight storm water harvesting sites located at confluences of tributary washes with the Santa Cruz River, the Old West Branch and the New West Branch. Confluences would be modified to capture and distribute storm water. Establishment of banks and terraces vegetated with a mix of riparian species was included on both banks of the river between Valencia Road and Irvington Road and on both banks from Ajo Way north through the Cottonwood Lane area. A third concept considered restoration activities similar to those developed for the second concept but differed in that it would have included irrigation of restored areas. As measures were refined and areas for alternative implementation were identified these concepts evolved into the initial array of alternatives.

In the process of developing the initial array of alternatives the low water concept was replaced by a "Xeroriparian" concept. The team felt that development of a grouped restoration features conceived to be supported entirely by concentration of rainfall and harvesting of runoff ensured a viable minimum project as well as providing a basis for assess the gains produced by differing levels of irrigation. As alternative design proceeded the team recognized that the Xeroriparian features would need irrigation for a short period during the initial establishment of habitat and could need supplemental water during periods of extended drought. However, these alternatives have no requirement for regular irrigation. In addition to the Xeroriparian concept (number 2 above), features were also placed into "Mesoriparian" and "Hydroriparian" groups. The project area was divided into three regions or geomorphic settings: 1) the active channel, 2) the adjoining terraces, and 3) the historic floodplain. The active channel refers to the area where water flows most frequently and where perennial flow would be found if it still existed. The terraces are the adjacent land features that are elevated only slightly above the active channel. Lower terraces might be flooded by a 2-5 year event and the upper terraces would be flooded by a 5-10 year event. The historic floodplain is the area adjacent to the entrenched channel of the Santa Cruz River. Although the historic floodplain has been cut off from the river due to down cutting resulting from human activities, in the past this area would have been flooded by infrequent events in the range of a 25-year and greater event.

Using the concepts of riparian communities and geomorphic setting a matrix of grouped features was created. This matrix is included as **Table 8-1**. The matrix allowed initial consideration of every potential combination of feature groups, including no action, to create forty-seven potential alternatives. Preliminary screening of these alternatives was accomplished applying three factors that embodied the planning objectives and constraints identified in the early stages of the study. Based on the planning objectives, alternatives were screened out that:

- Failed to provide sufficient area of diverse habitat
- Were inconsistent with the natural progression of riparian communities
- Were likely to produce unacceptable impacts on flood conveyance

The first criterion is relatively straightforward. In applying the first criteria both the number of cover types restored and the total acreage restored were taken into consideration. Alternatives restoring two or fewer riparian cover types were discarded unless they occupied all or most of the project area. Alternatives that restored only the active channel were considered too small unless they utilized the majority of that area.

The second criterion, "consistency with natural progression" merits some explanation. It is based on the fact that hydroriparian communities occur where water flows on or near the surface at all, or nearly all times of the year; mesoriparian communities experience occasional prolonged surface water flow and occur where subsurface water is usually within the reach of the roots of larger bushes and trees, and xeroriparian communities experience infrequent surface flows of shorter duration. In geomorphic terms, hydroriparian plants are most often found adjacent to the active channel or in the adjoining lower terraces. Mesoriparian plants would be found in the lower or upper terraces and xeroriparian would be found in the upper terraces or the historic floodplain. While diminished flows might lead to drier communities occurring nearing the active channel, one would never expect to find hydroriparian plants in the historic floodplain or to find a drier community near the channel with a wetter one up gradient at a greater distance from the channel.

As used in this analysis, the active channel includes primary low flow and any channel braids or back waters that would be inundated when the low flow channel is filled. With a few exceptions described later, alternatives that violated this "natural logic" were eliminated. The terraces refer to those areas elevated above the active channel but below the tops of the soil cement banks and their natural counter parts while the historic floodplain takes in the areas adjacent to the incised river that were historically part of the Santa Cruz River's riparian ecosystem.

Finally, while the Santa Cruz River channel has substantial capacity to convey flood flows, restoration measures that encourage the growth of thick stands of vegetation throughout the channel would reduce that capacity and run a high risk of inducing flood damages as a result. Therefore, alternatives that would create extensive new woody vegetation and obstructions in both the terraces and the active channel were eliminated.

Application of these screening criteria resulted in elimination of thirty-three (33) of the forty-seven (47) possible alternatives. The results of this screening are presented in **Table 8-2**. Those alternatives eliminated from further consideration are gray shaded.

Table 8-1 Alternative Features Matrix

	Active Channel Features	Floodplain Terrace Features	Historic Floodplain Features
No Action* (Without Project) *Listed items are anticipated consequences rather than measures to be implemented as in the other rows.	1. Continued instability of channel due to erosion. 2. Continued refuse dumping. 3. Continued degraded habitat.	1. Continued erosion loss of lower terraces creating cliff-like banks. 2. Eventual application of soil cement on unprotected banks armoring entire reach.	1. With expanded soil cement bank protection, continued historic floodplain encroachment by development.
Xero-Riparian (Establishment & Emergency Irrigation)	1. Construct aquitards upstream of existing and new grade control structures. 2. Divert low flow from New West Branch into remnant headwaters of Old West Branch. 3. Plantings of riparian grasses/shrubs	1. Water harvesting from local runoff. 2. Create tributary aquitard deltas with two-tiered aquitards. 3. Plantings on terraces and aquitards.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Water harvesting from local runoff. 3. Replace steep banks with stabilized planted terraces
Meso-Riparian (Irrigation)	1. Construct and provide supplemental irrigation to aquitards upstream of existing and new grade control structures. 2. Introduce periodic flow into the Old West Branch just upstream of its confluence with the Enchanted Hills Wash and on other tributaries downstream of that point. 3. Plantings of riparian grasses	1. Create tributary single-tiered aquitard deltas. 2. Irrigate and plant terraces with mesquite along upper terrace. 3. Stabilize active channel banks by establishing thickly rooted mesquite at the edge of the lower terraces.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Plant and irrigate historic floodplain. 3. Replace steep banks with stabilized planted terraces
Hydro-Riparian (Perennial Flow With Irrigation)	1. Restore perennial flow with multiple points of distribution into the main Santa Cruz and tributary channels. 2. Plant cottonwood-willow bundles at edges of perennial flow where erosion protection needed. 3. Construct perennial channel features (e.g., pools, runs, and riffles).	1. Create tributary aquitard deltas with hydraulic link to perennial flow. 2. Irrigate and plant low terraces with riparian grasses to maintain flood conveyance and discourage colonization by invasive species. 3. Irrigate and plant upper terraces with mesquite/cottonwood-willow.	Hydro Riparian plants do not occur in areas of the floodplain that are not subject to frequent inundation. Even so, measure 3 from the mesoriparian floodplain is carried forward to mitigate greater erosion risks associated with increased channel roughness in combinations where "No Action" is paired with Perennial Flow.

Table 8-2 Alternative Screening

Active Channel	Terraces	Floodplain	Screen Out	Reason
No Action	Xero	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	Xero	Meso	Yes	Not Consistent with Natural Pattern
No Action	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Meso	Xero		
No Action	Meso	Meso		
No Action	Meso	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Hydro	Xero	Yes	Not Consistent with Natural Pattern
No Action	Hydro	Meso	Yes	Not Consistent with Natural Pattern
No Action	Hydro	No Action	Yes	Not Consistent with Natural Pattern
No Action	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	No Action	Meso	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Meso	Yes	Not Consistent with Natural Pattern
Xero	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	Xero	Xero		
Xero	Xero	Meso	Yes	Not Consistent with Natural Pattern
Xero	Meso	No Action	Yes	Not Consistent with Natural Pattern
Xero	Meso	Xero	Yes	Not Consistent with Natural Pattern
Xero	Meso	Meso	Yes	Not Consistent with Natural Pattern
Xero	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Meso	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Meso	No Action	Xero	Yes	Not Consistent with Natural Pattern
Meso	No Action	Meso	Yes	Not Consistent with Natural Pattern
Meso	Xero	No Action		
Meso	Xero	Xero		
Meso	Xero	Meso	Yes	Not Consistent with Natural Pattern
Meso	Meso	No Action		
Meso	Meso	Xero		
Meso	Meso	Meso		
Meso	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Hydro	No Action	No Action		
Hydro	No Action	Xero	Yes	Not Consistent with Natural Pattern
Hydro	No Action	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Xero	No Action		
Hydro	Xero	Xero		
Hydro	Xero	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Meso	No Action	Yes	Too much reduction in conveyance
Hydro	Meso	Xero	Yes	Too much reduction in conveyance
Hydro	Meso	Meso	Yes	Too much reduction in conveyance
Hydro	Hydro	No Action		
Hydro	Hydro	Xero		
Hydro	Hydro	Meso		

9.0 WATER BUDGET FOR PROJECT ALTERNATIVES

The water budget analysis was generated based on total inflow and outflow in ac-ft/yr along the study reach of the Santa Cruz River basin in Township 14 South, Range 13 East, Sections 14, 22, 23, 25, 26, 27, 34 and 35, and Township 15, South, Range 13 East, Sections 2, 3, 10, 11, 14, and 15. A short description of contributing factors in the water budget calculations is provided below.

The 100 feet or more depth to existing groundwater, in combination with insufficient flows to support habitat, result in an existing conditions water budget that is incapable of supporting larger amounts of habitat. More efficient capturing and retention of the existing flood flows within the study area may result in an incremental increase in the amount of habitat that is supportable.

Each of the potential water sources has been evaluated based on the quality, quantity, and seasonality of flow. A few dependable and supplemental sources of water are available to supply the Santa Cruz River Restoration 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 Community, CAP, or TRAP could make other water sources available upon institutional commitments. These entities will need to decide if, how much, and when they will commit the water to the Santa Cruz River Restoration Project. The pumped withdrawal is not considered at this point, but it will be described in the future study with project conditions.

Water supply sources are summarized in **Table 9-1**. The total annual volume of secondary effluent produced at the two treatment plants is 74,000 acre-ft (28,000 acre-ft at Ina Road and 46,000 acre-ft at Rogers Road), out of which about 10,000 acre-ft of reclaimed water is currently utilized. Another secondary effluent (100 – 300 acre-ft) form the Avra Valley Wastewater Treatment Facility can be used as a potential water resource with the addition of an NO_3 removal system. Surface water sources available from Santa Cruz River gaging station (09482500) at Tucson (average annual volume of 17,681 acre-ft) and tributaries (average annual volume of 9,020 acre-ft) can also be used as potential water supply sources. Thus, if one considers only the total annual irrigation need (55 to 8978 acre-ft/year) and the total available supply from different sources, it seems that the total irrigation need can be supplied by any one of the supply sources from reclaimed water, Santa Cruz River flows or tributary flows. However, a closer look at the variability of seasonal or monthly flows of the Santa Cruz River and tributaries indicate that, in a given month, the available flow can vary from zero (minimum) to the maximum (which is typically several times mean flow for that month). This monthly variation for the Santa Cruz River is very similar for the tributaries, as can be seen from the available stream flow records in similar watersheds located in the vicinity of the study. Availability of water from Santa Cruz River or tributaries is therefore subject to considerable uncertainty. Based on this consideration, available water supply and irrigation need for each alternative plan are summarized in **Table 9-1** and **Table 9-2**.

The estimate of volume of water that can be harvested from tributaries is approximate and is likely to increase depending on the availability of water at a given time and operation of tributary basins. However, considering the extreme variability of tributary flows as discussed above, it is suggested that an irrigation system be designed to meet all consumptive needs of vegetation using secondary effluent or reclaimed water, and utilize harvested water whenever possible, so that a reliable supply of irrigation water is provided during the initial establishment period. Adequate supply of reclaimed water is available to meet the requirements under this scenario; Roger Road Treatment Plant currently produces 46,000 acre-ft/year, compared to about 55 to 8,978 acre-ft/year of irrigation needed for the alternative plans. Use of groundwater as an alternative source for irrigation is not considered for this project because, according to the regulatory policy of the Arizona Department of Water Resources, groundwater withdrawal for irrigation use is allowed only if "grandfather" rights exist for such withdrawal. An "adaptive management" plan should be developed during the design process and implemented during project operation to maximize the use of harvested water and reduce the use of reclaimed water.

Table 9-1 Summary of Potential Water Resources

Water Supply Sources	Acre-ft/year	MGD
Reclaimed Water	~ 64,000 [1]	~ 57.14
Surface Water: Santa Cruz River	~ 17,681 [2]	~ 15.78
Surface Water: Tributaries	~ 9,020 [3]	~ 8.05
Secondary Effluents	~ 1,343 [4] – 3,577 [5]	~ 1.2 – 3.2
Storm Drains	Unknown [6]	Unknown

[1] Combined capacity of Ina and Rogers Road Treatment Plants (74,000 acre-ft) minus 10,000 acre-ft of Total current usage.

[2] Average annual runoff of Santa Cruz River gaging station at Tucson (09482500), which is, included the runoff (~9,020 acre-ft/year) from tributaries.

[3] Estimated average annual runoff.

[4] Approximate existing Avra Valley WWTF Capacity. Source: Avra Valley Basin Study, Pima County Wastewater management Department (July 2002)

[5] Approximate future (2012) Avra Valley WWTF Capacity. Source: Avra Valley Basin Study, Pima County Wastewater management Department (July 2002)

[6] It is a possible water source; insufficient data to estimate average annual volumes.

Table 9-2 Summary of Water Demands for Alternatives

Functional Assessment Tool Name[1]	GROUP: Active Channel	GROUP: Terraces	GROUP: Floodplain	PRECIP: Ann. Avg. Precip. (ft/yr)[2]	PERENNIAL CHANNEL: AREA (acres)	PERENNIAL CHANNEL: Evaporation Loss (ft/yr)[3]	PERENNIAL CHANNEL: Infiltration Loss (ft/yr)[4]	XERORIPARIAN: Shrub Scrub Area (acres)	XERORIPARIAN: Shrub Scrub Water Demand (ft/yr)	XERORIPARIAN: Mesq. (acres)	XERORIPARIAN: Mesq. Water Demand (ft/yr)	XERORIPARIAN: Emergent Marsh (acres)	XERORIPARIAN: Emergent Marsh Water Demand (ft/yr)
NMX	No Action	Meso	Xero	0.93		5.40	321.20	693	1.00	294	1.60		5.00
NMM	No Action	Meso	Meso	0.93		5.40	321.20		1.00		1.60		5.00
XXX	Xero	Xero	Xero	0.93		5.40	321.20	867	1.00	252	1.60	6	5.00
MXN	Meso	Xero	No Action	0.93		5.40	321.20	174	1.00	19	1.60		5.00
MXX	Meso	Xero	Xero	0.93		5.40	321.20	862	1.00	257	1.60		5.00
MMN	Meso	Meso	No Action	0.93		5.40	321.20		1.00		1.60		5.00
MMX	Meso	Meso	Xero	0.93		5.40	321.20	688	1.00	238	1.60		5.00
MMM	Meso	Meso	Meso	0.93		5.40	321.20		1.00		1.60		5.00
HNN	Hydro	No Action	No Action	0.93	19.00	5.40	321.20		1.00		1.60		5.00
HXN	Hydro	Xero	No Action	0.93	19.00	5.40	321.20	181	1.00	14	1.60		5.00
HXX	Hydro	Xero	Xero	0.93	19.00	5.40	321.20	867	1.00	252	1.60		5.00
HHN	Hydro	Hydro	No Action	0.93	19.00	5.40	321.20		1.00		1.60		5.00
HHX	Hydro	Hydro	Xero	0.93	19.00	5.40	321.20	624	1.00	116	1.60		5.00
HHM	Hydro	Hydro	Meso	0.93	19.00	5.40	321.20		1.00		1.60		5.00

Functional Assessment Tool Name[1]	MESORIPARIAN: Shrub Scrub Area (acres)	MESORIPARIAN: Shrub Scrub Water Demand (ft/yr)	MESORIPARIAN: Mesq. (acres)	MESORIPARIAN: Water Demand (ft/yr)	MESORIPARIAN: CWW (acres)	MESORIPARIAN: CWW Water Demand (ft/yr)	MESORIPARIAN: Emergent Marsh (acres)	MESORIPARIAN: Emergent Marsh Water Demand (ft/yr)
NMX		2.00	122	3.00	10	7.50		6.00
NMM	471	2.00	638	3.00	10	7.50		6.00
XXX		2.00		3.00		7.50		6.00
MXN		2.00		3.00		7.50	6	6.00
MXX		2.00		3.00		7.50	6	6.00
MMN		2.00	183	3.00	10	7.50	6	6.00
MMX		2.00	183	3.00	10	7.50	6	6.00
MMM	466	2.00	643	3.00	10	7.50	6	6.00
HNN	69	2.00	122	3.00		7.50		6.00
HXN	62	2.00	122	3.00	69	7.50	59	6.00
HXX		2.00		3.00		7.50		6.00
HHN	69	2.00	122	3.00		7.50		6.00
HHX	69	2.00	122	3.00		7.50		6.00
HHM	465	2.00	466	3.00		7.50		6.00

Functional Assessment Tool Name[1]	HYDRORIPARIAN: Shrub Scrub Area (acres)	HYDRORIPARIAN: Shrub Scrub Water Demand (ft/yr)	HYDRORIPARIAN: Mesq. (acres)	HYDRORIPARIAN: Mesq. Water Demand (ft/yr)	HYDRORIPARIAN: CWW (acres)	HYDRORIPARIAN: CWW Water Demand (ft/yr)	HYDRORIPARIAN: Emergent Marsh (acres)	HYDRORIPARIAN: Emergent Marsh Water Demand (ft/yr)	TOTAL: Area (acres)	TOTAL: Water Demand (acre-feet/yr)	TOTAL: Water Demand (mgd)
NMX		3.00		4.00		8.50		7.00	1119	562.52	0.50
NMM		3.00		4.00		8.50		7.00	1119	1889.12	1.69
XXX		3.00		4.00		8.50		7.00	1125	252.73	0.23
MXN		3.00		4.00		8.50		7.00	199	55.11	0.05
MXX		3.00		4.00		8.50		7.00	1125	261.73	0.23
MMN		3.00		4.00		8.50		7.00	199	474.71	0.42
MMX		3.00		4.00		8.50		7.00	1125	681.33	0.61
MMM		3.00		4.00		8.50		7.00	1125	1924.53	1.72
HNN		3.00		4.00	69	8.50	59	7.00	338	7394.19	6.60
HXN		3.00		4.00		8.50		7.00	526	7280.55	6.50
HXX		3.00		4.00	69	8.50	59	7.00	1266	7296.35	6.51
HHN	112	3.00	46	4.00	79	8.50	59	7.00	506	7842.77	7.00
HHX	112	3.00	46	4.00	79	8.50	59	7.00	1246	7963.37	7.11
HHM	112	3.00	46	4.00	79	8.50	59	7.00	1246	8977.77	8.01

[1] Alternatives are designed by combinations of four characters into groups of three. The letter used are N for no action, X for xeroriparian, M for mesoriparian, and H for hydroriparian. Each letter represents a row from the Alternative Features Matrix with the order of letter aligned to the columns.
For example, alternative HMN would be the result of combining hydroriparian active channel features and mesoriparian terrace features with no action in the historic floodplain.
[2] Average annual precipitation (1894-2002) at Tucson WFO (8815)station
[3] Environmental Restoration in Pima County/Pima County Administrator's Office/Dec. 1999
[4] Long term loss (0.88 ft/day), Galyean (1996)

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10.0 REFERENCES

Any studies have been conducted pertaining to water and related land resources within the study area. These studies have examined themes including development trends, environmental resources, water supply, groundwater recharge, wastewater management, flooding and erosion, geology, cultural resources, history, and recreation. The following is not intended to be a comprehensive list of previous reports, but to provide a sample of the types of studies that have been completed in the study area.

Cluff C.B., Katz, L.T., and Scovill, G.L., 1987, Effects of Channel Stabilization in Tucson Stream Reaches on Infiltration and Groundwater Recharge, Pima County Department of Transportation and Flood Control District

USGS, Water Resources Data Arizona Water Year (1996-2000)

Paseo de las Iglesias Draft Biological Resources Data, Prepared by Tetra Tech, Inc. for US Army Corps of Engineers

Statistical Summaries of Arizona Streamflow Data, USGS Water Resources Investigation

El Rio Antiguo Feasibility Report, Rillito River, Pima County, Arizona, US Army Corps of Engineers

Rio Salado Salt River, Arizona, Feasibility Report, Technical Appendices, US Army Corps of Engineers

Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01E Water Budget Draft Report (May, 2002), Prepared by Knight Piesold and Co.

Paseo de las Iglesias, Pima County, Arizona - Reconnaissance Phase Study, 905B Analysis (1999) Pima County, Arizona

Reconnaissance Phase Study, 905B Analysis (September 2000) *(Includes Tres Rio del Norte and Agua Caliente),* U.S. Army Corps of Engineers Los Angeles District

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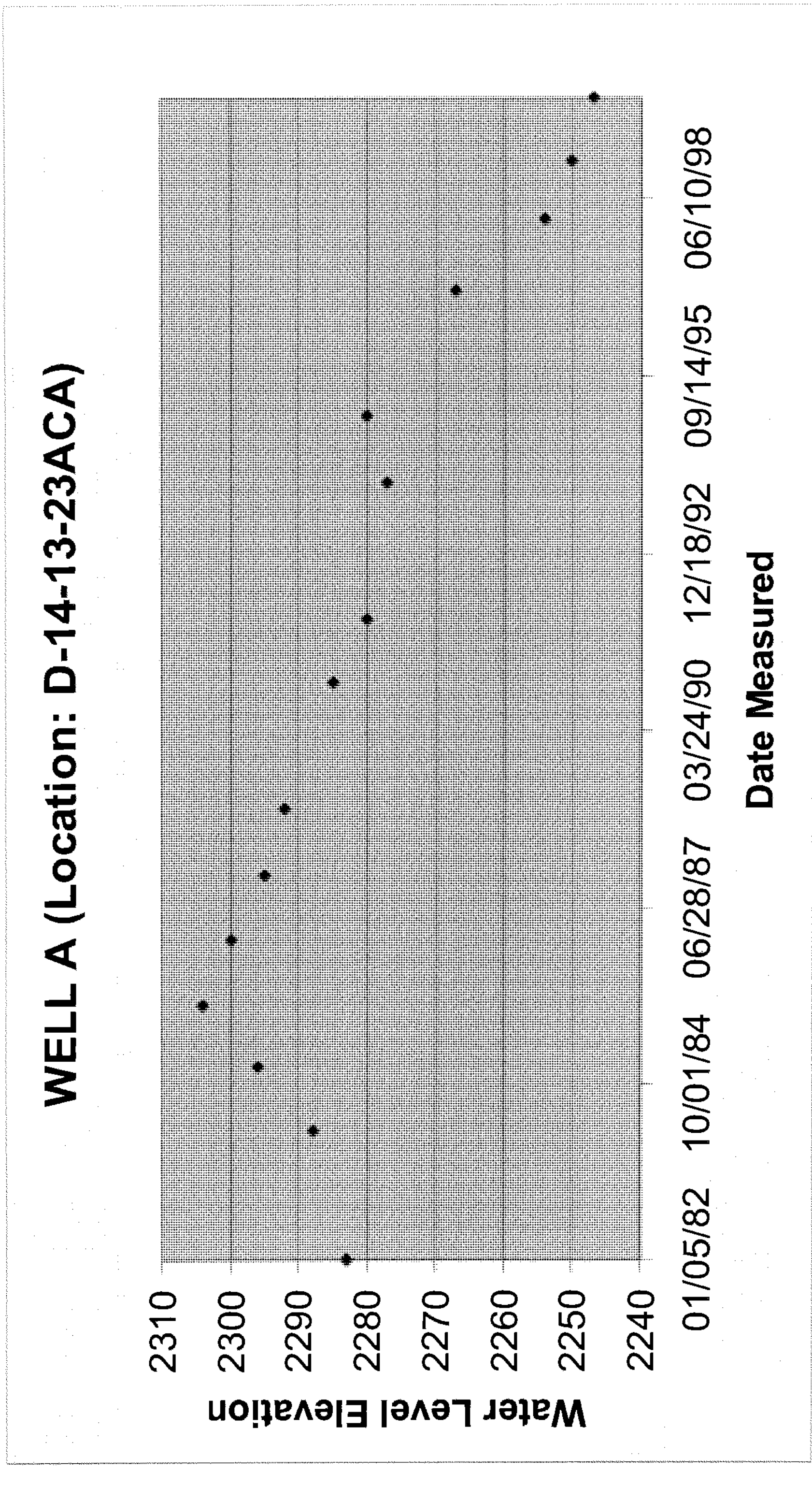
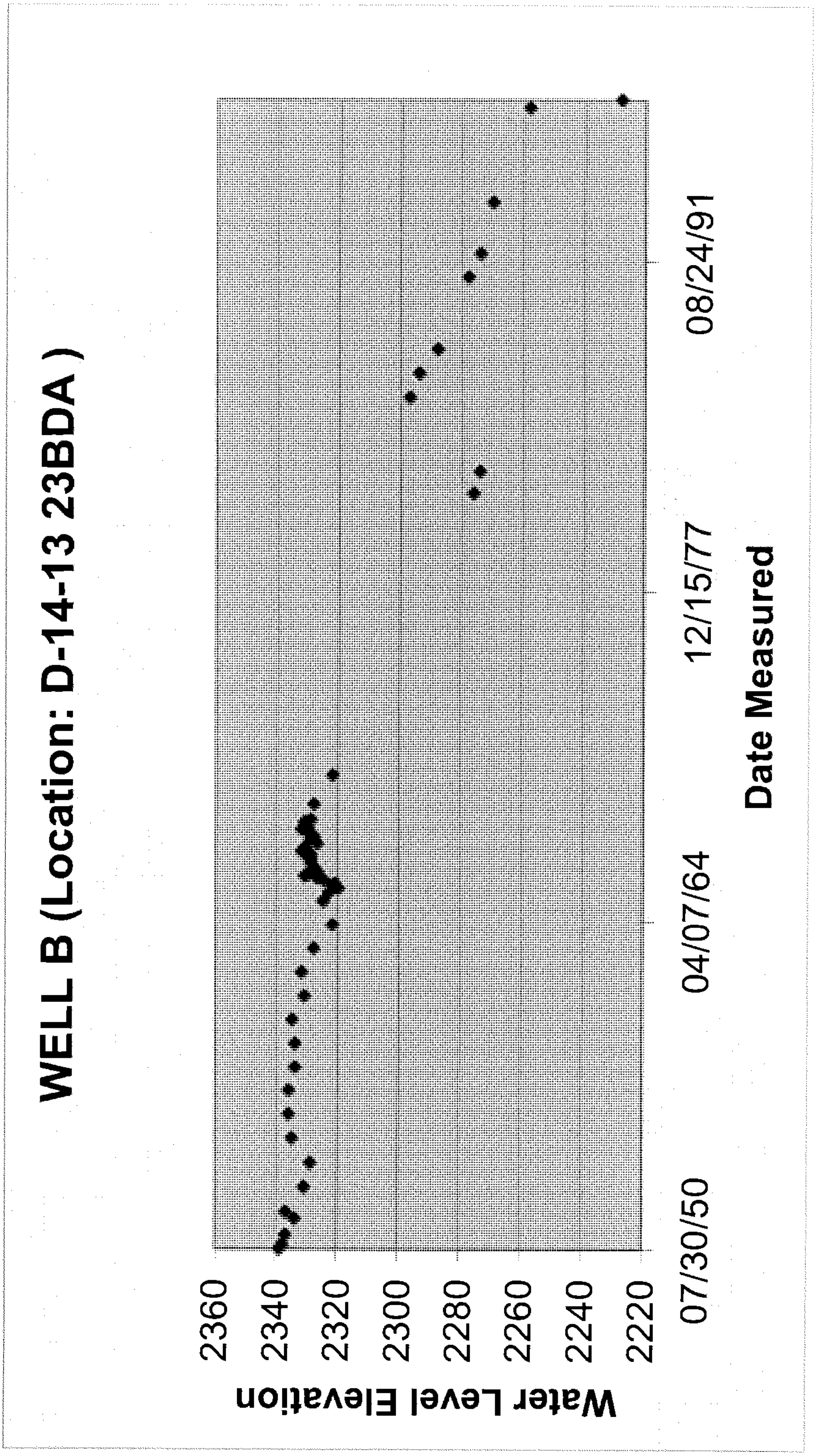
Galyean, K. , 1996, Infiltration of Wastewater Effluent in the Santa Cruz River Channel, Pima County, Arizona: U.S. Geological Survey Water-Resource Investigation Report 96-4021.

APPENDIX A

Groundwater Level Elevation


WELL A (Location: D-14-13-23ACA)
Water Level Elevation
2310
2300
2290
2280
2270
2260
2250
2240
01/05/82
10/01/84
06/28/87
03/24/90
12/18/92
09/14/95
06/10/98
Date Measured


WELL B (Location: D-14-13 23BDA)
Water Level Elevation
2360
2340
2320
2300
2280
2260
2240
2220
07/30/50
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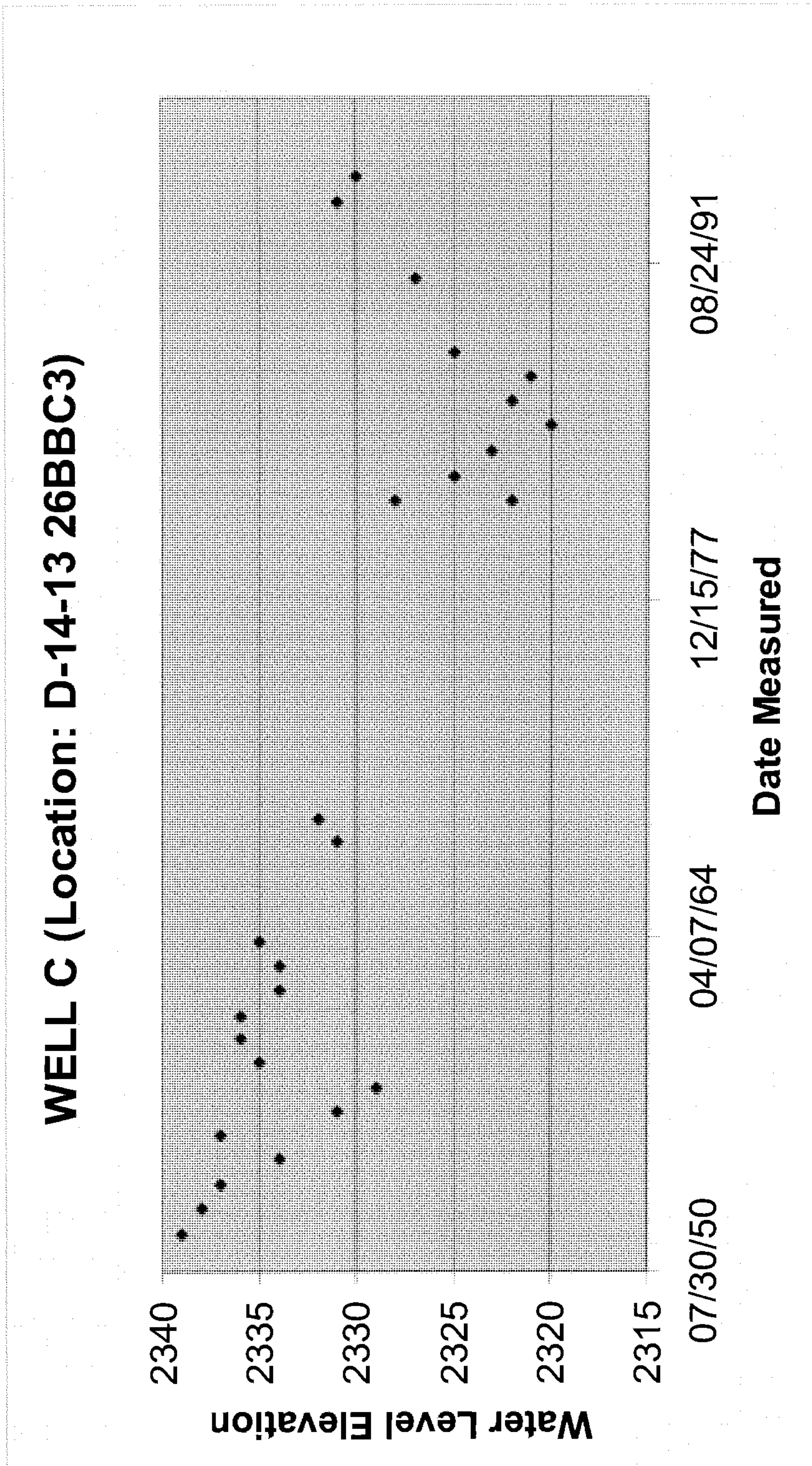
12/15/77
08/24/91
Date Measured


WELL C (Location: D-14-13 26BBC3)
Water Level Elevation
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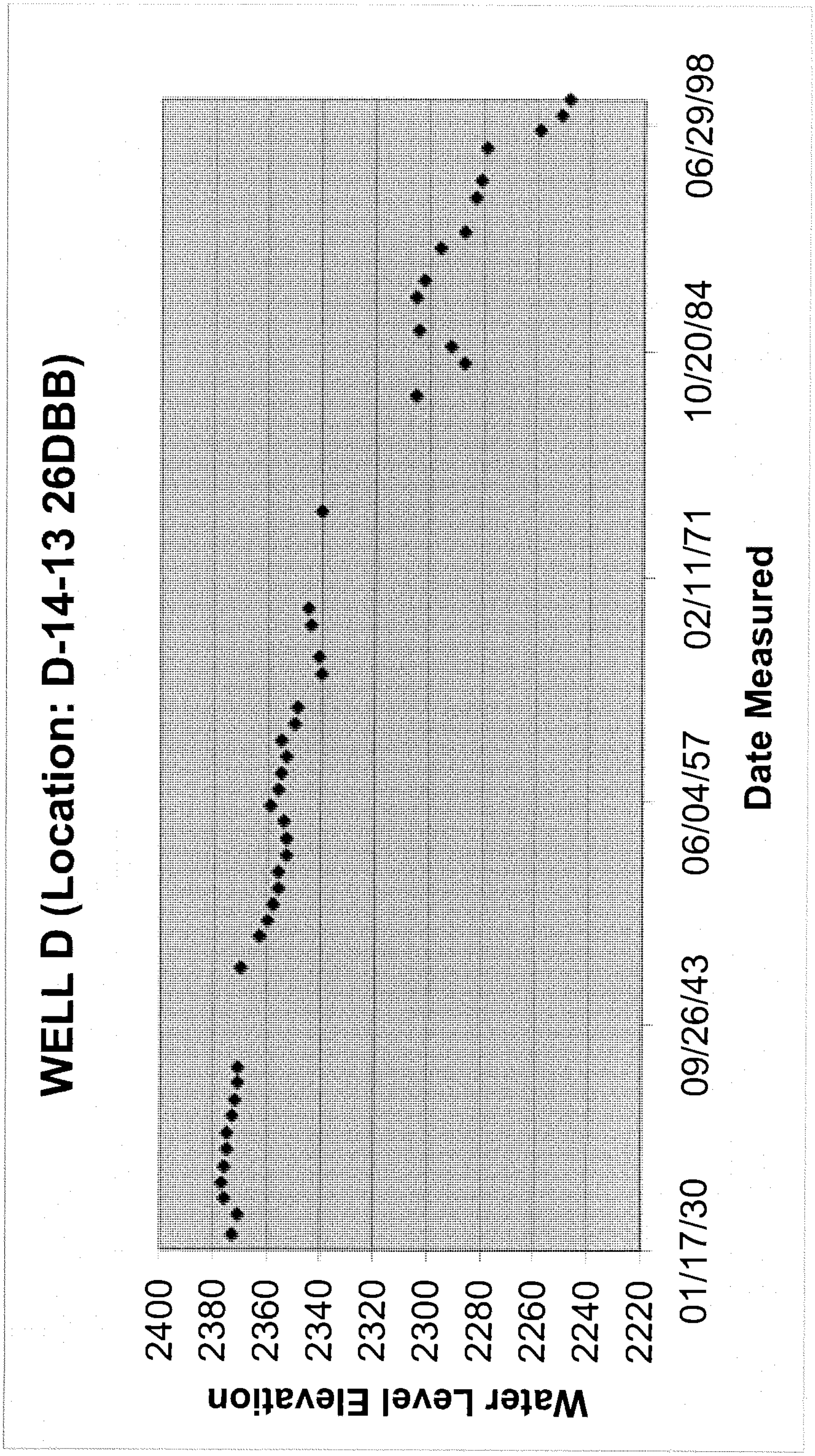
2335
2330
2325
2320
2315
07/30/50
04/07/64
12/15/77
08/24/91
Date Measured


WELL D (Location: D-14-13 26DBB)
Water Level Elevation
2400
2380
2360
2340
2320
2300
2280
2260
2240
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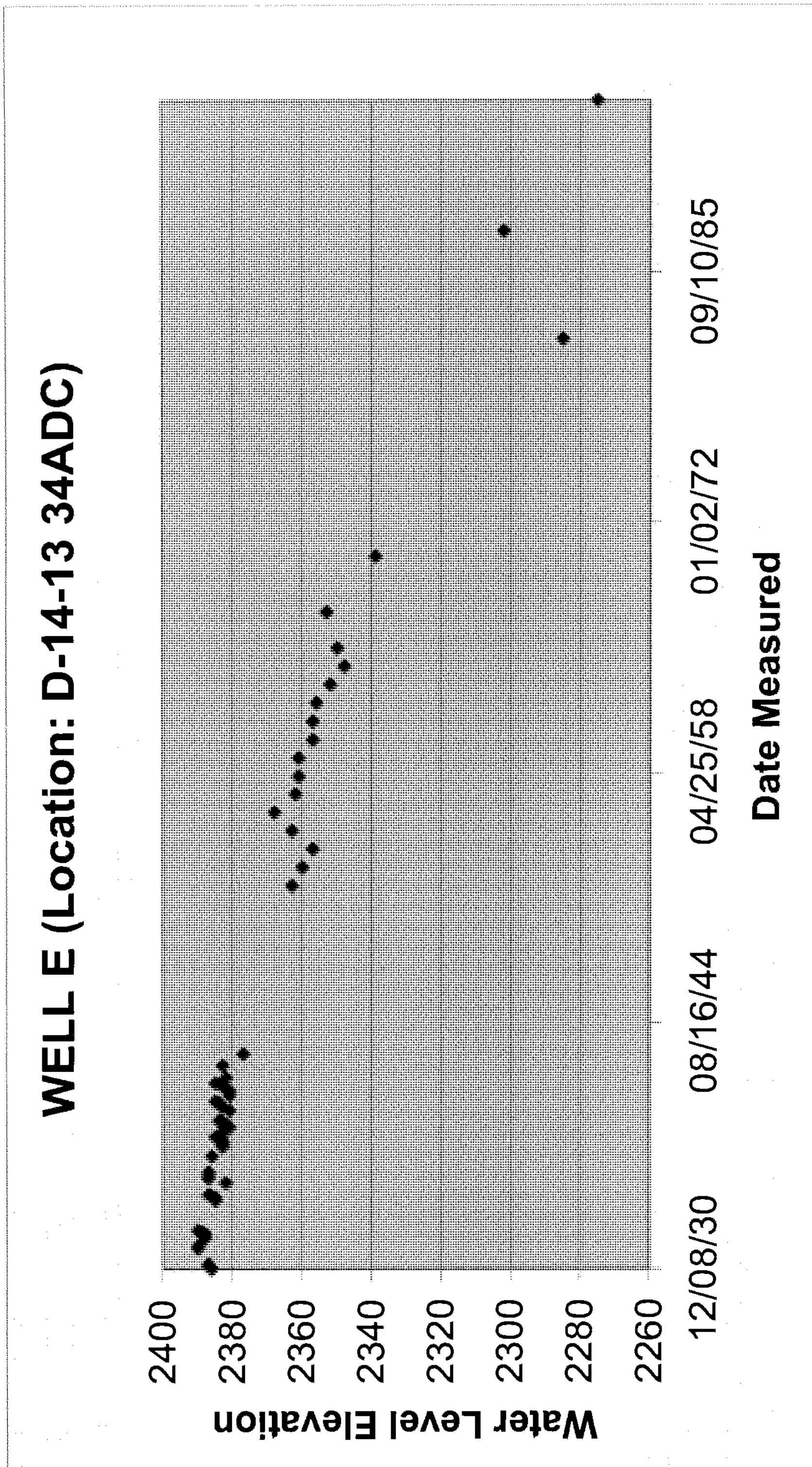
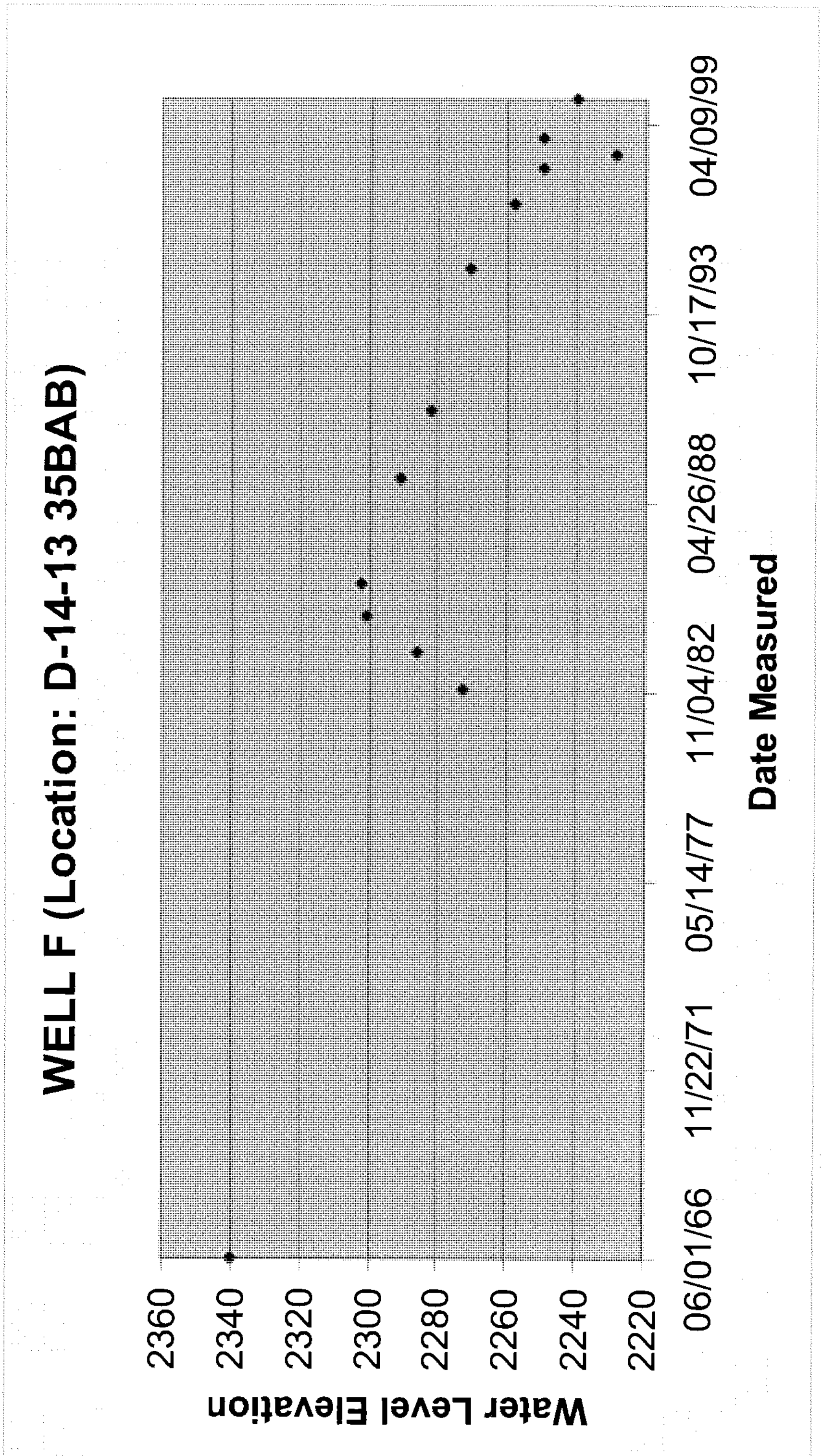
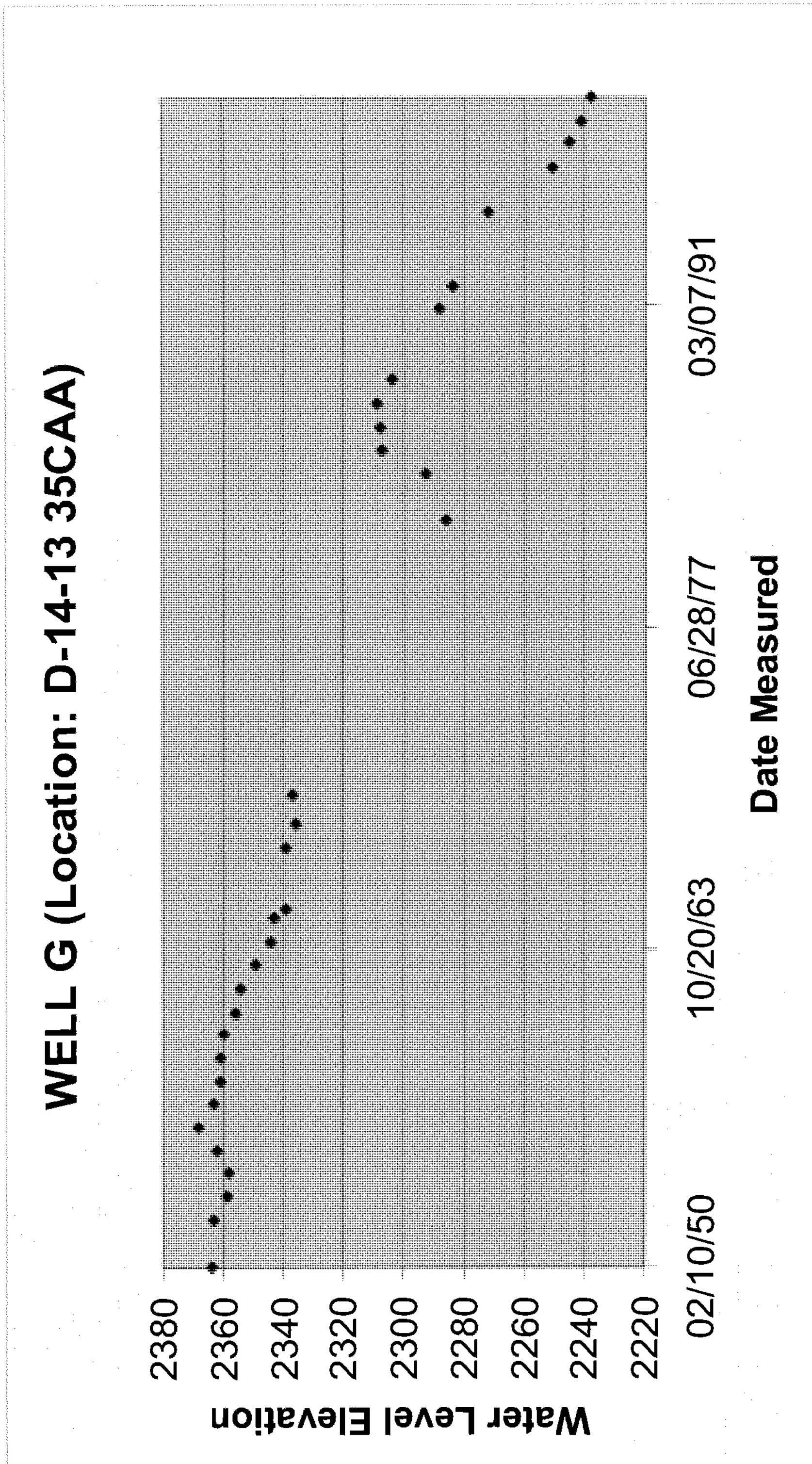
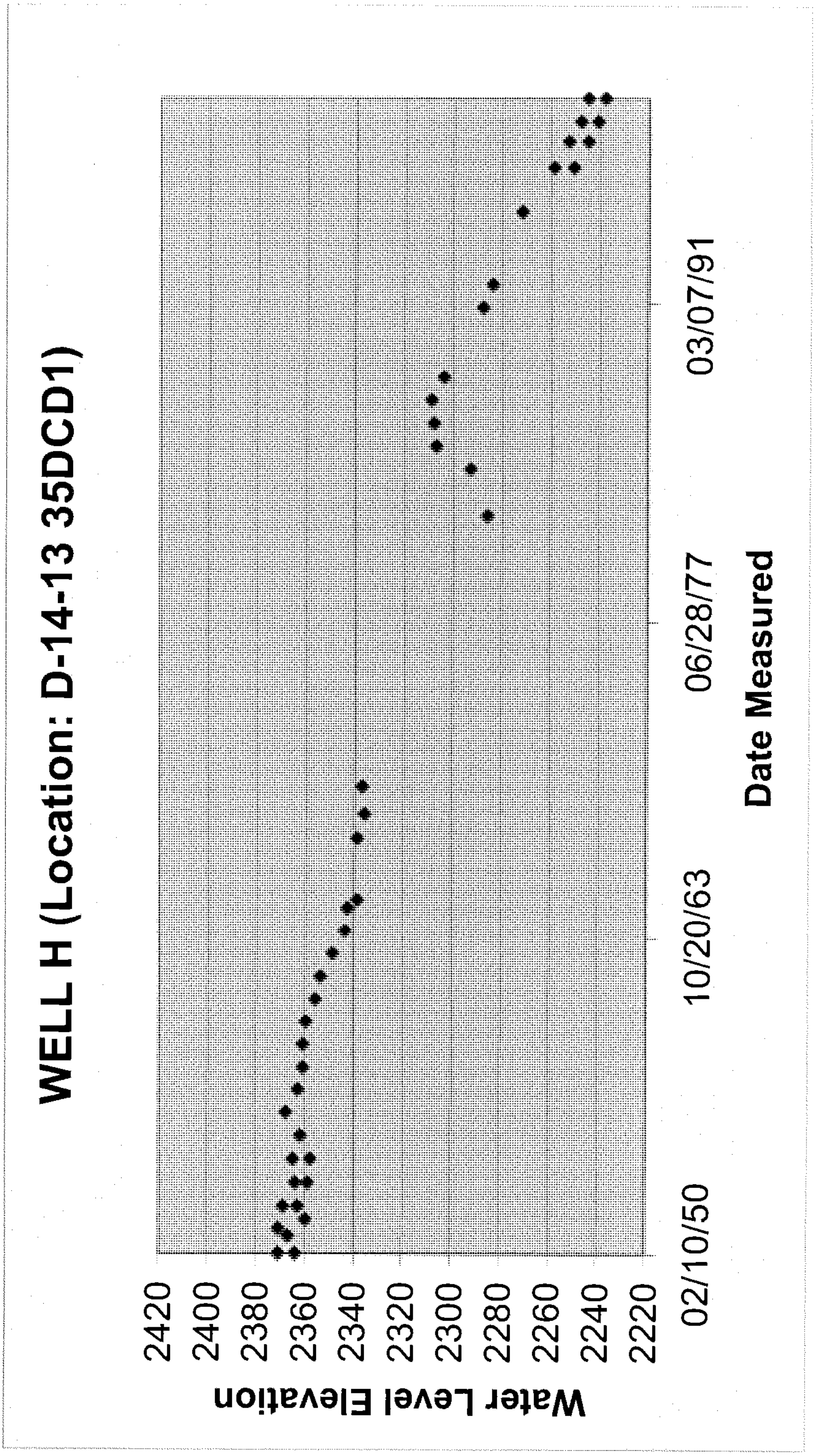
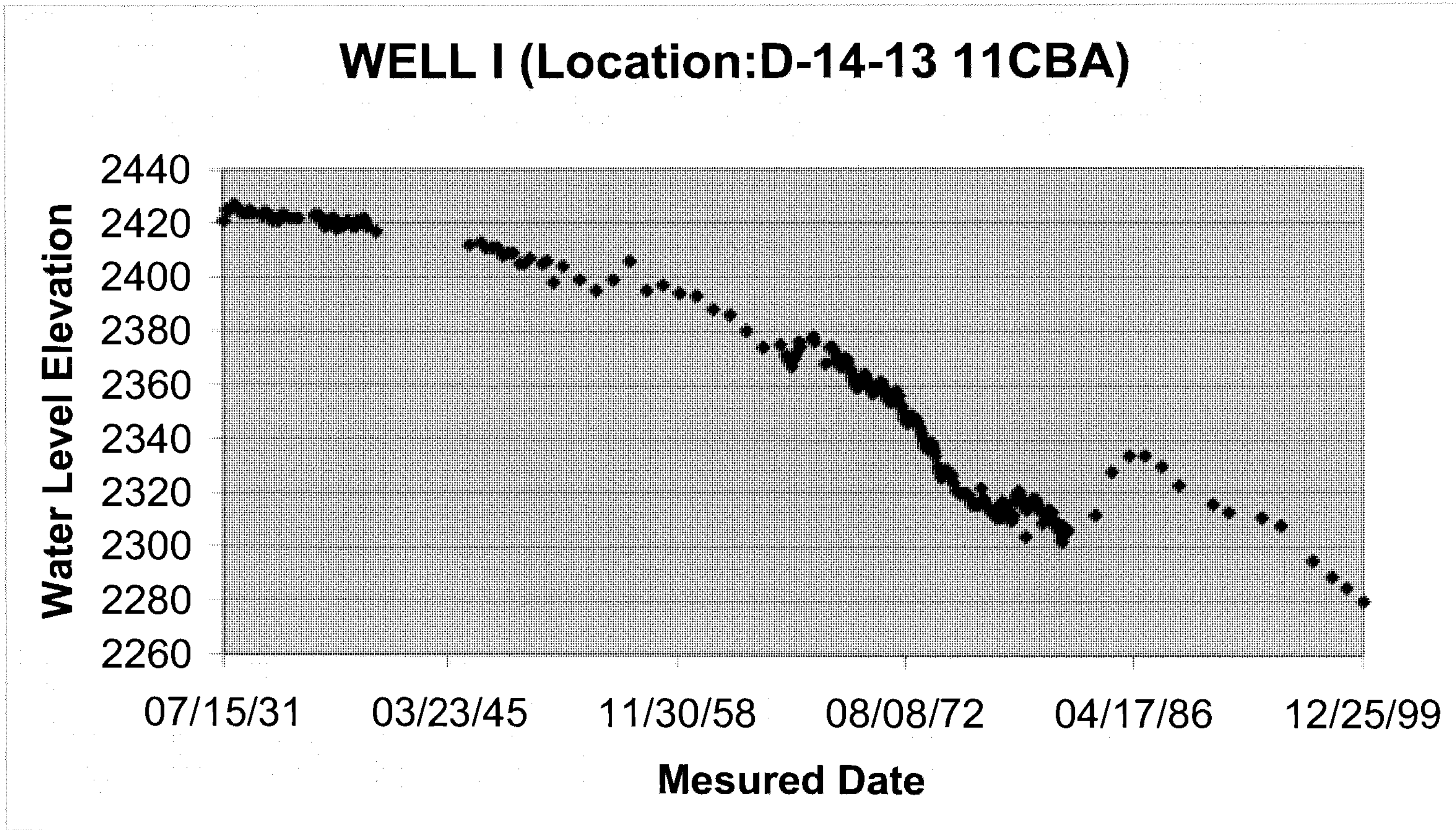
06/04/57
02/11/71
10/20/84
06/29/98
Date Measured

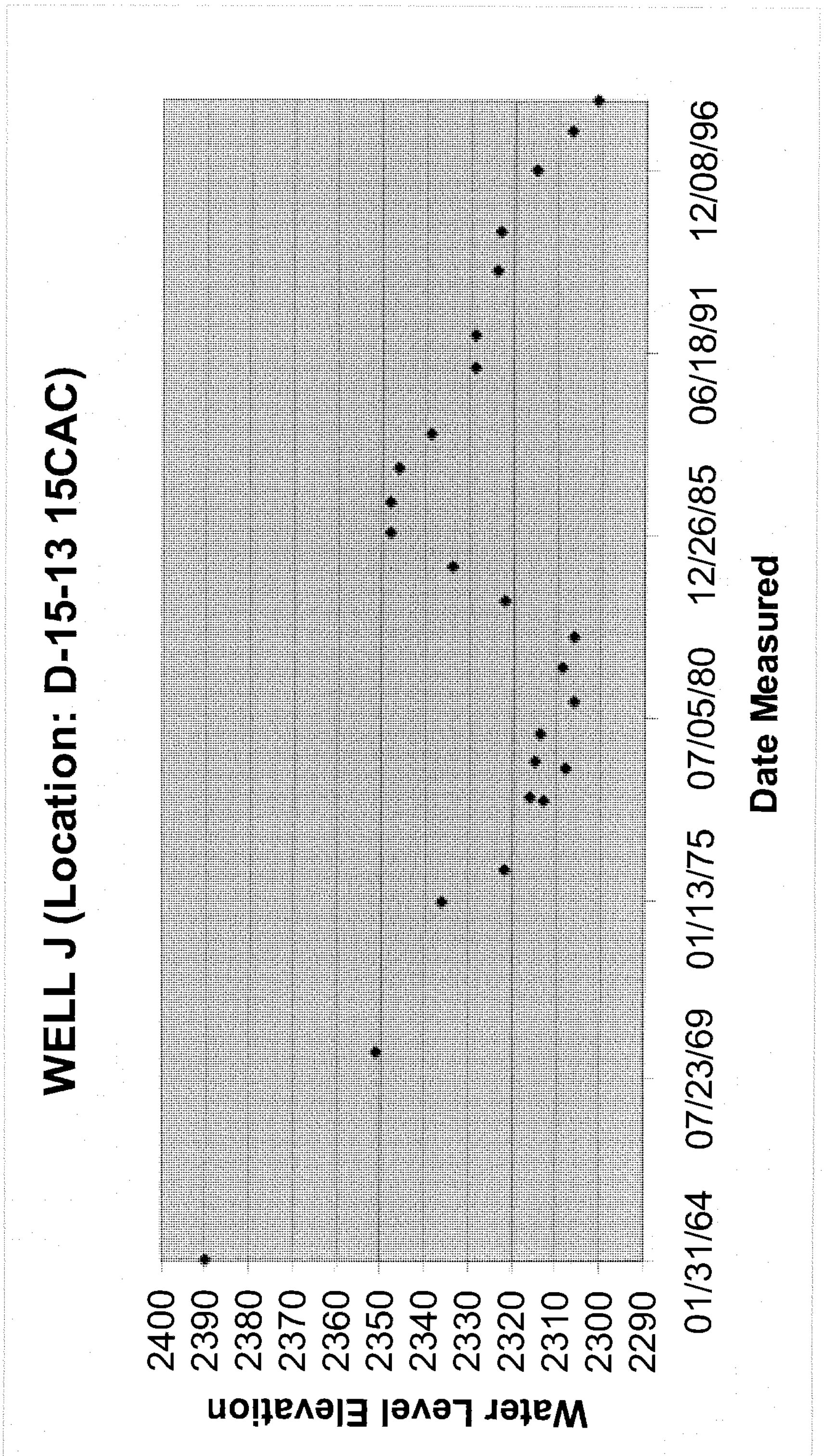

WELL E (Location: D-14-13 34ADC)
Water Level Elevation
2400
2380
2360
2340
2320
2300
2280
2260
12/08/30
08/16/44
04/25/58
01/02/72
09/10/85
Date Measured


WELL F (Location: D-14-13 35BAB)
Water Level Elevation
2360
2340
2320
2300
2280
2260
2240
2220
06/01/66
11/22/71
05/14/77
11/04/82
04/26/88
10/17/93
04/09/99
Date Measured

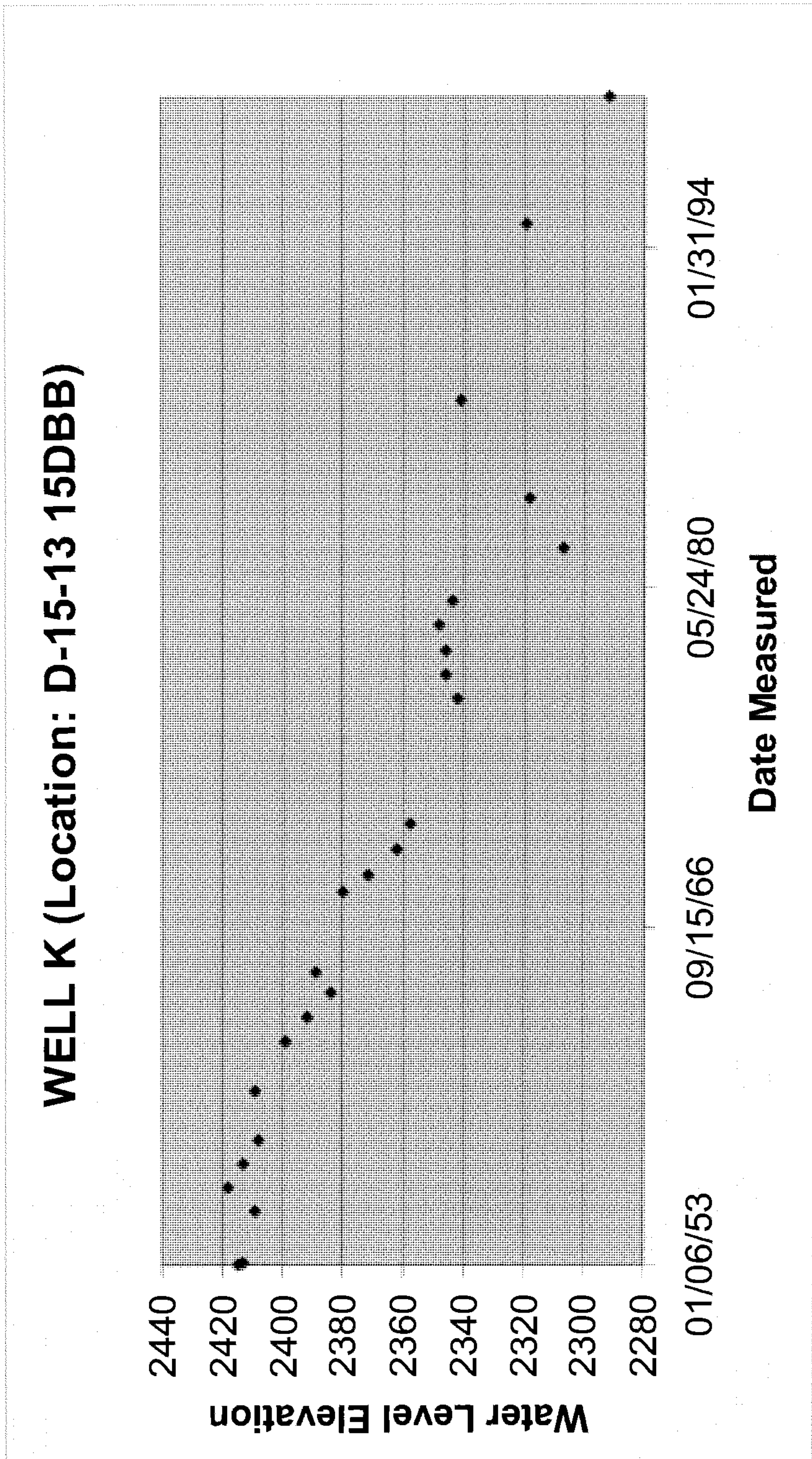

WELL G (Location: D-14-13 35CAA)
Water Level Elevation
2380
2360
2340
2320
2300
2280
2260
2240
2220
02/10/50
10/20/63
06/28/77
03/07/91
Date Measured


WELL H (Location: D-14-13 35DCD1)
Water Level Elevation
2420
2400
2380
2360
2340
2320
2300
2280
2260
2240
2220
02/10/50
10/20/63
06/28/77
03/07/91
Date Measured


WELL I (Location:D-14-13 11CBA)
Water Level Elevation
2440
2420
2400
2380
2360
2340
2320
2300
2280
2260
07/15/31
03/23/45
11/30/58
08/08/72
04/17/86
12/25/99
Mesured Date



WELL J (Location: D-15-13 15CAC)
Water Level Elevation
2400
2390
2380
2370
2360
2350
2340
2330
2320
2310
2300
2290
01/31/64
07/23/69
01/13/75
07/05/80
12/26/85
06/18/91
12/08/96
Date Measured


WELL K (Location: D-15-13 15DBB)
Water Level Elevation
2440
2420
2400
2380
2360
2340
2320
2300
2280
01/06/53
09/15/66
05/24/80
01/31/94
Date Measured

APPENDIX B

Groundwater Quality Data Table

Groundwater Quality Text Value*

Well ID	Collect data	pH	TDS	Bromide	Chloride	Fluoride	Nitrate as N	Surfate	Bicarbonate Alkalinity	Carbonate Alkalinity	Total Alkalinity	Calcium	Magnesium	Potassium	Sodium
D-14-13 35CAC	2-Mar-00	7.60	892	0.17	70	0.52	7.8	332	237		237	143	28	3.8	99
D-14-13 35CAC	8-May-00	7.30	901	0.14	71	0.45	7.8	334	237		237	143	28	3.9	101
D-14-13 35CAC	20-Nov-01	7.06		0.12	70	0.43	7.7	275	237		237	149	29		98
D-14-13 26ACC	2-Aug-00	8.60	324	0.14	17	1.5	1.3	95	95	<20	111	7.1	0.63	1.2	96
D-14-13 26ACC	13-Dec-00	8.35	326	0.13	12	0.78	2.3	98	119	<20	134	9.4	0.87	1.3	103
D-14-13 26ACC	25-Jun-01	6.92	349	0.13	13	1.2	1.6	98	113	<20	126	8	0.76	0.99	101
D-14-13 26ACC	10-Sep-01	8.16	351	0.14	13	1.1	1.7	95	108	<20	124	8	0.71	0.99	104
D-14-13 26ACC	30-May-02	8.77	320	0.11	14	1.3	1.4	101	102	<20	116	7.2	0.64		
D-14-13 35CAD	23-Feb-00		771	0.53	55	0.74	6.4	286	212		212	124	23	4.1	96
D-14-13 35CAD	16-May-00	7.20	791	0.56	58	0.65	6.6	304	210		210	128	24	4.1	97
D-14-13 35CAD	20-Nov-01	7.12		0.57	60	0.62	6.9	264	208		208	129	24		98
D-14-13 23BAD	2-Mar-00	7.40	674	<0.1	43	0.86	4.6	191	272		272	83	16	3	82
D-14-13 23BAD	12-Apr-00	7.26	675	0.073	41	0.81	4.5	183	276		276	94	18	3.6	95
D-14-13 23BAD	11-Apr-01					0.71	4.9								110
D-14-13 23BAD	31-Oct-01	7.24		0.41	42	0.68	4.6	196	300		300	109	21		96
D-14-13 23BAD	24-Jun-02	7.06					4.6								
D-15-13 02CAA	23-Feb-00	7.20	564	0.45	52	0.62	4.4	149	213		213	85	16	3.1	75
D-15-13 02CAA	8-May-00	7.37	581	0.43	51	0.52	4.4	153	216		216	88	16	3.1	77
D-15-13 02CAA	26-Nov-01	7.20		0.41	49	0.49	4.4	162	214		214	82	17		75
D-14-13 14ABC	30-Mar-00	7.78	712	0.31	38	1.4	2.9	248	246		246	71	11	3.7	151
D-14-13 14ABC	6-Sep-00	7.26	712	0.32	39	1.5	3	258	247		247	73	11	2.7	150
D-14-13 14ABC	12-Dec-00	7.14	699	0.25	37	1.4	2.9	246	240		240	73	11	3.6	146
D-14-13 14ABC	21-Mar-01	7.06	712	0.31	36	1.5	3	235	246		246	76	12	3.1	160
D-14-13 14ABC	12-Jun-01	7.41	703	<0.5	33	1.5	3	247	249		249	74	11	3.2	151
D-14-13 14ABC	3-Jul-01	7.23		0.31	36	1.4	3	245				74	11		154
D-14-13 14ABC	1-Aug-01	7.67		0.31	36	1.3	3	248				75	12		157
D-14-13 14ABC	6-Sep-01	7.61	727	0.29	36	1.2	3	248	245		245	74	11	3	155
D-14-13 14ABC	2-Oct-01	8.24		0.31	36	1.3	3	238				68	10		146
D-14-13 14ABC	5-Nov-01	7.37		0.3	35	1.3	3	242				74	11		155

Groundwater Quality Text Value* (Continue)

Well ID	Collect data	pH	TDS	Bromide	Chloride	Fluoride	Nitrate as N	Surfate	Bicarbonate Alkalinity	Carbonate Alkalinity	Total Alkalinity	Calcium	Magnesium	Potassium	Sodium
D-14-13 14ABC	4-Dec-01			0.3	35	1.3	3	244				73	11		154
D-14-13 14ABC	3-Jan-02	7.51		0.28	35	1.3	3	248				74	11		143
D-14-13 14ABC	4-Feb-02	7.10		0.3	36	1.3	3	244				70	11		139
D-14-13 14ABC	7-Mar-02	7.41		0.32	36	1.3	3	250				74	12		149
D-14-13 14ABC	2-Apr-02	7.23		0.3	36	1.3	3	263				74	12		144
D-14-13 14ABC	13-May-02	7.32		0.3	36	1.3	3	264				81	13		158
D-14-13 14ABC	3-Jun-02	7.27	698	0.3	36	1.3	3	264	247		247	77	12	3.1	149
D-14-13 14ABC	3-Jul-02	7.44		0.3	36	1.3	3	264							
D-14-13 14ACA	30-Mar-00	7.38	476	0.11	16	0.98	3.3	120	225		225	52	8.4	3.5	102
D-14-13 14ACA	6-Sep-00	7.32	458	0.12	16	1.1	3.3	117	223		223	48	6.8	2.4	94
D-14-13 14ACA	12-Dec-00	7.23	438	0.12	16	1	3.2	108	219		219	51	8.2	3.5	100
D-14-13 14ACA	21-Mar-01	7.03	439	<0.1	16	1.1	3.1	104	218		218	51	7.2	2.1	100
D-14-13 14ACA	12-Jun-01	7.80	429	<0.1	15	1	3	106	221		221	47	6.6	2.4	92
D-14-13 14ACA	3-Jul-01	7.34		<0.1	16	1	3.1	102				46	6.4		91
D-14-13 14ACA	1-Aug-01	7.80		<0.1	16	0.97	3	101				48	6.6		90
D-14-13 14ACA	5-Sep-01	7.48	450	<0.1	16	0.95	3	100	220		220	48	6.8	2.6	99
D-14-13 14ACA	2-Oct-01	8.62		<0.1	16	0.95	3.1	99				44	6.2		93
D-14-13 14ACA	5-Nov-01	7.41		<0.1	16	0.93	3	99				45	6.3		94
D-14-13 14ACA	4-Dec-01			<0.1	16	0.96	3	98				46	6.5		95
D-14-13 14ACA	3-Jan-02	7.46		<0.1	16	0.97	3	100				49	6.9		94
D-14-13 14ACA	4-Feb-02	7.10		<0.1	16	0.96	3	101				45	6.2		86
D-14-13 14ACA	7-Mar-02	7.45		<0.1	16	1	3	96				46	6.4		91
D-14-13 14ACA	2-Apr-02	7.27		<0.1	16	1	3	104				46	6.3		90
D-14-13 14ACA	8-May-02	7.38		<0.1	16	1	3	104				45	6.3		89
D-14-13 14ACA	3-Jun-02	7.21	426	<0.1	16	0.98	3	104	218		218	48	6.7	2.6	95
D-14-13 14ACA	3-Jul-02	7.40		<0.1	16	1	2.9	103							

UNITS (mg/l)

Text Value*:This field is the analysis results including the values that are less than (<) the detction limit. The numbers are generated from the database as text because of the inclusion of the "less than symbol" and to use them as numbers they must be

APPENDIX C

Tributary Analysis

I. INTRODUCTION

This appendix presents results of additional analyses for Groundwater and Water Budget Analysis performed in support of the feasibility study for the Paseo de las Iglesias Environmental Restoration Study. The following sections describe the procedures and estimates of average annual and monthly streamflows for the Santa Cruz River and tributaries joining the East and West bank. These results will be used for the water budget analysis of this environmental restoration project.

II. AVERAGE ANNUAL/MONTHLY STREAMFLOW FOR SANTA CRUZ RIVER

The United States Geological Survey (USGS) currently operates a streamflow gaging station at one location along the Santa Cruz River in study area - at Congress St. (#09482500) since 1905. Available long record (1905-2001) from this gaging station (#09482500) was used to estimate average monthly and annual flows for the Santa Cruz River (SCR) Tributaries and summarized in Table 4 of this report. It should be noted here that the variability of monthly flows is large, and for a given month, average monthly flow varies from a minimum of zero to several hundred cubic feet per second. Maximum, minimum and standard deviation of monthly flows are listed in Table 4-3 of this report, to indicate this large variability. Note that standard deviations of monthly flows typically vary.

III. AVERAGE ANNUAL/MONTHLY STREAMFLOW FOR TRIBUTARIES

III. 1. General

There are nineteen major tributaries joining the SCR in the study reach. Twelve tributaries – Hughes Wash, Santa Clara Wash, El Vado Wash, Valencia Wash, Airport Wash, Wyoming Wash, Irvington Wash, Rodeo Wash, Julian Wash, Mission View Wash, 18th Street Wash, Cushing Street– join the East bank, while seven tributaries – Ajo Wash, Enchanted Hills Wash, San Juan Wash, Cholla Wash, Old West Branch at Confluence with SCR, New West Branch at Confluence with SCR, Los Reales Road – join the west bank of the Santa Cruz River. Locations of these tributaries are shown in Figure 1-1 of this report. As a result, available streamflow data from gaged watersheds with similar characteristics are analyzed to provide estimates of average monthly and annual runoff volumes for the twelve tributaries shown in Figure 1-1 of this report.

Watersheds of tributaries joining the east bank are highly urbanized, while west bank tributaries have relatively natural or rural watersheds. Because of this difference in characteristics, two groups of similar watersheds were selected and available streamflow data are analyzed to develop two different relations for average annual runoff volumes.

For the tributary analysis, methodology and stream flow data gaged were used same with the El Rio Antiguo, Rillito River Environmental Restoration, since those are the watersheds in Tucson area with similar physical characteristics.

III. 2. Average Annual Runoff Volume

For the urbanized tributaries, stream flow data from the following six gaged watersheds in Tucson area with similar physical characteristics were utilized: Airport Wash, Railroad Wash, Tucson Arroyo, High School Wash, Arcadia Wash and Atterbury Wash. Table 1 summarizes physical characteristics and runoff data for these six watersheds. Available streamflow data from these watersheds are analyzed to develop a regression relation between the average annual runoff volume and independent variables representing physical characteristics for the watersheds.

From a sensitivity analysis, it was found that drainage area alone was not a good indicator, but drainage area combined with impervious area (in fraction) was the most important explanatory variables. Based on this consideration, the following relation for urban watersheds were obtained from multiple regression analysis:

$$AAR_u = 67.29 + 87.56\,(IA) + 17.30\,(IA)^2 \qquad (1)$$

where AAR_u = Average annual runoff for urban watersheds in acre-ft

A = Drainage area, in sq. miles

I = Impervious area, in fraction

Eq. (1) has a correlation coefficient of 0.985 and a standard deviation of 43.47. Average annual runoff volumes for the eleven urban tributaries are estimated using Eq. (1) and summarized in Table 4-5 of this report.

Table 1 Watershed Characteristics

Watershed/Station	Drainage Area (sq. mile)	Mean Basin Elevation (ft)	Forested Area (%)	Impervious Area (%)	Mean Annual Rainfall (in)	Mean Annual Runoff			
						cfs	Inch	Acre-ft	Percent of Rainfall
Airport Wash (9482400)	23.0	2700	1.1	9.1	10.8	0.43	0.25	311.3	2.3
Railroad Wash (9482950)	2.3	2490	0.0	51.6	11.0	0.21	1.24	152.0	11.3
Tucson Arroyo (at Vine Ave) (9483000)	8.2	2510	0.0	45.5	11.0	0.88	1.46	637.1	13.3
High School Wash (9483010)	0.95	2460	0.0	38.5	11.0	0.11	1.57	79.6	14.3
Arcadia Wash at Tucson (9485550)	2.72	2560	0.0	49.8	11.0	0.36	1.80	260.7	16.4
Atterbury Wash at Tucson (9485390)	4.97	-	-	13.3	11.0	0.23	0.63	166.5	5.7
Tanque Verde Creek near Tucson ((9483100)	43.0	4780	21.0	-	17.0	8.90	2.81	6,443.3	16.5
Sabino Creek near Tucson (9484000)	35.5	6300	85.0	-	22.6	14.0	5.35	10,135.5	23.7
Bear Creek near Tucson (9484200)	16.3	5860	82.0	-	20.6	4.7	3.91	3,402.6	19.0
Tanque Verde Creek at Tucson (9484500)	219.0	4340	36.0	-	16.7	33.0	2.04	23,890.9	12.2
Rincon Creek near Tucson (9485550)	44.8	4850	57.0	-	19.2	7.0	2.12	5,067.8	11.0

For West bank tributaries which have relatively natural or rural watersheds, stream flow data from the following five gaged watersheds in Tucson area having similar physical characteristics are utilized: Tanque Verde Creek near Tucson, Sabino Creek near Tucson, Bear Creek near Tucson, Tanque Verde Creek at Tucson and Rincon Creek near Tucson. Physical and runoff characteristics for these watersheds are summarized in Table 1. It was found that drainage area and mean basin rainfall were the most important independent variables for estimating average annual runoff for these watersheds. Based on this consideration, the following relation was developed for rural or natural tributaries using multiple regression analysis:

$$AAR_n = 0.252\ A^{0.924}\ P^{2.291} \quad \text{.........(2)}$$

where AAR_n = Average annual runoff for natural watersheds, in acre-ft.

A = Drainage area, in sq. miles

P = Mean basin annual rainfall, in inches

Eq. (2) has a correlation coefficient of 0.954. Average annual runoff for the eight rural or natural tributaries are estimated using Eq. (2) and summarized in Table 4-5 of this report. Basin rainfalls for the tributaries in Table 4-5 of this report are estimated as average value of the annual rainfall recorded at stations: # 8820 (Tucson AP). This station is the vicinity to the tributary watersheds.

From the above calculation, the total from the nineteen tributaries in the study reach, on an average annual basis, is **9,020** acre-ft.

III. 3. Average Monthly Runoff Volume

A review of the average monthly flows for the Santa Cruz River and the gaged watersheds used in the analysis in Section III. 2, indicates that variability of monthly flows is very large. As an example, this can be seen from Table 4-3 of this report, which shows that standard deviations of monthly flows are up to seven times the annual mean values. Consequently, any attempt to develop relations for monthly flows similar to Eq. (1) or Eq. (2) is likely to yield unreliable estimates. An alternative approach involves estimating monthly distributions as percent of annual runoff volumes from the available records for the gaged watershed analyzed in Section III. 2, and then apply them to get monthly values from the annual values estimated in Section III.2. This approach, though approximate but relatively more reliable, will be utilized in the following analysis.

From the available stream flow record, average monthly runoff values expressed as percent of average annual runoff are summarized in Table 2 for the eleven urban watersheds used in Section III.2 for developing Eq. (1). Similarly, Table 3 summarizes the corresponding values for the eight rural or natural watersheds. Average values indicated for each month are combined as average annual runoff values given in Tables 2 and 3, respectively, to estimate average monthly values for each of the nineteen watersheds, and the results are summarized in Table 4-6 of this report.

Table 2

Average Monthly Runoff as Percent of Average Annual Runoff for Urban Watersheds

Watershed	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Airport Wash*	1.7	2.6	1.2	0.4	0.1	0.2	38.0	16.0	23.5	10.6	2.0	3.7	100.0
Railroad Wash**	13.3	7.7	3.7	0.4	0.36	2.0	15.4	15.4	20.7	10.9	3.7	7.7	100.0
Tucson Arroyo*	5.4	4.8	3.5	0.8	0.7	1.0	26.4	27.8	10.2	7 .8	4.2	7.5	100.0
High School Wash*	9.5	5.6	7.1	1.2	1.4	1.5	17.8	20.9	17.4	8 .0	4.0	5.7	100.0
Arcadia Wash**	10.1	14.9	9.2	0.3	1.9	2.0	9.7	23.3	18.7	2.6	3.0	4.0	100.0
Atterbury Wash**	12.2	7.0	7.4	0.11	1.6	1.0	11.1	17.0	32.2	2.4	2.1	5.2	100.0
Average	8.7	7.1	5.4	0.5	1.0	1.3	19.7	20.1	20.5	7.1	3.2	5.6	100.0

* Data from Water Resources Investigations Report 98-4225, U.S.G.S., 1998, Ref. 3.

** Data from U.S.G.S. web site: http://waterdata.usgs.gov/az/nwis/monthly/

Table 3

Average Monthly Runoff as Percent of Average Annual Runoff for Natural Watersheds

Watershed	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Tanque Verde Creek (near Tucson)	13.8	19.8	14.0	3.2	0.3	0.1	3.0	7.7	9.0	4.3	1.9	23.1	100.0
Sabino Creek	16.5	17.4	21.6	7.7	1.3	0.3	3.6	8.4	6.0	2.7	2.6	11.9	100.0
Baer Creek	18.0	21.8	15.6	3.7	0.4	0.0	1.2	3.2	6.4	5.6	1.8	22.4	100.0
Tanque Verde Creek (at Tucson	42.0	17.0	21.0	4.0	0.27	0.0	0.37	0.78	0.12	0.03	1.0	13.0	100.0
Rincon Creek	23.9	18.2	16.1	3.7	0.2	0.1	4.3	13.6	4.0	1.9	1.3	12.7	100.0
Average	22.8	18.8	17.7	4.5	0.5	0.1	2.5	6.7	5.1	2.9	1.7	16.6	100.0

Data source: Water Resources Investigations Report 98-4225, U.S.G.S., 1998, Ref. 3.

APPENDIX D

Terminology of Monthly Statistics

Monthly Statistics

The Monthly Statistics view displays a suite of summary statistics on a month-by-month basis. This suite summarizes data over the entire period of record, reporting three types of statistics: **daily statistics, period statistics** (monthly or annual), and **exceedances**. Daily statistics are calculated against the daily observations. Period statistics are calculated against the population of valid monthly or annual totals or means for each period (month or year). Exceedances are calculated against all non-missing daily observations.

The values are reported by months, using all valid observations that fell within the month indicated. The *Year* column reports daily statistics for all values in the data record, and period statistics based on all of the annual values in the data record.

NOTE: Values which are flagged as accumulated are treated as missing when computing the various statistics.

Monthly Statistics

Station Name: DEATH VALLEY

Parameter: Maximum Temperature

	June	July	August	September	October	November	December	Year
# Days	988	961	991	960	986	956	989	11666
Avg Day	108.70	114.90	112.90	105.30	92.82	76.11	64.57	90.38
# Months	33	31	32	32	32	32	32	28
SDev Month	2.65	2.25	2.61	2.96	3.72	2.76	3.29	1.09
Min Month	104.40	110.30	106.70	98.50	86.19	71.10	56.45	87.71
Max Month	113.70	118.40	117.20	110.10	101.10	81.62	70.61	92.41
Avg Month	108.70	114.90	112.90	105.30	92.76	76.10	64.57	90.28
Skew Month	0.02	-0.35	-0.42	-0.60	0.18	-0.14	-0.39	-0.13
Kurt Month	1.85	2.18	2.75	2.42	2.31	2.16	2.48	2.95
M Min Year	1963	1982	1983	1985	1984	1964	1990	1982
M Max Year	1961	1988	1969	1974	1988	1986	1980	1989
Exceedences								
1%	123.00	125.00	123.00	118.00	110.00	92.44	79.00	122.00
5%	120.00	122.90	121.40	115.00	106.00	88.00	74.00	118.00
10%	118.00	121.00	120.00	114.00	104.00	86.00	72.00	115.00
20%	115.00	119.00	118.00	111.00	100.00	83.00	70.00	110.00
50%	109.00	115.00	114.00	106.00	93.00	76.00	65.00	91.00
80%	103.00	111.00	109.00	100.00	86.00	69.00	60.00	71.00
90%	98.00	108.00	105.00	96.00	82.00	66.00	57.00	65.00
95%	95.00	106.00	103.00	92.00	79.00	64.00	54.00	61.00
99%	89.00	101.00	95.00	85.00	71.86	60.00	47.00	54.66

The first two rows of statistics contain **daily statistics**: *# Days, Avg Day*. The third through eleventh rows of statistics contain **period statistics**: *# Months, SDev Month, Min Month, Max Month, Avg Month, Skew Month, Kurt Month, M Min Year and M Max Year*. Period statistics are based on all of the monthly or annual values in the full data record. The twelfth through twentieth rows of statistics contain **exceedances**.

The **daily statistics** are calculated based on all observations that fell within the month indicated, during the period of record. For example, *Avg Day* in *May* is the average daily value observed in all the months of May over the period of record. The column labeled *Year* expresses the values derived from days in all of the months (the entire data record). So, *Avg Day* in the *Year* column is the average daily value observed over the entire data record.

 # Days is the total number of valid days on which readings were taken during the period of record. Again, it refers to the period of the column in which the count is found. So, *# Days* in the *March* column is the number of days with observations in all of the months of March in the data record. It may not equal 31 times the number of years in the period of record because there may be days on which no observations were recorded ("missing days"). The *# Days* in the *Year* column is the number of days for which there are observations in the period of record. It will be equal to the sum of the monthly values.

The ***Avg Day*** is the average of the valid daily observations for the period

The next grouping is the **period statistics.** These are based on the population of monthly or annual totals or means (period values) for each month or year over the entire period of record.

Data are summarized to period values (month or year) according to the methods that are customary for the parameter. Period values for measurements of mass or volume like precipitation, snow, and evaporation are based on the monthly or annual totals. Period values for rates or state variables like wind speed or temperature are based on the monthly or annual averages.

For example, the *Max Month* for *July* for maximum temperature is the maximum mean July value observed over the period of record and *Max Month* for *Year* is the maximum annual mean observed over the entire data record.

 # Months is the number of valid periods (months or years) upon which the period statistics are based.

NOTE: Hydrosphere follows the National Climatic Data Center convention on valid statistics: a **valid month** cannot have more than 9 missing daily observations to be counted in the period statistics. A **valid year** cannot have a single invalid month.

SDev Month is the standard deviation of the period values: a measure of the distribution of period values about the *Avg Month*. There is a 66% probability that any period value will fall into the range defined by one standard deviation above and below the *Avg Month*.

Avg Month is the average period value in the data record.

Min Month is the minimum period value.

Max Month is the maximum period value.

Skew Month is the coefficient of skewness of the population of period values. Skewness measures the departure of the population of period values from a symmetrical (Gaussian, or bell-curve) distribution. Positive skewness indicates a population tailing off to the right (that is, one with a mode less than the median less than the mean).

Kurt Month is the monthly or period kurtosis. Sometimes known as the fourth moment, kurtosis is defined as the degree of peakedness or flatness of the curve graphing a distribution. It expresses the concentration of points about the mean.

Standard deviation, skewness and kurtosis were calculated in accordance with SPSS procedures (Nye, et al, 1975).

M Min Year is the year in which the *Min Month* occurred.

M Max Year is the year in which the *Max Month* occurred.

Exceedances rank the individual daily values for the entire data record. A value for 1% means that only 1% of the time were values observed that were greater than the value displayed. The 50% value represents the median. Exceedences are calculated using the Weibul formula to determine the plotting position and then locating (interpolating if necessary) the data value at that position.

$$P = M/(N+1)$$

where N is the number of values and M is the position of the value in the list of values ordered by decreasing value.

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1. INTRODUCTION

The U.S. Army Corps of Engineers (the "Corps") is conducting a feasibility study in the Paseo de las Iglesias reach of the Santa Cruz River to identify, define and solve environmental degradation, flooding and related water resource problems. These efforts are proceeding in partnership with the Pima County Department of Transportation and Flood Control District, the non-Federal sponsor.

The Paseo de las Iglesias study area was defined in coordination with the non-federal sponsor based on factors including but not limited to jurisdictional boundaries, physical impediments (i.e., highways), and historical floodplain limits. The Paseo de las Iglesias study area is approximately 5005 acres and consists of a 7-mile reach of the Santa Cruz River and its tributary washes. Beginning where Congress Street crosses the river in downtown Tucson the study area extends upstream to the south along the river to the boundary of the San Xavier District of the Tohono O'Odham Nation (see Figure 1). The eastern study boundary is represented by Interstates 10 and 19. The western study area boundary is represented by Mission Road and the San Xavier District of the Tohono O'Odham Nation. The study area name, Paseo de las Iglesias, translates to "Walk of the Churches." The study area derives its name from the fact that it provides the physical and cultural connection between the 18th century San Xavier Mission and the Mission San Augustin archeological site. This area is the cradle of modern day Tucson and has a lineage of continued habitation dating thousands of years before settlement of the area by the Spanish missionaries.

In the Southwest, riparian landscapes 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.

It is important to note that the basic ecological premise behind ecosystem restoration is the recovery of limiting components, defined by their primary functional characteristics, be they water, soils and/or habitat structure. The primary goal of this study was therefore focused on the restoration of such functional components within the study area. To measure the success of the ecosystem restoration proposals, the best available science was brought to bear. In most ecosystem restoration studies, benefits are measured using quantifiable techniques rather than qualitative assessments. It was important then, that the technique selected to quantify benefits for the studies be repeatable, efficient and effective, as results could be questioned by outside interests, and the participating agencies could not afford to spend excessive quantities of time evaluating alternatives.

In previous ecosystem restoration studies, the Losa Angeles District primarily evaluated wildlife benefits using a technique referred to as modified Habitat Evaluation Procedures (mHEP). The basic premise of this modified procedure focused on a field reconnaissance approach where biologists surveyed a study site to familiarize themselves with the current conditions of the study area. The solution was often efficient, however, the results were often not repeatable and clearly subjective. In other words, a new team of experts visiting the site could derive a wholly different set of HSI values for the communities, and baseline conditions would appear much worse or much better than this initial study predicts.

The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short time frame available for conducting assessments). Existing "generic" methods, designed to assess multiple wetland types throughout the United States, are relatively rapid, but lack the resolution necessary to detect significant changes in function. One way to achieve an appropriate level of resolution within the available time frame is to reduce the level of variability exhibited by the wetlands being considered (Smith et al. 1995).

The Hydro Geomorphic Assessment of Wetlands approach (HGM) was developed specifically to accomplish this task (Ainslie et al. 1999; Brinson 1993). HGM identifies groups of wetlands that function similarly using three criteria (geomorphic setting, water source, and hydrodynamics) that fundamentally influence how wetlands and riparian systems function.

For the purposes of this study, both the mHEP and HGM methodologies are presented herein to assess the Without and With Project Conditions.

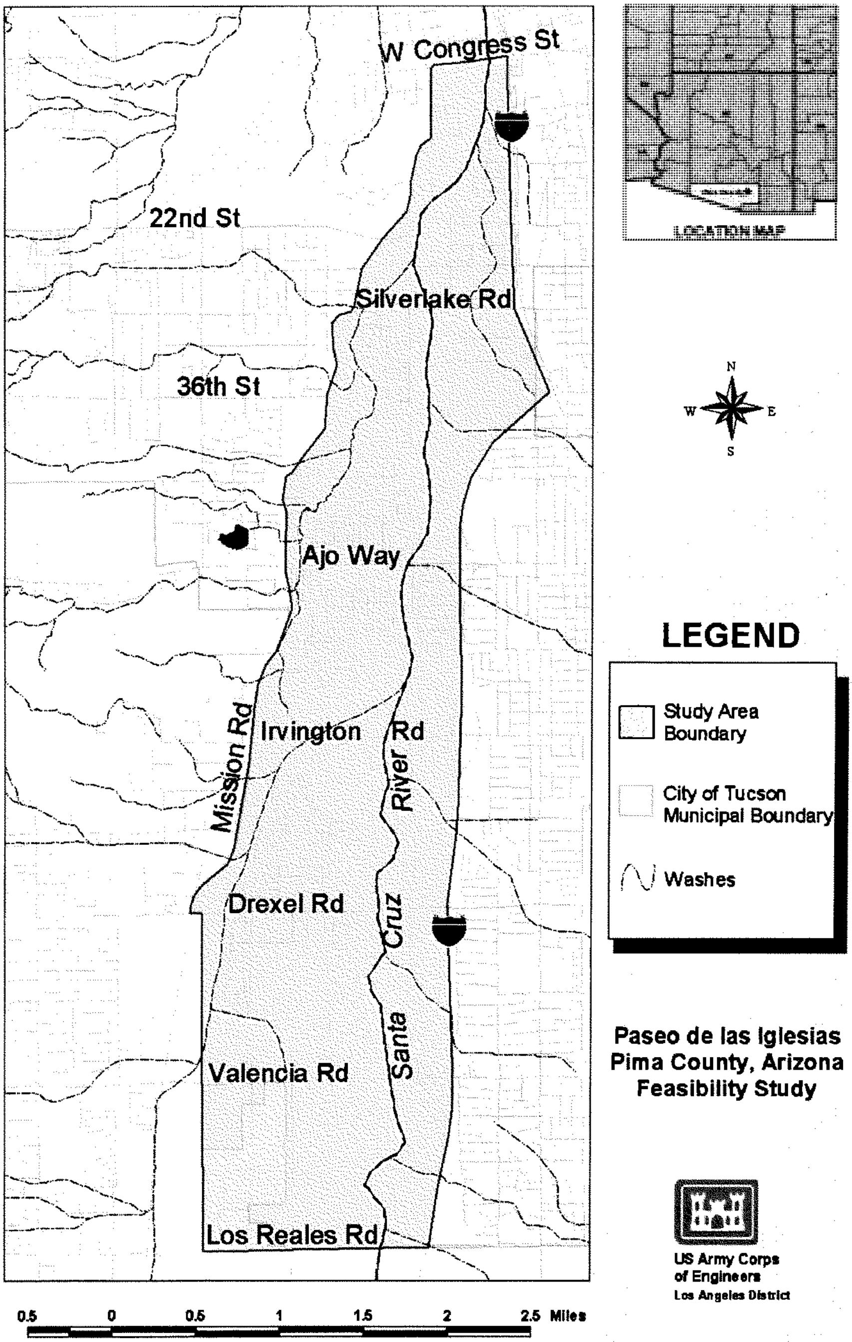


Figure 1: Paseo de las Iglesias Study Area

2. ECOSYSTEM RESTORATION EVALUATION METHODOLOGIES

2.1 Species-Based Habitat Indices

USACE presently uses the habitat unit concept to characterize the non-monetary outputs of ecosystems that must justify project costs. The concept is closely associated with development of the Habitat Evaluation Procedures (HEP) developed under the lead of the U. S. Fish and Wildlife Services (USFWS 1980a-c). HEP measures the effects of environmental change through a series of species-based Habitat Suitability Indices (HSI) developed for approximately 160 individual fish and wildlife species. The species-based HSI models rely on field measured habitat parameters, which are integrated into a single, probability-of-use index ranging from 0 to 1.0. HEP uses a simple multiplication product of impacted area in acres and HSI to calculate Habitat Units (HUs).

Species-based Habitat Suitability Index (HSI) models deployed in the traditional Habitat Evaluation Procedures (HEP) methodology are numerous, easy to use, are relatively inexpensive, but not immediately available or applicable to the arid southwest region, and do not capture all of the important habitat/ecosystem elements or all of the justifying value needed to restore ecosystems. Species-based HSI models are not scaled based on ecosystem integrity and should only be used to indicate a more naturally integrated ecosystem condition when the HSI value is known for the targeted restored condition. Few existing single-species HSI models satisfy these criteria well, but ecosystems might be characterized by new models for native dominant and keystone species, including dominant plant species and top-carnivore species, used in series with a few HSI models for rare species in the community. Several species-based HSIs might then "bracket" the community-habitat relationships satisfactorily, but the need for many new models offsets the main existing advantage.

2.2 Community-Based Habitat Indices

Existing community- based HSI models offer more promise than species-based HSI models because they are more efficient in capturing those habitat measures necessary for restoring ecosystem integrity and can be compared across a wide range of ecosystems for prioritization purposes (Stakhiv, et al. 2001). Community-based HSI models indicate relative ecosystem value more inclusively than species-based models because they link habitat more broadly to ecosystem components or functions. While species richness is relatively easy to link to habitat features in community-based HSI models, species richness may not predict the number of endangered species present in an ecosystem very well. Most species richness measures are limited to one to a few taxonomic categories, such as birds, fish, or aquatic insects. The taxonomic groups chosen for characterizing integrity may not characterize to fine enough degree the habitat needs of the endangered species. Complete models would need to account for this potential deficiency by assuring the diversity measure is inclusive of the vulnerable species or by including a separate relationship between vulnerable-species and habitat conditions. Again, each community would require a unique model of habitat-species relationships. Relatively few community prototype models have been developed, however, and most of the models would require considerable investment to cover the variety of ecosystems managed by the Corps.

2.3 FUNCTION-BASED INDICES

USACE's Environmental Laboratory (Engineer Research and Development Center, Vicksburg, MS) developed a similar approach to assessing the functional capacity of a wetland using standard wetland assessment protocols typically deployed in the regulatory arena. 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 model defines the relationships between one or more characteristics or 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 compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs) – quantifying the capacity of wetlands to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. 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 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. FCI models combine VSIs in a mathematical equation to rate the functional capacity of a wetland on a scale of 0.0 (not functional) to 1.0 (optimum functionality). An HGM subclass model is basically an assimilation of several FCI models combined in a specific fashion to mimic a site's functionality. Users can review and select several FCI models to evaluate the overall site functionality. All FCI models are described using a single FCI formula (refer to the Single Formula Subclass Models section below). 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.

2.4 PROCESS SIMULATION MODELS

Process simulation models are based (in theory) on ecosystem process and offer the greatest flexibility in use and management insight with respect to the output generated with incremental additions of restoration measures (Stakhiv, et al. 2001). Functional stability could in theory be analyzed directly. In terms of basic processes, similar principles operate across all ecosystems. However, process models rely on fundamental understanding of the way ecosystems operate and are extremely "information hungry". Much can be learned about how ecosystems work during assembly of process models, but the ultimate models for evaluating non-monetized environmental service are many years away even if research investment were substantially increased. The past objections to process models having to do with inadequate portability and computational capability are less likely to apply now. Even so, the details of resource partitioning into communities of different species richness and functional stability require much research and development. In the process of assembling such models, much more could be learned than from index models about managing ecosystem process for more reliable service delivery (sustainable development?) across all monetized and non-monetized services. Process simulation shows the most promise for incorporating tradeoff analysis within single model operations.

2.5 Selection of the HGM Method for the Arizona Studies

In 2002, the Los Angeles District began the process of formulating alternative designs for the five Arizona Ecosystem Restoration Planning Studies (El Rio Antiguo on the Rillito River, Paseo de las Iglesias and Tres Rios del Norte on the Santa Cruz River, Rio Salado Oeste and VaShly'ay Akimel on the Salt River). The District partnered with the U. S. Army Engineer Research and Development Center (ERDC) Environmental Laboratory (EL), the U.S. Fish and Wildlife Service (USFWS), and the Arizona Game and Fish Department (AGFD) to ensure all stakeholder issues were considered.

Setting ecosystem restoration objectives and performance criteria on the holistic recovery of "non-use" benefits, such as wildlife habitat, hydrology and biogeochemical processes, was critical to the overall planning process for the studies. It is important to note that the basic ecological premise behind ecosystem restoration is the recovery of limiting components, defined by their primary functional characteristics, be they water, soils and/or habitat structure. The primary goal of the studies was therefore focused on the restoration of such functional components within the study area. To measure the success of the ecosystem restoration proposals, the best available science was brought to bear. In most ecosystem restoration studies, benefits are measured using quantifiable techniques rather than qualitative assessments. It was important then, that the technique selected to quantify benefits for the studies be repeatable, efficient and effective, as results could be questioned by outside interests. Many rapid assessment techniques were readily available to the Evaluation Teams in off-the-shelf formats in 2002, but for the various reasons described in the next section, HGM (HydroGeoMorphic Assessment of Wetlands) was selected to quantify the anticipated benefits gained by the proposed ecosystem restoration activities.

Again, HGM emphasizes the functions associated with the range of physical and chemical attributes comprising habitat of wetland ecosystems. It also incorporates a structural index based on a set of species identified for the specific model application. Although models used in a HEP methodology might be more appropriate to a riparian setting in this region, their overall evaluation of potential changes to the ecosystem dynamic are limited when capturing wetland functionality as a whole. The HGM approach has one important advantage over the HEP methodology (HSI models in particular) in that it is more inclusive of all ecosystem functions relevant to ecosystem services. Available HEP models were limited to the habitat function in support of species richness, and might overlook key hydrologic influences experienced in high-flow periods.

2.6 Introduction To The HGM Process

Wetland ecosystems share a number of common attributes including relatively long periods of inundation or saturation, hydrophytic vegetation, and hydric soils. In spite of these common attributes, wetlands occur under a wide range of climatic, geologic, and physiographic situations and exhibit a wide range of physical, chemical, and biological characteristics and processes [Ainslie et al. 1999; Ferren, Fiedler, and Leidy (1996); Ferren et al. 1996a,b; Mitch and Gosselink 1993; Semeniuk 1987; Cowardin et al. 1979). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short time frame available for conducting assessments). Existing "generic" methods, designed to assess multiple wetland types throughout the United States, are relatively rapid, but lack the resolution necessary to detect significant changes in function. One way to achieve an appropriate level of resolution within the available time frame is to reduce the level of variability exhibited by the wetlands being considered (Smith et al. 1995).

The HydroGeoMorphic Assessment of Wetlands approach (HGM) was developed specifically to accomplish this task (Ainslie et al. 1999; Brinson 1993). HGM identifies groups of wetlands that function similarly using three criteria (geomorphic setting, water source, and hydrodynamics) that fundamentally influence how wetlands function. "Geomorphic setting" refers to the landform and position of the wetland in the landscape. "Water source" refers to the primary water source in the wetland such as precipitation, overbank floodwater, or groundwater. "Hydrodynamics" refers to the level of energy and the direction that water moves in the wetland. Based on these three criteria, any number of "functional" wetland groups can be identified at different spatial or temporal scales. For example, on a continental scale, Brinson (1993) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al. 1995).

Table 1. HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depression wetlands may have any combination of inlets and outlets or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that range from diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, vernal pools, and cypress domes are common examples of depression wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries, and are under the influence of sea level. They intergraded landward with riverine wetlands where tidal current diminishes, and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bi-directional flows from tides dominate over unidirectional ones controlled by floodplain slope of riverine wetlands. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent, and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water. Fringe table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bi-directional, usually controlled by water-level fluctuations resulting from wind or seiche. Lacustrine wetlands lose water by flow returning to the lake after flooding and evapotranspiration. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.

Table 1. (cont.) HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or sites with saturated overland flow with no channel formation. They normally occur on sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface.. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by down-slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands.
Mineral Soil	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces Flats where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater.. They are distinguished from flat upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become organic soil flats. They typically occur in relatively humid climates. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.
Organic Soil Flats	Organic soil flats, or extensive peat lands, differ from mineral soil flats in part because their elevation and Soil Flats topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peat lands are examples of organic soil flat wetlands.

Table 1. (cont.) HydroGeoMorphic Wetland Classes on a Continental Scale

HGM Wetland Class	Definition
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwoods on floodplains are an example of riverine wetlands.

In many cases, the level of variability in continental-scale wetland hydrogeomorphic classes is still too immense to develop assessment models that can be rapidly applied while being sensitive enough to detect changes in function at a level of resolution appropriate to the planning process. For example, at a continental geographic scale the depression class includes wetlands as diverse as California vernal pools (Zedler 1987), prairie potholes in North and South Dakota (Kantrud et al. 1989; Hubbard 1988), playa lakes in the high plains of Texas (Bolen et al. 1989), kettles in New England, and cypress domes in Florida (Kurz and Wagner 1953; Ewel and Odum 1984).

To reduce both inter- and intra-regional variability, the three classification criteria (geomorphic setting, water source, and hydrodynamics) are applied at a smaller, regional geographic scale to identify regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (Stewart and Kantrud 1971; Golet and Larson 1974; Wharton et al. 1982; Ferren, Fiedler, and Leidy 1996; Ferren et al. 1996a,b; Ainslie et al. 1999). In addition to the three primary classification criteria, certain ecosystem or landscape characteristics may also be useful for distinguishing regional subclasses in certain regions. For example, depression subclasses might be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo 1998). Slope subclasses might be based on the degree of slope, landscape position, source of water (i.e., through-flow versus groundwater), or other factors. Riverine subclasses might be based on water source, position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Examples of potential regional subclasses are shown in Table 2 (Smith et al. 1995; Rheinhardt et al. 1997).

Table 2. Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source, and Hydrodynamics

Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina Bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizonal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (mineral soil)	Precipitation	Vertical	Peat bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizonal	Bottomland hardwood forests	Riparian wetlands

Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of its geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process. Classifying wetlands based on how they function, narrows the focus of attention to a specific type or subclass of wetland, the functions that wetlands within the subclass are most likely to perform, and the landscape/ecosystem factors that are most likely to influence how wetlands in the subclass function. This increases the accuracy of the assessment, allows for repeatability, and reduces the time needed to conduct the assessment.

Designed to assess wetlands as a whole, the HGM technique focuses on a wetlands' structural components and the processes that link these components within a system (Bormann and Likens 1969). Structural components of the wetland and the surrounding landscape (e.g., plants, soils, hydrology, and animals) interact with a variety of physical, chemical, and biological processes. Understanding the interactions of the wetlands' structural components and the surrounding landscape features is the basis for assessing wetland functions and the foundation of the HGM Approach. By definition, wetland functions are the normal or characteristic activities that take place in wetland settings. 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. Examples of wetland functions evaluated with Functional Capacity Index (FCI) models are found in Table 3.

Table 3. Wetland functions measured in HGM and their value to the ecosystem

Functions Related to the Hydrologic Processes	Benefits, Products, and Services Resulting from the Wetland Function
Short-Term Storage of Surface Water: The temporary storage of surface water for short periods.	Onsite: Replenish soil moisture, import/export materials, and provide a conduit for organisms. Offsite: Reduce downstream peak discharge and volume, and help maintain and improve water quality.
Long-Term Storage of Surface Water: The temporary storage of surface water for long periods.	Onsite: Provide habitat and maintain physical and biogeochemical processes. Offsite: Reduce dissolved and particulate loading and volume, and help maintain and improve surface water quality.
Storage of Subsurface Water: The storage of subsurface water.	Onsite: Maintain biogeochemical processes. Offsite: Recharge surficial aquifers, and maintain base flow and seasonal flow in streams.
Moderation of Groundwater Flow or Discharge: the moderation of groundwater flow or groundwater discharge.	Onsite: Maintain habitat. Offsite: Maintain groundwater storage, base flow, seasonal flows, and surface water temperatures.
Dissipation of Energy: The reduction of energy in moving water at the land/water interface.	Onsite: Contribute to nutrient capital of ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Functions Related to Biogeochemical Processes	**Benefits, Products, and Services Resulting from the Wetland Function**
Cycling of Nutrients: The conversion of elements from one form to another through abiotic and biotic processes.	Onsite: Contributes to nutrient capital of the ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Removal of Elements and Compounds: The removal of nutrients, contaminants or other elements and compounds on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of the ecosystem. Contaminants are removed, or rendered innocuous. Offsite: Reduced downstream loading helps to maintain or improve surface water quality.
Retention of Particulates: The retention of organic and inorganic particulates on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of the ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.

Export of Organic Carbon: The export of dissolved or particulate organic carbon.	Onsite: Enhances decomposition and mobilization of metals. Offsite: Supports aquatic food webs and downstream biogeochemical processes.
Functions Related to Habitat	**Benefits, Products, and Services Resulting from the Wetland Function**
Maintenance of Plant and Animal Communities: the maintenance of plant and animal community that is characteristic with respect to species composition, abundance, and age structure.	Onsite: Maintain habitat for plants and animals (e.g., endangered species and critical habitats) forest and agriculture products, and aesthetic, recreational, and educational opportunities. Offsite: Maintain corridors between habitat islands and landscape/regional biodiversity.

Wetland functions represent the currency or units of the wetland system for assessment purposes, but the integrity of the system is not disconnected from each function, rather it represents the collective interaction of all wetland functions. Consequently, wetland assessments using the HGM approach require the recognition by both the Assessment Team and the end user that this link (i.e., between wetland function and system integrity) is critical. One cannot develop criteria, or models, to maximize a single function without having potentially negative impacts on the overall ecological integrity and sustainability of the wetland system as a whole. For example, one should not attempt to create a wetland to maximize water storage capacity without the recognition that other functions (e.g., plant species diversity) will likely be altered from those similar wetland types with less managed conditions. This does not mean that a wetland cannot be developed to maximize a particular function, but that it will typically not be a sustainable system without future human intervention.

The HGM approach is characterized and differentiated from other wetland assessment procedures in that it first classifies wetlands based on their ecological characteristics (i.e., landscape setting, water source, and hydrodynamics). Second it uses reference sites to establish the range of wetland functions. Finally, the HGM approach uses a relative index of function (Functional Capacity Index or FCI), calibrated to reference wetlands, to assess wetland functions. In the HGM methodology, a Variable Subindex (VSI), is a mathematical relationship that reflects a wetland function's sensitivity to a change in a limiting factor or variable within the Partial Wetland Assessment Area or PWAA (a homogenous zone of similar vegetative species, geographic similarities, and physical conditions that make the area unique). Similar to cover types in HEP, PWAAs are defined on the basis of species recognition and dependence, soils types, and topography. 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 an VSI = 1.0 represents a variable in abundance (not limiting) for the wetland.

Reference wetlands are wetland sites selected from a reference domain (a defined geographic area), selected to "represent" sites that exhibit a range of variation within a particular wetland type, including sites that have been degraded/disturbed as well as those sites with minimal disturbance (Ainslie et al. 1999). The use of reference wetlands to scale the capacity of wetlands to perform a function is one of the unique features of the HGM approach. Reference provides the standard for comparison in the HGM approach. Unlike other methods which rely on data from published literature or best professional judgment, the HGM approach requires identification of wetlands from the same regional subclass and from the same reference domain, collection of data from those wetlands, and scaling of' wetland variables to those data. Since wetlands exhibit a wide range of variability, reference wetlands should represent the range of conditions within the reference domain. A basic assumption of HGM is that the highest, sustainable functional capacity is achieved in wetland ecosystems and landscapes that have not been subject to long-term anthropogenic disturbance (Smith et al. 1995). It is further assumed that under these conditions the structural components and physical, chemical, and biological processes within the wetland and surrounding landscape reach a dynamic equilibrium necessary to achieve the highest, sustainable functional capacity. Reference standards are derived from these wetlands and used to calibrate variables. However, it is also necessary to recognize that many wetlands occur in less than standard conditions. Therefore, data must be collected from a wide range of conditions in order to scale model variables from 0.0 to 1.0, the range used for each variable subindex. To assist the user, a list of key terms related to the reference wetland concept in the HGM methodology (Table 4).

Table 4. Reference Wetland Terms and Definitions

Term	Definition
Reference domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected
Reference Wetland	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and disturbance and from human alteration.
Reference standard wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that wetlands is both sustainable and characteristic of the least human altered wetland sites in the least human altered landscapes. By definition, the functional
Reference standard wetlands variable condition	The range of conditions exhibited by model variables in reference standard wetlands. By wetland variable definition, reference standard conditions receive a variable subindex score of 1.0.
Site potential **- Mitigation Project Context**	The highest level of function possible, given local constraints of disturbance history, land use, (mitigation project or other factors. Site potential may be less than or equal to the levels of function in reference context) standard wetlands of the regio
Project target **- Mitigation Project Context**	The level of function identified or negotiated for a restoration or creation project.
Project standards **- Mitigation Project Context**	Project standards Performance criteria and/or specifications used to guide the restoration or creation activities (mitigation context) toward the project target. Project standards should specify reasonable contingency measures if the project target is not

In the HGM approach, an assessment model is a simple representation of a function performed by the wetland ecosystem (Ainslie et al. 1999). It defines the relationship between one or more characteristics or 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 compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs). An index of the capacity of wetland to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. 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 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. FCI models combine VSIs in a mathematical equation to rate the functional capacity of a wetland on a scale of 0.0 (not functional) to 1.0 (optimum functionality). An HGM subclass model is basically an assimilation of several FCI models combined in a specific fashion to mimic a site's functionality. Users can review and select several FCI models to evaluate the overall site functionality. All FCI models are described using a single FCI formula (refer to the Single Formula Subclass Models section below). 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.

Reference sites used for model calibration for Arizona Studies included The Nature Conservancy's Hassayampa River Preserve, the Verde River at the confluence with the Salt River, the Santa Cruz River at Tumacocori, the San Pedro River at the San Pedro National Riparian Conservation Area, and Tanque Verde Wash upstream of the Rillito River confluence. These sites were recommended based on the following criteria: 1) they were reasonable sites considering current conditions, 2) they were in a similar regional Riverine subclass to the Santa Cruz River with similar elevation, topography, gradient, and stream order, 3) they represented important aspects of pre-historical conditions, and 4) they were uniform across political boundaries. Model attendees agreed that no truly ideal reference site exists and restoration to the ideal was not achievable due to inability to remove all stressors. The goal in choosing these sites was that the hydrologic, biogeochemical and habitat characteristics be as undisturbed as possible.

HGM model variables represent the characteristics of the wetland ecosystem (and surrounding landscape) that influence the capacity of a wetland ecosystem to perform a function. HGM model variables are ecological quantities that consist of five components (Schneider 1994). These include: 1) a name, 2) a symbol, 3) a measure of the variable and procedural statement for quantifying or qualifying the measure directly or calculating it from other measurements, 4) a set of values [i.e., numbers, categories, or numerical estimates (Leibowitz and Hyman 1997)] that are generated by applying the procedural statement, and 5) units on the appropriate measurement scale. Table 5 provides several examples.

Table 5. Components of a typical HGM model variables

Name (Symbol)	Measure/Procedural Statement	Resulting Values	Units (Scale)
Redoximorphic Features (V_{REDOX})	Status of redoximorphic features/visual inspection of soil profile for redoximorphic features	Present/ Absent	unitless (Nominal Scale)
Floodplain Roughness (V_{ROUGH})	Manning's Roughness Coefficient (n) Observe wetland characteristics to determine adjustment values for roughness component to add to base value	0.01 0.1 0.21	unitless (Interval Scale)
Tree Biomass (V_{TBA})	Tree basal area/measure diameter of trees in sample plots (cm), convert to area (m), and extrapolate to per hectare basis	5 12.8 36	m^2/ha (Ratio Scale)

HGM model variables occur in a variety of states or conditions in reference wetlands (Ainslie et al. 1999). The state or condition of the variable is denoted by the value of the measure of the variable. For example, tree basal area, the measure of the tree biomass variable could be large or small. Similarly, recurrence interval, the measure of overbank flood frequency variable could be frequent or infrequent. Based on its condition (i.e., value of the metric), model variables are assigned a variable subindex. When the condition of a variable is within the range of conditions exhibited by reference standard wetlands, a variable subindex of 1.0 is assigned. As the condition deflects from the reference standard condition (i.e., the range of conditions that the variable occurs in reference standard wetland), the variable subindex is assigned based on the defined relationship between model variable condition and functional capacity. As the condition of a variable deviates from the conditions exhibited in reference standard wetlands, it receives a progressively lower subindex reflecting its decreasing contribution to functional capacity. In some cases, the variable subindex drops to zero. For example, when no trees are present, the subindex for tree basal area is zero. In other cases, the subindex for a variable never drops to zero. For example, regardless of the condition of a site, Manning's Roughness Coefficient (n) will always be greater than zero.

HGM combines both the wetland functionality (FCIs measured with variables) and quantity 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). Under the HGM methodology, one FCU is equivalent to one optimally functioning wetland acre. Like HEP, HGM can be used to evaluate further conditions and the long-term affects of proposed alternatives by generating FCUs for wetland functions over several TYs. In such analyses, 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 outcomes, alternative designs can be formulated, and trade-off analyses can be simulated, to promote environmental optimization.

2.7 HGM SOFTWARE

The vast number of calculations necessary to conduct the HGM analyses on a projects the size of the AZ Studies led the District to contact EL for technical assistance. Using the latest technological advancements, EL performed the necessary evaluations in less than three years. In addition to facilitating the application of HGM in the study, EL's biologists used the EXHGM (EXpert Hydrogeomorphic Approach to Wetland Assessments) software package to generate restoration benefits in a timely manner (refer to the software section later in this chapter). The EL team performed more than 2,500 iterations in the evaluations of the proposed designs in the wetland assessment described herein using the EXHGM software package.

EXHGM is a Microsoft Access© 2000 software package developed by EL to automate standard HGM calculations. EXHGM's programming architecture afforded the EL staff the opportunity to compare the resultant outputs of the two methodologies on similar platforms (i.e., results were reported in terms of units derived from quality and quantity calculations that could be reviewed in common software environments, namely Microsoft Excel and Microsoft Access formats). Again, the EXHGM the program should be viewed as a tool that can provide a rational, supportable, focused, and traceable evaluation of wetland functionality, and its application to the decision-making process is unquestionable. However, the user must understand the basic HGM tenets as defined in supporting literature (Brinson, 1993; Smith et al., 1995) prior to attempting application of the software. In other words, the user should not expect the EXHGM software to provide the only predictive environmental response to project development scenarios, and should understand the limitations of the methodology's response to predictive evaluations prior to its application.

The EXHGM program was designed to process large amounts of data quickly and efficiently, handling a large number of FCI models simultaneously. Each model can incorporate any number of cover types (or partial wetland assessment areas). Each cover type can include a large number of variables, and the user can incorporate as many life requisites or functions within each model as necessary. These capabilities support the examination of complex studies with large numbers of permutations. In some studies, it is not unusual to evaluate 10 - 15 FCI models (with more than 25 cover types) in an attempt to describe complex interdependencies (i.e., interrelationships) within the ecosystem. The large amount of tedious mathematical calculations necessary to compute HGM at this level requires a powerful tool to evaluate environmental output. EXHGM, enhanced by its abilities to communicate these activities in an organized fashion, can quickly accomplish this task. The number of permutations, processing speed, and program performances are limited only by the capacity of the user's hardware, where data storage becomes the limiting factor.

The EXHGM program allows the user to evaluate a large number of projected changes (future factors) across numerous years for each alternative design. Each package allows the user to assign future factors to each model for each year considered within the life of the project (i.e., each TY). This capability allows the user to manage forecasts across the long-term planning horizon, in an attempt to better reflect reality through the life of the project. Again, the number of permutations is limited only by the user's computer storage capacity. EXHGM evaluates any FCI-based model. In most instances, a wetland cannot be described using a single PWAA. A standard HGM tool must complete these computations, regardless of whether the model utilizes a single PWAA or multiple PWAAs. EXHGM can be used to calculate suitability for any single or multiple PWAA model whether the wetlands functionality is based on one or more multi-faceted functions.

The tool is capable of reevaluating FCI models as the user adapts previously created alternative designs to fit new situations. It is not necessary to reinvent FCI models, cover type interdependencies, or life requisite interrelationships once a standard evaluation configuration has been created. The software packages allow the user to open a previously created configuration and introduce change (e.g., adding field data, future factors, TYs, species, cover types, acreage quantities, etc.). This capability supports the software's utilization in a wide range of agency activities over the long term. For example, an alternative design developed to evaluate project impacts for a stream restoration study in the past, can be adapted to evaluate stream restoration projects throughout the region in the future. By simply altering the cover type composition of a previously developed EXHGM datafile, the software can account for regional variations, and quickly define functionality impacts. Thus, as projects are funded or evolve, EXHGM can be easily implemented with little effort devoted to modeling "setup."

3. HGM HABITAT EVALUATION

Based on the USFWS's Ecological Service Manual series on HEP (USFWS 1980a-c), and a series of protocols for HGM application developed by EL (Brinson 1993; Smith et al. 1995), there are 12 steps involved in the application HGM when assessing an ecosystem restoration project:

1) Build a multi-disciplinary Evaluation Team.
2) Define the project.
3) Determine goals and objectives.
4) Map Partial Wetland Assessment Areas (PWAA's).
5) Select, modify and/or create model(s).
6) Conduct field sampling.
7) Perform data management and statistical analysis.
8) Calculate Baseline Conditions.
9) Generate Without Project Conditions and calculate outputs.
10) Generate With Project Conditions and calculate outputs.
11) Develop Relative Value Indices and perform trade-offs
12) Report the results of the analyses.

The following sections describe these steps in further detail and discuss their various applications to the Paseo de las Iglesias Feasibility Study.

3.1 EVALUATION TEAM

An interagency, interdisciplinary team was formed to lead both the model selection/development phase of the project, and to establish the baseline and future without project conditions of the study area. Evaluation Team members for this study included representatives from the U. S. Army Corps of Engineers (USACE) Los Angeles District, USACE Environmental Laboratory (EL), U. S. Fish and Wildlife Service (USFWS), Arizona Game and Fish Department, Pima County Flood Control District, David Miller and Associates, and SWCA Environmental Consultants.

3.2 PROJECT DEFINITION

3.2.1 The Ecosystem Restoration Approach

By definition, an ecosystem can be described as an integrated unit, identified as a biotic community enjoined with its physical environment. Inherent within this definition, is the concept of a structural and functional system, unified through life processes. According to Stakhiv et. al., an ecosystem is characterized as a viable unit of the community and a interactive habitat (2001). Ecosystems then, are hierarchical and can be viewed as nested sets of open systems in which the physical, chemical, and biological processes form interactive subsystems. It is important to note that by definition ecosystems can be microscopic in size or can be as large as the biosphere. Thus, ecosystem restoration efforts can be directed at different sized ecosystems within the nested set, spanning multiple states, more localized watersheds or smaller complexes of habitat.

3.3 SETTING GOALS AND OBJECTIVES

In an attempt to generate quantifiable objectives for the study, the Evaluation Team set out specific ecosystem restoration goals, and developed a series of performance measures to assess the success of the ecosystem restoration designs.

3.3.1 Project Goals

The Federal planning objective for ecosystem restoration studies is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. The specific objectives for environmental restoration within the study area have been identified as follows:

- Increase the acreage of functional riparian and floodplain habitat within the study area;
- Increase the wildlife and habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe and historic floodplain;
- Provide passive recreation opportunities;
- Provide incidental benefits of flood damage reduction, reduced bank erosion, reduced sedimentation and improved surface water quality consistent with the ecosystem restoration; and
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

The Evaluation Team was asked to outline the primary arid riparian system and communities within the project area, generate a list of performance measures upon which restoration success could be measured, and select an evaluation tool to measure the success of restoration efforts within this system. Four major communities or systems were identified: 1) Cottonwood-Willow Forests; 2) Mesquite Woodlands, 3) River Bottom Areas (largely unvegetated, including emergent); and 3) Scrub-Shrub (e.g., Rabbit bush, Quail bush, Ironwood, and Saltbush).

3.3.2 Ecosystem Assessment Performance Measures (Objectives)

The goal of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded (Stakhiv et. al., 2001). Ecosystem level measures address the question of what are the appropriate compositions, structures, and functions of each ecosystem (Haufler et al. 2002). Ecosystem level measures define the "acceptable" range of conditions for any stand or reach in a landscape to qualify as "suitable" for contributing to the amount needed for adequate ecological representation. Function-related measures ensure that ecosystems "look right" and function appropriately to ensure conservation of biological diversity and ecosystem integrity. Performance measurement is required to understand the gap between actual and expected levels of achievement in ecosystem restoration initiatives and when corrective action may be warranted. The results indicated by a performance measure will generally be compared with expectations specified by a performance target (which might be based on a benchmark best practice, a technical standard or some specified progression from the baseline value). Therefore, performance measures should correspond with performance targets and indicate the extent to which the study's design is achieving these performance expectations. Performance measures are an important source of feedback for effective management.

Early in the evaluation process, the Evaluation Team reviewed the relevant ecosystem problems, and the study goals and objectives. They then generated a list of quantifiable ecosystem restoration success criteria (i.e., performance targets on the basis of restored acreages and functional lift) to gauge the success of the proposed alternatives, and compared these alternatives in an iterative fashion. Specifically, these performance targets focused on the existing wetland quantity and quality, but additionally expanded to incorporate proposed conditions of the region. For more details, refer to the individual study reports.

3.3.3 Project Life and Target Years.

Given these goals and objectives, the District designated a "Project Life" of 50 years for the study, and asked the Evaluation Team to develop a series of Target Years within this 50-year setting to generate projections of both Without Project and With Project activities. Target years for the studies therefore included TY0 (Baseline Conditions), TY1 (Year of Construction) and TY51 (End of Project) to capture this 50-year span. Two additional Target Years (11 and 26) were included to capture significant anticipated changes in vegetative cover and structure in the study area between TY1 and TY51.

3.4 PARTIAL WETLANDS ASSESSMENT AREA MAPPING

3.4.1 Cover Types

Habitats evaluated within the study area were classified as one of four Partial Wetland Assessment Areas (PWAAs) or cover types for Arizona riverine systems. These are Cottonwood-Willow, Mesquite, Scrub-Shrub (Sonoran Desert Wash Community), and Riverbottom (dry, potential emergent wetlands or cienega). These are homogenous zones of similar vegetative species, geographic similarities, and physical conditions that make the PWAA unique. In general, cover types are defined based on species recognition and dependence, soils types and topography. Other areas such as a buffer zone, urban areas, and desert areas were tracked but not evaluated.

All four cover types or PWAAs were mapped within the study boundaries (See Figure 2). Note that the mapping of these cover types adjacent to the channel was completed for planning purposes and in order to consider the effects of adjacent land use

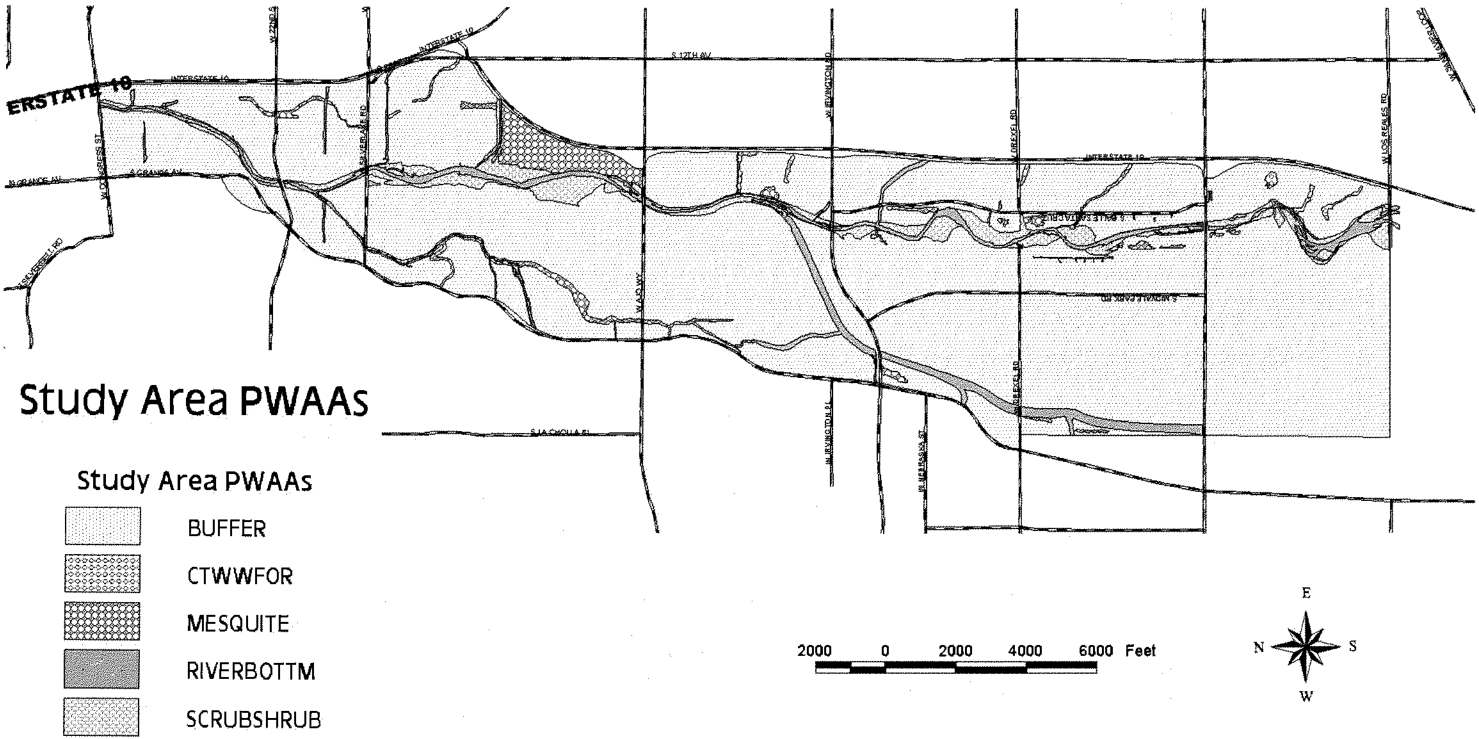


Figure 2: Partial Wetland Assessment Area Mapping for the Paseo de las Iglesias Study Area

on the study area, not with the intent that actual project features will be planned to that extent. Scattered remnants of natural vegetation remain, those cover types include mesquite, and scrub-shrub lands. Natural cienegas or seasonal emergent wetlands have disappeared from the study area. To evaluate the wetland conditions using HGM, the study area is divided into manageable sections and quantified in terms of acres.

The total study area includes 5005 acres.

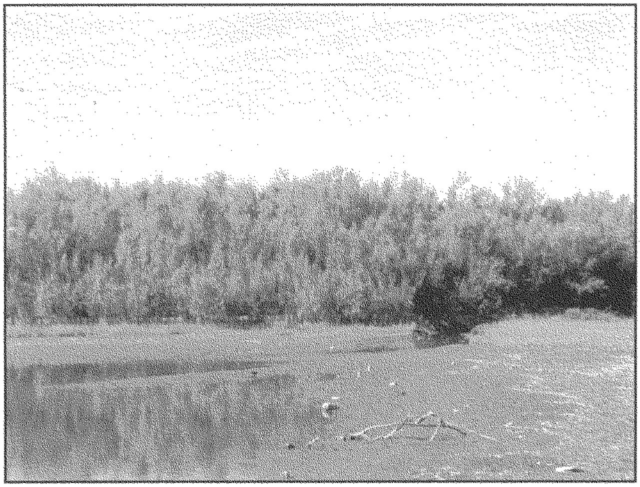
TABLE 6: PWAA Mapping Acreages

COVER TYPE	ACRES
Cottonwood/Willow Forest	0
Mesquite Bosque	160
Riverbottom (includes low flow and grasses)	173
Scrub-shrub (Sonoran Desert Wash Communities)	256
Total	**589**

3.4.1.1 Cottonwood-Willow Forest

Cottonwood-willow forest is a high-quality hydro riparian habitat in Arizona. Riparian habitats are defined as habitats or ecosystems that are associated with rivers or streams or are dependent on the existence of perennial or ephemeral surface or subsurface water. They are further characterized by having diverse assemblages of plant and animal species in comparison with adjacent upland areas. These plant species are also found in habitats that are narrow, linear strands of vegetation parallel to the main direction of water flow that may occur in riverine flood channels and along the banks of streams.

In the Sonoran Desert, riparian areas nourish cottonwood-willow forests, one of the most rare and most threatened forest types in North America. An estimated 90% of these critical wet landscapes have been lost, damaged or degraded in the last century. This loss threatens at least 80% of Arizona wildlife, which depends upon riparian habitats for survival. The growth of Tucson and surrounding areas, past land uses such as farming, grazing, gravel mining, and pumping of groundwater have altered the Santa Cruz River. Where it was once perennial it is now an ephemeral stream. This has contributed to the disappearance of cottonwood and willow habitat within the study area. Incasive species, such as Salt Cedar depicted below, have now moved into the river and continue to thrive.



Salt Cedar has invaded the study area

3.4.1.2 Scrub-Shrub Lands (Desert Wash)

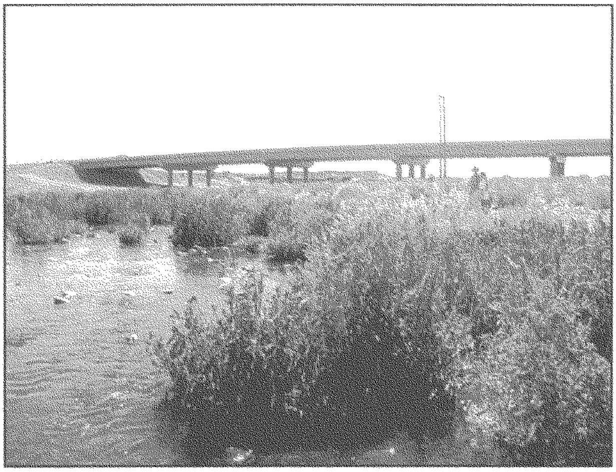
Scrub-shrub is the name given to the desert wash plant community in the functional assessment model. This cover includes shrub-dominated communities common along the low flow channel of the river as well as those common to the floodplain fringe. A healthy scrub-shrub community supports a diverse plant and wildlife community. Various combinations of desert-wash species such as burro bush, rabbit bush, quail bush, saltbush, and occasionally creosote bush dominate them.

The existing scrub/shrub community occupies more acreage (256 ac.) than any other cover type within the study area. The majority of that acreage is on the low terraces elevated only slightly above the dry low flow channel of the Santa Cruz River. Compared to the reference sites and the model biodiversity for shrub-scrub, this cover type is severely lacking in diversity in the study area. Many of these areas have been highly disturbed in the past from the construction of bank protection, off road vehicle traffic, illegal dumping, and gravel mining activities.

Scrub-shrub lands are dominated by saltbush and often cobble and sand substrate.

3.4.1.3 River Bottom (Dry Flow Channels)

The River Bottom includes the low flow channel (dry), tributary channels, and the gravel and sand bars within the braided river channel totaling 173 acres. The riverbottom should include emergent vegetation and the unique Southwestern cienega types of vegetation. The cienega is applied in North American areas with Hispanic history to a broad spectrum of marshy and swampy areas. In the Southwest, and particularly in a seasonal cienega, low sedges and grasses dominate the plant community. This community type was once common, but no longer exists. Low flow channels and depressions within the river bottoms of the Santa Cruz River have been almost entirely eliminated. These features are unvegetated when present so the acres listed reflect areas where the cover type would be expected to occur. Due to the composition and lack of diversity within the project area dry river bottom, low flow channel, and emergent wetlands are all combined into this one cover type.



Santa Cruz River Low flow channel – Tres Rios del Norte

3.4.1.4 Mesquite Woodlands

Mesquite woodlands or "bosques" historically thrived over large areas within the river floodplain and on higher terraces of the river and were common into the 1940s. These communities have been nearly eliminated from the river ecosystem by a combination of anthropogenic activities (e.g., cutting for firewood) and an ever-lowering aquifer combined with an altered flood regime. Contiguous mesquite stands currently exist along the Old West Branch of the Santa Cruz River. Several smaller patches are scattered throughout the historic floodplain of the Santa Cruz. These small bosques generally consist of struggling trees that have been isolated from the river by soil cement banks and are threatened by urbanization. Together, these areas of mesquite-dominated woodlands total 160 acres.

Typical mesquite woodlands

3.5 SELECTING AND MODIFYING THE FCI MODELS

At the time of this study, very few HGM subclass models were published for distribution. EL was leading a research work unit under the Ecosystem Management and Restoration Research Program (EMRRP) for the development of HGM subclass models. After several interviews with District personnel regarding the wetland subclasses existing in the study area, EL facilitators identified the need to modify and existing subclass model developed in the District for the Santa Margarita Study for riverine overbank systems (Lee et al. 1997). A workshop was convened in May of 2001 to develop the model. Forty-nine local and regional experts attended and participated in five days of intensive model development. All federal state and local agencies as well as local and regional experts from Arizona State University, the University of Arizona, and private consultants participated in the model workshop.

3.5.1 FCI Model Selections

Initially, each workshop member was asked to identify wetland functions they deemed important to the success of the wetland subclass. USACE EL facilitators tallied votes, and the functions were ranked on the basis of votes. Ten functions were subsequently identified for the Paseo HGM subclass model:

1) Maintenance of Characteristic Dynamics
2) Dynamic Surface Water Storage/Energy Dissipation
3) Long Term Surface Water Storage
4) Dynamic Subsurface Water Storage
5) Nutrient Cycling
6) Detention of Imported Elements and Compounds
7) Detention of Particles
8) Maintain Characteristic Plant Communities

9) Maintain Spatial Structure of Habitat
10) Maintain Interspersion and Connectivity

These FCI functions were selected on the basis of their representation of ongoing critical ecosystem processes within the wetland subclass. Based on the expert's opinions, riverine overbank model was associated with the four dominant cover types or PWAAs (Cottonwood-Willow Forests, Mesquite Woodlands, River Bottom, and Scrub-Shrub).

3.6 FIELD SAMPLING

Basic site characterization, mapping and data collection are the first steps in inventorying an ecosystem restoration site (USACE 2000; Fischenich 1999). Characterization for the study area 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 Geographic Information System (GIS). As part of the basic site characterization, historical data on landscape-scale habitat conditions, land-use characteristics and ownership patterns was collected as well. Site- and landscape-level data were collected and historical data was obtained and reviewed. These datasets, in turn, were used to characterize the baseline conditions of the study area.

Several members of the Paseo Evaluation Team participated in the field sampling efforts initiated in the early spring months of 2001 and again in April of 2003. The 3-4 member field crews, facilitated by USACE personnel, included members from five (5) separate federal, state, and local agencies, experts from nearby universities, and consultants.

3.6.1 Variables Measured In the Field

A total of sixteen (16) FCI variables were measured during the field sampling efforts. These variables are described in detail in Table 7. Variables were sampled according to protocols listed in these tables.

3.6.2 Field Sampling Protocol

100-m transects were laid down within the boundaries of the four cover types within the study area and variables were measured using one-meter quadrats at 10 m intervals (i.e., ten sampling stops or stations per transect were made). In most instances, data collected on the cover type transects were averaged to generate a cover type score for the site. This strategy reduced the coefficients of variance (i.e., standard deviations of the field data). When class data was recorded (e.g. deacy and surface inflow class data), the modes were calculated instead of averages across transects within the cover type.

3.6.3 Variables Obtained Without Field Sampling

Some variables could be obtained through various historical records, aerial photos or mathematical calculations rather than through active field sampling. In addition, a total of 13 FCI variables were obtained from District resources and spreadsheet calculations. These variables are described in detail in Table 8.

Table 7: FCI Variables Measured in the Field Sampling Effort for the Wetland Assessment

VAR Code	Variable Description	Methodology, Techniques and Assumptions	Logic
AGSA	Algal Growth Coverage (%)	Percent of quadrat with algae, algal remnants, or water present.	Fxn 5: NUTRIENT & 6: ELEMENTS - Algal growth is an indicator for wetness at the surface. If there is water present long if enough for algal mats to grow, then the water is there long enough for vegetation to take up nutrients in the system.
BUFFCOV	Vegetation Cover in the Buffer Zone (%)	Measure percent cover of vegetation vs. bare ground within the quadrat.	Fxn 11: BUFFER - Buffer cover is important for protecting animals as they travel from wetland area to the uplands. Native vegetation is highly preferable over non-native vegetation.
CWD	Cover of Dead and Down Woody Debris Larger Than or Equal to 2.5" in Diameter (Coarse)	Percent of quadrat with coarse woody debris present.	Fxn 2: WATSTORENR - Coarse woody debris along with microtopography and trees serve as indicators of roughness as a substitute for Manning's n value. Fxn 5: NUTRIENT - Coarse woody debris in various stages of decay indicates that the function is on-going and sustainable. Fxn 7: DETPARTICL - Coarse woody debris provides surface roughness which reduces water velocity. This enables organic and inorganic particulates to settle and to be detained. Fxn 9: HABSTRUCT - Coarse woody debris detains coarse and fine particulate matter, and therefore, influences channel morphology (e.g. pool-riffle complexes). Coarse woody debris also provides energy sources and substrates for the microbial activity that is important in nutrient cycling and other biogeochemical processes. Coarse woody debris also provides habitat for a wide variety of invertebrates and vertebrates.
DECAY	Presence of Coarse Woody Debris in Various Stages of Decomposition	Class data: 0 = No data 1 = One Class present 2 = Two Classes Present 3 = Three Classes Present 4 = Four Classes Present 5 = Five Classes Present 6 = No coarse wood - variable is recoverable 7 = No coarse wood - variable is not recoverable Five stages of decay: 1 = Logs recently fallen, bark attached, leaves and fine twigs present, no fungi present 2 = Logs with loose bark, no leaves and fine twigs present, fungi may be present 3 = Logs without bark, few stubs of branches present, fungi may be present 4 = Logs without bark or branches, heartwood in advance state of decay, fungi may be present .	Fxn 5: NUTRIENT - Coarse woody debris in various stages of decay indicates that the function is on-going and sustainable.

FWD	Cover of Dead and Down Woody Debris Smaller Than in Diameter (Fine)	Percent of quadrat with fine woody debris present.	Fxn 5: NUTRIENT -Fine woody debris in various stages of decay indicates that the function is on-going and sustainable. Fxn 7: DETPARTICL -Fine woody debris provides surface roughness which reduces water velocity. This enables organic and inorganic particulates to settle and to be detained. Fxn 9: HABSTRUCT - Fine woody debris provides energy sources and substrates for the microbial activity that is important in nutrient cycling and other biogeochemical processes.
INVASIVES	Presence/Absence of invasive species.	Denote the presence or absence of invasive species.	Fxn 8: PLANTS - A healthy plant community comprises a high percentage of native, non-invasive plants. As a system becomes disturbed, sensitive native species are out-competed by invasive, non-native species.
LITTER	Cover of Leaf Litter and Other Detrital Matter (%)	Percent of quadrat with litter cover present	Fxn 5: NUTRIENT and Fxn 6: ELEMENTS - Litter/detrital layer of debris provides energy and substrate for microbial processes which result in the conversion of elements and compounds. Fxn 9: HABSTRUCT - The litter layer is important for cover, food and nesting of various vertebrates and invertebrates.
SPECRICH	Species Richness	Count (and if possible identify) the number plant species present	Fxn 8: PLANTS - Some measure of plant species diversity is needed, if one is to assess the function of maintaining characteristic plant communities. Riparian ecosystems can be species -rich. Maintaining regional biodiversity is a key riverine function.
SURFIN = SURFINRILL + SURFINLAT	Surface inflow to wetland via sheetflow.	Class data: 0=No data 1=Any of the following are present & similar to reference standard: rills on adjacent upland slopes; lateral tributaries entering floodplain and infiltrating 2=Both indicators, present & less than the reference standard 3=Both indicators, absent & some sedimentation occurs on wetland surface 4=Both indicators, absent & channelization prevents sedimentation on wetland surface	Fxn 6: ELEMENTS - When precipitation rates exceed soil infiltration rates, overland flow in uplands adjacent to riverine wetland may be a water source. Indicators include the presence of fill and rearrange litter on the uplands leading to the floodplain.

TOPO = MICROTOPO + MACROTOPO	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.	Class data for FPA: 0 = No data 1 = Macro and microtopo. relief 2 = Homogenous surfaces with macro and microtopo. relief 3 = Homogenous surface & lacks macro and microtopo. relief 4 = Steep bank, recoverable 5 = Steep bank, not recoverable	Fxn 2: WATSTORENR & Fxn 3: WATSTORLNG - Topographic features such as pits and ponds, provide areas that can store surface water as well as provide roughness. Fxn 7: DETPARTICL - Macro- and microtopographic relief provide surface roughness and complexity to the system. Flowing water must move into, over, through, or around these features. Velocity is reduced allowing particulates to be detained. Fxn 8: PLANTS, Fxn 9: HABSTRUCT and Fxn 10: INTERSPERS- Topological complexity offers a variety of ecozones and ecotones that supply the habitat needs of -, wetland-, and edge-adapted species.
TVV	Abundance as measured through vegetation volume.	Record the number of decimeter hits within each meter interval. A hit is defined as any vegetation within a 10-dm radius of the rod, per vertical decimeter. These estimations can be based on comparisons with lower intervals where hits can be directly measured.	Fxn 2: WATSTORENR - Coarse vegetative along with microtopography and trees serve as indicators of roughness as a substitute for Manning's n value. Fxn 5: NUTRIENT - Vegetative cycle nutrients through soil and water nutrient uptake, biomass accumulation and litter production. Fxn 6: ELEMENTS - Vegetative are long-term sinks for elements and compounds. Fxn 7: DETPARTICL - Vegetative slow the velocity of water which must move around them and provide roughness to the system. The roughness dissipates hydrologic energy and allows for particulates to be detained. Fxn 8: PLANTS - Vegetative density, as determined from reference standards, is characteristics of healthy system. Vegetative density will alter with various degrees of perturbation.
VEGSTRATA	Number of Vegetation Layers present	Record the number of layers present. Layers include: Tall (>10 m) broad-leaved tree Short broad-leaved tree Tall microphyllous tree Short microphyllous tree Tall (>1 m) broad-leaved shrub Short broad-leaved shrub Short (<1 m) microphyllous shrub Short microphyllous shrub Vine Epiphyte Bunch grass Non-bunch grass Forb Lichens or biotic soil crusts	Fxn 9: HABSTRUCT - As the number of vegetation layers at a site increases, so do the number of niches for bird species. The use of 1 meter height increments may provide a more sensitive measure of this diversity-related structural property than does the use of only 3 layers (e.g., ground, shrub, tree).
WIS	Wetland indicator score	Record wetland indicator score for species identified in SPECRICH. Scores are as follows: 1 = OBLIGATE 2 = FACULTATIVE WET 3 = FACULTATIVE 4 = FACULTATIVE UPL 5 = UPLAND	Fxn 8: PLANTS - A healthy wetland plant community comprises a high percentage of wetland, native, non-invasive plants. As a system becomes disturbed, sensitive native species are out-competed by non-wetland, invasive, non-native species.

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Table 8: FCI Variables Obtained From Other Methods

VAR Code	Variable Description	Methodology, Techniques and Assumptions	Logic
BUFFLENGTH	Area with Sufficient Buffer Length (%)	Landscape Variable Class data: 0 = No data 1 = 100% of the reach has a right & left bank buffers 2 = Only 1 side of the reach has 100% buffering 3 = 75% of the reach has right & left bank buffers 4 = Only 1 side of the reach has 75% buffering 5 = 50% of the reach bas right & left bank buffers 6 = Only 1 side of the reach has 50% buffering 7 = 25% of the reach has right & left bank buffers 8 = Only 1 side of tbe reach has 25% buffering 9 = 0% of the reach has right & left bank buffers	Fxn 11: BUFFER - Buffer serves as a protective zone against urban encroachment to the riverine wetland, therefore the longer the buffer the more protection.
BUFFWIDTH	Width of Buffer Zone (m) (i.e., Distance to nearest Human Disturbance)	Landscape Variable Class data: LANDUSE =1.0 and BUFFWIDTH=1.0 (100m for perrenial streams or 50m for ephemeral streams), score = 1.0 LANDUSE<1.0 and BUFFWIDTH<1.0, score = LANDUSE x BUFFWIDTH LANDUSE = 0 and BUFFWIDTH=1.0, score = 1.0 Curve depends on type of flow in channel. For perennial flows, (San Pedro, Tumacocori, Hassayampa, Salt River, Pasco, Tres Rios del Norte, Oeste) curve is 0,0,100,1	Fxn 8: PLANTS - A healthy plant community comprises a high percentage of native, non-invasive plants. As a system becomes disturbed, sensitive native species are out-competed by invasive, non-native species. Fxn 9: HABSTRUCT - Coarse woody debris detains coarse and fine particulate matter, and therefore, influences channel morphology (e.g. pool-riffle complexes). Coarse woody debris also provides energy sources and substrates for the microbial activity that is important in nutrient cycling and other biogeochemical processes. Coarse woody debris also provides habitat for a wide variety of invertebrates and vertebrates. Fxn10: INTERSPERS - Contiguous vegetation cover offers both horizontal and vertical connectivity throughout the riverine system. Fxn 11: BUFFER - Buffer serves as a protective zone against urban encroachment to the riverine wetland, therefore the wider the buffer the more protection.
CONTIG	Contiguous Vegetation Cover Between Wetlands and Uplands (%)	Landscape Variable	Fxn10: INTERSPERS - Contiguous vegetation cover offers both horizontal and vertical connectivity throughout the riverine system.
DEPSATSED	Depth of Saturated Sediments (m)	Class data for CTWWFOR: 0 = No data 1 = 0 m 2 = 1 - 3 m 3 - > 3 m Class data for MESQUITE: 0 = No data 1 = 0 m 2 = 1 - 7 m 3 = > 7 m Class data for RIVERBOTTM 0 = No data 1 = 0 m 2 = 001 - 025 m 3 = > 025 m	Fxn 4: WATSTORSUB - Availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic drawdown of water table.

FPA	Floodprone area	Landscape Variable Class data: 0 = No data 1 = FPA not clearly modified 2 = FPA is confined on one side 3 = FPA is confined and >1.5X bankful width 4 = FPA is confined and <1.5X bankful width, recoverable 5 = FPA is confined and <2X bankful width, not recoverable 6 = Concrete Channel	Fxn 1: CHANNELDYN - The erosion, transportation, and deposition of sediment is a function of stream velocity and sediment diameter. Constrictions of the stream channel and/or FPA may result in increased velocity and, therefore, may result in increased sediment entrainment and transport. Further, widening of the stream channel and/or FPA may result in decreased velocity and, therefore, may result in decreased sediment entrainment and transport. Fxn 2: WATSTORENR - Dynamic surface water storage and energy dissipation are functions of surface area and surface roughness. FPA is often straightened, confined, and cleared, and these activities result in a loss of surface area and surface roughness. Fxn 7: DETPARTICL - Unconfined and unmodified FPAs generally provide greater roughness and greater surface area, reducing hydrologic energy and allowing particulates to be retained.
FREQ	Frequency of Inundation	Class data: 0 = No data 1 = Perennial Flow 2 = Intermittent 3 = Saturated (Q1) 4 = Temporarily flooded seasonal high (Q2) 5 = Temporarily flooded bankful (Q10) 6 = Temporarily flooded large flood (Q25) 7 = Temporarily flooded major flood (Q100) 8 = Temporarily flooded super flood (>Q100)	Fxn 2: WATSTORENR & Fxn 3: WATSTORLNG - Fxn 6: ELEMENTS - Without flooding from overbank flow, there would be little opportunity for waterborne materials on streams to be removed by biogeochemical processes operating on floodplain wetlands. For an unaltered site that receives flooding at a 2 - to 5-year intervals, the 2- to 5-year intervals would score a 1.0: an annual flooding regime would be inappropriate for that site and would score less than 1.0.
LANDBUFF	Computation only	Landscape Variable Class data: LANDUSE =1.0 and BUFFWIDTH=1.0 (100m for perrenial streams or 50m for ephemeral streams), score = 1.0 LANDUSE<1.0 and BUFFWIDTH<1.0, score = LANDUSE x BUFFWIDTH LANDUSE = 0 and BUFFWIDTH=1.0, score = 1.0	Fxn 8: PLANTS - A healthy plant community comprises a high percentage of native, non-invasive plants. As a system becomes disturbed, sensitive native species are out-competed by invasive, non-native species. Fxn 9: HABSTRUCT - Coarse woody debris detains coarse and fine particulate matter, and therefore, influences channel morphology (e.g. pool-riffle complexes). Coarse woody debris also provides energy sources and substrates for the microbial activity that is important in nutrient cycling and other biogeochemical processes. Coarse woody debris also provides habitat for a wide variety of invertebrates and vertebrates. Fxn10: INTERSPERS - Contiguous vegetation cover offers both horizontal and vertical connectivity throughout the riverine system. Fxn 11: BUFFER - Buffer serves as a protective zone against urban encroachment to the riverine wetland, therefore the wider the buffer the more protection.

LANDUSE	Type of Adjacent Landuse	Landscape Variable Class data: 0 = No data 1 = Active sand and gravel operations 2 = Commercial/ Industrial 3 = Paved roads 4 = Multi-family residential (apartments and duplexes) 5 = Single-family residential (individual houses) 6 = Gravel roads, dirt roads, bike paths, and infrequently visited structures 7 = Inactive sand and gravel operations 8 = Agricultural cropland 9 = Open space (parks, golf course, etc) 10 = Pristine, uninhabited areas	Fxn 8: PLANTS - A healthy plant community comprises a high percentage of native, non-invasive plants. As a system becomes disturbed, sensitive native species are out-competed by invasive, non-native species. Fxn 9: HABSTRUCT - Coarse woody debris detains coarse and fine particulate matter, and therefore, influences channel morphology (e.g. pool-riffle complexes). Coarse woody debris also provides energy sources and substrates for the microbial activity that is important in nutrient cycling and other biogeochemical processes. Coarse woody debris also provides habitat for a wide variety of invertebrates and vertebrates. Fxn10: INTERSPERS - Contiguous vegetation cover offers both horizontal and vertical connectivity throughout the riverine system. Fxn 11: BUFFER - Buffer serves as a protective zone against urban encroachment to the riverine wetland, therefore the wider the buffer the more protection.
PORE	Soil pore space available for storing subsurface water. Performance is related to soil texture and permeability.	Class data: 0 = No data 1 = Soil texture is sand-sandy loam; no restrictive layer 2 = Soil finer than sand-has restrictive layer 3 = Soil texture is finer restrictive layer 4 = Modal soil profile highly compacted in the upper 24" 5 = Non-porous layer	Fxn 3: WATSTORLNG - A sand-sandy loam soil provides both high pore space and high permeability so water can quickly seep below surface therefore decreasing the long term surface storage. Fxn 6: ELEMENTS -
Q	Alterations of Hydroregime	Class data: 0 = No data 1 = No additions, diversions, or damming of flow affecting the assessment area (e.g. water harvesting, farming practices, stormwater management, etc) 2 = Evidence of additions, diversions, or damming of flow, BUT no evidence of significant impacts to channel pattern, dimension, and profile 3 = Evidence of additions, diversions, or damming of flow, AND there is evidence of changes in vegetation abundance; No evidence of increase sediment or scour 4 = Evidence of additions, diversions, or damming of flow, AND there is evidence of increase sediment or scour 5 = Evidence of additions, diversions, or damming of flow, AND there is evidence of significant impacts to channel pattern, dimension, and profile; Variable is recoverable 6 = Permanent alterations to hydroregime are evident; Variable is not recoverable	Fxn 1: CHANNELDYN - Alterations of the assessment area hydroregime can result in changes in discharge, bedload, vegetation, bank stability, and attendant channel morphology.
SED	Extent of sediment delivery to the water/wetland from culturally accelerated sources.	0 = No data 1 = No Culturally Accelerated Sources of Sediment Input 2 = Culturally Accelerated Sources Present and Little or No Evidence of Culturally Accelerated Sediment Delivery 3 = Culturally Accelerated Sources Present and Evidence of Culturally Accelerated Sediment Delivery 4 = Culturally Accelerated Sources, Evidence of Sediment Delivery - Causing Extreme Change in Channel Morphology and/or Vegetation Morphology	Fxn 1: CHANNELDYN - Fxn 7: DETPARTICL - Rates of sediment accumulation that exceed normal background rates indicate that the function is not sustainable.

SUBIN	Subsurface flow into the water/wetland via interflow and return flow.	Class data for adjacent areas: 0 = No data 1 = Undistributed, subsurface flow evident 2 = Undisturbed & subsurface flow is observed 3 = Disturbed soils and plant communities 4 = Utilized for agricultural activities 5 = Fill 6 = Impervious 7 = Concrete channel	Fxn 3: WATSTORLNG - Subsurface flow into the water/wetland, either from adjacent lands or upstream sources, is water that can be stored. Fxn 6: ELEMENTS - Subsurface flow into the water/wetlands increases soil moisture and can sustain it during times of lower flow.
SURFIN = SURFINRILL + SURFINLAT	Surface inflow to wetland via sheetflow.	Class data: 0=No data 1=Any of the following are present & similar to reference standard: rills on adjacent upland slopes; lateral tributaries entering floodplain and infiltrating 2=Both indicators, present & less than the reference standard 3=Both indicators, absent & some sedimentation occurs on wetland surface 4=Both indicators, absent & channelization prevents sedimentation on wetland surface	Fxn 6: ELEMENTS - When precipitation rates exceed soil infiltration rates, overland flow in uplands adjacent to riverine wetland may be a water source. Indicators include the presence of fill and rearrange litter on the uplands leading to the floodplain.
TOPO = MICROTOPO + MACROTOPO	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.	Class data for FPA: 0 = No data 1 = Macro and microtopo. relief 2 = Homogenous surfaces with macro and microtopo. relief 3 = Homogenous surface & lacks macro and microtopo. relief 4 = Steep bank, recoverable 5 = Steep bank, not recoverable	Fxn 2: WATSTORENR & Fxn 3: WATSTORLNG - Topographic features such as pits and ponds, provide areas that can store surface water as well as provide roughness. Fxn 7: DETPARTICL - Macro- and microtopographic relief provide surface roughness and complexity to the system. Flowing water must move into, over, through, or around these features. Velocity is reduced allowing particulates to be detained. Fxn 8: PLANTS, Fxn 9: HABSTRUCT and Fxn 10: INTERSPERS- Topological complexity offers a variety of ecozones and ecotones that supply the habitat needs of -,
TRIB	Presence of connected tributaries	Landscape Variable Class data: 0 = No data 1 = All tributaries (channel and riparian corridor) are unmodified and connect to the mainstem 2 = Some tributaries are modified (consolidated, redirected, or channelized) but still connected to the mainstem 3 = Tributaries are highly modified/channelized, OR not connected to the mainstem	Fxn 10: INTERSPERS -

3.7 DATA MANAGEMENT AND STATISTICAL ANALYSIS

All data management for variables, functions, and field sampling was performed by the USACE Environmental Laboratory and then input into ExHGM software for statistical analysis and quality control.

3.8 PASEO DE LAS IGLESIAS BASELINE CONDITIONS

Once the baseline inventory was conducted, and both the variable means/modes and the cover type acreages were determined, the baseline conditions in terms of Functional Capacity Units (FCUs) were generated. Strictly speaking, the means/mode values for each variable were applied to the Variable Subindex graphs as dictated by the model documentation. For example, if the percent of ground cover in the CTWWFOR PWAAs at Site X was 50 percent on average, the value "20" was entered into the "X-axis" on the Variable Subindex curve below, and the resultant VSI score (Y-axis) was recorded (VSI = 1.0).

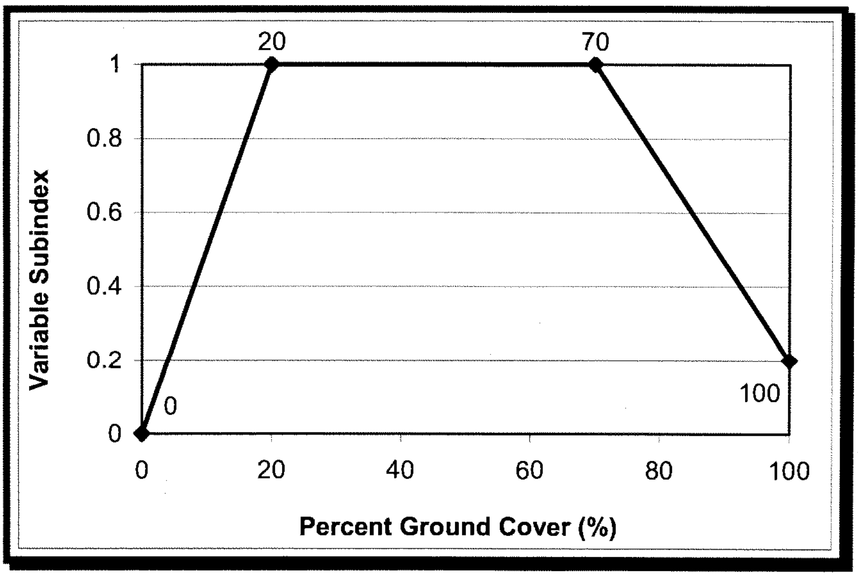


Figure 3: Example Variable Subindex (VSI) curve

The process was repeated for every associated variable and PWAA per model. The individual VSI scores were then entered into the HSI formula on a PWAA-by-PWAA basis, and individual PWAA FCIs were generated. Each answer, referred to as the PWAA FCI was then weighted by the relative area (RA)[1] of the PWAA, and

[1] Relative Area: In HGM, the relative area is a mathematical process used to "weight" the various applicable PWAAs on the

combined with the answers from the remaining associated PWAAs in an additive fashion. The model's formula was considered to be the sum of the PWAA FCIs as follows:

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

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

The final step was to multiply the FCI result against the habitat acres (i.e., PWAA acres associated with the model). The final results, referred to as Functional Capacity Units (FCUs), quantified the quality and quantity of the wetland conditions at the site at TY0 (Baseline). The details of baseline results are fully documented in each project's reports. The distribution of these Cover Types is illustrated in Figure 2 with acreages listed in Tables 9 and 10. The total study area includes 5005 acres.

Table 9: Mapped Cover Type Acreages

COVER TYPE	ACRES
Cottonwood/Willow Forest	0
Mesquite Bosque	160
Riverbottom (includes low flow and grasses)	173
Scrub-shrub (Sonoran Desert Wash Communities)	256
Total	**589**

Non-riparian cover designations within the study area are tabulated in the Table 10 below:

TABLE 10: Mapped Non-PWAA Cover Types

COVER TYPE	ACRES
AGCROP	416
DESERT	237
DITCHES	99
PARK	86
SOIL CEMENT	21
URBAN	3557
Total	**4416**

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basis of quantity. To derive the relative area of a model's PWAA for the study, the following equation was utilized:

$$\text{Relative Area} = \frac{\text{PWAA Area}}{\text{Total Area}}$$

where: PWAA Area = only those acres assigned to the PWAA of interest
Total Area = the sum of the acres utilized in the model

3.10.1 Baseline Functional Capacity Indices (Ecosystem Quality)

As previously noted, functional capacity indices are scaled from 0.0 to 1.0. An index of 1.0 indicates that a PWAA performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under optimum conditions. 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. Baseline (i.e., existing) FCI and FCU conditions measured within the study area are shown in Table 11 below and illustrated in Figures 4 and 5. Definitions of each function were provided in Table 3 earlier in this chapter. FCIs were applied to study area cover types to calculate FCUs. These results show that riparian and wetland habitats within the study area have low functional values and are therefore highly degraded.

TABLE 11: Baseline Functional Assessment Summary

Function Name	Weighted Functional Capacity Index (FCI)	Applicable Acres	Baseline Functional Capacity Units (TY0 FCUs)
Fxn 01: Maintenance of Characteristic Dynamics	0.200	589	118
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.692	589	408
Fxn 03: Long Term Surface Water Storage	0.188	589	111
Fxn 04: Dynamic Subsurface Water Storage	0.000	589	0
Fxn 05: Nutrient Cycling	0.339	589	200
Fxn 06: Detention of Imported Elements and Compounds	0.297	589	175
Fxn 07: Detention of Particles	0.329	589	194
Fxn 08: Maintain Characteristic Plant Communities	0.168	589	99
Fxn 09: Maintain Spatial Structure of Habitat	0.204	589	120
Fxn 10: Maintain Interspersion and Connectivity	0.197	589	116

Functions 1 through 4 are hydro-geomorphic functions. The hydro-geomorphic characteristics of a riverine ecosystem are the primary ecosystem drivers; these include flow regime, geophysical setting, intermediate-scale geomorphic processes, and anthropogenic impacts that interact and vary in importance across spatial scales in controlling stream environments and shaping biotic communities. As shown below, all but one of the FCIs for these functions are extremely low for the study area:

- *Function 1, Maintenance of Characteristic Dynamics,* is 0.20 because of the effects of channelization, modification of the channel with soil cement, past farming practices and artificially accelerated input of sediment from upstream development.

- *Function 2, Dynamic Surface Water Storage/Energy Dissipation,* has a high value that is most likely a result of the relatively wide channel in the unprotected reaches.
- *Function 3, Long Term Surface Water Storage* scored low as a result of modification of the flood prone area, construction of soil cement, disappearance of perennial flow and lack of a restrictive soil layer to slow infiltration and lack of subsurface flow.
- *Function 4, Dynamic Subsurface Water Storage,* had the lowest score possible because of the depth to groundwater levels due to pumping of groundwater in the Tucson Basin.

Functions 5 to 7 reflect the biogeochemical processes or the availability of nutrients in the ecosystem.

- *Function 5, Nutrient Cycling,* was very low with the study area due because of the lack of sources of organic material.
- *Function 6, Detention of Imported Elements and Compounds,* was extremely low due to lack of perennial flow, lack of a restrictive soil layer, lack of organic sources and a disconnected floodplain due to soil cement banks.
- *Function 7, Detention of Particles,* was very low due to modification of the flood prone area throughout the study area, culturally accelerated sediment sources upstream, and lack of organic input sources within the study area.

Functions 8 to 11 are related to the habitat within the ecosystem.

- *Function 8, Maintain Characteristic Plant Communities,* scored low because of the percent of invasives measured, the low number of plant species, the lack of obligate wetland species present and the low percentages of tree, shrub and herb canopy.
- *Function 9, Maintain Spatial Structure of Habitat,* scored low because of its low number of vegetation layers, and lack of organic debris and litter.
- *Function 10, Maintain Interspersion and Connectivity* also scored low due to lack of perennial flow, low percentages of contiguous vegetation cover between the riverbed and uplands, and modifications to tributary connections to the Santa Cruz.

Figure 4 illustrates the baseline functional level of the Paseo de las Iglesias study area. All indices show that the site is functioning poorly from an ecosystem standpoint. The average FCI is 0.26 for Paseo de las Iglesias study area. The lowest rated Reference Site, the Salt River, was rated at 0.57 (see Figure 6).

To compare Functional Capacity Units (FCUs) between the reference site(s) and the study area, the FCI for each reference site was multiplied times the same acreage per PWAA that exists in the Paseo de las Iglesias study area. When the Paseo de las Iglesias site is compared to the Arizona reference sites (see Figure 7), the area has a much lower functional capacity index for desirable cover types. This illustrates the inability of the habitat within this reach to sustain itself. The average across the eleven functions for the existing conditions in the study area is 154 AAFCUs, compared to the results for the Salt River Reference Site (the least productive of the five reference sites), which was 333 AAFCUs.

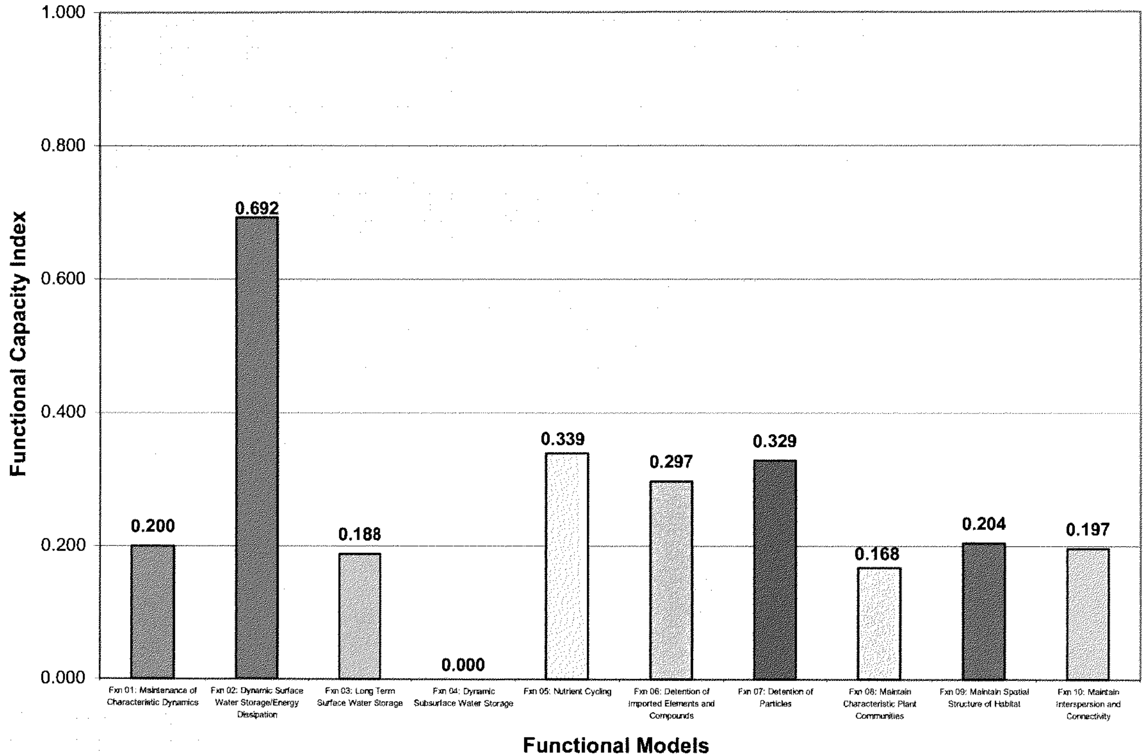


FIGURE 4: Baseline Functional Capacity Index Results

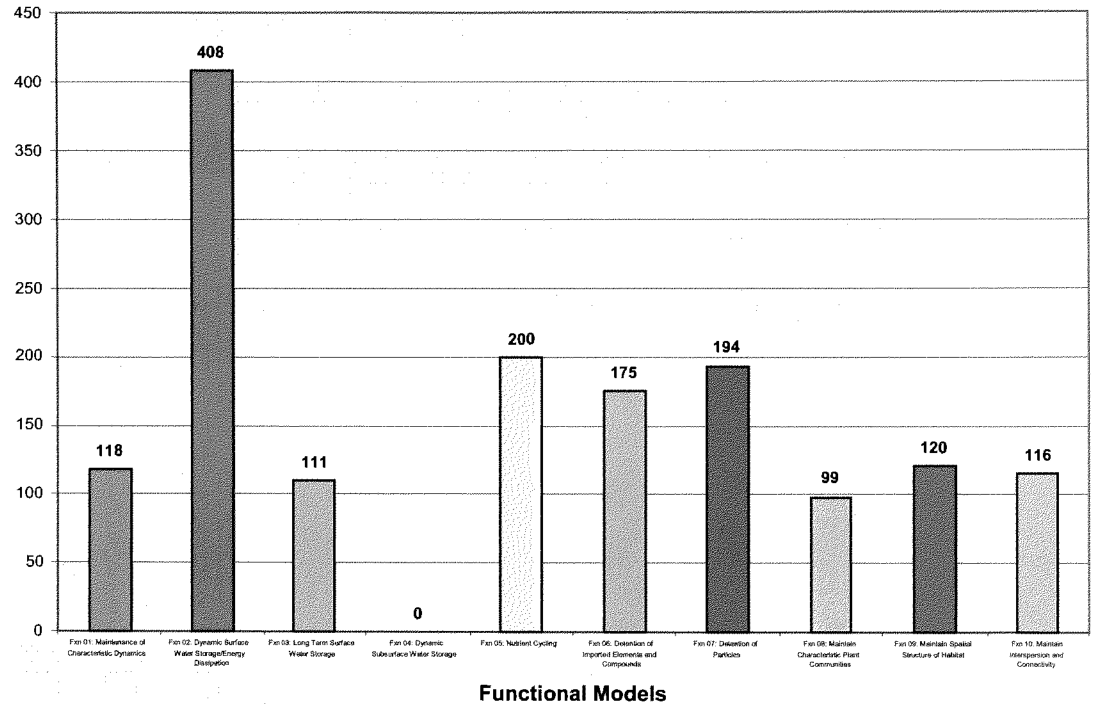


Figure 5: Baseline Average Annual Functional Capacity Units

Figure 6: FCI Comparisons between Reference Sites and Paseo de Las Iglesias

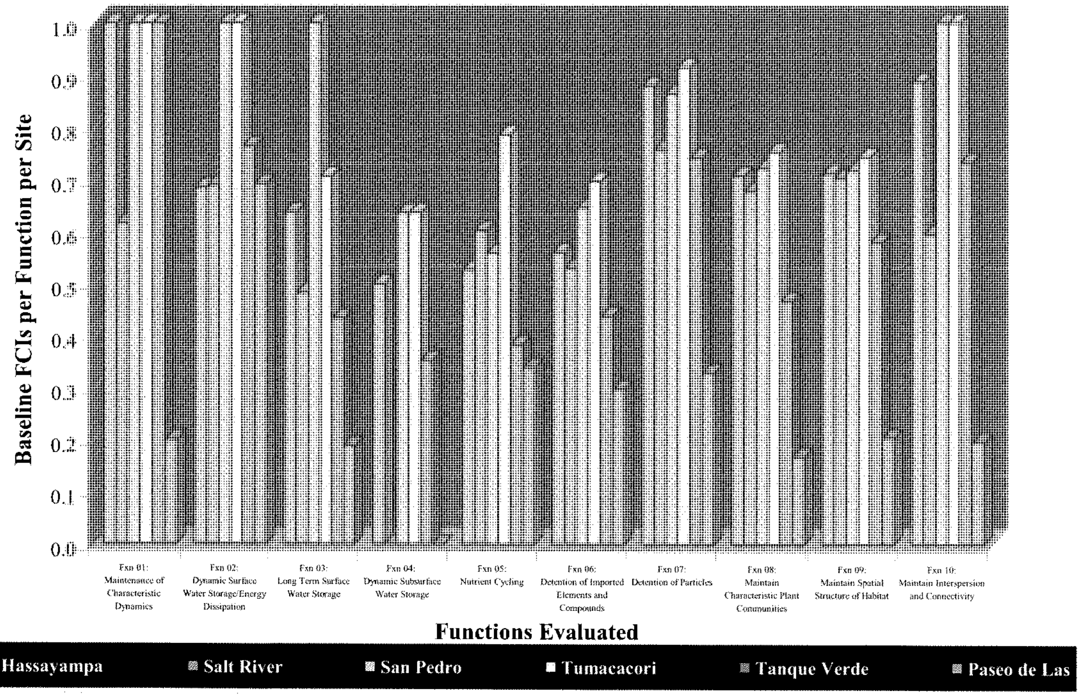
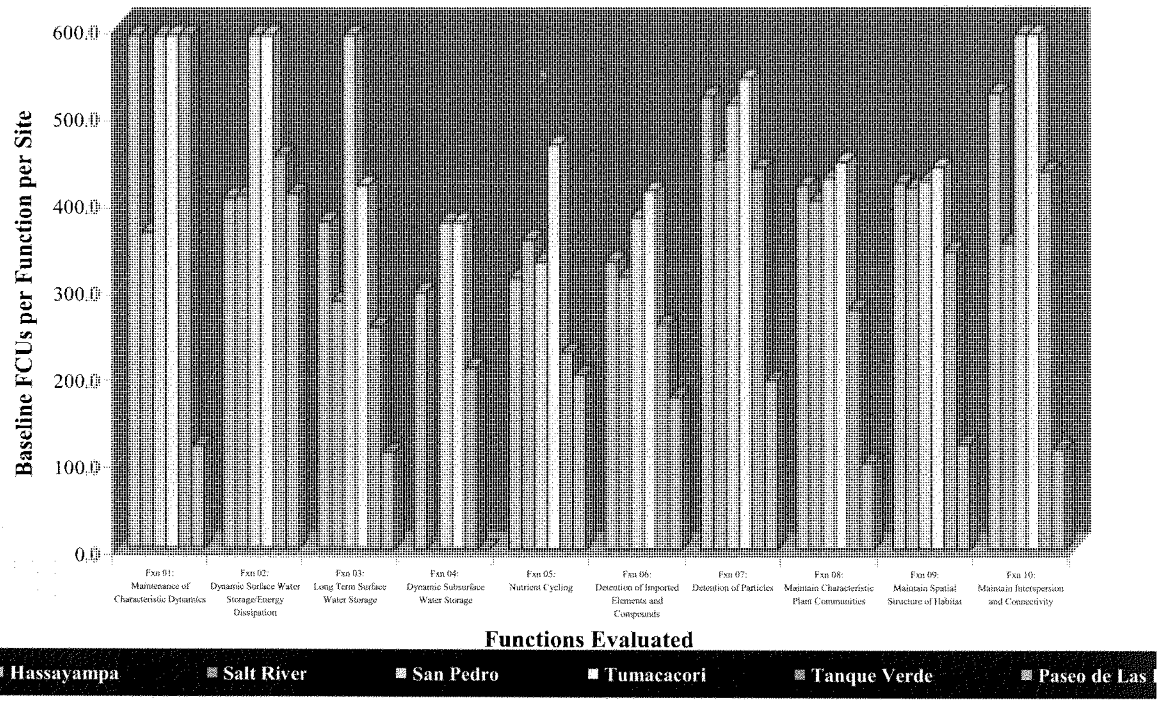


Figure 7: FCU Comparisons between Reference Sites and Paseo de Las Iglesias



3.9 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 (USACE 2000). 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 HGM, a judgment-based method, supported by the scientific and professional expertise of the evaluation team, is often relied upon to forecast the effectiveness of ecosystem restoration alternatives, rate project performance, and determine many other important aspects of both Without Project and With Project conditions.

The Without Project condition is universally regarded as a vital and important element of the evaluation (USACE 2000). 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. It is important to note that by definition, the "No Action Alternative" is the Without-Project condition that describes the future that society would have to forego if action was taken. Conversely, the Without-Project condition is the result when no action is taken. When formulating plans the No Action Alternative must always be considered. In essence, this requires that any action taken be more "in the public interest" than doing nothing. The Without-Project condition becomes the default recommendation.

The Without Project description must adequately describe the future (USACE 2000). Significant variables, elements, trends, systems, and processes must be sufficiently described to support good decision-making. Without Project descriptions must be rational. Forecasts must be based on appropriate methods, and professional standards must be applied to the use of those methods. Accuracy is an important element of a rational scenario. All future scenarios should be based on the assumption of rational behavior by future decision-makers and must make sense. Scenarios should not rely on an unlikely series of events or irrational behavior. A good scenario must pass the test of making common sense. Without Project conditions are not "before-and-after" comparisons. Without Project conditions are not mere extensions of existing conditions, and should be oriented toward comparing alternative future scenarios. The Without Project condition must be inclusive in the sense that it is subjected to rigorous review and comment as part of the public participation process (and throughout the coordination and review process).

3.9.1 Without Project Condition Functional Capacity Results

As a result of development pressures and the availability of residentially-zoned land, population will continue to increase along this 7-mile reach of the Santa Cruz River, regardless of project status. Without-project, the riverbanks will most likely be soil cemented, thus greatly decreasing native vegetation growth and the floodplain area. In addition, the use of soil cement would increase the amount of developable land in the study area and result in increased residential and non-residential development adjacent to the River. This development would greatly reduce, if not preclude, the opportunity for ecological restoration and that would accrue from an integrated program of water resources and riparian restoration.

Increased development will reduce or eliminate ecosystem restoration opportunities. Over the past century, a reduction in vegetation adjacent to the river has resulted in a detrimental loss of wildlife habitat. For the Without Project Condition, this trend is expected to continue at an accelerated rate, due to the pressures of urbanization and competing demands on water and other resources within the region and study area.

This loss of value is reflected in the decrease of the average Functional Capacity Index for the study area from 0.26 in the base year to 0.18 in Year 51. The future Without Project Condition Functional Capacity Indices (FCI) is presented graphically in Figure 8.

Figures 9 presents the Without Project FCI comparisons between the reference sites and the study area in Target Year 51.

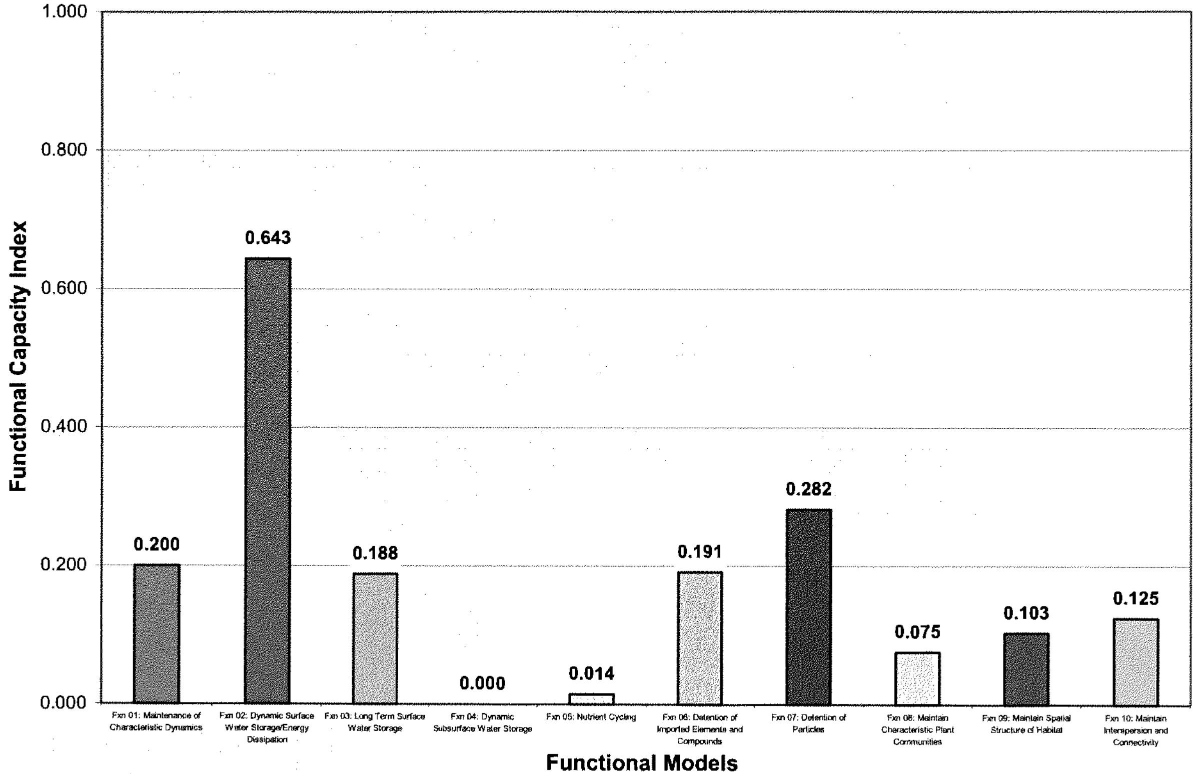
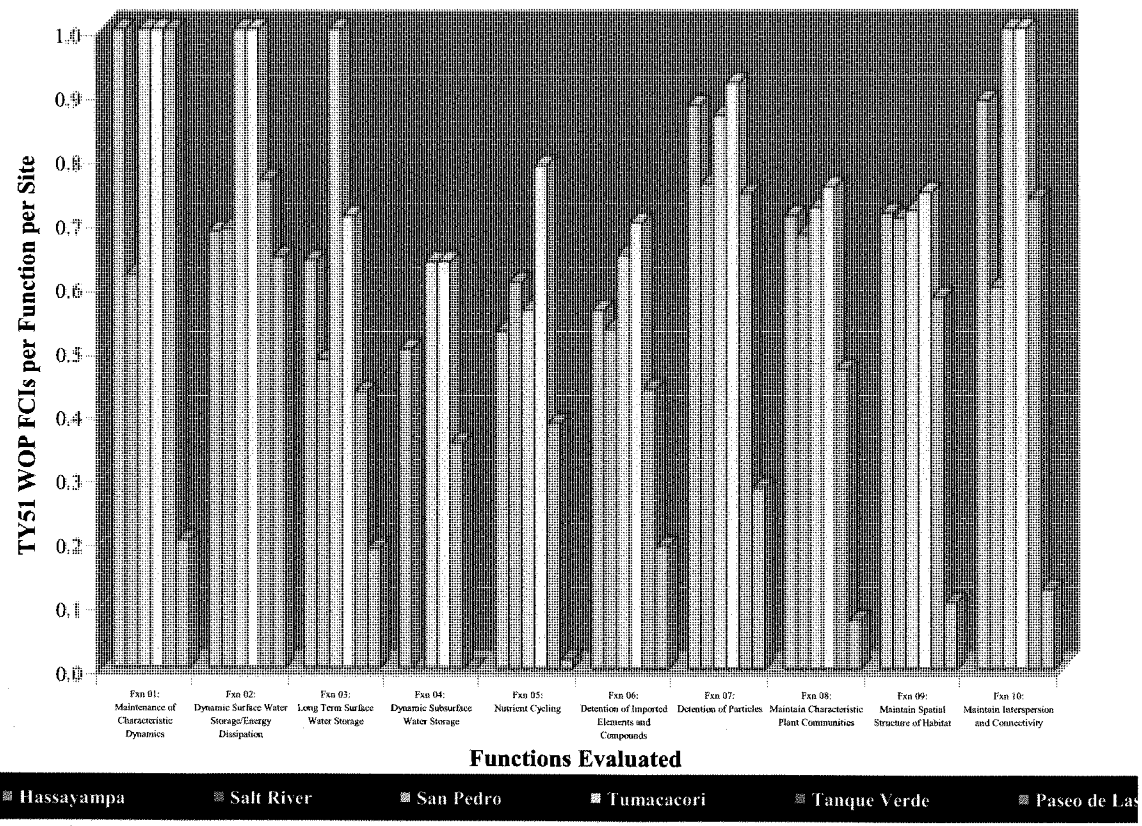


Figure 8: Future Without Project FCIs for Paseo de las Iglesias

Figure 9: WOP FCI Comparison of Paseo de las Iglesias and Reference Sites



3.9.2 Annualized Units for the Without Project Condition

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 "life of the project" and is defined as that period of time between the time that the project becomes operational and the end of the project life 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-start impacts. However, if no pre-start changes are evident, then the "life of the project" and the "period of analysis" are the same. In HGM, 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 life of the project. 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), and can be expressed mathematically in the following fashion:

$$\text{AAFCUs} = \sum \text{Cumulative FCUs} \div \text{Number of years in the life of the project}$$

where: Cumulative FCUs =

$$\sum (T_2 - T_1)\left[\left((A_1 F_1 + A_2 F_2) \div 3\right) + \left((A_2 F_1 + A_1 F_2) \div 6\right)\right]$$

and where:
T_1 = First Target Year time interval
T_2 = Second Target Year time interval
A_1 = Area of available wetlands at beginning of T_1
A_2 = Area of available wetlands at end of T_2
F_1 = FCI at beginning of T_1
F_2 = FCI at end of T_2

This is a generalized formula and requires that the FCI and area of the available habitat for each target year. The numbers "3" and "6" are constants derived from the integration of FCI x Area for the interval between any two target years. This formula is applied to the time intervals between target years. The formula was developed to precisely calculate cumulative FCUs when either FCI or area or both change over a time interval. The rate of change of FCUs may be linear (either FCI or area change over the time interval) – the formula will work in either case.

Although the characteristics of this environmental decline will vary within the study area, the overall effect will be the reduction of existing habitat value. The study area AAFCUs for the Without Project Condition are shown in Figure 10. Figure 11 presents a comparison between the reference sites and the study area for the Without Project AAFCUs.

The accompanying reduction trend in Function Capacity Units from 154 to 71 is presented in Figure 12.

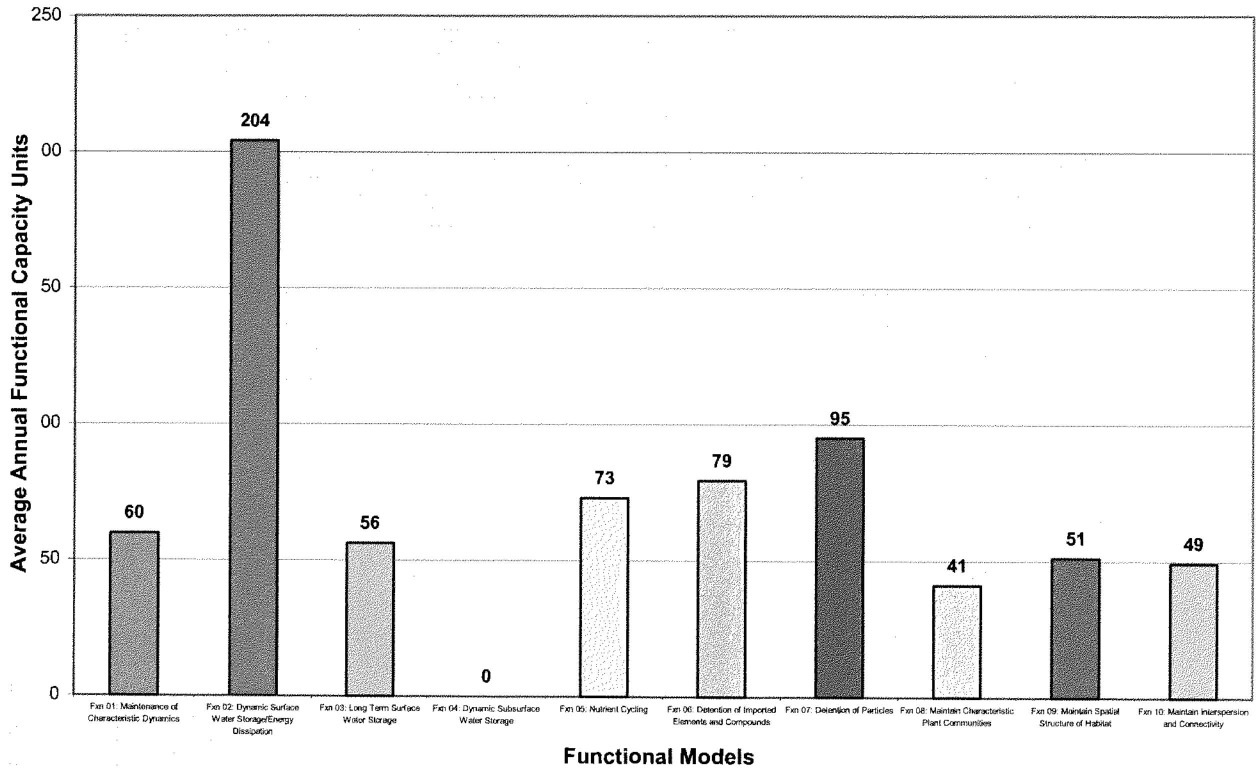
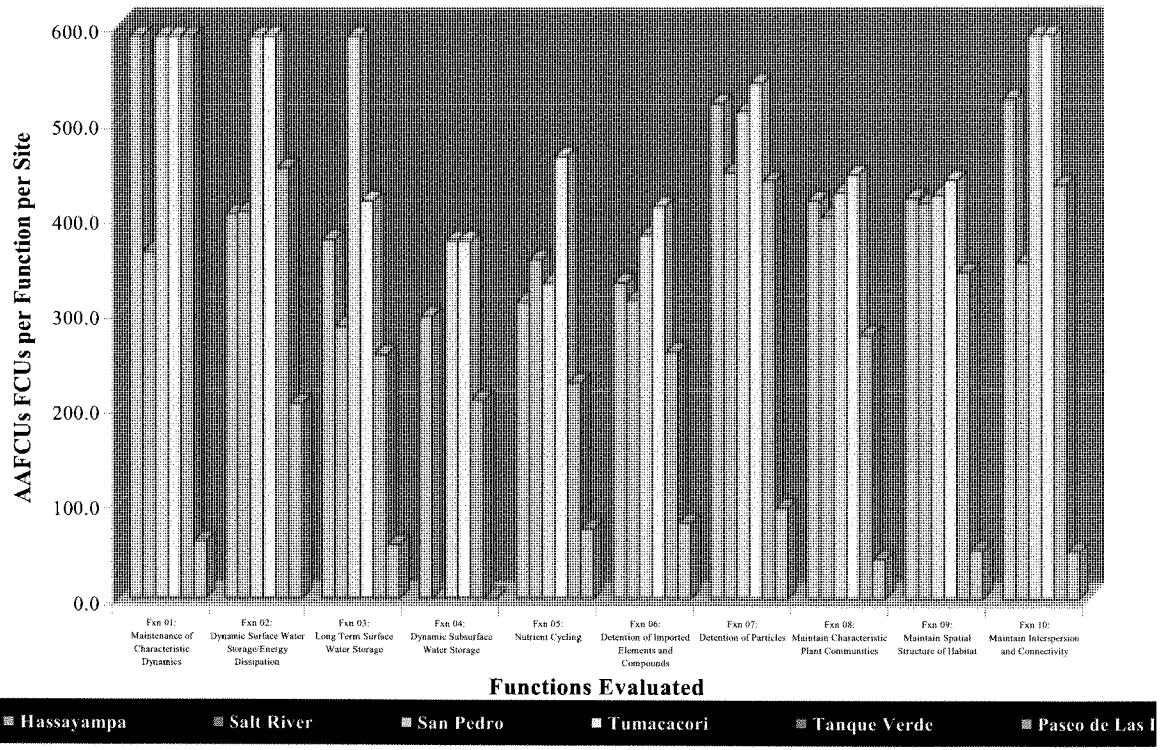


Figure 10: Future Without Project AAFCUs

Figure 11: WOP AAFCU Comparisons between Reference Sites and Paseo de Las Iglesias



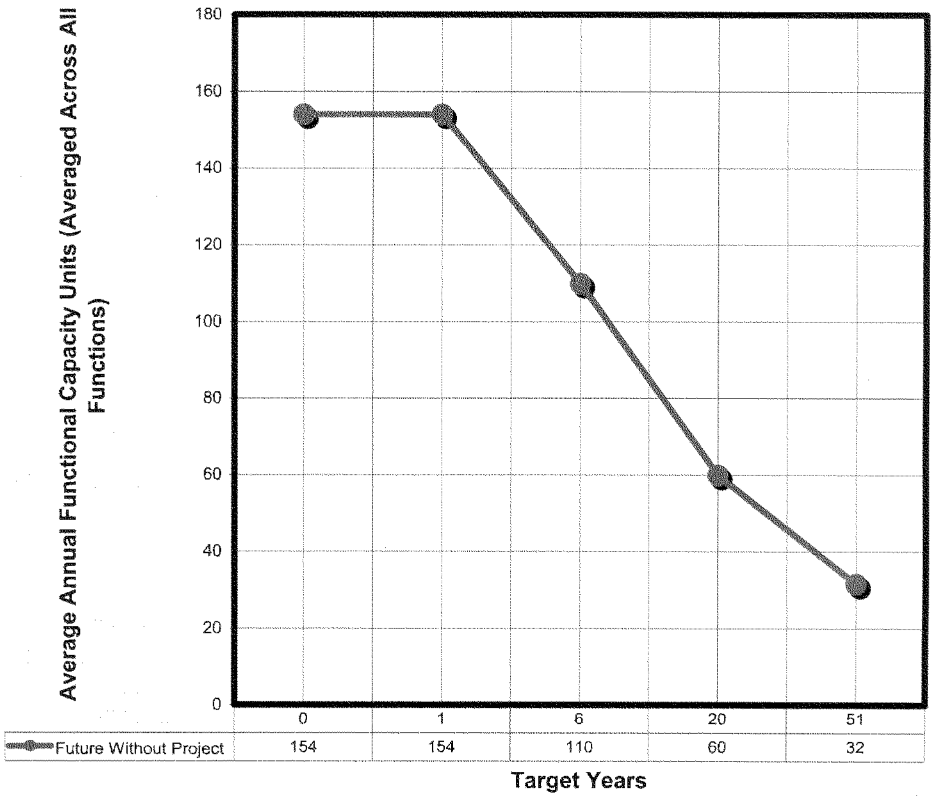


Figure 12: Trend in AAFCU's for the Without Project Condition7

3.10 WITH PROJECT CONDITIONS AND OUTPUTS

Throughout plan formulation, the Evaluation Team met on a regular basis to develop projection trends for each alternative. Alternatives were dropped from the analysis if their approaches were incongruous with the overall "restoration concept"; if their designs were impossible to achieve due to conflicting relationship with flood conveyance; or if the results were thought to be biologically unproductive. Various design and operation/maintenance activities were discussed in detail, and the outcomes of each were incorporated into the forecasting.

3.10.1 Alternative Development

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.

The awareness of the importance of water availability as a constraint on plan formulation was evident in the earliest stages of alternative development. The process began with three broad concepts for restoration that were characterized by high, medium and low water demand. Another attribute of these concepts was that the level of engineering effort increased along with water demand. Those became the starting point for development of an initial array of alternatives.

In the process of developing the initial array of alternatives the low water concept was replaced by a "Xeroriparian" concept. The team felt that development of restoration features to be supported entirely by rainfall and harvesting of runoff ensured a viable minimum project as well as providing a basis for assessing the gains produced by differing levels of irrigation. As alternative design proceeded the team recognized that the Xeroriparian features would need irrigation for a short period during the initial establishment of habitat and could need supplemental water during periods of extended drought. However, these alternatives have no requirement for regular irrigation. In addition to the Xeroriparian concept features were also placed into Mesoriparian and Hydroriparian groups. In this way groups of features were aligned with the major different riparian communities as associated with the frequency and duration of the presence of water.

The concept of differing levels of engineering effort was explored but was not found to provide a sufficiently distinct set of alternatives. This concept was replaced with the idea of associating the riparian feature groupings with a geomorphic setting. The project area was divided into three regions; the active channel, the adjoining terraces and the historic floodplain. The active channel refers to the area where water flows most frequently and where perennial flow would be found if it existed. The terraces are the adjacent land features, which are elevated only slightly above the active channel. Lower terraces might be flooded by a 2-5 year event and the upper terraces would be flooded by a 5-10 year event. The historic floodplain is the area adjacent to the entrenched channel of the Santa Cruz River. Although it has been cut off from the river due to down cutting resulting from human activities, in the past this is the area that would have been flooded by infrequent events in the range of 10 year and greater.

Using the concepts of riparian communities and geomorphic setting a matrix of grouped features was created. This matrix is included as Table 12. The matrix allowed initial consideration of every potential combination of feature groups, including no action, to create forty-seven potential alternatives. Preliminary screening of these alternatives was accomplished applying three factors that embodied the planning objectives and constraints identified in the early stages of the study. The specific goals identified for this study are to:

- Increase the acreage of functional riparian and floodplain habitat within the study area;
- Increase the wildlife and habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe and historic floodplain;
- Provide passive recreation opportunities;
- Provide incidental benefits of flood damage reduction, reduced bank erosion, reduced sedimentation and improved surface water quality consistent with the ecosystem restoration; and
- Integrate desires of local stakeholders consistent with Federal policy and local planning efforts.

Based on these goals, alternatives were screened out that:

- Failed to provide sufficient area of diverse habitat
- Were inconsistent with the natural progression of riparian communities
- Were likely to produce unacceptable impacts on flood conveyance

The first criteria is relatively straightforward. In applying the first criteria both the number of cover types restored and the total acreage restored were taken into consideration. The second criteria, consistency with natural progression merits some explanation. It is based on the fact that hydroriparian communities occur where water flows at all, or nearly all times of the year; mesoriparian communities experience frequent prolonged water flow and xeroriparian communities experience infrequent flows of shorter duration. In geomorphic terms, hydroriparian plants are most often found adjacent to the active channel or in the adjoining lower terraces. Mesoriparian plants would be found in the lower or upper terraces and xeroriparian would be found in the upper terraces or the historic floodplain. While diminished flows might lead to drier communities occurring nearing the active channel one would never expect to find hydroriparian plants in the historic floodplain or to find a drier community near the channel with a wetter one above it at a greater distance from the channel.

As used in this analysis, the active channel includes primary low flow and any channel braids or back waters that would be inundated when the low flow channel filled. With a few exceptions described later, alternatives that violated this "natural logic" were eliminated. The terraces refer to those areas elevated above the active channel but below the tops of the soil cement banks and their natural counter parts while the historic floodplain takes in the areas adjacent to the embanked river that were historically part of the Santa Cruz River's riparian ecosystem.

Finally, while the Santa Cruz River channel has substantial capacity to convey flood flows, the growth of thick stands of vegetation throughout the channel would reduce that capacity and run a high risk of inducing flooding as a result. Therefore, alternatives that would create extensive new vegetation in both the terraces and the active channel were eliminated.

Application of these screening criteria resulted in elimination of thirty-three of the forty-seven possible alternatives. The results of this screening are presented in Table 13 and those alternatives eliminated from further consideration are gray shaded.

Table 12: Alternative Features Matrix

	Active Channel Features	Floodplain Terrace Features	Historic Floodplain Features
No Action* (Without Project) *Listed items are anticipated consequences rather than measures to be implemented as in the other rows.	1. Continued instability of channel due to erosion. 2. Continued refuse dumping. 3. Continued degraded habitat.	1. Continued erosion loss of lower terraces creating cliff-like banks. 2. Eventual application of soil cement on unprotected banks armoring entire reach.	1. With expanded soil cement bank protection, continued historic floodplain encroachment by development.
Xero-Riparian (Establishment & Emergency Irrigation)	1. Construct aquitards upstream of existing and new grade control structures. 2. Divert low flow from New West Branch into remnant headwaters of Old West Branch. 3. Plantings of riparian grasses/shrubs	1. Water harvesting from local runoff. 2. Create tributary aquitard deltas with two-tiered aquitards. 3. Plantings on terraces and aquitards.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Water harvesting from local runoff. 3. Replace steep banks with stabilized planted terraces
Meso-Riparian (Irrigation)	1. Construct and provide supplemental irrigation to aquitards upstream of existing and new grade control structures. 2. Introduce periodic flow into the Old West Branch just upstream of its confluence with the Enchanted Hills Wash and on other tributaries downstream of that point. 3. Plantings of riparian grasses	1. Create tributary single-tiered aquitard deltas. 2. Irrigate and plant terraces with mesquite along upper terrace. 3. Stabilize active channel banks by establishing thickly rooted mesquite at the edge of the lower terraces.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Plant and irrigate historic floodplain. 3. Replace steep banks with stabilized planted terraces
Hydro-Riparian (Perennial Flow With Irrigation)	1. Restore perennial flow with multiple points of distribution into the main Santa Cruz and tributary channels. 2. Plant cottonwood-willow bundles at edges of perennial flow where erosion protection needed. 3. Construct perennial channel features (e.g., pools, runs, and riffles).	1. Create tributary aquitard deltas with hydraulic link to perennial flow. 2. Irrigate and plant low terraces with riparian grasses to maintain flood conveyance and discourage colonization by invasive species. 3. Irrigate and plant upper terraces with mesquite/cottonwood-willow.	Hydro Riparian plants do not occur in areas of the floodplain that are not subject to frequent inundation. Even so, measure 3 from the mesoriparian floodplain is carried forward to mitigate greater erosion risks associated with increased channel roughness in combinations where "No Action" is paired with Perennial Flow.

Table 13: Alternative Screeening

Active Channel	Terraces	Floodplain	Screen Out	Reason
No Action	Xero	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	Xero	Meso	Yes	Not Consistent with Natural Pattern
No Action	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Meso	Xero		
No Action	Meso	Meso		
No Action	Meso	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Hydro	Xero	Yes	Not Consistent with Natural Pattern
No Action	Hydro	Meso	Yes	Not Consistent with Natural Pattern
No Action	Hydro	No Action	Yes	Not Consistent with Natural Pattern
No Action	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	No Action	Meso	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Meso	Yes	Not Consistent with Natural Pattern
Xero	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	Xero	Xero		
Xero	Xero	Meso	Yes	Not Consistent with Natural Pattern
Xero	Meso	No Action	Yes	Not Consistent with Natural Pattern
Xero	Meso	Xero	Yes	Not Consistent with Natural Pattern
Xero	Meso	Meso	Yes	Not Consistent with Natural Pattern
Xero	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Meso	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Meso	No Action	Xero	Yes	Not Consistent with Natural Pattern
Meso	No Action	Meso	Yes	Not Consistent with Natural Pattern
Meso	Xero	No Action		
Meso	Xero	Xero		
Meso	Xero	Meso	Yes	Not Consistent with Natural Pattern
Meso	Meso	No Action		
Meso	Meso	Xero		
Meso	Meso	Meso		
Meso	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Hydro	No Action	No Action		
Hydro	No Action	Xero	Yes	Not Consistent with Natural Pattern
Hydro	No Action	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Xero	No Action		
Hydro	Xero	Xero		
Hydro	Xero	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Meso	No Action	Yes	Too much reduction in conveyance
Hydro	Meso	Xero	Yes	Too much reduction in conveyance
Hydro	Meso	Meso	Yes	Too much reduction in conveyance
Hydro	Hydro	No Action		
Hydro	Hydro	Xero		
Hydro	Hydro	Meso		

As can be seen in Table 12, combinations of the four riparian categories with the three geomorphic regions form groups of management measures that designate alternatives. The combinations detailed in Table 12 are labeled with letters in this section for simplicity. The letters used are N for no action, X for xeroriparian, M for mesoriparian and H for hydroriparian. Each letter represents a row from the Alternative Features Matrix with the order of the letter aligned to the columns. For example, alternative HMN would be the result of combining hydroriparian active channel features and mesoriparian terrace features with no action in the historic floodplain. A brief description of each alternative remaining after prescreening is provided below. (For more detail, view Table 13 for reasons why thirty-three out of forty-seven possible alternatives were screened out of consideration).

No Action Within Active Channel

Alternatives NNN, NMX, and NMM remain after all combinations were made with no action remaining constant in the active channel. NNN calls for no action in the active channel, no action in the terraces, and no action in the historic floodplain. NMX implements no features in the active channel, a mesoriparian environment in the terraces, and xeroriparian features for the historic floodplain. NMM does nothing within the channel but implements mesoriparian action for both the terraces and historic floodplain.

NNN is considered the no action option and is one of the alternatives required by USACE in order to comply with the requirements of NEPA. No Action assumes that no project would be implemented by the federal government or by local interests to achieve the study area planning objectives. No action also takes into account the future without project condition likely to occur over the period of study. The No Action Plan forms the basis from which all other alternative plans are measured.

NMX and NMM, the two other remaining alternatives with no action in the active channel, represent a departure from the screening criteria. These alternatives are not consistent with natural patterns likely to occur given a mesoriparian environment in the terraces because one would normally find a hydoriparian or mesoriparian plant community in the active channel if flow were frequent enough to support a mesoriparian community on the terraces. However, they remain within consideration because of the need to avoid unacceptable reductions in flood conveyance. By leaving the active channel undisturbed, this has the least possible impact to conveyance.

Common features of both alternatives include:

1. The construction and planting of water harvesting bains at the confluences of 11 tributaries. The aquitard features would involve excavating in the area where the tributaries enter the terraces. Excavation would be to a depth of approximately four feet, a liner membrane would be laid, and the excavated area would be filled with layers of appropriately sized gravel covered with granular fill.

2. The implementation of a permanent irrigation system for mesoriparian areas. Permanent irrigation would combine construction of feeder pipelines to move water through the project area with use of open channels and level spreaders to distribute water at specific locations. In some cases, such as the tributary aquitards, a simple outflow would be sufficient.

3. The installation of temporary irrigation for xeroriparian areas and stabilized terraces in areas with steep unprotected banks.

4. The amendment of soil would be common to both mesoriparian and xeroriparian areas with the latter having additional surface treatments to improve the grounds ability to concentrate rainfall.

5. The cutting back into the historic floodplain would create gentler and more stabile slopes and would modify reaches of steep natural banks. The method of stabilization would be a function of the amount of land available for the new terrace area. Where available land is not a constraint banks will be graded at a 5-foot horizontal to 1-foot vertical slope and planted. Vegetated slopes of this grade are considered stable. A different treatment will be used in areas where there is not enough land to create a 5:1 slope but sufficient space exists to create slopes between 5:1 and 2:1. In those cases the banks will be laid back to the minimum slope that can be fit into the available space. These slopes will also be vegetated however; a geotextile layer will be installed prior to planting to ensure slope stability. In areas where insufficient space exists to accommodate 2:1 slopes placement of rip rap or soil cement may be necessary for bank protection. Such applications will be decided on a case-by-case basis.

6. The restoration or enhancement of 1,119 acres of habitat. Both NMX and NMM are dominated by xeroriparian shrub (shrubscrub) and mesquite with a few small pockets of cottonwood-willow. NMX is comprised of 693 acres of xeroriparian shrub, 416 acres of mesquite and ten acres of cottonwood-willow. In NMM the addition of irrigation to the historic floodplain reverses the dominance xeroriparian plants producing 638 acres of mesquite, 471 acres of shrubscrub and 10 acres of cottonwood-willow.

A difference between NMM and NMX is that for NMX there is no permanent irrigation in the historic floodplain. Two features added to compensate for this are the addition efforts at surface treatment and the creation of a number of shallow depressions to concentrate local run-off.

Xeroriparian Within Active Channel

One alternative including xeroriparian features in the active channel was carried forward. This alternative, XXX, pairs xeroriparian channel features with xeroriparian restorations on the terraces and in the historic floodplain

Features of alternative include:

1. The construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch.

2. The construction of aquitards on the upstream side of six existing grade structures. The implementation of aquitard features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to preclude significant impacts on flood flows. The aquitards would be expanded in size since, without irrigation, plants would be much more dependent on water harvesting.

3. The diversion of low flows would be accomplished by placing a diversions structure in the New West Branch channel to pond low flows through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel.

4. The soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. Also, the off channel areas to concentrate local runoff would be created in the floodplain.

5. The restoration of 1,125 acres of habitat. It is dominated by 867 acres of xeroriparian shrub (Shrub Scrub) with 252 acres of Mesquite and 6 acres of emergent marsh (riverbottom).

Mesoriparian Within Active Channel

Five alternatives including mesoriparian features in the active channel were carried forward. Each of these alternatives places mesoriparian measures in the channel in combination with terrace and floodplain measures described above. They are MXN, MMN, MXX, MMX, and MMM.

Two of the five-mesoriparian channel alternatives (MXN and MMN) have mesoriparian habitat within the channel and no restoration in the historic floodplain. The difference is the treatment of the terraces. One plan calls for xeroriparian while the other calls for mesoriparian restoration treatment for the terraces. Both plans produce only 199 acres of restored or enhance habitat. MXN restores or enhances 6 acres of emergent marsh, 174 acres of xeroriparian shrub and 19 acres of mesquite while MMN restores the same 6 acres of emergent marsh with the remaining 193 acres consisting of mesquite.

The other three alternatives (MXX, MMX and MMM) have mesoriparian restoration within the channel for all three plans while two plans have xeroriparian treatment in the floodplain and two plans have mesoriparian improvements along the terraces. One plan has mesoriparian areas in the floodplain while the remaining plan has xeroriparian treatment along the terraces. All three plans produce 1,125 acres of restored or enhanced habitat. Alternative MXX is dominated by 862 acres of xeroriparian shrub with 257 acres of mesquite and 6 acres of emergent marsh. MMX is predominantly xeroriparian shrub at 688 acres with 421 acres of mesquite, 10 acres of cottonwood-willow and 6 acres of emergent marsh, MMM continues the trend with mesquite becoming dominant at 643 acres, 466 acres of xeroriparian shrub, 10 acres of cottonwood-willow and 6 acres of emergent marsh.

The major changes in channel features from the one outlined for the xeroriparian alternatives consists of deletion of the diversion to the Old West Branch since irrigation reduces the need to establish this link; introduction of irrigation water into the lower reach of the Old West Branch and irrigation of the grade control aquitards. The irrigation would not be constant but would consist of adding water to extend the flow period following natural events. In this way the volume and duration of flow in these areas would be increased to mimic mesoriparian conditions.

Hydroriparian Within the Active Channel

Six alternatives including hydroriparian features in the active channel were carried forward. Three of the six alternatives (HNN, HXN and HHN) involve no action in the historic floodplain. The differences occur in the treatment of the terraces. One plan calls for no action, the second plan calls for xeroriparian, and the third plan calls for hydroriparian restoration in the terraces. HNN produces 319 restored acres with 122 acres of mesquite, 69 acres of cottonwood-willow, 69 acres of riparian shrub and 59 acres of emergent marsh. HXN produces 507 restored or enhanced acres with 243 acres of riparian shrub, 136 acres of mesquite, 69 acres of cottonwood-willow and 59 acres of emergent marsh. HHN produces 487 restored or enhanced acres with 181 acres of riparian shrub, 168 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. The other three alternatives are HXX, HHX and HHM. Three use xeroriparian treatment in the floodplain while one uses mesoriparian treatment. Two apply restoration of the terraces by xeroriparian treatment and two by hydroriparian treatment. HXX produces 1247 restored acres with 867 acres of riparian shrub, 253 acres of mesquite, 69 acres of cottonwood-willow and 59 acres of emergent marsh. HHX produces 1227 restored or enhanced acres with 805 acres of riparian shrub, 284 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh. HHM produces 1227 restored or enhanced acres with 577 acres of riparian shrub, 512 acres of mesquite, 79 acres of cottonwood-willow and 59 acres of emergent marsh.

Implementation of these alternatives involves replacing the channel features with a perennial flow channel. It would require grading the active create low flow averaging six feet in width and one-half foot in depth. Grading would also create depress ional areas on each side of the low flow channel about ten feet in width where soil saturation conditions resulting from infiltration would be conducive to emergent marsh. Finally, a band of cottonwood-willow varying in width from ten to twenty feet would be positioned adjacent to the emergent marsh to further utilize infiltrating water from the perennial channel.

Because of the conveyance impacts that would result from the creation of perennial flows, terrace features are limited to either xeroriparian or hydroriparian. In the xeroriparian terrace features, both upper and lower level terraces would include finish grading to provide micro topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. In the hydroriparian terrace features, the upper level terraces are irrigated and planted with mesquite and pockets of cottonwood-willow. The lower terraces would be planted with riparian grasses and would be maintained as xeroriparian shrub with larger shrubs or medium sized trees periodically cut back to retain cross-sectional area for conveyance of larger flood flows.

Finally, the alternatives including no action in the historic floodplain include the stabilized terraces described for the xeroriparian and mesoriparian floodplain. While this measure produces significant restoration benefits, it is carried forward her to mitigate greater erosion risks associated with increased channel roughness.

3.10.2 With Project Condition Functional Assessment

With the general trends of the Without Project Condition (i.e. the No Action Alternative) in mind, the study team developed acreage and variable projections for the fourteen proposed alternatives. When possible, the Team offered suggestions to enhance the alternatives given the goals and functions.

The most producing alternative was HHM (519 AAFCUs). The second and third highest alternatives were HXX (491 AAFCUs) and HHX (490 AAFCUs). The least productive alternatives were MMN (115 AAFCUs) and MXN (62 AAFCUs) the restoration alternative calls for mesoriparian approach taken in the active channel, xeroriparian approach deployed in the floodplain terraces, and no action being taken in the historic floodplain. No alternative resulted in a loss of functionality.

Trends over a 50-year period for all alternatives, including No Action, are presented in Figure 13. As a general rule, the Team assumed that much of the land made for the project would be converted to productive riparian settings, and the existing Mesquite would diminish from urban development. Alternatives that incorporated the deployment of harvesting basins as well as those alternatives that opted for a vegetative watercourse were assumed to have high habitat quality. Regardless of the manner in which it was achieved, the Team assumed vegetative growth, and the health of wildlife would increase appropriately. The Team also attempted to capture the vegetative succession of this area in increments over time (low quality early in the life of the project, and higher quality later in the life of the project). By restoring, developing, and protecting these areas, the Team assumed the habitat would be buffered from human disturbance factors, thereby improving the overall value of the habitat in the urban setting.

The overall HGM results for each alternative are summarized in Table 14. The results show that alternative HHM (the restoration alternative calls for hydroriparian approach in the active channel and in the floodplain terraces and mesoriparian approaches deployed in the historic floodplain) produced the highest net AAFCUs across the suite of functions.

Table 14: With Project Functional Assessment Results

RANK	ALTERNATIVE	AAFCUs
1	H-H-M	519
2	H-X-X	491
3	H-H-X	490
4	M-M-M	454
5	N-M-M	451
6	M-M-X	409
7	X-X-X	406
8	M-X-X	402
9	M-X-X	375
10	H-H-N	194
11	H-X-N	188
12	H-N-N	155
13	M-M-N	115
14	M-X-N	62

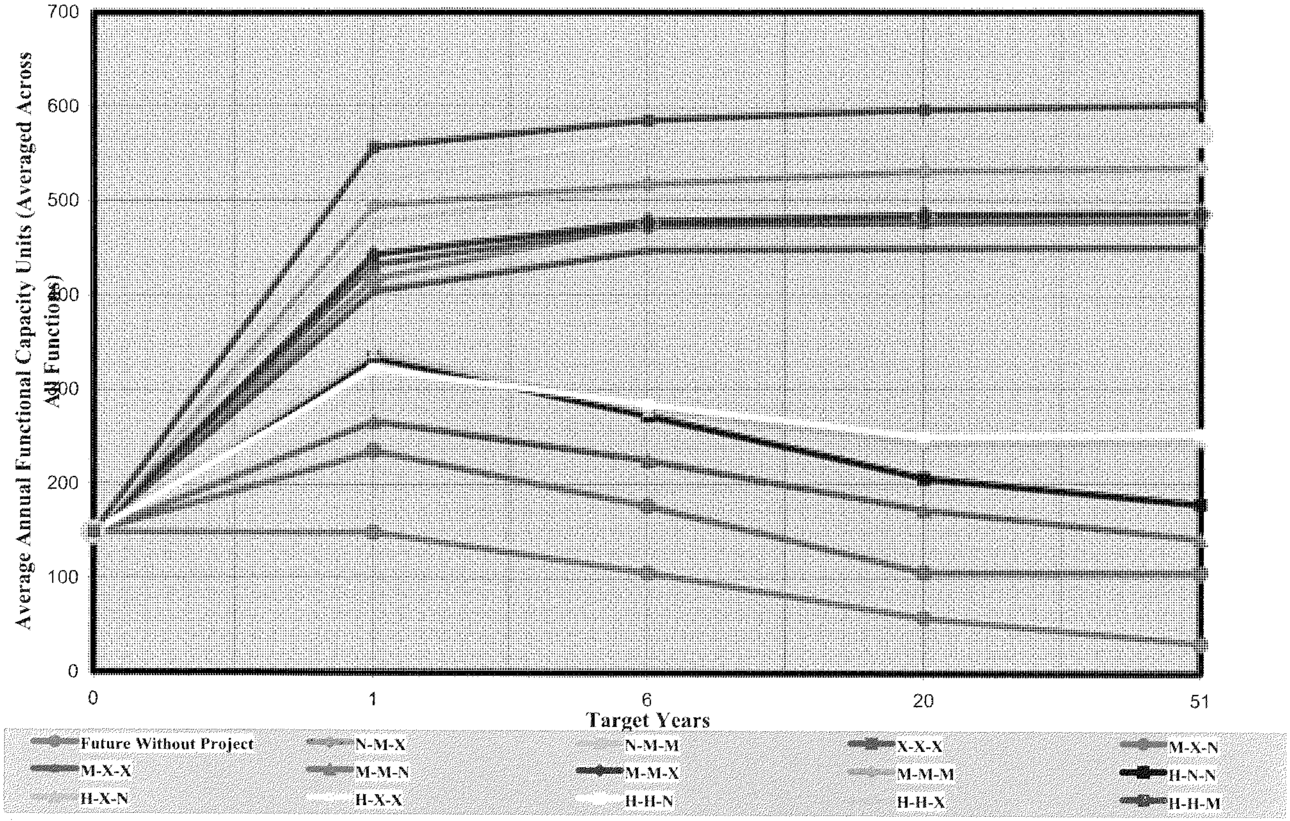


Figure 13: Trends in AAFCUs for Alternatives Evaluated

3.11 RELATIVE VALUE INDICES AND TRADE-OFFS

3.11.1 General Discussion

The "best" alternatives cannot be selected from among a set of "good" alternatives unless there is a means in which to compare them. It is only by comparison that an alternative is no longer "good enough," or that a "good" alternative becomes the "best" alternative. The purpose of the comparison step is to identify the most important criteria alternatives can be evaluated against, and compare the various alternatives across those criteria. Ideally, the comparison of alternatives concludes with a ranking of alternatives or some identification of the best course of action for the decision-makers. When all the important alternative designs are measured in the same units (e.g., ecological units, acres, dollars etc.), the comparison can be simple. More realistically, alternative designs are measured in a combination of dollars, ecological units, acres, housing relocations, water quality changes, noise levels, navigation safety, changed erosion rates, or a host of other tangible or intangible units. When this occurs, planners have to advise decision-makers about trade-offs (i.e., value judgments). Trade-offs are made throughout the planning process, throughout all screening activities, but they take on special significance as the study team, decision-makers and other stakeholders move toward selecting the best, most likely alternative future for a society. These trade-offs are first made regarding the individual alternatives under evaluation. The question is asked: "Is it good enough to warrant further consideration?" Alternative designs can be dropped from further analysis for a variety of reasons including cost ineffectiveness, design inconsistencies, and biological unproductiveness to name a few. Afterwards, trade-offs are considered across, and among, all the alternatives. Trade-offs are undertaken when contrasting outputs are encountered. For example, Alternative 1 may be less costly, but restores fewer wetlands than Alternative 2, a more costly design that restores significantly more wetland acres.

Trade-off analysis is a multi-criteria evaluation method commonly used by USACE when it is impossible (or not desirable) to express all alternative effects in a single metric - more than one evaluation metric can be considered (i.e., HEP, HGM, and costs together) in a trade-offs analysis (Edmunds and Letey 1973). Trade-offs enable planners to account for the entire gamut of differing (but relevant) criteria when comparing alternatives. Trade-offs can be as simple, or as complex, as necessary to afford the greatest suite of comparisons. In a simple application, trade-offs can frequently rely on professional judgment. Planners "trade-off" alternative contributions to objectives based on their own accumulated technical expertise, general experience, and specific knowledge of the study area (including stakeholder views and values). In essence, planners sit down and develop an alternative with "a little more of this" and "a little more of that," where the trade-offs made tend to be of a subjective nature. However, more quantifiable approaches exist to conduct trade-off analyses in a controlled environment.

Simple weighting is a sophisticated and simple approach to trade-offs that can be used when there are no apparent "winning" or dominant alternatives among those compared. In HGM, models are selected to emphasize the importance of specific functions, and can be "traded-off" by incorporating a weighting scheme into the calculation of final FCUs. By applying Relative Value Indices (RVIs) to the resultant outputs, function priorities can be characterized, and mathematical "weights" can be applied to HGM activities accordingly. In the overall scheme of project design, RVIs serve as prisms to concentrate attention on those changes that will impact the area's significant resources. The determination of "value" is a somewhat subjective exercise in the HGM process, but the HGM methodology provides avenues of documentation and justification necessary to support decisions in this arena (USFWS 1980b). Thus, RVIs can be used to perform trade-offs among functions, or simply to "level" the playing field.

3.11.2 Trade-Offs Decisions

Subsequent to the HGM modeling results of the 14 alternatives, the Study Team performed an exercise to evaluate the effects of Relative Value Indexing (RVI). The models were then rerun for: 1) Functions 2, 4 , and 8 only, 2) water functions only, 3) soils/biochemical functions only, and 4) habitat functions only. The results in the rankings of the alternatives are presented in Table 15 below:

Table 15: Trade-Off Comparison of Results

Rank	No Trade-Offs: Alt. (AAFCUs)	Fxns. 2, 4, & 8 Only	Water Fxns. Only	Soil Fxns. Only	Habitat Fxns. Only
1	H-H-M (519)	H-H-M (502)	M-M-M (601)	H-X-X (645)	H-X-X (372)
2	H-X-X (491)	H-H-X (465)	N-M-M (594)	H-H-X (632)	H-H-X (366)
3	H-H-X (490)	H-X-X (458)	H-H-M- (589)	H-H-M (629)	H-H-M (317)
4	M-M-M (454)	M-M-M (445)	M-M-X (493)	M-X-X (591)	N-M-M (134)
5	N-M-M (451)	N-M-M (443)	N-M-X (486)	M-M-X (588)	M-M-M (127)
6	M-M-X (409)	M-M-X (390)	X-X-X (481)	M-M-M (585)	N-M-X (126)
7	N-M-X (406)	N-M-X (387)	H-H-X (466)	X-X-X (580)	M-M-X (119)
8	X-X-X (402)	X-X-X (384)	H-X-X (466)	N-M-X (580)	X-X-X (117)
9	M-X-X (375)	M-X-X (348)	M-X-X (411)	N-M-M (579)	M-X-X (111)
10	H-H-N (194)	H-H-N (184)	H-H-N (233)	H-X-N (233)	H-H-N (110)
11	H-X-N (188)	H-X-N (182)	H-X-N (217)	H-H-N (226)	H-X-N (105)
12	H-N-N (155)	H-N-N (145)	H-N-N (189)	H-N-N (186)	H-N-N (77)
13	M-M-N (115)	M-M-N (113)	M-M-N (160)	M-M-N (122)	M-M-N (47)
14	M-X-N (62)	M-X-N (55)	M-X-N (63)	M-X-N (97)	M-X-N (26)

The RVI analysis did not significantly alter the rankings of the 14 alternatives when compared to the original model results using all ten functions. Weighting with the water and soils/biochemical functions only did increase the outputs (AAFCUs) slightly, however using only the habitat functions, the outputs decreased significantly.

Based on the results of the RVI exercise, the Study Team decided that all ten functions should be weighted equally and trade-offs analysis was not applied to the results.

3.12 HGM RESULTS AND ECONOMIC ANALYSIS

3.12.1 Economic Analysis Process

Between 1986 and 1987, the Headquarters' Office of the U.S. Army Corps of Engineers (USACE) provided policy directing Corps Districts to perform a type of cost analysis referred to as Incremental Cost Analysis (ICA) for all feasibility-level studies. The required ICA is, in effect, a combination of both a Cost Effectiveness Analysis (CEA) and Incremental Effectiveness Analysis (ICA). Together, the CEA/ICA evaluations combine the environmental outputs of various alternative designs with their associated costs, and systematically compare each alternative on the basis of productivity. Cost effectiveness analyses focus on the identification of the least cost alternatives and the elimination of the economically irrational alternatives (e.g., alternative designs which are inefficient and ineffective). By definition, inefficient alternative designs produce similar environmental returns at greater expense. Ineffective alternative designs result in reduced levels of output for the same or greater costs. The incremental cost analysis is employed to reveal and interpret changes in costs for increasing levels of environmental outputs.

In 1990, USACE issued Engineer Regulation 1105-2-100 (U.S. Army Corps of Engineers 1990) directing planners, economists, and resource managers to conduct CEA/ICA for all recommended mitigation plans. Later, in 1991, USACE produced Policy Guidance Letter Number 24 that extended the use of cost analysis to projects that restored fish and wildlife habitat resources (U.S. Army Corps of Engineers 1991). In the Corps' Engineering Circular 1105-2-210, the incorporation of cost analysis was declared "fundamental" to project formulation and evaluation (U.S. Army Corps of Engineers 1995). To facilitate the inclusion of these basic economic concepts into the decision-making process, USACE published two reports detailing the procedures to complete both incremental and cost effective analysis (Orth 1994; Robinson et al. 1995). Based on these reports, there were nine steps that should be completed to evaluate alternative designs based on CEA/ICA. These were as follows:

A. Formulate all possible combinations of alternative designs by:

   1. Displaying all outputs and costs.
   2. Identifying filters, which restrict the combination of alternative designs.
   3. Calculating outputs and costs of combinations.

B. Complete a cost effective analysis by:

4. Eliminating economically inefficient alternative designs.
5. Eliminating economically ineffective alternative designs.

C. Develop an incremental cost curve by:

6. Calculating the average costs.
7. Recalculating average costs for additional outputs.

D. Complete an incremental cost analysis by:

8. Calculating incremental costs.
9. Comparing successive outputs and incremental costs.

In the ICA terminology, an alternative design is considered the With Project condition (i.e., "Build A Dam," "Develop a Wetland," "Restore the Riparian Zone," "Management Plan A," etc.). Under an alternative design, a series of scales (i.e., variations) can be defined which are modifications or derivations of the initial With Project conditions (i.e., "Develop 10 acres of Low Quality Wetlands," "Develop 1,000 acres of High Quality Wetlands", etc.). Often, these scales are based on differences in intensity of similar treatments and can, therefore, can be "lumped" under an alternative design class or category. During the first steps of CEA/ICA, all possible combinations of alternative designs and their scales are formed. As a general rule, intra-scale combinations (i.e., combinations of variations within a single alternative design) are not allowed - these activities would occupy the same space and time.

In most instances, CEA/ICA results are displayed in tables, scatter plots, and/or bar charts. These illustrative products assist decision-makers in the progressive comparisons of alternative design costs, and the increasing levels of environmental outputs. Before a user makes a decision based upon the outputs generated by the CEA/ICA, they must determine whether cost thresholds exist which limit production of the next level of environmental output (i.e., cost affordability). In addition, factors such as curve anomalies (i.e., abrupt changes in the incremental curve), output targets, and output thresholds can influence the selection of alternative designs. All detailed information and results of the CEA/ICA analyses are presented in the Appendix H, Economics of the Paseo de las Iglesias Feasibility Report.

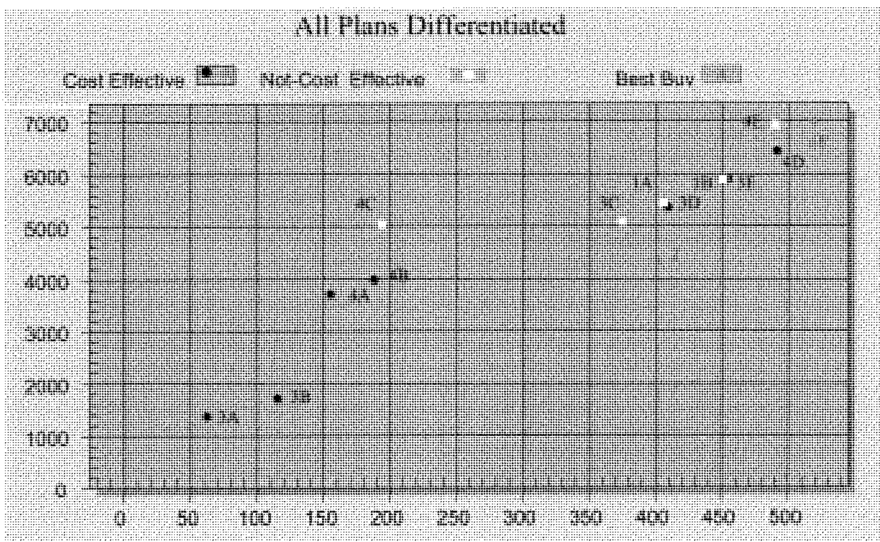
3.12.2 Incremental Cost Analysis (ICA) Overview

IWR-Plan uses two techniques address the question: is the alternative worth it in the cost evaluation process? First, the results of the habitat assessment were compared using Cost Effectiveness Analysis (CEA). When comparing alternatives using CEA, those alternatives that produce increased levels of output (AAFCUs) for the same or lesser costs were considered "effective" solutions and were retained. These alternatives were, in turn, compared on the basis of cost efficiency (i.e. those alternatives that produce similar levels of output (AAFCUs at a lesser expense). The "efficient" solutions were submitted to Incremental Cost Analysis (ICA) (i.e. determining changes in costs for increasing levels of outputs). Once evaluated, through a computer program called IWR-Plan, on the basis of cost effectiveness and incremental cost analysis, the best buy solutions were revealed (those that are both cost effective and incrementally effective).

3.12.3 Final Array of Alternatives:

The top average cost alternative and incrementally effective and efficient solution evaluated was XXX. The second ranked average cost and cost effective plan was MMM; however. The third ranked average cost plan was not cost efficient and effective as shown in the CEA ranking and did not rank as a best buy plan.

Figure 14: All Plans Differentiated
(CEA Plans and Best Buy Plans Labeled)



AAFCU's

The incremental cost analysis indicates that alternatives listed in Table 14 are cost efficient and cost effective. Of the best buy plans, XXX is the least costly to build at $4,330,533 but also produces the least amount of AAFCUs (402) at $10,770 per AAFCU. HHM will cost an additional $2,645,644 on an average annual basis and produce 117 additional AAFCUs for an incremental cost of $22,610 on an average annual basis per additional AAFCU. This means HHM can be implemented for only 117 more units but the incremental cost per additional incremental AAFCU will be more then twice XXX at $10,770.

XXX has the least average cost, is the ICA best buy and is cost effective. It produces 402 AAFCUs and is ranked 8th place in the HGM. XXX rates 5th overall in total average annual cost. On the other hand, HHM is the largest plan at 14th place overall in total average annual cost. It is 7th place in average cost and 5th place in cost effective analysis. It is the second best buy plan.

The two alternatives identified by cost effectiveness and incremental cost analyses represent the extremes of the water requirements for the analyzed alternatives. The selection of a either a restoration alternative utilizing almost no water or one utilizing nearly 9,000 acre-feet per year would potentially pose problems with respect to public acceptability. Residents have expressed a desire for restoration beyond what might be accomplished without irrigation however; there are a number of restoration sites under study and committing such a large volume to a single project would most likely be opposed by local citizens. In addition to public acceptability, there would be a substantial fiscal burden and complex political agreements associated with committing 9,000 acre-feet per year to a single restoration project.

For these reasons a third alternative, Alternative 3E, was added to the final array despite the fact that it was not a "Best Buy". The primary reason for selecting Alternative 3E is that it comes closest to presenting a mid-point in water demand between Alternatives 2A and 4F. Alternative 3E restores mesoriparian habitat to the project area with pockets of hydroriparian plantings. Alternative 3E, with an annual water budget of just under 2,000 acre-feet, provides a substantial reduction from 4F while still committing enough water to sustain mesoriparian plant communities. In addition, although Alternative 3E is incrementally more expensive that Alternative 4F, it ranks second for cost effectiveness with a cost of $12,598 per average annual functional capacity unit.

4. HEP EVALUATION

4.1 CROSSWALKS BETWEEN HEP AND HGM

Ecosystems are generally characterized in terms of their structural components and the processes that link these components (Bormann and Likens 1969). Structural components of the ecosystem and the surrounding landscape, such as plants, animals, detritus, soil, and the atmosphere, interact through a variety of physical, chemical, and biological processes such as the movement of air and water, and the flow of energy and nutrients. Understanding how the structural components of the ecosystem, and the surrounding landscape are linked together by processes is the basis for assessing ecosystem functions. Since modified HEP was used in past District studies, and HGM is a more recent development for these ongoing studies, it is important to address similarities in their approaches to measuring ecosystem integrity, and discuss the use of multiple tools in evaluations of this magnitude. It is also important to validate the use of these two tools in an ecosystem setting, to assure users that the success of ecosystem restoration studies in the future can be evaluated effectively and efficiently using a combination of the HEP and HGM methodologies.

As one might expect, the HEP and HGM approaches are quite similar, varying only in matters of terminology and assessment focus. Probably the most important issue to address when approaching a HEP or HGM study is the communication of results in scientific syntax to the applicants and users. To that end, Table 16 has been included here to demonstrate crosswalks between terms used in HEP and "sister" terms used in the HGM application process.

Table 16: Terminology crosswalks between the HEP and HGM methodologies

Parameters	HEP Terminology	HGM Terminology
Measurable parcel of land defined by its vegetative cover, soils, and topography	Cover Type (CT)	Partial Wetland Assessment Area (PWAA)
An attribute or characteristic of landscape (or the surrounding landscape) that influences the capacity of wetland to perform a function or the suitability of the area to support a species or community	Variable	Variable
The index that rates the variable relative to optimum conditions. Both Indices are, by definition, scaled from 0.0 to 1.0.	Suitability Index (SI)	Variable Subindex (VSI)
A mathematical aggregation of the Variable Indices used to describe the interrelationships among variables that define the suitability or functionality of the site.	Habitat Suitability Index (HSI)	Functional Capacity Index (FCI)
The product of the quality of the site (determined by the HSI or FCI) multiplied by the quantity of the site. Unit = Quality Index X Quantity	Habitat Unit (HU)	Functional Capacity Unit (FCU)
Target Years are units of time measurement that allow users to anticipate and direct significant changes (in area or quality) within the project (or site).	Target Year (TY)	Target Year (TY)
The measure of future habitat conditions estimated for both baseline (Without Project) and design (With Project) conditions. Projected long-term effects of the project are reported in terms of average annual units. Average Annual Units = For each Target Year . . . Average Quality X Average Quantity	Average Annual Habitat Unit (AAHU)	Average Annual Functional Capacity Unit (AAFCU)
A technique deployed to emphasize the value or priority of the results in a "weighting" fashion.	Relative Value Index (RVI)	Relative Value Index (RVI)

The distinguishing difference between the HEP and HGM methodologies is the biological component they each were designed to assess. HEP was designed to interpret the effects of environmental change through a species or community-based habitat suitability relationship across the landscape - a habitat maintenance function in the ecosystem setting. Although the HEP technique was not initially developed to assess additional ecosystem functions, combinations of HSI models in the HEP methodology indirectly measure ecosystem functionality across terrestrial and aquatic systems. In other words, HSI model parameters correlate closely with measures of ecosystem integrity such as improved water quality (i.e., turbidity, pH, salinity, and temperature - factors in many fish HSI models), patchiness and/or disturbance (i.e., distance to cover and water, riparian zone widths, human disturbance - factors of many bird and mammal HSI models) and both plant community and wildlife habitat maintenance (a factor of all the HSI models developed). Of course, HSI models are limited because they define only animal habitats as they pertain to physical and chemical characteristics of the landscape. HSI models do not, for example, include geomorphic setting, water source, and hydrodynamics - features that that directly relate to aquatic ecosystem integrity. But a combination of well-chosen species- or community-based models can be deployed to capture and reflect change in ecosystem functions across the site.

The model selection process can "make" or "break" an ecosystem study, and it is extremely important that the selection process focuses on the study's performance measures (i.e., success criteria), community incidence and architecture, and model parameters directly contributing to the ecosystem function. To do this, it has been suggested that habitat evaluation teams select guild representative models rather than game species models. A guild representative is, by definition, an animal (or plant) that belongs to a group of functionally similar species with comparable habitat requirements whose members interact strongly with one another. If results indicate a decline in a guild representative's habitat, it is assumed that species within this guild will be subject to same decrease in habitat suitability, and the guild as a whole will decline. Thus, species HSI models should be selected as representatives of an identifiable guild.

In addition, model selection should be based on sensitivity of the species or community to the proposed changes. Thus, identification of proposed actions, and limiting factors within a model must be reviewed and compared prior to model selection. Although results are tallied in terms of habitat change to the specific species (or community), projected change is derived at the variable level. In other words, the team does not project a decline in habitat suitability for Species A. Instead, the evaluation team generates estimated changes on a variable-by-variable basis given a proposed project design (i.e., water depth will decrease, herbaceous vegetation will increase by 25 percent, the forested wetlands will expand by 15 percent, etc.) regardless of species or community association. Thus ecosystem functions (floodwater detention, habitat maintenance, characteristic plant community maintenance, etc) are inadvertently captured in the application of a species-based or community-based HSI model. To this end, HSI models can be relied upon to measure at least some, but obviously not all, ecosystem functions in both terrestrial and aquatic systems (including wetlands), the primary function being Maintenance of Wildlife Habitat, and secondarily the Maintenance of Characteristic Plant Communities.

HGM, on the other hand, was specifically designed to assess wetland functions rather than individual wildlife species requirements. Strictly speaking, HGM applications are limited to wetlands defined as areas with less than one meter of standing water present. Thus, HGM was not designed to evaluate all systems within the ecosystem. However, HGM is a powerful tool that can define the normal, or characteristic, activities that take place in a wetland ecosystem setting. As wetlands perform a wide variety of simple and complex activities based on their physical, chemical, and biological attributes, HGM has been designed to measure functional capacity. The combination of HGM, with its functional assessment approach, and HEP, with its coverage of both aquatic and terrestrial settings, can blanket the entire study area, capturing changes in ecosystem activities across the landscape. Maintenance of ecological integrity, the function that encompasses all of the structural components and processes in an aquatic and/or terrestrial ecosystem, can therefore be assessed using a combination of HEP and HGM.

4.2 HABITAT EVALUATION PROCEDURE METHODS

HEP has been used for the past few decades as a planning and evaluation tool to document the quality and quantity of available habitat for selected wildlife species under baseline and future conditions. HEP was developed by the U.S. Fish and Wildlife Service (USFWS) for use in impact assessment and project planning (USFWS 1976, 1980). HEP provides a quantification of wildlife habitat based on two variables:

1) The Habitat Suitability Index (HSI), a unitless number between 0 and 1, where 0 represents no habitat and 1 represents optimum habitat or ideal conditions. If several patches of similar habitat are included in a study area, the HSI is calculated for each, then an average HSI is assigned to the habitat type.

2) The total area of each habitat type within the study area.

The HSI (or average HSI) for each habitat type is multiplied by the total area of the habitat type to derive a score for Habitat Units (HU). Then, HUs for all habitat types within the study area are summed, to yield total HU for the study area under either baseline or future conditions. In some cases, an Average Annual Habitat Unit (AAHU) is derived, which is the total number of HUs gained or lost as a result of a proposed action, divided by the life of the action. Comparison of HUs and AAHUs can be used to support selection of project alternatives.

The first generation HEP used vegetation cover types, and evaluated existing or projected conditions with regard to ideal conditions (USFWS 1976). The second generation HEP used a compilation of HSIs for selected species of fish and wildlife (USFWS 1980). The HSI value is derived from an evaluation of the ability of key habitat components to supply the living requisites of the selected species, comparing existing habitat conditions and optimum habitat conditions. Optimum conditions are those associated with the highest potential densities of the species within a defined geographic area. The HSI value obtained from this comparison thus becomes an index to carrying capacity for those species. Usually several species of interest are selected for the HEP, and the final values used are aggregate values for all evaluation species.

HSIs were developed for many species of fish and wildlife (Table 17). Only a few species for which HSIs have been developed are known to occur, or are likely to occur, within the study area of Paseo de las Iglesias. Available HSI models are indicated in Table 17. Of these species, American Coot, Marsh Wren, Red-winged Blackbird, Yellow Warbler, and Yellow-headed Blackbird are not likely to occur regularly under current conditions, but are expected to migrate to the area if appropriate conditions are created for them. Of the other species known or likely to occur in the study area, the Bobcat, Brewer's Sparrow, and Lark Bunting are transients or migrants in the area, and the available HSIs are for specific breeding populations. Thus, the available HSIs are not suitable for application in evaluating the Paseo de las Iglesias project alternatives. Development of HSIs for appropriate species is beyond the scope of this analysis.

Table 17: Habitat Suitability Index Models Currently Available

Species with * are currently known to occur in the study area; species underlined are considered likely to occur following completion of the project, depending on alternative selected.
Source: U.S. Geological Survey 2003

- Alewife and Blueback Herring
- American Alligator
- American Black Duck (wintering)
- American Coot
- American Eider (breeding)
- American Oyster, Gulf of Mexico
- American Shad
- American Woodcock (wintering)
- Arctic Grayling Riverine Populations
- Arizona Guild and Layers of Habitat
- Atlantic Croaker
- Baird's Sparrow
- Bald Eagle
- Barred Owl
- Beaver
- Belted Kingfisher
- Bigmouth Buffalo
- Black Bear (Upper Great Lakes)
- Black-Bellied Whistling Duck
- Black Brant
- Black Bullhead
- Black-Capped Chickadee
- Black Crappie
- Black Duck (Wintering)
- Black-Shouldered Kite
- Black-Tailed Prairie Dog
- Blacknose Dace
- Blue Grouse
- Blue-Winged Teal
- Bluegill
- Bobcat
- Brewer's Sparrow*
- Brook Trout
- Brown Pelican (eastern)
- Brown Shrimp
- Brown Thrasher
- Brown Trout
- Bullfrog
- Cactus Wren*
- Canvasback (breeding habitat)
- Carp, Common
- Catfish,
  - Channel
  - Flathead
- Chinook Salmon
- Chum Salmon
- Clapper Rail
- Coho Salmon
- Common Carp
- Common Shiner
- Creek Chub
- Croaker, Juvenile Atlantic
- Cutthroat Trout
- Diamondback Terrapin
- Downy Woodpecker
- Drum, Red (larval and juvenile)
- Eastern Cottontail
- Eastern Meadowlark
- Eastern Wild Turkey
- English Sole (juvenile)
- Fallfish
- Ferruginous Hawk
- Field Sparrow
- Fisher
- Flounder, Southern and Gulf
- Forster's Tern
- Fox Squirrel
- Gadwall (breeding)
- Gizzard Shad
- Gray Partridge
- Gray Squirrel
- Great Blue Heron
- Great Egret
- Greater Prairie Chicken
- Greater Sandhill Crane
- Greater White-Fronted Goose (wintering)
- Green Sunfish
- Gulf Menhaden
- Hairy Woodpecker
- Inland Silverside
- Inland Stocks of Striped Bass
- Juvenile Atlantic Croaker
- Juvenile English Sole
- Juvenile Spot
- Lake Trout
- Lark Bunting*
- Laughing Gull
- Least Tern
- Lesser Scaup (breeding)
- Lesser Snow Goose (wintering)
- Lewis' Woodpecker
- Littleneck Clam
- Longnose Dace
- Longnose Sucker
- Coolwater & Coldwater Reservoirs
- Mallard (Mississippi Valley)
- Marsh Wren
- Marten
- Mink
- Moose, Lake Superior Region
- Mottled Duck
- Muskellunge
- Muskrat
- Northern Bobwhite
- Northern Pike
- Northern Pintail (Gulf Coast wintering)
- Osprey
- Paddlefish
- Pileated Woodpecker
- Pine Warbler
- Pink Salmon
- Red-Winged Blackbird
- Redbreast Sunfish
- Redear Sunfish
- Redhead (wintering)
- Roseatte Spoonbill
- Ruffed Grouse
- Sharp-Tailed Grouse
- Shelter-Belt Community
- Shortnose Sturgeon
- Slider Turtle
- Slough Darter
- Smallmouth Bass
- Smallmouth Buffalo
- Snapping Turtle
- Snowshoe Hare
- Southern and Gulf Flounders
- Southern Red-Backed
- Southern Kingfish
- Spotted Bass
- Spotted Owl
- Spotted Seatrout
- Striped Bass, Coastal
- Swamp rabbit
- Turkey
- Veery
- Walleye
- Warmouth
- Western Grebe
- White Bass
- White Crappie
- White Ibis
- White Shrimp
- White Sucker
- White-Fronted Goose (wintering)
- White-Tailed Deer
- Williamson's Sapsucker
- Wood Duck
- Yellow Perch
- Yellow Warbler*
- Yellow-Headed Blackbird*

Also considered for this analysis was the "Arizona Guild and Layers of Habitat Models" (Short 1984). This approach was specifically developed for western Arizona, near but outside of the region of the Paseo de las Iglesias project. Enough similarity between the two regions exists, however, so that the figures developed by Short might be applicable to the Paseo study area. Short's approach compares structural diversity (i.e., number of vertical layers of habitats, such as tree canopy, tree bole, shrub midstory, understory, etc) of habitat *X* to riparian forest (cottonwood-willow, the cover type with the highest number of layers) as a standard. The HSI tends to increase as habitat structure becomes more complex, and habitats with greater structural diversity receive higher HSIs. The more closely a cover type resembles cottonwood-willow, the higher the HSI. This approach does not show changes that would occur in a vegetation community, such as Sonoran Interior Strand Mixed Riparian Shrub, that has limited structural diversity. The Paseo de las Iglesias project intends to improve the shrub community in ways that do not include structural diversity, such as changes in density, contiguity, and self-maintenance of vegetation. Because these qualities are important components of the baseline conditions and of the proposed alternatives in the Paseo de las Iglesias project, Short's approach is not appropriate for use in this case.

Due to limitations of the aforementioned HSI models, an alternative approach, based on the first generation (1976) HEP approach, was selected for this study. This approach, which is described below, is more appropriate than the other available methods for the particular conditions of the study area and for the project alternatives considered.

Vegetation communities in the Paseo de las Iglesias study area were delineated using the definitions of Brown, Lowe, and Pase (Brown 1980, 1994), which is the standard used by most biologists in this region (see following section). Areas of similar vegetation conditions were delineated in the field on aerial photographs. Subsequently, the aerial photographs were digitized, and area calculations for each vegetation community were made using Arcview 3.2. Baseline conditions were evaluated for each community within the study area, based on the degree to which they approximate current concepts of healthy, pristine, natural conditions for each vegetation community as a functional ecosystem. A linear rating scale of habitat suitability (i.e., Habitat Suitability Index, or HSI) ranging from 0.0 to 1.0 was created based on specifically defined criteria (see Table 18). Within the study area, discrete areas of each community were evaluated based on these criteria. An average HSI for each community was then calculated for at least five locations (where five or more were available). By multiplying the average HSI value by the total measured area of each cover type, a single value was calculated to obtain Habitat Units (HU) for that community. Without Project and With Project conditions were estimated for the expected vegetation communities and conditions 50 years post project. Within the study area, undisturbed vegetation conditions are no longer present to serve as a standard for comparing existing vegetation communities. Consequently, evaluating the degree to which current conditions approximate ideal natural conditions was based on current vegetation communities outside the study area.

Table 18: Habitat Suitability Index Criteria

Value	Condition
1.0	Natural condition for the vegetation community, with mature individuals of long-lived species and a full age-class range of the native species appropriate to the site. Either natural reproduction of the community is occurring, or natural succession is proceeding to an appropriate subsequent seral stage. The vegetation community is consistent with the natural processes of climatic, fluvial, geological, and ecological processes. All expected native species of plants and animals are present. No invasive non-native species are present. There is no evidence of anthropogenic disturbance. The area is as large as natural processes permit, and is not fragmented by areas that have had natural vegetation removed by human activities.
0.7-0.99	Near natural condition for the vegetation community, with some mature individuals of long-lived species and representation of a range of age classes of the native species appropriate for the site. The vegetation community is consistent with the natural process of climatic, fluvial, geological, and ecological processes. Most expected species of native plants and animals are present. Invasive non-native species are not established. Evidence of anthropogenic disturbance is limited and does not obviously impact the vegetation community. The area is as large as natural processes permit, but has been somewhat fragmented by areas that have had natural vegetation removed by human activities.
0.5-0.69	Remnants of the natural condition of vegetation remain and are obvious to the trained eye. Some mature individuals of long-lived species are present, and there is some evidence of successful continuing reproduction and maturation of the community. The community is generally consistent with natural processes, although it may show effects of anthropogenic disturbance that impacts the vegetation community. The community may be dependent upon some level of maintenance for survival. Larger species of native animals are absent and unlikely to occur. Some invasive non-native species have become established in small areas, but do not dominate the community. The area may be small and isolated from other areas of similar vegetation.
0.3-0.49	Natural vegetation community is not obvious because few remnants are present. Few or no individuals of long-lived species are present or there is little or no evidence of successful reproduction and maturation of the community. The community is clearly subject to anthropogenic influence, and may be dependent upon active maintenance for survival. Some expected species of native plants and animals are present, but others are absent, including larger animal species. Invasive non-native species have become extensively established and may have become dominant.
0.2-0.29	Natural vegetation community is difficult to ascertain, but some native plant and animal species are present. The community has been obviously impacted by human activities, and has diversity and density limited by direct impacts. Invasive non-native species are the dominant, or at least a very important, component of the area.
0.1-0.19	Small and isolated patches of native vegetation are present, with intervening areas of no vegetation or weedy growth including invasive non-native species. Native plants and animals are few, and consist only or primarily of opportunistic species or species with extremely broad habitat selection.
ess than 0.1	Natural vegetation has been removed and has not become re-established. Non-native vegetation is present, but very limited in extent. Few native plants and animals are present, and consist only or primarily of opportunistic species or species with extremely broad habitat selection or (animals) are just passing through.

4.3 BASELINE MODIFIED HEP ANALYSIS:

Species considered in establishing the HSI's included any species or habitat community of interest to any regulatory or management agency of the Federal, State or local government. These included species listed by the U.S. Fish and Wildlife Service as Threatened, Endangered, or Candidate species, and species designated as Wildlife Species of Special Concern in Arizona (WSCA) by the Arizona Game and Fish Department that are known or likely to occur in the study area. In addition, species currently included as Priority Vulnerable Species in Pima County's Sonoran Desert Conservation Plan are considered. Priority Vulnerable Species are those 55 species that Pima County has determined are at risk or have been extirpated but have potential to be reintroduced within the county.

The results of the mHEP analysis of existing conditions in the study area indicate that the majority of the existing natural habitat has an average HSI of 0.4 on a scale where 1.0 indicates the best quality habitat and less than 0.1 indicates a complete lack of natural vegetation. Table 19 summarizes the results of the modified mHEP analysis. Distribution of the BLP cover types is shown in Figure 15.

TABLE 19: Modified HEP Analysis Results

BLP Code	Vegetation Classification to Series Level	Acres in Study Area	% of Study Area	Habitat Suitability Index (Average)	Habitat Units
154.1	Sonoran Desertscrub Biome				
154.12	Paloverde-Mixed Cacti Series	237	4.7	0.73	173
154.17	Saltbush Series	96	1.9	0.57	54.7
224.5	Sonoran Riparian Deciduous Forest and Woodlands Biome				
224.52	Mesquite Series (includes 234.71 Mixed Scrub Series of Sonoran Deciduous Riparian Scrub Biome)	160	3.2	0.60	96
234.7	Sonoran Deciduous Riparian Scrub Biome				
234.72	Saltcedar Disclimax Series	87	1.7	0.40	34.8
254.7	Sonoran Interior Strand Biome				
254.71	Mixed Shrub Series	261	5.2	0.50	130.5
300	Cultivated and Cultured Uplands				
314.1	Urban: Residential, commercial, and industrial	3045	60.8	0.20	609
314.15	Recreational (=maintained park)	86	1.7	0.30	25.8
364.1	Sonoran Vacant or Fallow lands	934	18.7	0.10	93.4
400	Cultivated and Cultured (or Anthropogenic water dependent) wetlands				
414.12	Urban Drainage	99	2.0	0.20	19.8
Total Study Area		**5005**	**100**	**0.25**	**1251**

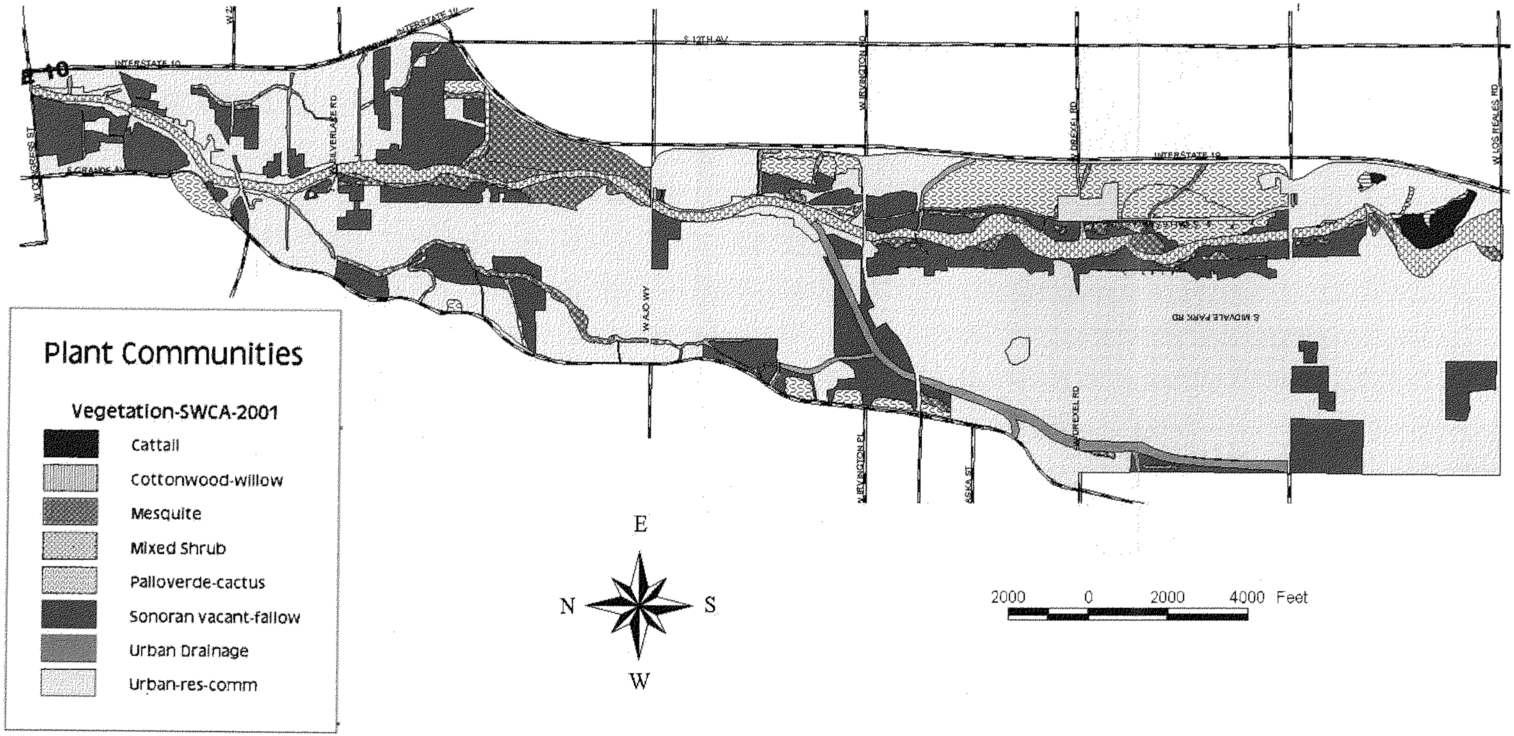


Figure 15: BLP Plant Communities Mapping for the Paseo de las Iglesias Study Area

4.4 HABITAT EVALUATION PROCEDURE (MHEP) FOR WITH PROJECT CONDITIONS

4.4.1 Purpose

A habitat restoration project, called the Paseo de las Iglesias project, is being planned by the Los Angeles District of the U.S. Army Corps of Engineers (USACE), with the Pima County Department of Transportation and Flood Control District as the local sponsor, for a seven-mile reach of the Santa Cruz River in Tucson, Arizona. One of the purposes of the planning process is to identify the most economically practicable and ecologically sustainable means to achieve restoration objectives in the study area. This modified Habitat Evaluation Procedure (mHEP) analysis is one component of the planning process.

4.4.2 Study Area

The study area consists of approximately 5,005 acres of urban and disturbed land on both sides of the Santa Cruz River, a frequently disturbed, deeply entrenched ephemeral channel. Urban development and intensive alteration of natural landscapes have effectively isolated the river channel from natural biological communities. Current on-going disturbances include channel bank erosion, urban development, active and inactive agricultural fields and landfills, off-road vehicle use, soil cement lined banks, wildcat dumping, and transient camps. Due to extensive, basin-wide groundwater pumping, the river that has dried up and the former aquatic and riparian communities have vanished. Remnant mesquite (*Prosopis velutina*) bosques are represented only in diminished, isolated pockets of stunted trees sprouting from cut stumps. Non-native plant species, including saltcedar (*Tamarix ramosissima*) and Athel tamarisk (*T. aphylla*), have replaced most of the native cottonwood (*Populus fremontii*) and willow (*Salix gooddingii*) riparian communities. No portion of the study area is without some impacts of human activity. Within the study area, approximately 1,200 acres of vacant lands associated with the river have been tentatively identified where restoration activities may occur.

4.5 VEGETATION COMMUNITIES

This section describes vegetation communities present within Paseo de las Iglesias study area currently and those that are proposed to be created under proposed alternatives. Baseline descriptions are based on field reconnaissance conducted in 2002 and 2003.

Sonoran Desertscrub

Sonoran Desertscrub is the characteristic upland community in the region. It is typified by open to dense stands of drought and heat tolerant deciduous trees and shrubs that have small leaves, and often thorns. Vegetation density and diversity is often related to local conditions. Within the study area, this biome forms two distinctive vegetation series, which are distributed as isolated outcrops between roads and developed areas: Paloverde-Mixed Cacti and Saltbush. Dominant woody perennial species include creosote bush (*Larrea tridentata*) on gravely soils and fourwing saltbush (*Atriplex canescens*) on silty soils. Currently the Sonoran Desertscrub community represents approximately 6.6 per cent of the study area, and it has been generally disturbed by human activities. Multiple dirt roads and wildcat dumpsites and the establishment of invasive non-native species such as buffelgrass and red brome degrade this community. The average HSI for this community at baseline is 0.65.

Sonoran Riparian Deciduous Forest and Woodland

This vegetation community is typically encountered along perennial or intermittent drainage ways and springs, where vegetation is able to tap shallow subsurface water. It consists of two associations, cottonwood-willow and mesquite.

Cottonwood-willow: Historically this community was dominant within the study area, but it has been eliminated as a result of human activities over the past century and has not been present for several decades. It is generally considered to be the most important, and among the rarest, of wildlife habitat types in the southwestern U.S. (Brown 1994). Most of the historic cottonwood-willow forest that historically existed in the region was eliminated in the twentieth century as a result of water use projects and declining water tables. Fremont cottonwood and one or more species of willows (e.g. *Salix gooddingii*) are the dominant tree species. Other species commonly occurring in this community are velvet ash (*Fraxinus pennsylvannica* var. *velutina*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), velvet mesquite, and the exotic tamarisk (*Tamarisk chinensis*). Common shrubs include: lotebush (*Zizyphus obtusifolia*), singlewhorl burrobush (*Hymenoclea monogyra*), wolfberry (*Lycium* spp.), desert broom (*Baccharis sarothroides*) and others.

Mesquite: In addition to mesquite, common plant species in the Mesquite Woodland are catclaw acacia (*Acacia constricta*), blue paloverde (*Parkinsonia florida*), pitseed goosefoot (*Chenopodium berlandieri*), lotebush, fourwing saltbush, and various species of forbs, grasses, and vines. In the study area, mesquite trees in some remaining stands are relatively large, reaching heights between 10 and 20 feet. None, however, approach the 60-foot height of those trees that existed pre-settlement. Furthermore, the existing trees are not regenerating. Despite their comparatively small size, however, the remaining mesquite trees in the study area, especially where they occur in dense stands, provide important habitat for wildlife. The baseline average HSI for this community is 0.50.

Sonoran Deciduous Riparian Scrub

This vegetation community is primarily limited to the areas adjacent to washes, but an example is also found within the Santa Cruz River bed. In the study area, the Sonoran Deciduous Riparian Scrub Biome is represented by a Saltcedar Disclimax series, which is present primarily in the areas formerly vegetated by Sonoran Riparian Deciduous Forest and Woodland. This vegetation type has limited structural diversity and is dominated by plant species that are adapted to xeric conditions, in particular non-native invasive species such as Athel tamarisk and saltcedar, which form open to dense stands. Typically, trees in this series are less than 20 feet tall and are regularly subjected to intensive flood events. Other common species occurring within this vegetation type within the study area are Bermudagrass (*Cynodon dactylon*), camphorweed (*Heterotheca subaxillaris*), western tansymustard (*Descurania pinnata*), and Jerusalem thorn (*Parkinsonia aculeata*). The baseline average HSI for this community is 0.40.

Sonoran Interior Strand Mixed Shrub

This vegetation community is found within the Santa Cruz River mainstem and associated wash channels where it is subject to frequent flood events and regular scouring. It includes the existing low-flow channels, because the areas of vegetation change rapidly as a result of flow events. Scattered patches of vegetation, some of which may be quite dense, typically characterize Strand habitats. Vegetation primarily consists of shrubs that are well adapted to occasional flooding. Soils are usually sand and gravel, with small silt deposits and very low organic content. Common species in this community include many that are also associated with scrubland communities, such as saltbush, lotebush, singlewhorl burrobrush, and desert broom. Also found in this vegetative community are annuals, short-lived perennials, and invasive species, such as Adonis blazingstar (*Mentzelia multiflora*), camphorweed, Canadian horseweed (*Conyza canadensis*), common sunflower (*Helianthus annuus*), desert horsepurselane (*Trianthema porulacastrum*), western tansymustard, and buffelgrass (*Pennisetum ciliare*). The baseline average HSI for this community is 0.50.

Sonoran Interior Marshland

Emergent vegetation in this community varies from pure stands of saltgrass (*Distichilis spicata*) and bulrush (*Scirpus* spp.) to more commonly dense stands of reed (*Phagmites australis*) and/or southern cattail (*Typha domingensis*). Scrubland vegetation such as saltcedar, quailbush (*Atriplex lentiformes*) and mesquite typically border the marshland. Understory vegetation consists of whorled marshpennywort (*Hydrocotyle verticillata*), spearmint (*Mentha spicata*) and a variety of rushes and grasses. This community is no longer present within the study area, but was historically an important component of the landscape.

Cultivated and Cultured Uplands

This broad category encompasses areas where most native vegetation has been removed as a result of past or ongoing human activity. Non-native landscaping plants are an important, and in many cases the only, component of the vegetation. This category includes residential properties, building sites, landscaped recreation areas, agricultural areas, closed landfills, and other disturbed areas. Based on ecological and aesthetic characteristics, the Cultivated and Cultured Upland community can be subdivided into the following subcategories: Urban Land, Recreational Land, Sonoran Vacant or Fallow Land, and Urban Drainages.

Urban Land (Residential, Commercial, and Industrial): Much of the land in this category is essentially devoid of native vegetation, or, where vegetation does occur, it is usually sparse and scattered. As a general rule, the current condition of vegetation can be classified along the following continuum (from greatest impact to least impact): industrial, commercial, heavy residential, and light residential (Brown 1980). Included in Urban classification are horse properties and small agricultural fields around houses. Common plant species include velvet mesquite, burroweed (*Isocoma tenuisecta*), Jerusalem thorn, prickly Russian thistle (*Salsola tragus*), native and nonnative grasses, and numerous ornamentals and cultivars. Included among the ornamentals is a large stand of fan palms located on the west side of the river, between Irvington Road and Ajo Way, in a large mobile home park. The average baseline HSI for this community is 0.20.

Recreational Land: Recreational lands consist of parks, including the Santa Cruz River Park and two small urban parks. This classification is composed of a wide array of vegetation types, ranging from predominantly nonnative landscaped trees and shrubs to comparatively natural vegetation that is actively maintained. Vegetation structure and density is highly variable. Common plants found on recreational lands include olive (*Olea europaea*), gum (*Eucalyptus* sp.), Goodding's willow, netleaf hackberry, Chinaberrytree (*Melea azederach*), tuna cactus (*Opuntia ficus-indica*), European fan palm (*Chamaerops humilus*), velvet ash (*Fraxinus velutina*), Florida hopbush (*Dodonea viscosa*), velvet mesquite, creosote bush and whitethorn acacia. The average baseline HSI for this community is 0.30.

Sonoran Vacant or Fallow Land: Historically, vacant or fallow lands were part of the upper terrace and/or floodplain of the Santa Cruz River, and many of them were used for agricultural production. During the 1950's and 1960's, however, most of these areas were retired from agricultural production. Today, these areas consist of fallow agricultural fields, closed landfills, inactive gravel pits, and other areas that have been recently disturbed but are not currently being used for other purposes. Most of these lands are owned by either the City of Tucson or Pima County. Most woody perennial vegetation has been removed from these lands. The most commonly established plant species are velvet mesquite, Jerusalem thorn, Athel tamarisk, burroweed, and a variety of native and non-native grasses and forbs. The average baseline HSI for this community is 0.10.

Urban Drainages: Urban drainages are drainage ways or conveyance channels for urban runoff that are maintained as part of the City's floodwater drainage system. Many of these drainages may originally have been natural washes, but have undergone bank stabilization and channel modification. Others are entirely artificial in origin. They are currently impacted by flooding, channel maintenance activities, transient camps, and wildcat dumping. Urban drainages are now vegetated primarily by non-native species and escaped cultivars, although remnant patches of native vegetation remain. In the study area, common plant species include Jerusalem thorn, camphorweed, Bermudagrass, red brome (*Bromus rubens*), mesquite, rough cocklebur, African sumac, and desert broom. The average baseline HSI for this community is 0.20.

4.6 ALTERNATIVES CONSIDERED

Alternatives were developed through a planning process that included input from a team of planners, ecologists, hydrologists, engineers, floodplain managers, and cost accountants. The process included a Hydrogeomorphic (HGM) Analysis and Incremental Cost Analysis (ICA), which are described in separate reports. The alternatives considered herein for comparative purposes and applied only to the No Action Alternative, the Hydric Alternative (HHM) and the Xeric Alternative (XXX), which were selected as the top two "Best Buy" alternatives by the HGM and ICA process and represent the broadest range of restoration efforts.

4.6.1 No Action Alternative

The USACE is required to consider the option of "no action" as one of the alternatives in order to comply with the requirements of NEPA. No Action assumes that no project would be implemented by the federal government or by local interests to restore or manage native vegetation in the study area and achieve the other planning objectives of the Paseo de las Iglesias project.

In the absence of a restoration project within the study area, there would be continued development of urban land along the river corridor. This would further degrade the existing habitat, and prevent future restoration from being practical, feasible, or cost effective. Both public and private interests have prepared numerous development concepts for this area, primarily because of its marketable location along the Interstate 19 (I-19) corridor. If river restoration does not occur, it is anticipated that development will significantly alter the existing vegetation. In order to maximize development acreage in areas adjacent to the river, a conventional, engineered solution for bank protection and erosion control (i.e., soil cement) would likely be implemented. In addition, the use of soil cement would increase the amount of developable land in the study area and result in increased residential and non-residential development adjacent to the river.

Native biotic communities that are regionally declining will be lost in the study area under the No Action alternative. Native plant species diversity will probably decrease, although an increase in invasive non-native and cultivated species will probably occur, so there will likely be an increase in total species diversity. Species that are regionally rare and sensitive to human impacts will decrease or be eliminated. After 50 years or less, the study area will have lost all vestiges of the historically natural dominant vegetation communities, and they will likely never recover in this area. No new stands of cottonwood-willow and no new marshland will develop within the study area. The mesquite community will continue to degrade as a result of insufficient water to support growth to tree stature, lack of a flood regime that fosters establishment and growth of seedlings, and woodcutting of remaining trees. Most of the mesquite community will be replaced by urban development. The Sonoran desertscrub community will continue to deteriorate as a result of human impacts, including development of the overbank areas as well as impacts by off-road vehicles, equestrians, and fires. Soil cement banks will prevent establishment and survival of native riparian plants. The Sonoran interior strand mixed shrub community will deteriorate as a result of increased erosion and disturbance by human activities, and by increased flood velocity and frequency resulting from the increase in impermeable surface on the watershed and soil cementing the banks. In all communities, increased disturbance will favor the establishment of non-native plant species.

4.6.2 Hydric Alternative

This alternative calls for creation of 79 acres of new cottonwood-willow community and 59 acres of Sonoran Interior Marsh, with provision of sufficient water to sustain growth to maturity. Land for the newly created cottonwood-willow and marsh communities will be taken from existing Sonoran interior strand, mixed scrub (128 acres) and urban drainage (10 acres). The cottonwood-willow and marsh communities will not be naturally self-regenerating or self-sustaining, but will depend on irrigation water because there are no practicable alternatives that can restore natural flood processes and a natural groundwater level sufficient to sustain these communities. Because of this dependence on irrigation and maintenance, the cottonwood-willow and marsh communities HSI cannot exceed 0.69. A total of 160 acres of the existing mesquite community will be retained, and an additional 352 acres of mesquite will be planted, bringing the total mesquite community to 512 acres. Land for newly created mesquite will be taken from vacant and fallow land (352 acres). Survival and recruitment of mesquites and other component species of this community will be enhanced by the provision of water beyond the natural background supply and improvement of soil. Trees will be able to grow to large stature because sufficient water will be provided by irrigation and water harvesting to sustain them. Dependence on irrigation and other maintenance limits the potential HSI to 0.69. . Native mixed shrub (128 acres) in the interbank area will be preserved and enhanced by reduction of erosion, water harvesting, interplanting with additional native species characteristic of this community, and exclusion of disturbance by off-road vehicles. The addition of 449 acres of planted mixed shrub will bring the total for this community to 577 acres under this alternative. Land for the newly created mixed shrub community will come from Sonoran desertscrub (65 acres), vacant and fallow land (373 acres), and urban drainage (11 acres). This community is expected to have an HSI of 0.99 because it will be naturally sustained.

Under this alternative all of the native plant communities will be retained and enhanced or recreated in a pattern that differs somewhat from the historic pattern, but is sustainable with maintenance and addition of water.

4.6.3 Xeric Alternative

This alternative involves irrigation only for establishment and emergency (drought) survival of plants. This alternative does not support a new cottonwood-willow community. It includes creation of six acres of marsh at aquitards (water retaining structures at strategic locations). Land for the marsh will come from existing strand mixed shrub community. The marsh will not depend on irrigation, but will capture natural rainfall runoff. However, it will be dependent upon occasional maintenance following floods. The HSI for the marsh, therefore, cannot exceed 0.69. All (160 acres) of the existing mesquite community will be retained, and 92 acres of new mesquite will be planted, bringing the total mesquite community to 252 acres. Land for the newly created mesquite community will come from existing urban drainage (10 acres) and vacant and fallow land (82 acres). Survival and recruitment of mesquites and other component species of this community will be enhanced by the provision of water beyond the natural background supply (only when needed in drought emergencies), for establishment of new plantings, and by water harvesting methods. Trees will be able to grow to larger stature than under current conditions because sufficient water will be provided by irrigation and water harvesting to sustain them. Dependence on irrigation and other maintenance limits the potential HSI to 0.69, but the limited irrigation compared to the Hydric Alternative suggests a HSI of 0.60 would more accurately describe this community under this alternative. . Native mixed shrub (159 acres) in the interbank area will be preserved and enhanced by reduction of erosion, water harvesting, interplanting with additional native species characteristic of this community, and exclusion of disturbance by off-road vehicles. The addition of 708 acres of planted mixed shrub will bring the total for this community to 867 acres under this alternative. The expected HSI for this community is 0.99 because it will be naturally sustained. Land for the newly created mixed shrub community will be taken from existing urban vacant and fallow agricultural land (556 acres), Sonoran desertscrub (65 acres) and Sonoran deciduous riparian scrub (87 acres).

Under the Xeric Alternative, all of the native plant communities will be retained and enhanced or recreated in a pattern that differs somewhat from the historic pattern, but is sustainable with minimal maintenance and without addition of water except to establish plantings and sustain vegetation during extreme drought conditions.

4.7 RESULTS

Results of the HEP analysis of the baseline and alternative conditions at 50 years after the project is completed are shown in Table 20. The results indicate that both of the action alternatives are clearly better than the No Action Alternative and an improvement over baseline conditions. It is counterintuitive that the Xeric Alternative ranks slightly higher than the Hydric Alternative using this method of analysis. The HUs for the Hydric Alternative are, perhaps, deceptively undervalued because the HSIs are limited to 0.69 for the cottonwood-willow and marsh communities. This value is the best fit to the criteria in Table 19, because these communities will be dependent upon the artificial addition of water and other maintenance. However, it should be recognized that the wildlife values of these communities would be very high, as long as water and maintenance are provided. There is a difference in HSI for mesquite between the two action alternatives. The mesquite community will mature more rapidly under the Hydric Alternative than under the Xeric Alternative, and the trees will be larger and probably of greater value to many species of wildlife. However, the HSI will not exceed 0.69 because the mesquite community will be dependent upon maintenance and irrigation. Also, the high value for the Strand, Mixed Shrub community, 0.99 under both alternatives, favors the Xeric Alternative, which has more of this community than the Hydric Alternative has.

Other approaches to defining HSI may result in different values. It appears that the HGM modeling process may differentiate between the alternatives with greater precision and accuracy than is possible with this HEP approach and HSI criteria.

Table 20: Vegetation Classification, Areas, Habitat Suitability Indices (H.S.I.), and Habitat Units (HU) within Study Area Under Three Alternatives

	Baseline			No Action Alternative			Hydric Alternative			Xeric Alternative		
Vegetation Classification	Acres	H.S.I.	HU	Acres	H.S.I.	HU	Acres	H.S.I.	HU	Acres	H.S.I.	HU
Sonoran Desertscrub	33	0.65	216.5	--	--	--	--	--	--	--	--	- -
Mesquite	60	0.50	80.0	--	--	--	512	0.69	353.3	252	0.60	151.2
Riparian Scrub (saltcedar)	7	0.40	34.8	--	--	--	--	--	--	--	--	- -
Strand (Mixed Shrub)	61	0.50	130.5	173	0.50	86.5	577	0.99	571.2	867	0.99	858.3
Urban	045	0.20	609.0	4212	0.20	842.4	3424	0.20	684.8	3484	0.20	696.8
Recreational	6	0.30	25.8	86	0.30	25.8	86	0.30	25.8	86	0.30	25.8
Vacant or Fallow lands	34	0.10	93.4	354	0.10	35.4	200	0.10	20.0	200	0.10	20.0
Urban Drainage	9	0.20	19.8	180	0.20	36.0	68	0.20	13.6	110	0.20	22.0
Cottonwood-Willow	-	--	- -	--	--	--	79	0.69	54.5	--	--	- -
Sonoran Interior Marshland	-	--	- -	--	--	--	59	0.69	40.7	6	0.69	4.1
Total	5005		1209.8	5005		1026.1	5005		1763.9	5005		1778.3

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6. GLOSSARY

Alternative

In HEP 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:

<u>Alternative 1:</u> Plant food plots, increase wetland acreage by 10 percent, install 10 goose nest boxes, and build a fence around the entire site.

<u>Alternative 2:</u> Build a dam, inundate 10 acres of riparian corridor, build 50 miles of supporting levee, and remove all wetlands in the levee zone.

<u>Alternative 3:</u> 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 facines along the stream bank for stabilization purposes.

Average Annual Habitat Units (AAHUs)

A quantitative result of annualizing Habitat Unit (HU) gains or losses across all years in the period of analysis.

AAHUs = Cumulative HUs ÷ Number of years in the life of the project, where

Cumulative HUs =

Sum $(T_2 - T_1)[((A_1 H_1 + A_2 H_2) / 3) + ((A_2 H_1 + A_1 H_2) / 6)]$
and where:

T_1 = First Target Year time interval
T_2 = Second Target Year time interval
A_1 = Area of available habitat at beginning of T_1
A_2 = Area of available habitat at end of T_2
H_1 = HSI at beginning of T_1
H_2 = HSI at end of T_2

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 =

$$\text{Sum } (T_2 - T_1)[((A_1 F_1 + A_2 F_2) / 3) + ((A_2 F_1 + A_1 F_2) / 6)]$$

and where:

T_1 = First Target Year time interval
T_2 = Second Target Year time interval
A_1 = Area of available wetland assessment area at beginning of T_1
A_2 = Area of available wetland assessment area at end of T_2
F_1 = FCI at beginning of T_1
F_2 = FCI at end of T_2

Baseline Condition

In the habitat assessment and planning analyses, baseline is the point in time before proposed changes, and is synonymous with Target Year (TY = 0).

Compensation

Also referred to as mitigation, in terms of wildlife habitat value loss, functional capacity loss, or environmental impacts, these are the methods or actions by which the inflicting agency or group offsets the unavoidable loss, of or damage to, these resources due to the proposed action.

Cost Effectiveness Analysis (CEA)

An economic analysis completed to determine the least-cost, economically rational, alternatives. Economically rational alternatives are, by definition, both the efficient and effective alternatives. The results of a cost effectiveness analysis are often displayed in tables, bar charts and scatter plots.

Cover Type

A homogenous zone of similar vegetative species, geographic similarities and physical conditions that make the area unique. In general, cover types are defined on the basis of species recognition and dependence.

Ecosystem	An ecosystem is a biotic community, together with its physical environment, considered as an integrated unit. Implied within this definition is the concept of a structural and functional whole, unified through life processes. Ecosystems are hierarchical, and can be viewed as nested sets of open systems in which physical, chemical and biological processes form interactive subsystems. Some ecosystems are microscopic, and the largest comprises the biosphere. Ecosystem restoration can be directed at different-sized ecosystems within the nested set, and many encompass multi states, more localized watersheds or a smaller complex of aquatic habitat.
Effective Alternatives	When comparing alternatives, these alternatives produce <u>increased</u> levels of outputs (AAHUs from HEP or AAFCUs from HGM) for the same or lesser costs.
Efficient Alternatives	When comparing alternatives, these alternatives produced <u>similar</u> levels of output (AAHUs from HEP or AAFCUs from HGM) at a lesser expense.
Equivalent Optimal Area (EOA)	The concept of EOA is used in HEP when the composition of the landscape, in relation to providing life requisite habitat, is an important consideration. An EOA is used to weight the value of the Life Requisite SI to compensate for this inter-relationship. For example, for optimal wood duck habitat conditions, at least 20 percent of an area should be composed of cover types providing brood-cover habitat. If an area has less than 10 percent in this habitat, the suitability is adjusted downward.
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 HEP and 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 ten quadrats, within a riparian forest cover type. The values recorded are each considered "field data." Means of variables are applied to derive suitability indices and/or functional capacity indices.

Functional Capacity Index Model (FCI)

In the HGM, an FCI Model is a quantitative estimate of functional capacity for a wetland. The ideal goal of an FCI model is to quantify and produce an index that reflects functional capacity at the site. The results of an FCI analysis can be quantified on the basis of a standard 0-1.0 scale, where 0.00 represents low functional capacity for the wetland, and 1.0 represents high functional capacity for the wetland. An FCI model can be defined in words, or mathematical equations, that clearly describe the rules and assumptions necessary to combine functional capacity indices in a meaningful manner for the wetland.
For example:

$$FCI = (VSI\ V_1 * VSI\ V_2) / 4,$$

where:

$VSI\ V_1$ is the Variable Subindex (VSI) for variable 1;
$VSI\ V_2$ is the VSI for variable 2

Functional Capacity Units (FCUs)

A quantitative environmental assessment value considered the biological currency in HGM. Functional Capacity Units are calculated by multiplying the area of available wetland (quantity) by the quality of the wetland based on functionality. Quality is determined by measuring limiting factors describing wetland function, and is represented by values derived from Functional Capacity Indices (FCIs).

FCU = AREA X FCI.

Changes in FCUs represent potential impacts or improvements of proposed actions.

Future Factor (FF)

A unit of quality change, used to define the anticipated changes in mean field data, by target year, on a variable-per-cover type basis, rather than on a species-by-species basis. FF values are multiplicative factors (1.0, 1.5, 0.5, etc.), directly multiplied against the mean baseline condition, to allow project managers an opportunity to forecast changes over time on the site or project. For example, if the project manager anticipates a 50 percent increase in height of grass in the grassland cover type between TY_0 and TY_1, the baseline FF = 1.0, and the increase is an additional FF = 0.5, thus the overall FF = 1.0 + 0.5 = 1.5. In most instances, FFs less than 1.0 represent decreases in quality at the site, and FFs greater than 1.0 represent increases in quality at the site. Of course, this change is dependent upon the relationship between the species, the function, the cover type or PWAA, and the suitability index/functional capacity index for the model.

Guild

A group of functionally similar species with comparable habitat requirements whose members interact strongly with one another, but weakly with the remainder of the community. Often a species HSI model is selected to represent changes (impacts) to a guild.

Habitat Suitability Index Model (HSI)

In HEP, an HSI Model is a quantitative estimate of habitat conditions for an evaluation species or community. The ideal goal of an HSI model is to quantify and produce an index that reflects carrying capacity at the site. The results of an HSI analysis can be quantified on the basis of a standard 0-1.0 scale, where 0.00 represents low quality habitat for the species/community and 1.0 represents high quality habitat for the species/community. An HSI model can be defined in words, or mathematical equations that clearly describe the rules and assumptions necessary to combine suitability indices in a meaningful manner for the species.
For example:

$$HSI = (SI\ V_1 * SI\ V_2) / 4$$

where:

$SI\ V_1$ is the SI for variable 1;
$SI\ V_2$ is the SI for variable 2

Habitat Units (HUs)

A quantitative environmental assessment value, considered the biological currency in HEP. Habitat Units are calculated by multiplying the area of available habitat (quantity) by the quality of the habitat for each species or community. Quality is determined by measuring limiting factors for the species (or community), and is represented by values derived from Habitat Suitability Indices (HSIs).

HU = AREA X HSI.

Changes in HUs represent potential impacts or improvements of proposed actions.

Increment

In cost analyses, this term represents the change in cost divided, by the change in outputs between those solutions that survive the cost effectiveness filtration of alternatives. An increment then, is used to answer the question: "Is it worth it to take the next leap in cost?" Increments are displayed in bar charts and tabular reports.

Incremental Cost Analysis (ICA)

An economic analysis is completed to reveal and interpret changes in costs for increasing levels of outputs (e.g., AAHUs from HEP or AAFCUs from HGM). The results of an incremental cost analysis are often displayed in bar charts and tables.

Independent Alternatives

These alternatives can be implemented alone or in concert with their dependent alternatives.

Ineffective Alternatives

When comparing alternatives, these alternatives produce reduced levels of output (AAHUs from HEP or AAFCUs from HGM) for the same or greater costs.

Inefficient Alternatives

When comparing alternatives, these alternatives produced similar levels of output (AAHUs from HEP or AAFCUs from HGM) at a greater expense.

Life Requisite Suitability Index (LRSI)

In HEP, an LRSI is a mathematical equation that reflects a species' or community's sensitivity to a change in a limiting life requisite component within the habitat type. In HEP, LRSIs are depicted using scatter plots and bar charts (i.e., life requisite suitability curves). The LRSI value (Y axis) ranges on a scale from 0.0 to 1.0, where an LRSI = 0.0 means the factor is extremely limiting and an LRSI = 1.0 means the factor is in abundance (not limiting) in most instances.

Limiting Factor

A variable whose presence/absence directly restrains the existence of a species or community in a habitat. A deficiency of the limiting factor can reduce the quality of the habitat for the species or community, while an abundance of the limiting factor can indicate an optimum quality of habitat for the same species or community.

Measure

The act of physically sampling variables such as height, distance, percent, etc., and the methodology followed to gather variable information (i.e., see "Method" below). In some economic terms, a "measure" is considered a hierarchy of alternatives that can be subdivided further into scales or increments.

Method

In HEP or HGM applications, this is the mode/protocol followed to collect and gather field data. It is important to document the relevant criteria limiting the collection methodology. For example, the time of data collection, the type of techniques used, and the details of gathering this data should be documented as much as possible. An example of a method would be:

> *Between March and April, run five random 50-m transects through the relevant cover types. Every 10-m along the transect, place a 10-m^2 quadrat on the right side of the transect tape and record the percent herbaceous cover within the quadrat. Average the results per transect.*

Multiple Formula Model (aka Life Requisite Model)	In HEP, there are two types of HSI Models, the Single Formula Model (refer to the definition below) and the Multiple Formula Model. In this case a multiple formula model is, as one would expect, a model that uses more than one formula to assess the suitability of the habitat for a species or a community. If a species/community is limited by the existence of more than one life requisite (food, cover, water, etc.), and the quality of the site is dependent on a minimal level of each life requisite, then the model is considered a Life Requisite Model. In order to calculate the HSI for any Life Requisite Model, one must derive the value of a Life Requisite Suitability Index (see definition below) for each life requisite in the model – a process requiring the user to calculate multiple LRSI formulas. This multi-formula processing has led to the name "Multiple Formula Model" in HEP.
Non-Additive Situations	These situations occur when the combination of alternatives results in non-cumulative outputs or costs. Often this condition arises when environmental, economic and/or management factors contradict summative outcomes. For example, if the implementation of two separate alternatives can save on mobilization and demobilization costs, the project manager can reduce the overall combined cost to reflect this savings. The solution is considered "non-additive." This information is included in the cost analyses.
Non-Combinable Situations	These situations occur when mutually exclusive alternatives exist in the project. Often this condition arises when environmental, economic and/or management factors contradict combinable outcomes. For example, the alternative "construction of a new highway through the Florida Everglades" will conflict with the alternative "preservation and enhancement of the existing wetlands, precluding any development." If the only alternatives are to provide protection to the wetlands, or build the highway, these two alternatives are deemed "non-combinable" on the basis of environmental incompatibility. This information is included in the cost analysis evaluations.
Partial Wetland Assessment Area (PWAA)	A homogenous zone of similar vegetative species, geographic similarities and physical conditions that make the area unique. In general, PWAAs are defined on the basis of species recognition and dependence, soils types and topography.

Plans of Interest These situations occur when an outside qualitative factor directly influences the decision to implement an alternative, regardless of its environmental productivity or cost effectiveness. Several factors (i.e., political importance, aesthetic implications, environmental significance, community support, etc.) can compel decision-makers to evaluate alternatives that would have been eliminated under normal situations because of their ineffectiveness. For example, a "green belt" solution replacing a concrete channel through a business district might not be cost effective, or environmentally productive, but the co-sponsor (i.e., the local business association) can insist this alternative be evaluated as part of the project. This alternative is now considered a "Plan of Interest" alternative in cost analyses.

Project Manager Any biologist, economist, hydrologist, engineer, decision maker, resource project manager, planner, environmental resource specialist, limnologist, etc., who is responsible for managing a study, program, or facility.

Relative Value Index Is a value that is used to adjust AAHUs/AAFCUs to accommodate social, economic, ecological and political considerations? Judging criteria for relative values are defined by the decision-making team. Relative weights are calculated for each criterion, and then each evaluation model is rated against each criterion.

RVI = relative weight * value assigned to each evaluation model.

Relative Area In HEP and 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:

$$\text{Relative Area} = \frac{\text{Cover Type Area}}{\text{Total Area}}$$

where:

Cover Type Area = only those acres assigned to the cover type (or PWAA) of interest

Total Area = the sum of the acres utilized in the model.

Scale (1) In some geographical methodologies, the scale is the defined size of the image in terms of miles per inch, feet per inch, or pixels per acres; (2) scale can also refer to variations of the alternative in some cost analysis software packages.

Single Formula Model In HEP, there are two types of HSI Models, the Single Formula Model and the Multiple Formula Model (refer to the definition above). In this instance, an HSI model (or an FCI model in HGM) is based on the existence of a single life requisite requirement (or single wetland function requirement in HGM), and a single formula is used to depict the relationship between quality and carrying capacity (or functional capacity in HGM) for the site.

Site The location upon which the project manager will take action, evaluate alternatives and focus cost analysis.

Solutions In cost analysis, this is the alternative (see definition above.)

Spreadsheet A type of computer file or page that allows the organization of data (alpha-numeric information) in a tabular format. Spreadsheets are often used to complete accounting/economic exercises.

Suitability Index (SI) In HEP, an SI is a mathematical equation that reflects a species' or community's sensitivity to a change in a limiting factor (i.e., variable) within the habitat type. In HEP, SIs are depicted using scatter plots and bar charts (i.e., suitability curves). The SI value (Y-axis) ranges on a scale from 0.0 to 1.0, where an SI = 0.0 means the factor is extremely limiting, and an SI = 1.0 means the factor is in abundance (not limiting) for the species/community (in most instances).

Target Year (TY)

A unit of time measurement used in HEP, that allows the project manager to anticipate and direct significant changes (in area or quality) within the project (or site). As a rule, the baseline TY is always TY = 0, where the baseline year is defined as a point in time before proposed changes would be implemented. As a second rule, there must always be a TY = 1, and a TY = X_2. TY_1 is the first year land- and water-use conditions are expected to deviate from baseline conditions. TY_{X2} designates the ending target year. A new target year must be assigned for each year the project manager intends to develop or evaluate change within the site or project. The habitat conditions (quality and quantity) described for each TY are the expected conditions at the end of that year. It is important to maintain the same target years in both the environmental and economic analyses.

Trade-offs

Are used to adjust the AAHUs/AAFCUs by considering human values. There are no right or proper answers, only acceptable ones. If trade-offs are used, outputs are no longer directly related to optimum habitat.

Variable

A measurable parameter that can be quantitatively described, with some degree of repeatability, using standard field sampling and mapping techniques. Often, the variable is a limiting factor for a species (or community), used in the development of SI curves and measured in the field (or from aerial photos) by personnel, to fulfill the requirements of field data collection in a HEP or HGM application. Some examples of variables include: height of grass, percent canopy cover, distance to water, number of snags in 0.4 hectare or average annual water temperature.

Variable Subindex (VSI)

In HGM, a VSI is a mathematical equation that reflects a wetland function's sensitivity to a change in a limiting factor (i.e., variable) within the PWAA. In HGM, VSIs are depicted using scatter plots and bar charts (i.e., functional capacity curves). The VSI value (Y-axis) ranges on a scale from 0.0 to 1.0, where a VSI = 0.0 represents a variable that is extremely limiting and a VSI = 1.0 represents a variable in abundance (not limiting) for the wetland.

With Project Condition

Also referred to as the alternative, this is the condition of the site after an alternative is implemented.

Without Project Condition

Sometimes referred to as the Baseline condition, or the Existing condition, this is the expected condition of the site without implementation of an alternative; referred to as the "No Action" condition in planning studies. The habitat conditions at TY 0 always refer to the pre-existing conditions.

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX E

DESIGN

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

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1.0 OBJECTIVE

The objective of the Paseo de las Iglesias project is to implement restore riparian habitat in the vicinity of eastern Pima County. 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 Paseo de las Iglesias project is located in eastern Pima County, Arizona. The study area extends along the Santa Cruz River between Congress Street downstream to Los Reales Road upstream for a total length of approximately 7.5 miles.

3.0 PROJECT DESIGN DEVELOPMENT

3.1 Typical Project Design Features

A. Tributary Water Harvesting Basins

Tributary water harvesting basins will be constructed along the main channel of the Santa Cruz in areas that are typically protected from high energy discharges. The best location for the construction of a basin is at the confluence of the main channel and a tributary wash where fluvial deposition has been prevalent. The basin should be located on a raised bar or terrace and should be rectilinear in shape with a length to width ratio greater than 1.5. The long axis of the basin will be roughly aligned with the wash channel centerline. With this type of layout configuration, surface water from the tributary wash can be diverted into the basin and captured.

The basins will consist of an excavated depressional area that is back-filled with high porous media (gravel and sand) to promote infiltration into the near subsurface. The basin will provide detention storage for channel flow through infiltration and will minimize surface evaporation while providing subsurface moisture for rooted vegetation. The porous media will be sorted and graded by size through the depth of the basin to provide a matrix for root mass development from the establishment of vegetation on the surface.

Construction techniques include excavation of existing grades to a depth of approximately 48-inches below grade. To protect against possible washout during storm events, the side slopes of the basin will be shallow and no steeper than a five percent grade. Excavated material will be inspected and useable material stockpiled on-site for backfill. It is anticipated that approximately 25 percent of the cut material will be suitable for backfill. The remaining 75 percent will be loaded and hauled to the southern project area disposal site.

Upon certification that the subgrade surface is free of debris and protuberances, the excavated surface will be compacted to 90 percent Proctor. Clean sand, part of which can be reclaimed from existing cut material, will be back-filled into the basin directly overtop the compacted earth floor. The sand layer will be approximately 12-inches in depth and tapered to 4-inches in depth around the basin perimeter. The second layer to be filled will consist of 12-inches of No. 57 bluestone, or approved equivalent, and will serve to allow quick infiltration and provide a matrix for root mass development. Over top of the bluestone, the third layer of back-fill will consist of 12-inches of No. 2 gravel, or approved equivalent, which will promote quick infiltration and provide a filter layer to trap organic material. The top most layer will consist of 12-inches of native topsoil and loam mix, part of which can be reclaimed from existing cut material, which will serve as the high-organic layer to promote vegetative success.

The proposed surface of the water harvesting basin will be fine graded to direct channel discharges toward the basin interior. A planting mix of cottonwood willow and mesquite will consist of the dominant woody vegetation. Figure 5 illustrating the Airport Wash Diversion Basin (discussed later in this appendix) also provides an illustration for the tributary water harvesting basins with the exception that the downstream excavated trench slope grade for the tributary basin would not to exceed 5%.

B. Grade Control Structure Water Harvesting Basins

In order to limit deep infiltration losses of flow in the main channel, certain areas will be designated for construction of water harvesting basins, similar in design to the Tributary Water Harvesting Basins described above. Grade Control Water Harvesting Basins will be constructed immediately upstream of five existing grade control structures along the main channel of the Santa Cruz River. Each basin will be approximately 1-acre in area and will be rectilinear in shape, with a length to width ratio greater than 1.5. The long axis of the basin will be roughly aligned with the main channel centerline.

The basins will consist of an excavated depressional area that is back-filled with high porous media (gravel and sand) to promote infiltration into the near subsurface. The basin will provide detention storage for channel flow through infiltration and will minimize surface evaporation while providing subsurface moisture for rooted vegetation. The porous media will be sorted and graded by size through the depth of the basin to provide a matrix for root mass development from the establishment of herbaceous vegetation on the surface.

Grade Control Water Harvesting Basins will be designed and constructed identical to Tributary Water Harvesting Basins and will only differ in the type of vegetation that will be permitted to grow. Whereas woody vegetation, like cottonwood willow and mesquite, will be planted on the Tributary Water Harvesting Basins, only herbaceous non-woody vegetation will be permitted to flourish on the Grade Control Water Harvesting Basins. Emergent type grasses and reeds that display low hydraulic friction coefficients will be planted. Operation and maintenance practices will be instituted to remove any undesirable woody vegetation that would potentially cause increased hydraulic friction across the invert of the main channel.

C. Bank Stabilization through Excavation

Stream banks along the Santa Cruz River are highly unstable and nearly vertical cliffs composed of weakly cemented sands which are greatly susceptible to instability from wind and water erosion. These cliffs, which are devoid of vegetation, are unprotected from erosion from shear stresses during flood events, high winds and desiccation. Some of these unstable over-steep banks can be cut back through excavation to gentler slopes and then re-vegetated for ecosystem improvements.

Two variations of bank excavation were investigated to stabilize the unstable slopes. Each variation is a function of the amount of land available in the historic floodplain that is adjacent to the river bank under consideration for excavation. Where available land is not a constraint, banks are graded to a five-on-one horizontal to vertical (5:1 H:V) slope and then stabilized through vegetation. In areas where insufficient space exists to accommodate 5:1 slopes, placement of soil cement will be necessary for bank protection.

Excavation of the unstable slopes will be completed only above the 2-year flood water surface elevation and will continue upslope at a uniform 5:1 grade. Channel features that exist below the 2-year flood water surface elevation will be protected during excavation and returned to their pre-construction conditions before the project is completed. Cut material from the excavation will be loaded and hauled to the disposal area located at the abandoned sand and gravel quarry site at the southern end of the project area. Excavated material will not be side cast on-site. The potential for increases in erosion will be 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.

All excavated slopes will be stabilized with vegetation and irrigated to promote quick growth. Irrigation practices on the excavated slopes will be comprised of leach field piping and pressure flow directed to the site from irrigation main lines located along the historic floodplain. Detailed analysis of the resulting stability of the regraded slopes will be performed as part of the final design phase and the recommendations of that analysis will be incorporated into the project construction plans and specifications..

D. Bank Stabilization with Soil Cement

In areas where insufficient space exists in the Historic Floodplain to accommodate 5H:1V excavated slopes, the placement of soil cement will be necessary for bank protection. Soil cement has been used extensively along the Santa Cruz River and in many other areas within Pima County and southern Arizona. Proven construction techniques have been established and adopted by various permitting authorities at the local and state level. Notwithstanding the industry accepted construction methods, the following paragraph describes soil cement application assumption used for concept design development.

At five locations along the Santa Cruz River, there are areas that exhibit moderate to severe bank instability in close proximity to the project boundaries. In these areas, real estate within the historic floodplain is limited in width and prohibits large excavation measures required for bank stability projects. With the application of soil cement, a narrow project footprint is all that is needed for successful stabilization of the eroding river banks. The total length of soil cement required is approximately 4,700 linear feet with a length-weighted average above grade vertical height of 19 feet.

Soil cement application will be required in five locations and will be based on several assumptions. The finished slope of a soil cement project will be on a 1H:1V grade. At least 10 feet of subsurface soil cement will be constructed to support the entire structure and to provide toe protection in the event of erosion. Combining the subsurface vertical depth of 10 feet with the average above grade vertical height of 19 feet, the total vertical application of soil cement will average at an approximate height of 30 feet. The top elevation of each soil cement section will terminate at the approximate elevation of the adjacent historic floodplain. The thickness of the soil cement will be approximately 8 feet which will be comprised of individual 8-inch thick lifts.

E. Irrigation System Design for Furrow Irrigation

Furrow irrigation will be established in the designated planting areas of the Historic Floodplain and will consist of cut furrows to receive surface flow for flood irrigation. This system will include all necessary piping and will be considered as permanent irrigation for the life of the project.

The design and construction of a permanent irrigation system requires the presence of a pressure water main that is brought to the project area and can sustain the water demands set by the irrigation requirements. At the location of the water main, header group piping will be installed along the Santa Cruz River channel that will convey the water toward specific locations within the project that will require irrigation. With the establishment of header groups, piping schemes and water distribution regimes will be facilitated and controlled on a systematic basis.

Gated supply piping will be installed in cut trenches and will provide flood irrigation water to each furrow by way of small diameter flexible tubing. Pressure regulation will be needed along supply piping to prevent scour and soil erosion that may result by irrigation applied at high pressures. At each small diameter tubing, water will be introduced into the furrow and allowed to gravity flow down the furrow. The rate of irrigation, amount to be applied to each furrow, and the duration will be adjusted at each planting area based on trial and error as it is assumed that the areas to receive furrow irrigation are heterogeneous in soil composition and topography.

Proper design of furrow irrigation requires detailed knowledge of the near surface geology and soil conditions to allow for efficient irrigation and to minimize losses due to infiltration and evapotranspiration. Sub-desert region irrigation practices prevalent in central and southern Arizona, where soil conditions consist of sand and loam, are successful when the furrow lengths are limited to a maximum distance of approximately 600 linear feet. At this furrow length, when considering soil conditions, the soil moisture depletion in the effective root zone is minimized, which allows for greater plant uptake.

The biggest requirement for successful furrow irrigation is that the field must have a positive and continuous furrow grade, which requires precision land grading. Precision grading results in positive field drainage that greatly enhances vegetative production. The furrow grade should be a minimum of 0.1 percent and no more than 0.5 percent with furrow grades between 0.15 and 0.3 percent as the most desirable. Furrow spacing to support the proposed mesquite and shrub planting should be eight (8) feet center-to-center. Each furrow will be triangular in cross section with an average depth of eight (8) inches and 3H:1V slide slopes.

After each planting area is graded for flood irrigation drainage, furrows will be excavated with the cut material side cast in the area between adjacent furrows. Prior to planting, the invert of each furrow will be compacted with a wheeled vehicle for one pass to create a flow channel along the furrow that will promote longitudinal distribution of flood irrigation to the hydraulically most remote point of the furrow. Plants will be installed along the shoulder of each side of each furrow, so that each plant is positioned close to irrigation sources. At initial plant installation, weeds will be removed from the furrow invert to insure each furrow receives adequate irrigation along its entire length. Weed control will continue within the furrows until such time that installed plants have established mature roots and will be able to compete for water sources. A typical furrow irrigation cross section is shown in Figure 1.

F. Irrigation System Design for Leach Field Pipes

Leach field irrigation will be installed on all excavated and natural slopes and second bench areas designated for ecosystem planting. Leach field irrigation will consist of buried pipes that will provide water to the roots of installed plants, and will rely on header pipes providing flow from water main pipes. Water distribution will commence through pressure flow from header group pipes with water pressures dropping to provide just enough flow through leach field pipe at the base of installed plant root masses. The leach field pipes, by definition, will be fitted with orifice openings to allow water to seep into the surrounding soil formation. With this type of irrigation, water is provided directly to the roots of the installed plants without potential looses due to surface evaporation or deep infiltration.

All piping from the header pipes to the leach field pipes will be installed in the subsurface. Trenches will be excavated and backfilled with the same material; excess cut material will be hauled off-site to the disposal area located at the southern end of the project area. Header pipes will be installed on gravel beds and protected within reason from rotational, tensile, or compressive forces. Leach field pipes, used on excavated and natural slopes, will be installed in trenches and overtop medium permeability geosynthetic fabric. The geosynthetic fabric will be used to provide a semi-permeable layer directly underneath the leach pipes to minimize deep infiltration and will induce a downslope flow regime of the irrigation water. The fabric will have an allowable permeability not to exceed 10^{-4} cm/sec. Geosynthetic fabric will not be used when installing leach field pipe on the second bench areas, which have very shallow surface grades.

Leach field piping will be installed parallel to topographic contours and will be limited to a length not to exceed 2,000 linear feet. It has been assumed that this limit in length will help to minimize operation and maintenance requirements by limiting the number of fittings required for each pipe run and to minimize head losses. Leach field pipe will be installed in trenches with a 10-foot center-to-center separation. Each pipe run will be installed no greater than 12-inches below grade, with the crown of the pipe located approximately 4-inches below grade. Leach field pipes will be wrapped in filter fabric to limit clogging to the orifice openings.

Plants will be installed between the leach field pipes and will be offset from the center line of the pipes by a minimum distance of 18-inches on the upslope side and 24-inches on the down slope side. Minimum separation distances will be applied to irrigation practices on the excavated and natural slopes to prevent roots from clogging the leach field pipes. A typical irrigation leach field cross section is shown in Figure 2.

G. Sprinkler Irrigation System Design

The design and construction of a permanent sprinkler irrigation system requires the presence of a pressure water main that is brought to the project area and can sustain the water demands set by the irrigation requirements. At the location of the water main, distribution piping will be installed along the Santa Cruz River channel that will convey the water toward specific locations within the project that will require irrigation. With the establishment of distribution groups, piping schemes and water distribution regimes will be facilitated and controlled on a systematic basis. This system will include all necessary piping and sprinkler heads and will be considered as permanent irrigation for the life of the project.

Sprinkler irrigation will be applied to the first bench areas within the Santa Cruz River valley. First bench areas are distinguished by fluvial geomorphological features that include areas raised above the main channel invert that display sedimentation buildup through natural processes. The first bench is typically located above the 2-year water surface elevation and supports a variety of low lying vegetation that can withstand moderate hydrodynamic forces resulting from infrequent inundation.

Sprinkler irrigation in these areas is best suited due to the remote delivery of irrigation water and the less intrusive construction requirements. All associated piping that delivers water to the individual sprinkler heads will be installed in subsurface at the toe of the second bench. Excavation and placement of all piping will occur at an elevation above the 25-year water surface elevation. Trenches will be excavated and backfilled with the same material; excess cut material side cast and compacted on-site. Distribution pipes will be installed on gravel beds and protected within reason from rotational, tensile, or compressive forces. In narrower reaches of the Santa Cruz River where the banks have been stabilized with soil cement the sprinkler heads will be mounted on the soil cement banks

Sprinkler heads will be designed to provide for long reach distribution with an arc radius of approximately 150 feet. Distribution pipe sizing and pressure requirements will be adjusted with commercially available sprinkler heads to attain the 150-foot distribution pattern. Sprinkler heads will be installed at an interval distance to provide for 25 feet of distribution overlap from each adjacent head. Thrust blocks will be installed at each elbow or bend in the piping to maintain system integrity and prevent damage or erosion to surrounding areas.

3.2 Specific Project Design Features

A. Let Down Structures for Gully Stabilization

At five locations along the Santa Cruz River valley there are moderate to severely eroded gullies that have formed from stormwater runoff spilling over the valley cliffs in an uncontrolled manner. All five gullies are located between Irvington Road and Valencia Road, four of which are located on the right descending bank, one of which is located on the left descending bank. These gullies are formed through the discharge of small catchment areas that have been isolated from larger catchments due to constructed municipal features including roads and bridges. The catchment areas are located within the historic floodplain in areas typically characterized as devoid of vegetation. The formation of the gullies are currently unchecked by any stabilization efforts and will continue to erode if appropriate measures are not taken.

The construction of let down structures will allow for stormwater discharge from the historic floodplain to the Santa Cruz River in a non-erosive manner. Let down structures will comprise Pipe Slope Drains for the non-erosive conveyance of stormwater through the gully features. Each site will then be backfilled to bury the conveyance piping and return the river valley walls to natural looking conditions. Fill material will be obtained from other project areas where cut material is in surplus. The conveyance piping will consist of bituminous coated corrugated metal piping typically used for road culverts. All piping will be supported on a gravel base and protected from excessive overburden forces.

The initial construction of the Let Down Structures will consist of the removal of debris and woody vegetation within the limits of the gully. The gully invert will then be graded to receive conveyance piping. A gravel base will be installed along the piping alignment to support the piping. After the piping is installed and secured to the gully slopes, fill material will be dumped and compacted to bury the piping and return the river valley wall to its original condition. Pipe end fitting will be installed with protective wingwalls and trash racks to allow for non-erosive discharge and prevent clogging of the conveyance piping. At the discharge end of the piping, an energy dissipation structure will also be installed. Figure 3 illustrates the Let Down Structure

B. Water Diversion Channel

A water diversion channel will be constructed along the left descending bank of the Airport Wash to capture surface runoff for diversion to a small basin. At the upstream end of the existing drop structure along the wash channel, a level spreading device will be constructed to divert a portion of the surface flow into a trapezoidal diversion channel. The channel will extend approximately 1,000 linear feet and will deliver surface water to a newly planted area for ecosystem restoration. The cut material from the excavation of the diversion channel will be mounded to construct a horse-shoe shaped low-head embankment on the downstream side of the area. The embankment will prevent the surface water from flowing back into the tributary channel which will therefore provide irrigation for the ecosystem restoration planting. Design calculations are presented in Tables 1 and 2. Figure 4 illustrates the water diversion channel and Figure 5 illustrates the basin design.

Table 1
Airport Wash Basin Diversion Channel
Rating Table for Trapezoidal Channel

Project Description	
Project File	c:\docume~1\billbi~1\my documents\paseo\hydraulics\furrow d.fm2
Worksheet	Airport Wash Diversion Chnnl
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Mannings Coefficient	0.030
Channel Slope	0.005000 ft/ft
Left Side Slope	3.000000 H : V
Right Side Slope	3.000000 H : V
Bottom Width	4.00 ft

Input Data	Minimum	Maximum	Increment
Depth	0.10	2.00	0.10 ft

Rating Table

Depth (ft)	Discharge (cfs)	Velocity (ft/s)
0.10	0.31	0.72
0.20	1.01	1.09
0.30	2.04	1.39
0.40	3.40	1.63
0.50	5.09	1.85
0.60	7.12	2.05
0.70	9.50	2.23
0.80	12.26	2.39
0.90	15.39	2.55
1.00	18.92	2.70
1.10	22.86	2.85
1.20	27.23	2.99
1.30	32.03	3.12
1.40	37.29	3.25
1.50	43.01	3.37
1.60	49.22	3.50
1.70	55.93	3.62
1.80	63.14	3.73
1.90	70.88	3.85
2.00	79.16	3.96

Table 2
Airport Wash Basin Diversion Channel
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\docume~1\billbi~1\my documents\paseo\hydraulics\furrow d.fm2
Worksheet	Airport Wash Diversion Chnnl
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.005000	ft/ft
Depth	1.25	ft
Left Side Slope	3.000000	H : V
Right Side Slope	3.000000	H : V
Bottom Width	4.00	ft

Results		
Discharge	29.57	cfs
Flow Area	9.69	ft²
Wetted Perimeter	11.91	ft
Top Width	11.50	ft
Critical Depth	0.94	ft
Critical Slope	0.015669	ft/ft
Velocity	3.05	ft/s
Velocity Head	0.14	ft
Specific Energy	1.39	ft
Froude Number	0.59	
Flow is subcritical.		

3.3 Planting Activities

Prior to planting, site preparation would include rough grading and scarifying of subsoil to receive topsoil, mulching/crimping/tilling of topsoil, and placement of rocks and coarse woody debris. Hydro-seeding would be used to spread a mix of native seed, mulch and fertilizer over all areas.

Plantings of mesquite and riparian shrubs will be interspersed throughout the project area. In the terraces and on the vegetated banks riparian shrub will be the dominant cover type while mesquite will dominate in the historic floodplain. Areas of cottonwood-willow will be planted at the tributary basins and emergent marsh will be created at the grade control basins.

Plantings will include mesquite planted with a high density using larger specimens of mesquite, blue palo verde, netleaf hackberry, wolfberry, graythorn, catclaw acacia, fourwing saltbush, and sacaton. Fremont cottonwood, Gooding's Willow, and velvet ash will be added to the plantings at the tributary water harvesting basins. Native herbaceous grasses will be planted in the water harvesting basins upstream of existing grade-control structures.

3.4 Recreational Features

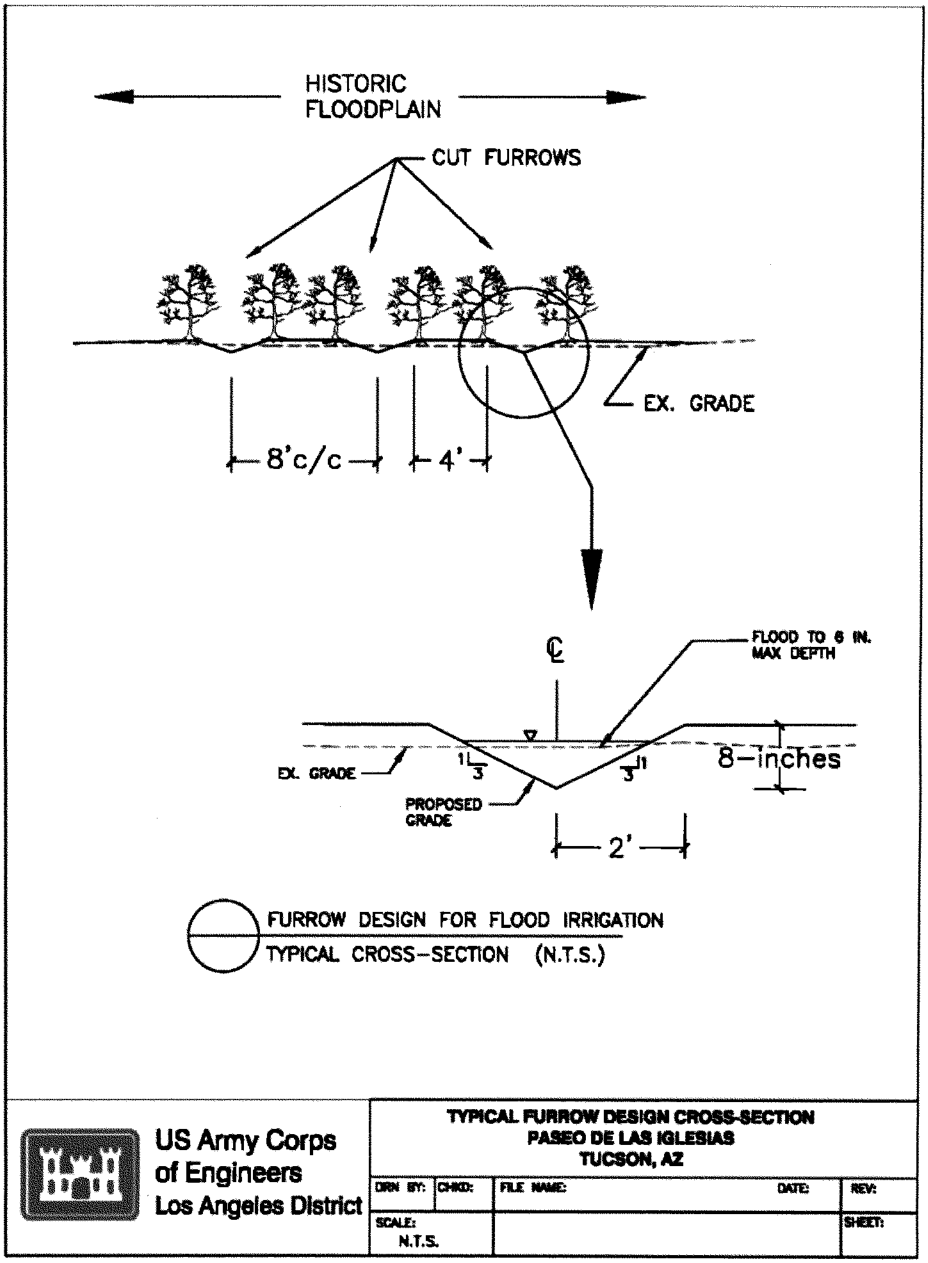
The County has indicated they would like to include recreation features within the proposed project. Within the proposed recreation areas, improvements to the project may consist of a multipurpose trail system that incorporates the potential for educational benefits associated with habitat restoration, and the inclusion of benches and ramadas, and native plant material. Incidental to the primary project objective of the proposed project (environmental restoration) is the creation of passive recreational opportunities associated with the restored habitat areas, including the use of maintenance roads as trails for walking and biking, and areas for observing wildlife and learning about the natural history of the river. Also, interpretive signage should also be included as part of the project for public use and involvement to better understand the habitats and natural history associated with the river channel. Recreational features considered are as follows:

a. Install three new Comfort Stations on the west bank. The restroom building is erected on a concrete slab and constructed of interlocking 8"Wx16"Lx8"H split concrete blocks. The building has 3 doors, 4 Lexan windows, and 4 steel roof panels. A typical comfort station is shown in Figure 6.
b. Multipurpose trails with paved trail, unpaved trail, and decomposed granite (DG) trail are used in both north and south banks. A typical cross section of each trail is shown in Figure 7.
c. Install 16 new parking spaces at each of five locations. On the east bank near Valencia Road and midway between Silverlake Road and Ajo Way. On the west bank south of Valencia Road, approximately midway between Valencia road and Drexel Road, and approximately midway between Ajo Way and Irvington Road.

3.4 Project Maps

Figures 8 through 31 provide mapping of the project area with the locations of all project features identified.

Figures


HISTORIC
FLOODPLAIN
CUT FURROWS
EX. GRADE
8'c/c
4'
℄
FLOOD TO 6 IN.
MAX DEPTH
EX. GRADE
1
3
3
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8-inches
PROPOSED
GRADE
2'
FURROW DESIGN FOR FLOOD IRRIGATION
TYPICAL CROSS-SECTION (N.T.S.)
US Army Corps
of Engineers
Los Angeles District
TYPICAL FURROW DESIGN CROSS-SECTION
PASEO DE LAS IGLESIAS
TUCSON, AZ
DRN BY:
CHKD:
FILE NAME:
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REV:
SCALE:
N.T.S.
SHEET:

Figure 1

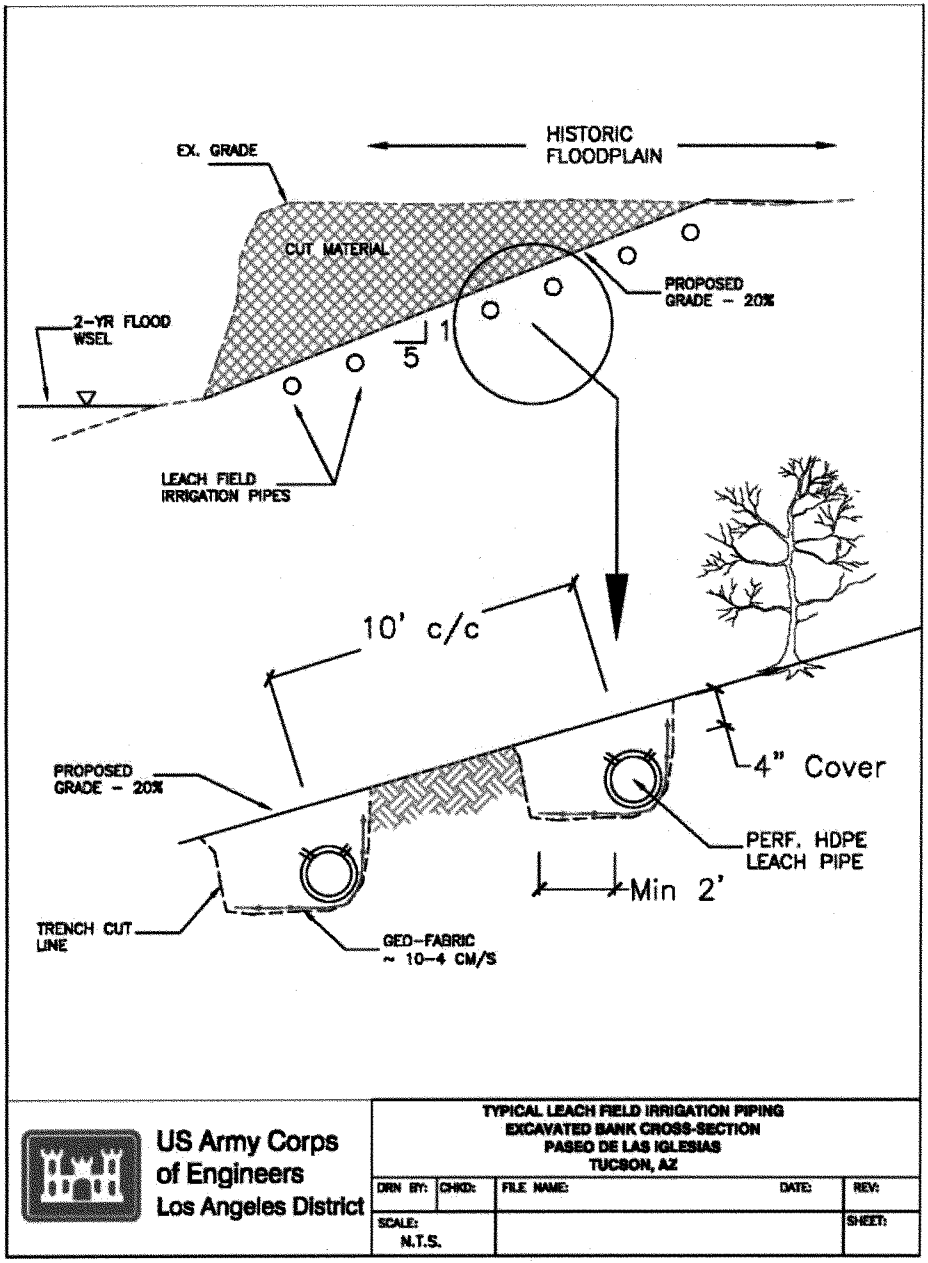
HISTORIC
FLOODPLAIN
EX. GRADE
CUT MATERIAL
PROPOSED
GRADE – 20%
2-YR FLOOD
WSEL
1
5
LEACH FIELD
IRRIGATION PIPES
10' c/c
4" Cover
PROPOSED
GRADE – 20%
PERF. HDPE
LEACH PIPE
Min 2'
TRENCH CUT
LINE
GEO-FABRIC
~ 10-4 CM/S
US Army Corps
of Engineers
Los Angeles District
TYPICAL LEACH FIELD IRRIGATION PIPING
EXCAVATED BANK CROSS-SECTION
PASEO DE LAS IGLESIAS
TUCSON, AZ
DRN BY:
CHKD:
FILE NAME:
DATE:
REV:
SCALE:
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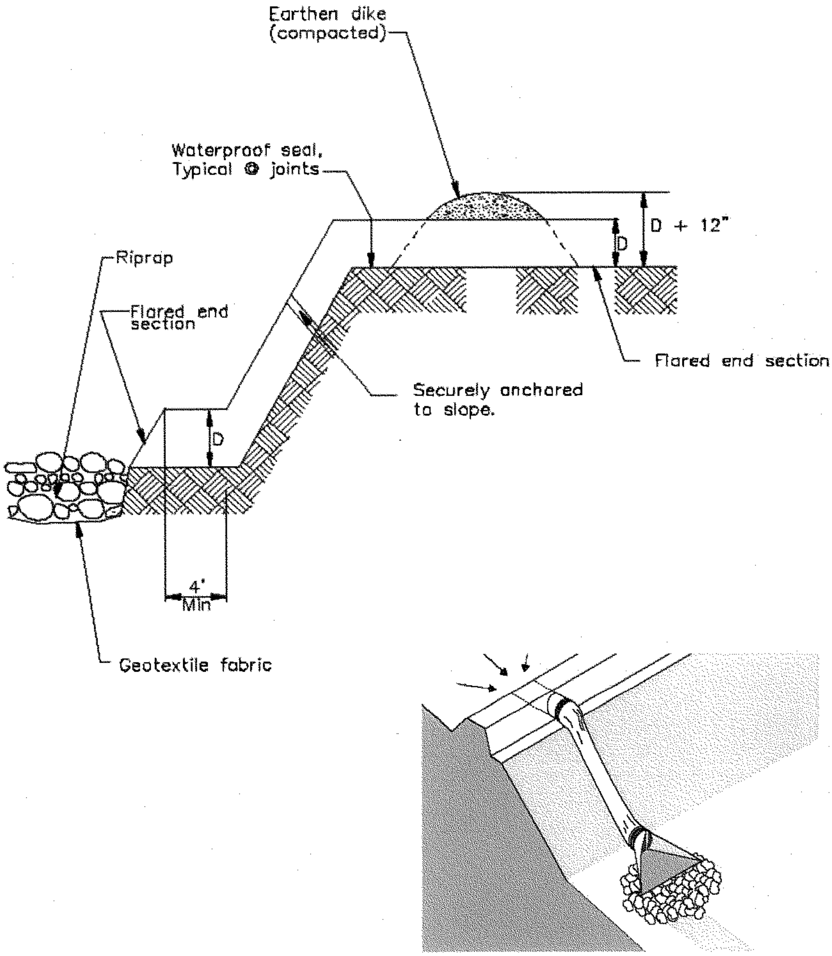
Figure 2



US Army Corps
of Engineers
Los Angeles District

PIPE SLOPE DRAIN DETAIL AS PART OF LET DOWN STRUTURE PASEO DE LAS IGLESIAS TUCSON, AZ				
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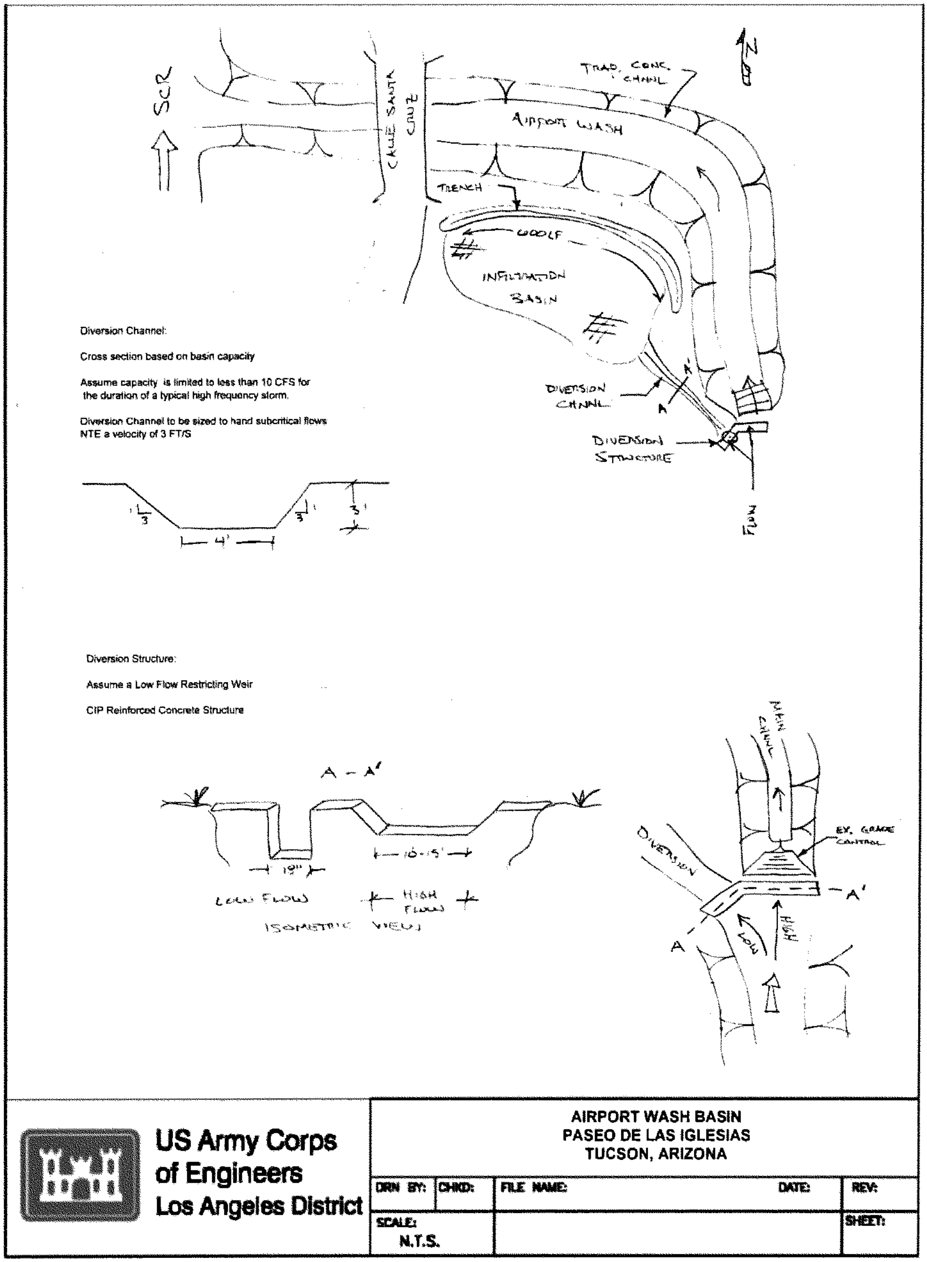
Figure 3


SCR
CALLE SANTA CRUZ
TRAP. CONC. CHNNL
AIRPORT WASH
N
TRENCH
WOOLF
INFILTRATION BASIN
DIVERSION CHNNL
A
A'
DIVERSION STRUCTURE
FLOW
Diversion Channel:
Cross section based on basin capacity
Assume capacity is limited to less than 10 CFS for the duration of a typical high frequency storm.
Diversion Channel to be sized to hand subcritical flows NTE a velocity of 3 FT/S
1
3
3'
4'
Diversion Structure:
Assume a Low Flow Restricting Weir
CIP Reinforced Concrete Structure
A – A'
18"
10-15'
LOW FLOW
HIGH FLOW
ISOMETRIC VIEW
MAIN CHNNL
EX. GRADE CONTROL
DIVERSION
LOW
HIGH
US Army Corps of Engineers Los Angeles District
AIRPORT WASH BASIN
PASEO DE LAS IGLESIAS
TUCSON, ARIZONA
DRN BY:
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FILE NAME:
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REV:
SCALE:
N.T.S.
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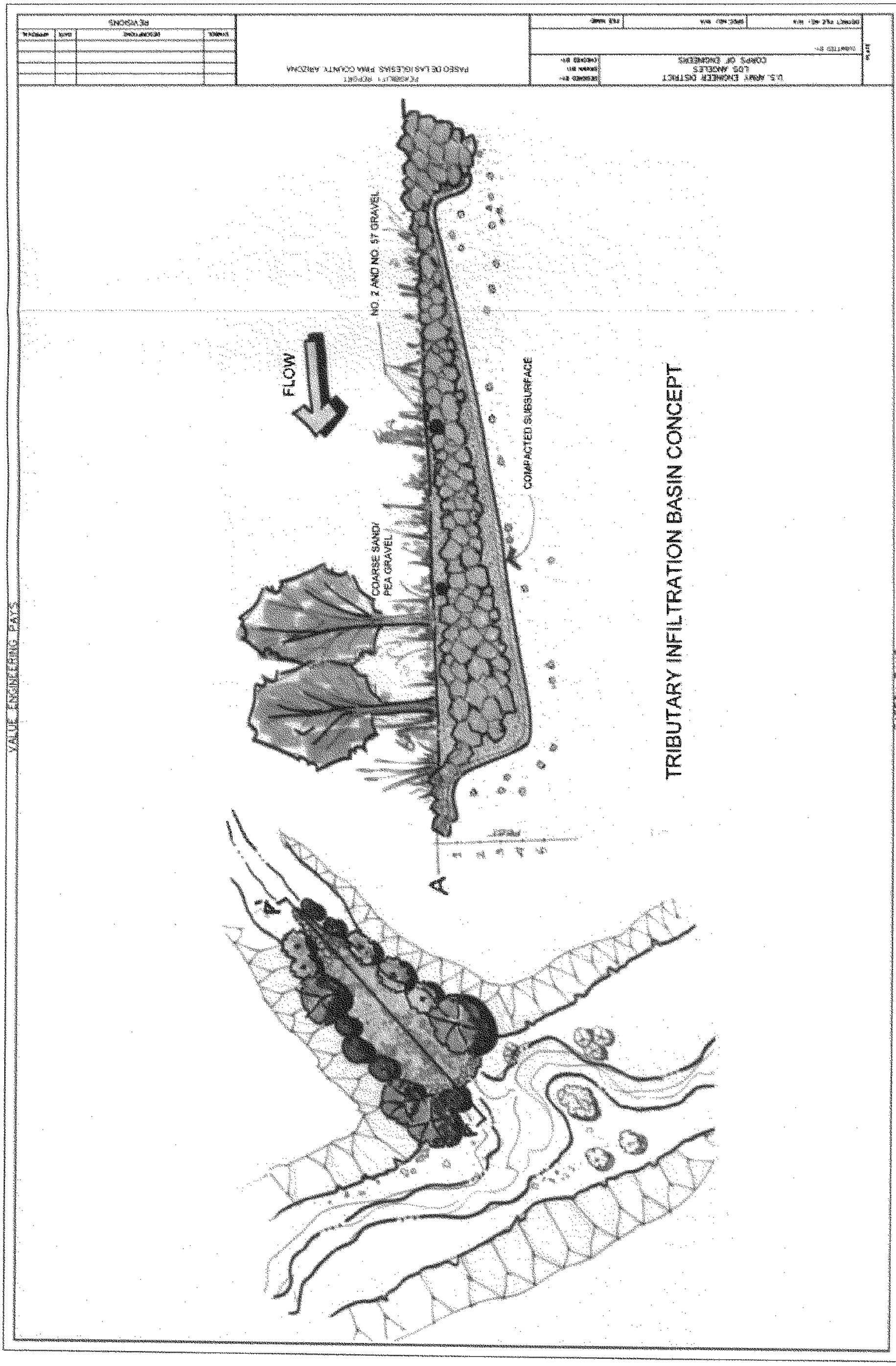
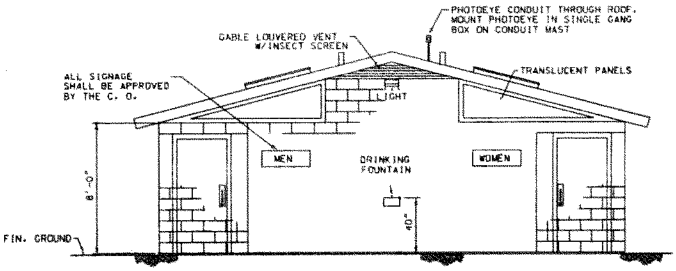
Figure 4

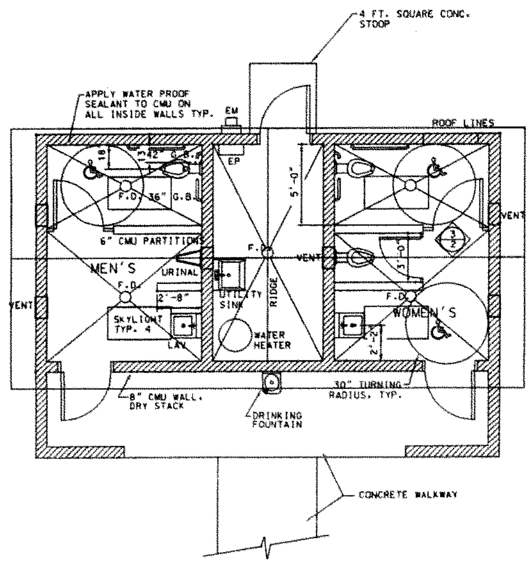
Figure 5


U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
FEASIBILITY REPORT
PASEO DE LAS IGLESIAS PIMA COUNTY, ARIZONA
REVISIONS
FLOW
NO. 2 AND NO. 57 GRAVEL
COARSE SAND/
PEA GRAVEL
COMPACTED SUBSURFACE
TRIBUTARY INFILTRATION BASIN CONCEPT
VALUE ENGINEERING PAYS
SAFETY PAYS



FRONT ELEV.

NOT TO SCALE



FLOOR PLAN

NOT TO SCALE

US Army Corps of Engineers
Los Angeles District

COMFORT STATION PASEO DE LAS IGLESIAS TUCSON, AZ				
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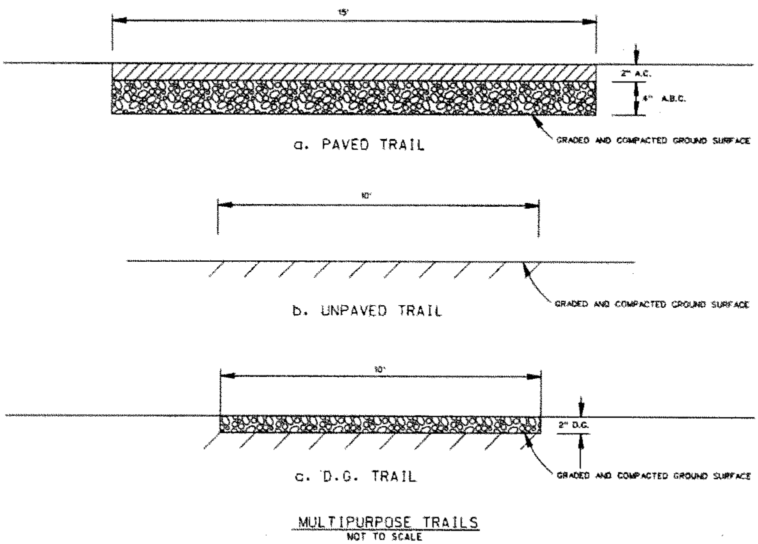
SCALE: N.T.S.				SHEET:

Figure 6



US Army Corps of Engineers
Los Angeles District

MULTI-PURPOSE TRAILS
PASEO DE LAS IGLESIAS
TUCSON, AZ

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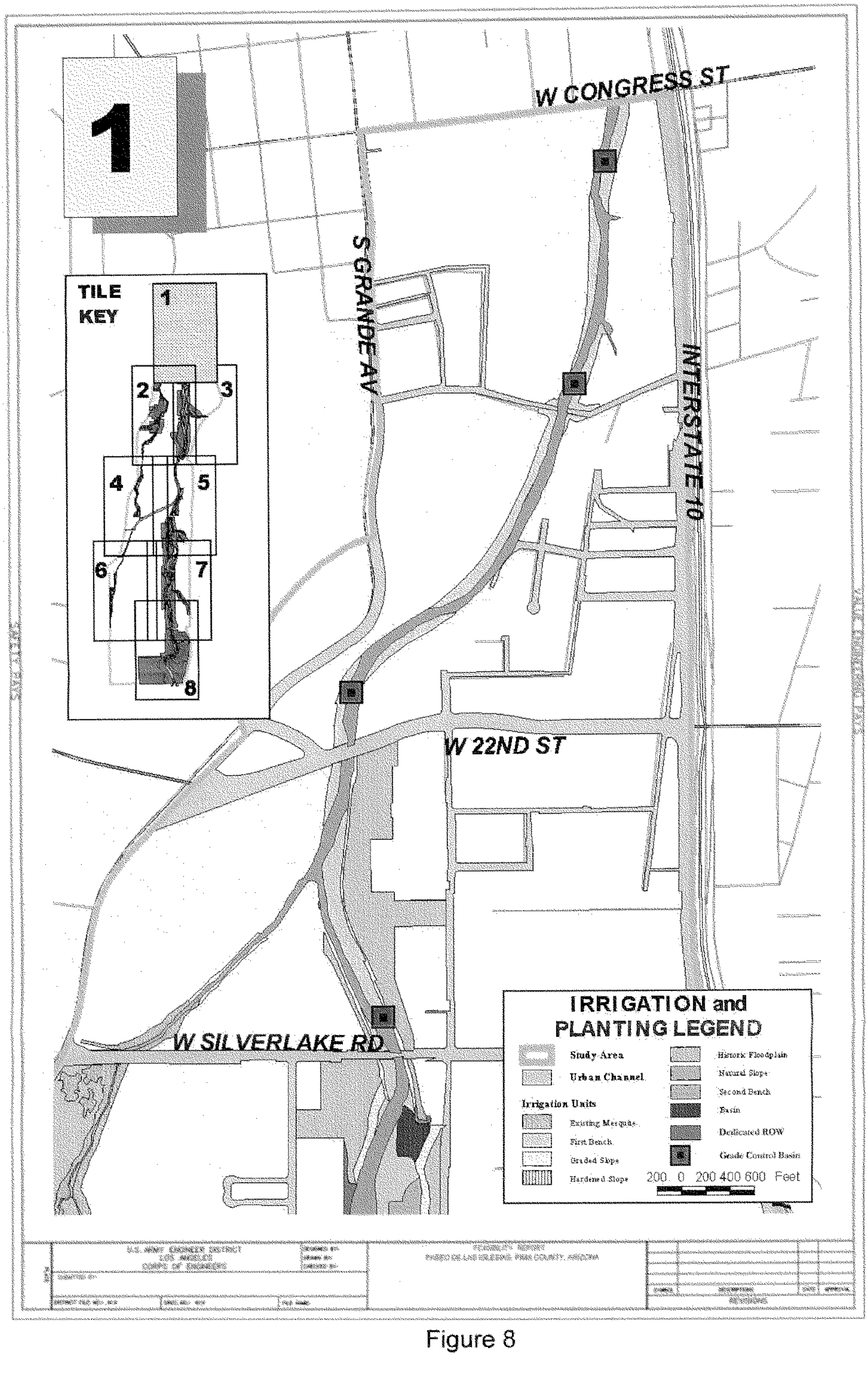
SCALE: N.T.S.				SHEET:

Figure 7


1
TILE KEY
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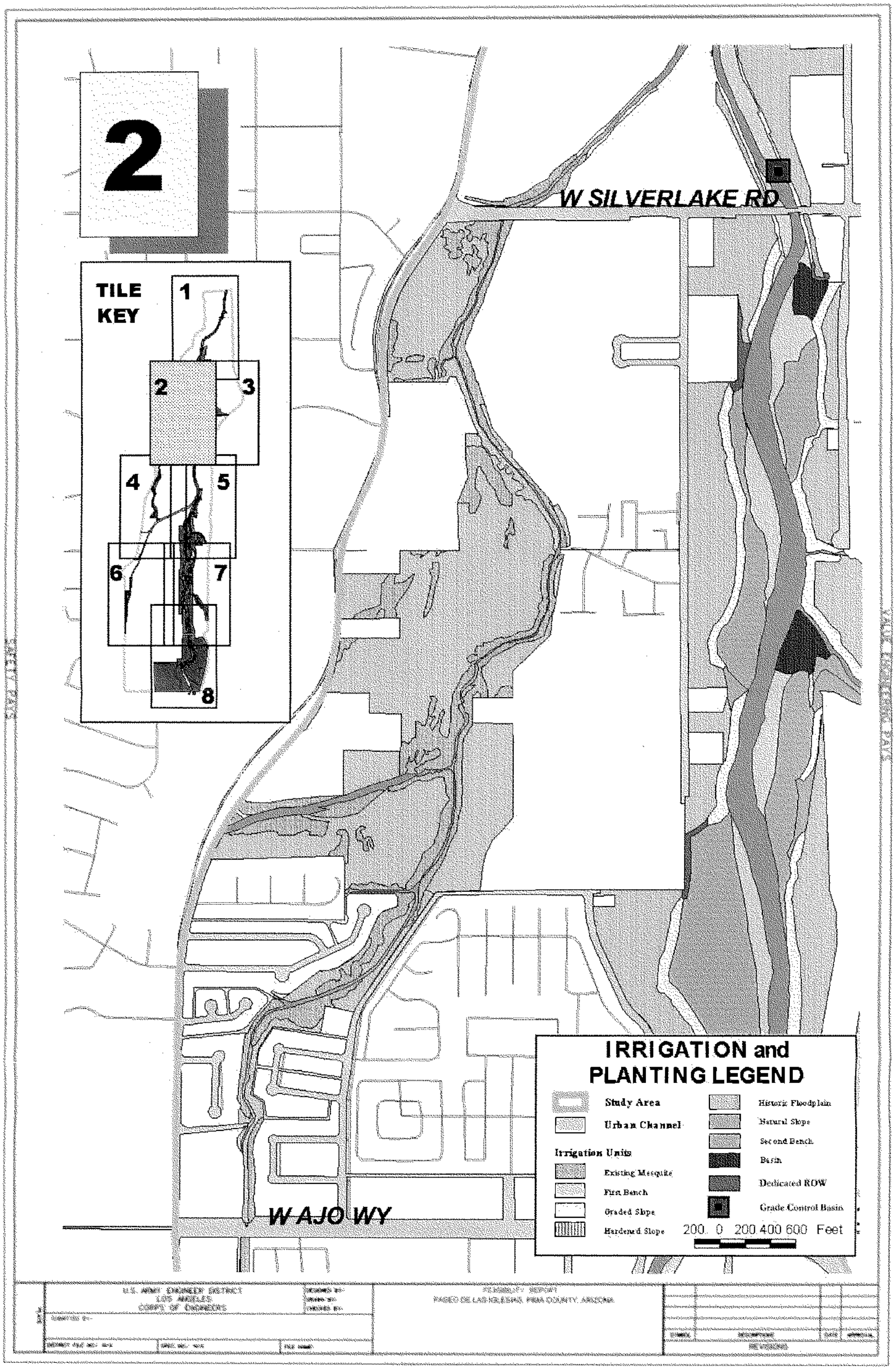
S GRANDE AV
INTERSTATE 10
W 22ND ST
W SILVERLAKE RD
IRRIGATION and PLANTING LEGEND
Study Area
Urban Channel
Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
Basin
Dedicated ROW
Grade Control Basin
200 0 200 400 600 Feet

Figure 8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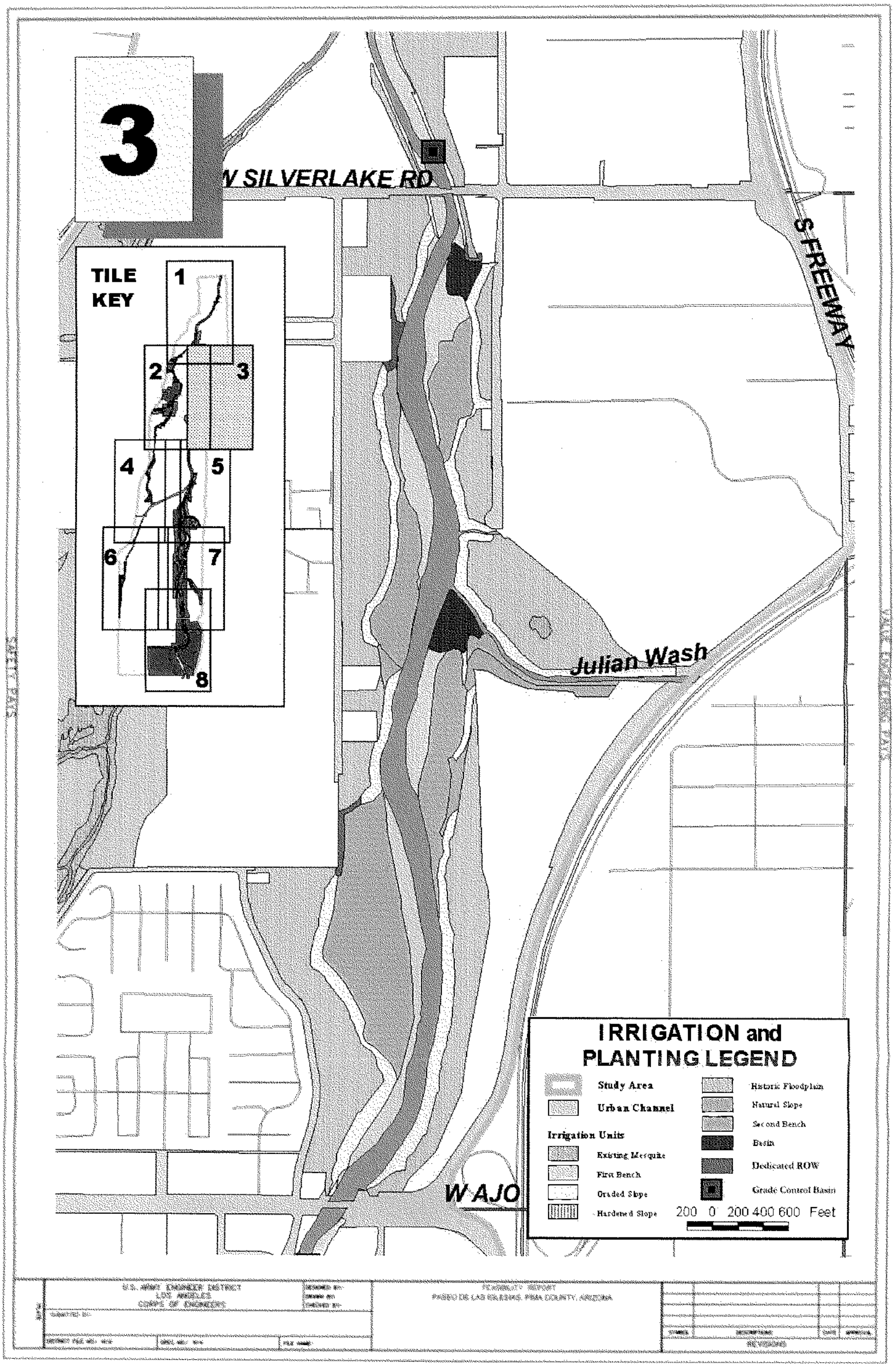
Study Area
Urban Channel
Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
Basin
Dedicated ROW
Grade Control Basin
200 0 200 400 600 Feet

Figure 9


3
W SILVERLAKE RD
S FREEWAY
TILE KEY
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Julian Wash
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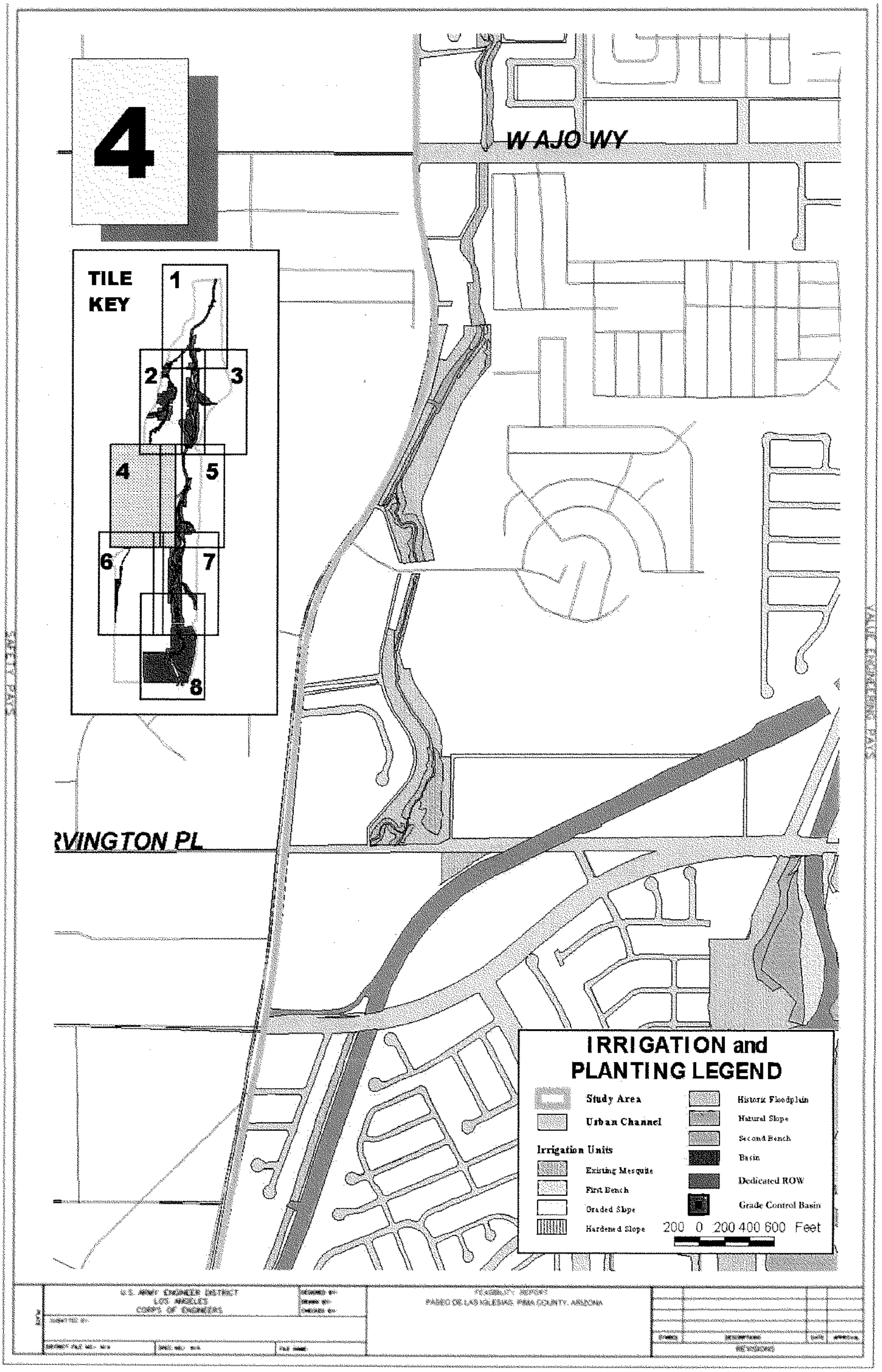
IRRIGATION and PLANTING LEGEND
Study Area
Urban Channel
Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
Basin
Dedicated ROW
Grade Control Basin
200 0 200 400 600 Feet

Figure 10


4
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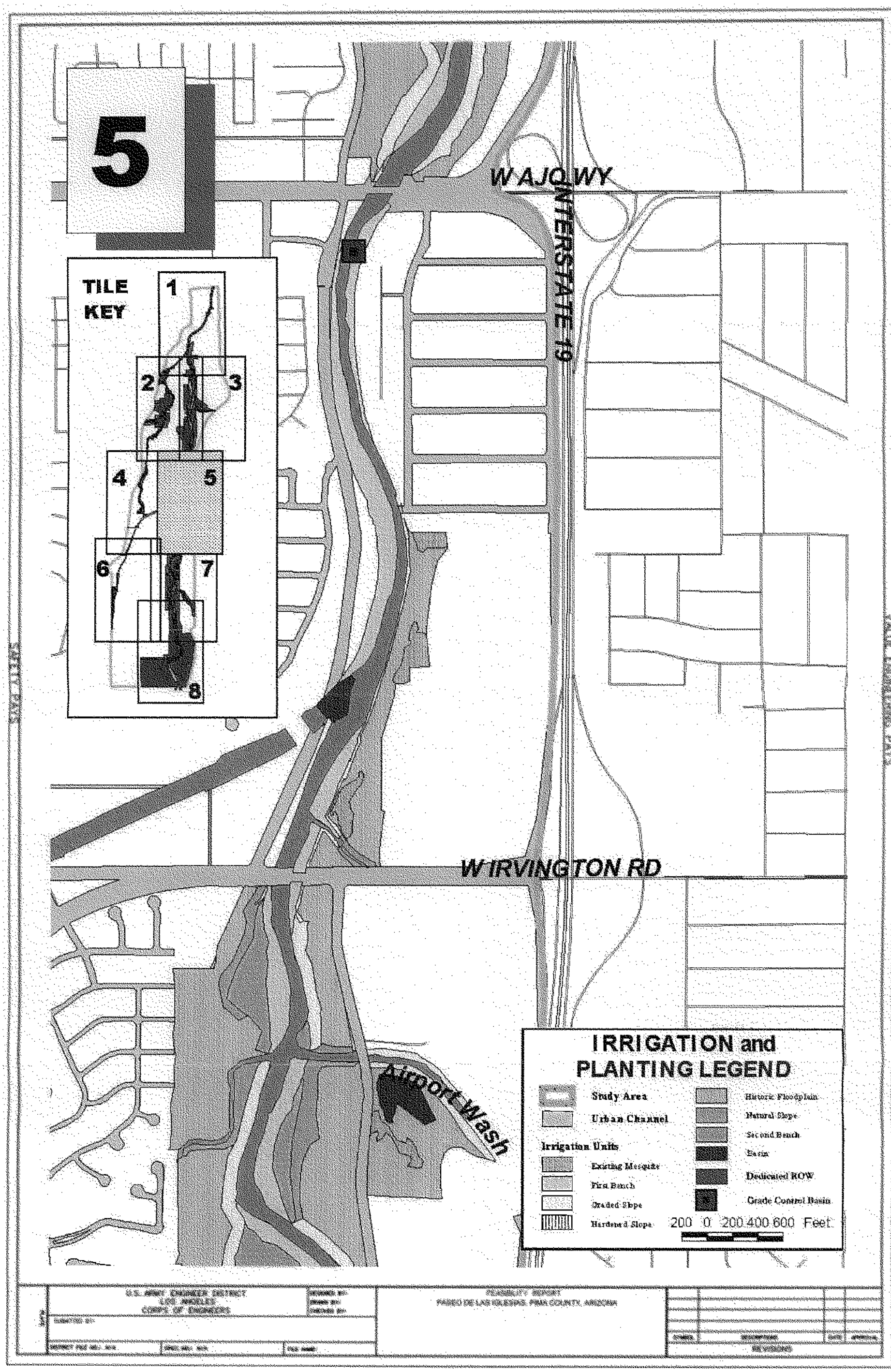
RVINGTON PL
IRRIGATION and PLANTING LEGEND
Study Area
Urban Channel
Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
Basin
Dedicated ROW
Grade Control Basin
200 0 200 400 600 Feet
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
FEASIBILITY REPORT
PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA

Figure 11


5
TILE KEY
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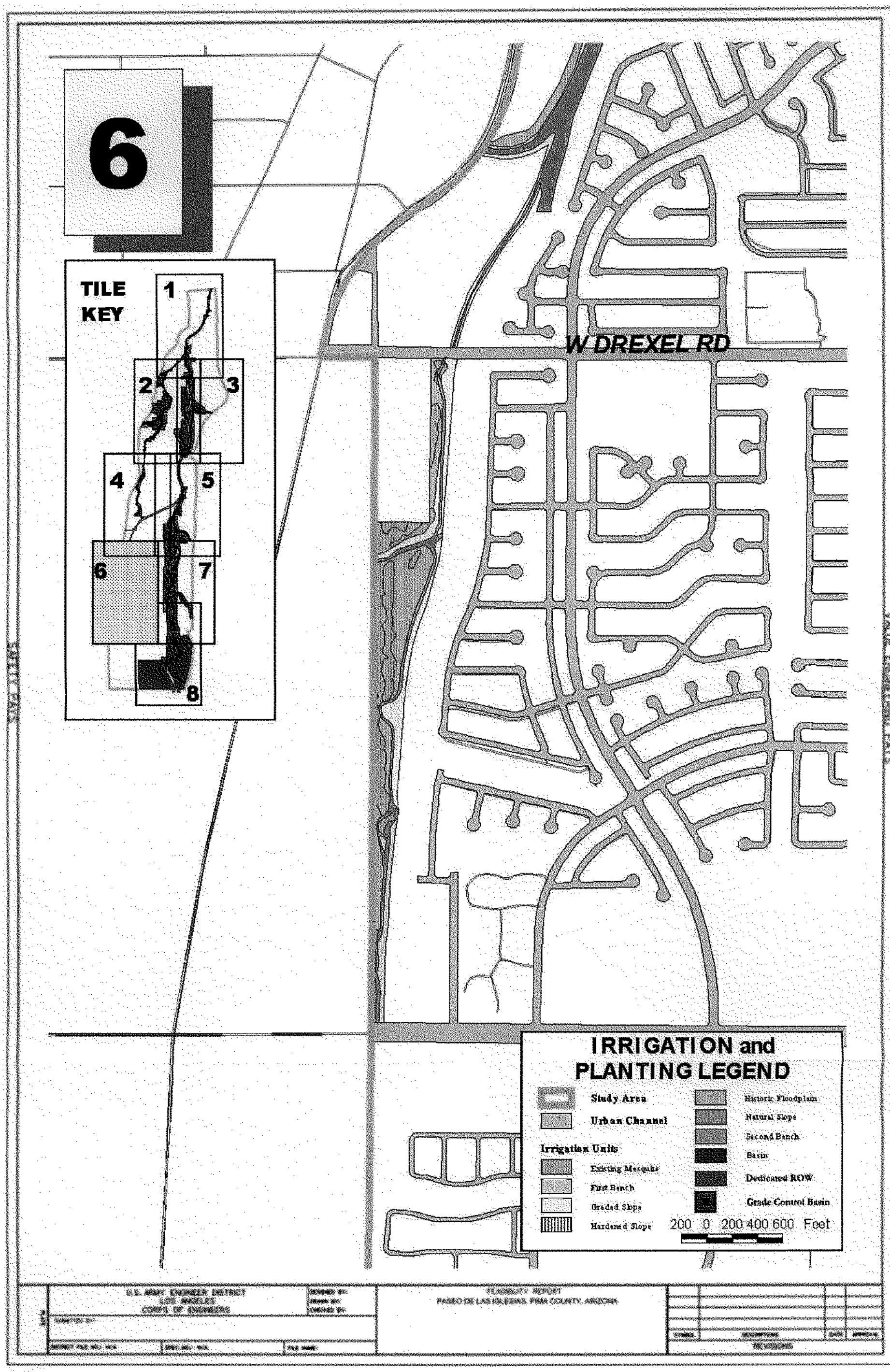
7
8
W AJO WY
INTERSTATE 19
W IRVINGTON RD
Airport Wash
IRRIGATION and PLANTING LEGEND
Study Area
Urban Channel
Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
Basin
Dedicated ROW
Grade Control Basin
200 0 200 400 600 Feet
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
FEASIBILITY REPORT
PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA
REVISIONS

Figure 12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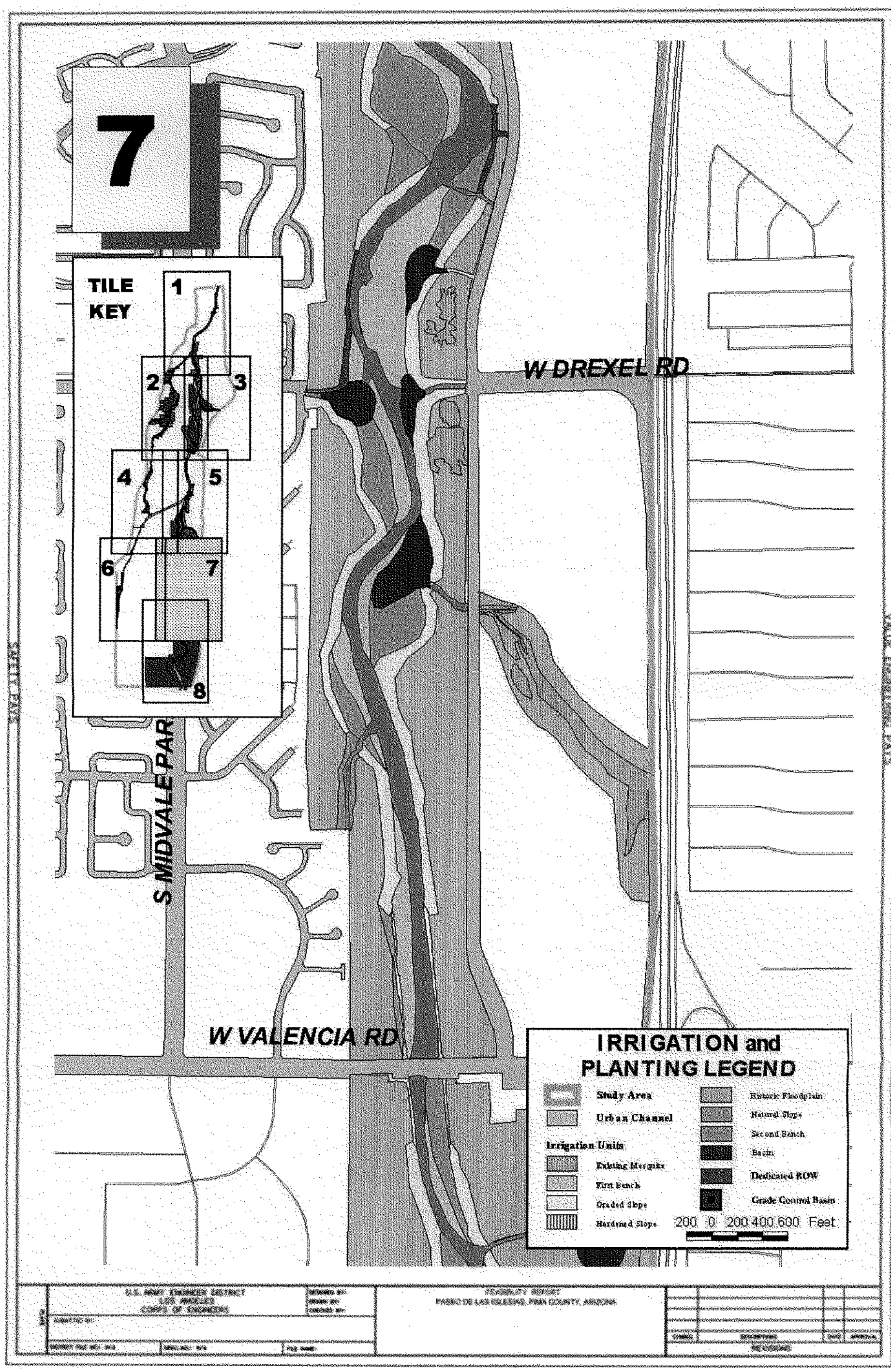
IRRIGATION and PLANTING LEGEND
Study Area
Urban Channel
Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
Basin
Dedicated ROW
Grade Control Basin
200 0 200 400 600 Feet

Figure 13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Study Area
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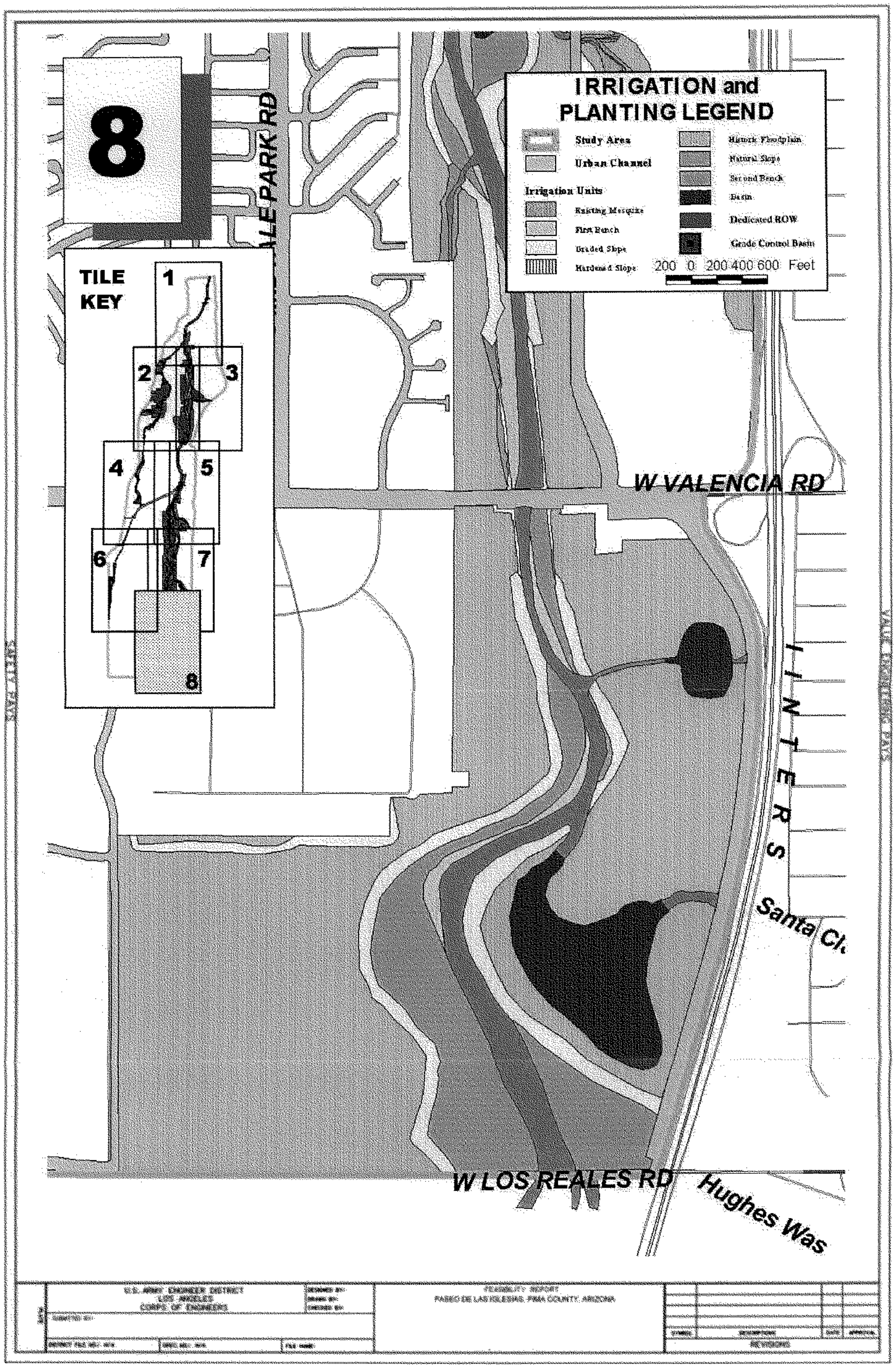
Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
Basin
Dedicated ROW
Grade Control Basin
200 0 200 400 600 Feet

Figure 14



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IRRIGATION and PLANTING LEGEND
Study Area
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Irrigation Units
Existing Mesquite
First Bench
Graded Slope
Hardened Slope
Historic Floodplain
Natural Slope
Second Bench
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Dedicated ROW
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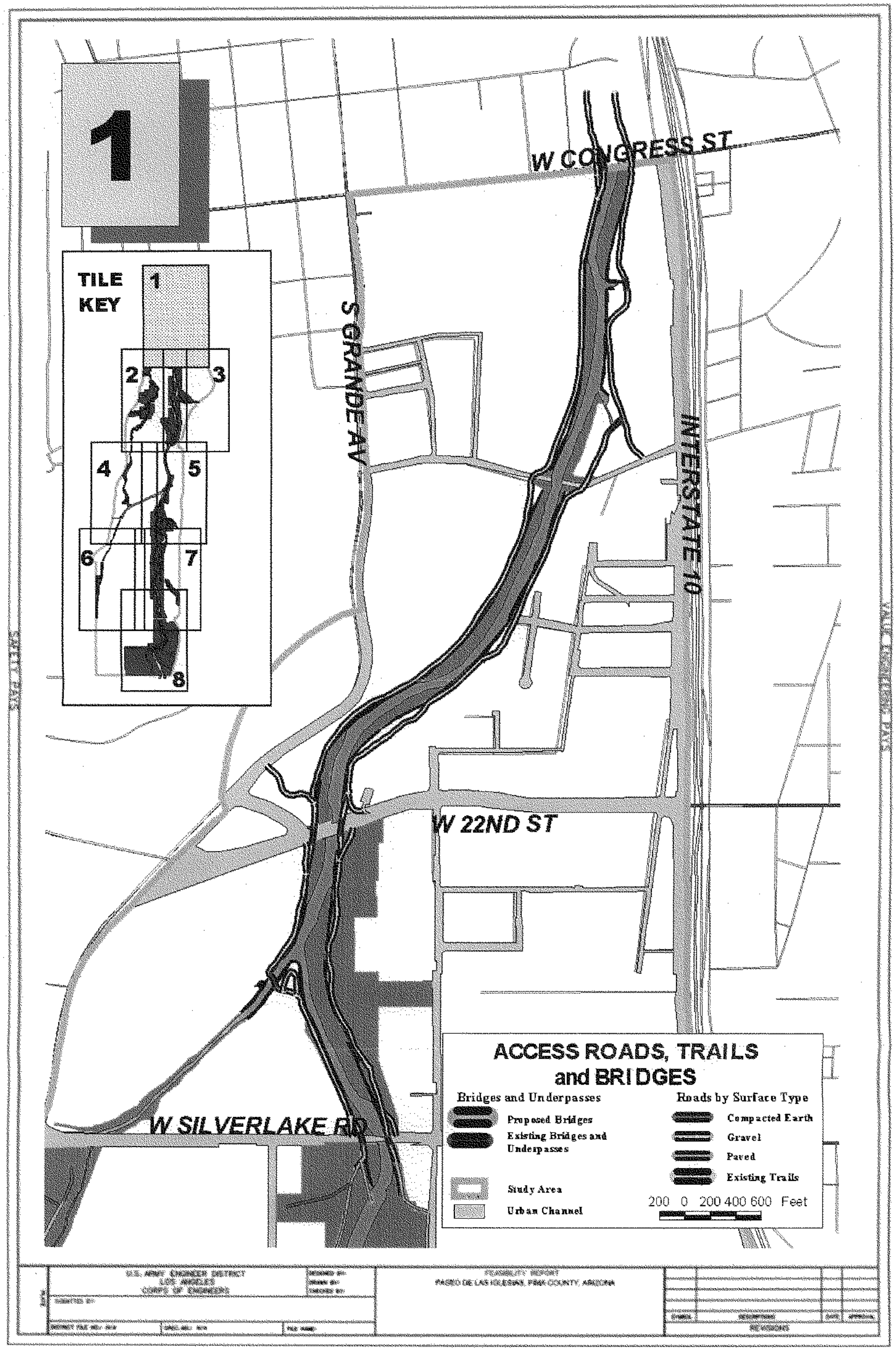
W LOS REALES RD
Hughes Was
Santa Cl
INTERS

Figure 15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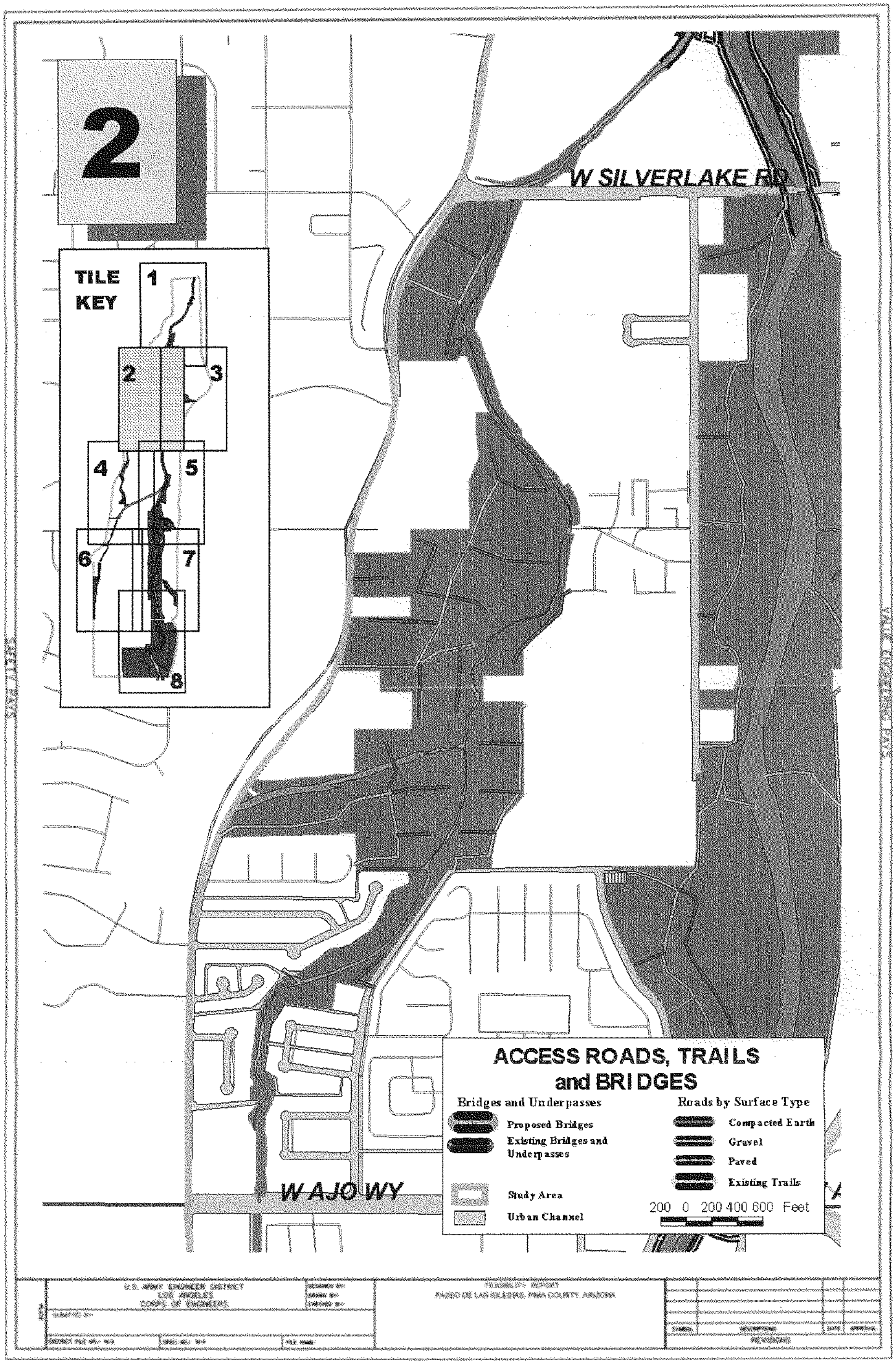
W SILVERLAKE RD
ACCESS ROADS, TRAILS and BRIDGES
Bridges and Underpasses
Proposed Bridges
Existing Bridges and Underpasses
Study Area
Urban Channel
Roads by Surface Type
Compacted Earth
Gravel
Paved
Existing Trails
200 0 200 400 600 Feet

Figure 16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Bridges and Underpasses
Proposed Bridges
Existing Bridges and Underpasses
Roads by Surface Type
Compacted Earth
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Existing Trails
Study Area
Urban Channel
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CORPS OF ENGINEERS
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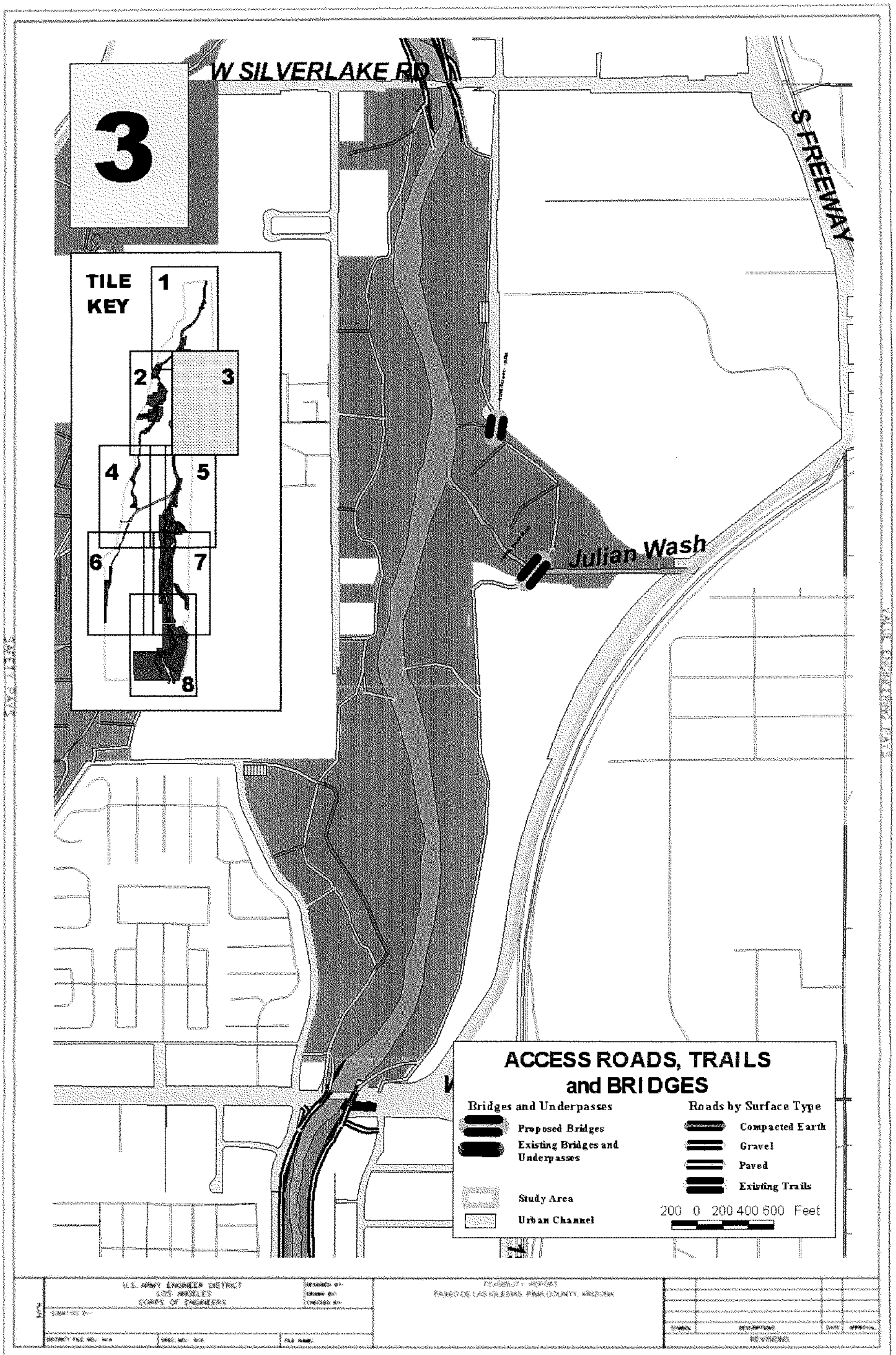
Figure 17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and BRIDGES
Bridges and Underpasses
Proposed Bridges
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Underpasses
Study Area
Urban Channel
Roads by Surface Type
Compacted Earth
Gravel
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Existing Trails
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U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
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PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA
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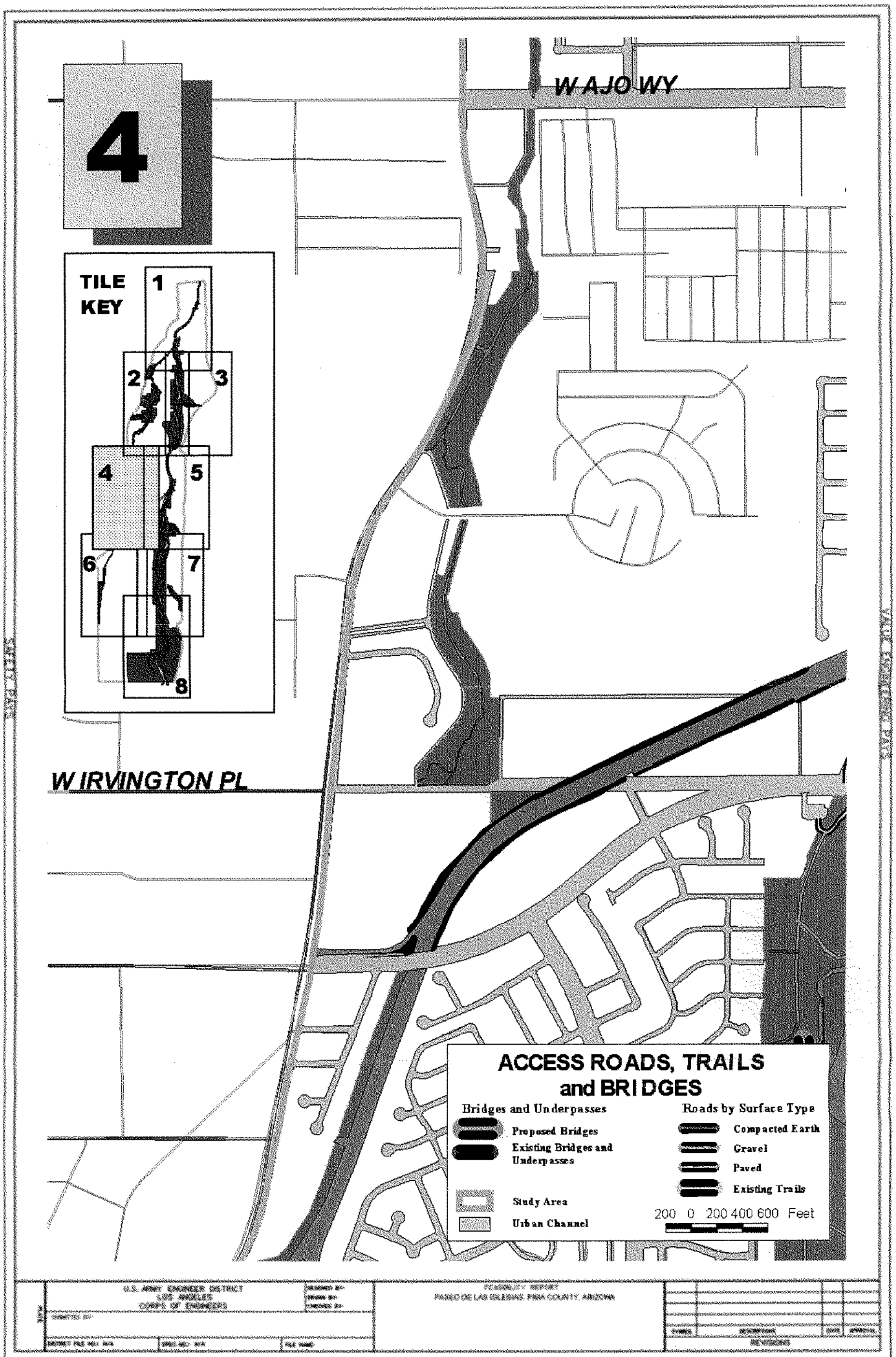
Figure 18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Study Area
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Roads by Surface Type
Compacted Earth
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CORPS OF ENGINEERS
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PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA
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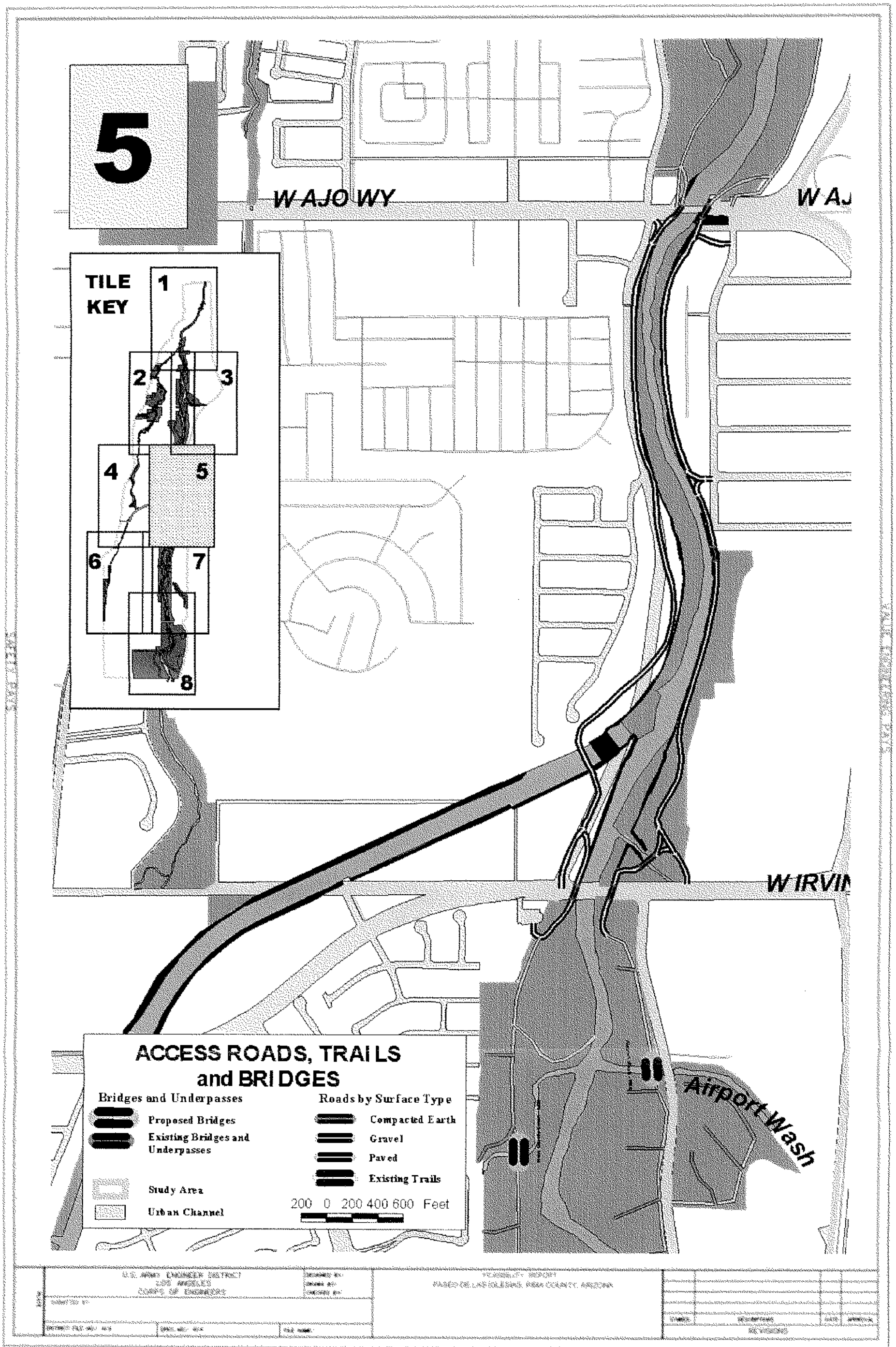
Figure 19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Bridges and Underpasses
Proposed Bridges
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Study Area
Urban Channel
Roads by Surface Type
Compacted Earth
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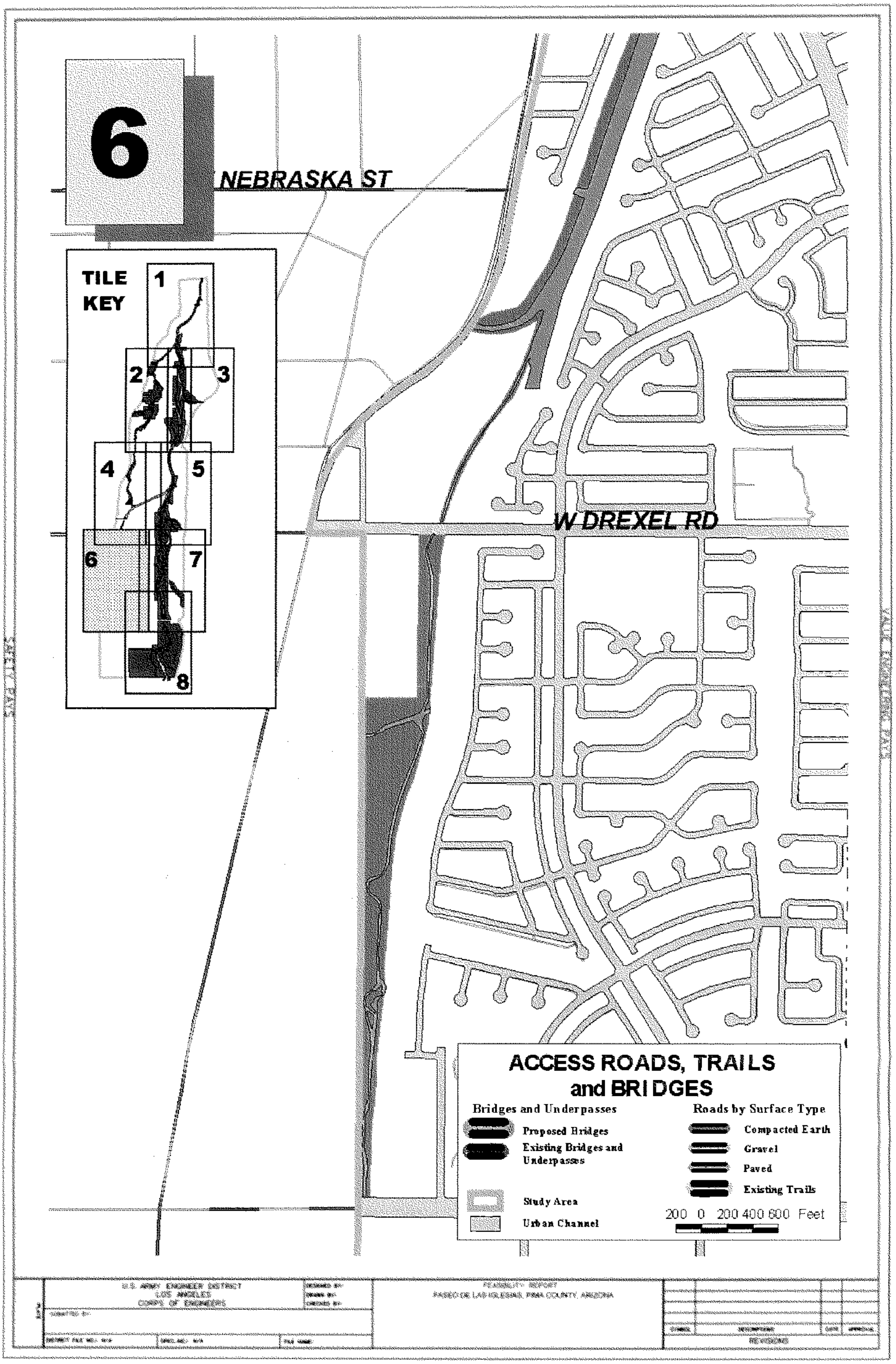
Existing Trails
200 0 200 400 600 Feet

Figure 20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Bridges and Underpasses
Proposed Bridges
Existing Bridges and Underpasses
Study Area
Urban Channel
Roads by Surface Type
Compacted Earth
Gravel
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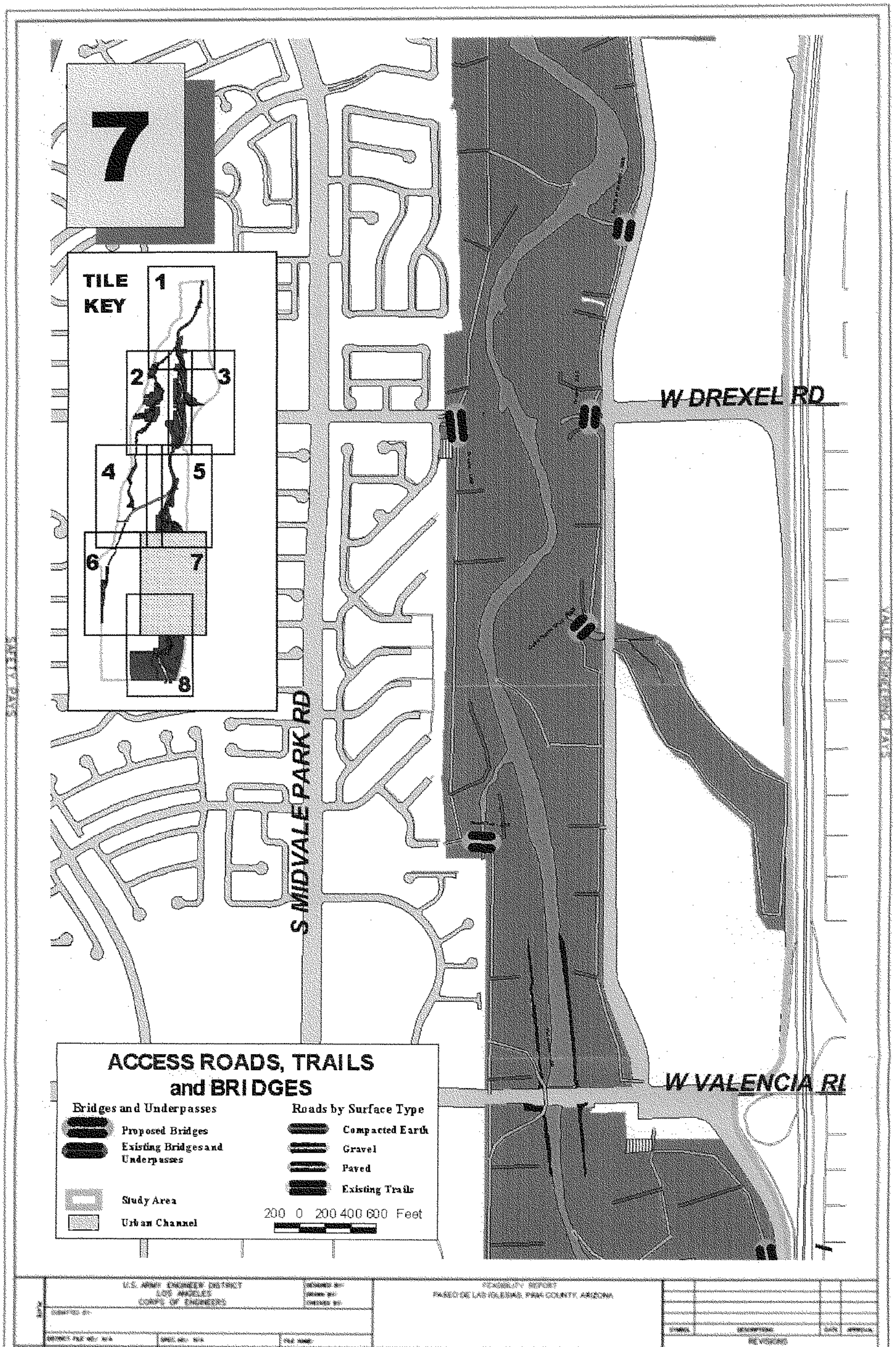
Figure 21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and BRIDGES
Bridges and Underpasses
Proposed Bridges
Existing Bridges and Underpasses
Study Area
Urban Channel
Roads by Surface Type
Compacted Earth
Gravel
Paved
Existing Trails
200 0 200 400 600 Feet
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
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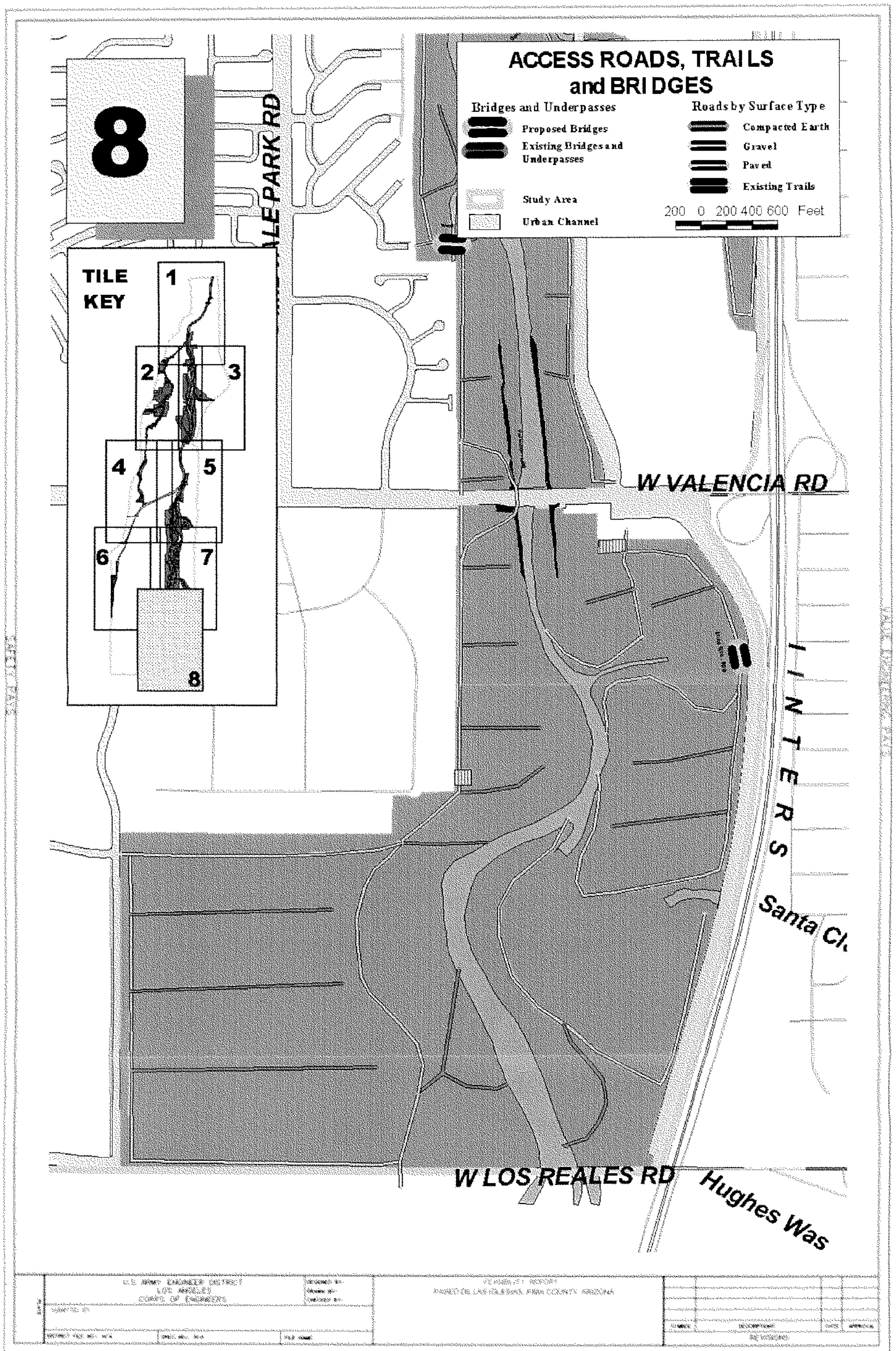
PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA
REVISIONS

Figure 22



ACCESS ROADS, TRAILS and BRIDGES
Bridges and Underpasses
Proposed Bridges
Existing Bridges and Underpasses
Study Area
Urban Channel
Roads by Surface Type
Compacted Earth
Gravel
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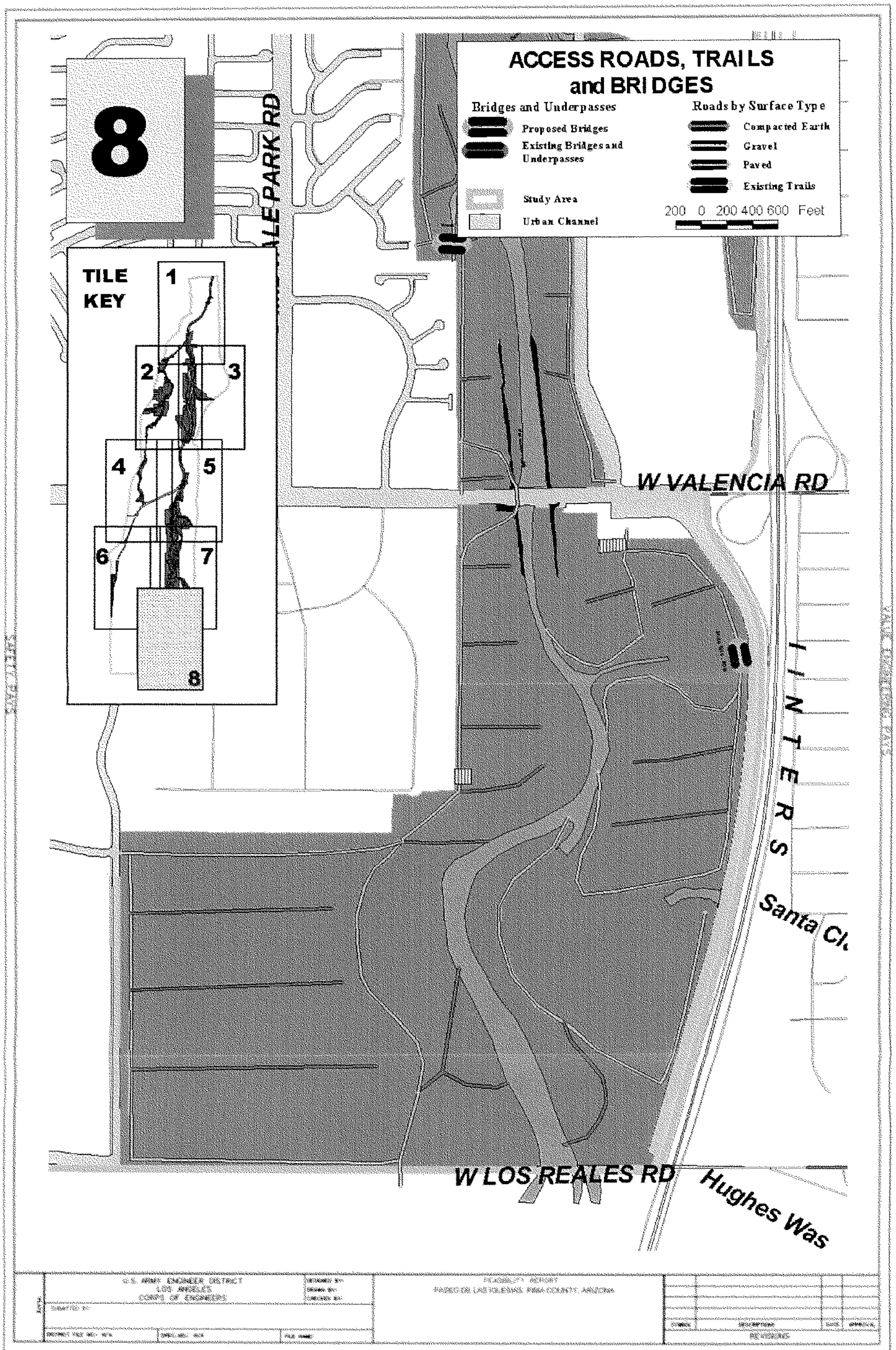
Figure 23



ACCESS ROADS, TRAILS and BRIDGES
Bridges and Underpasses
Proposed Bridges
Existing Bridges and Underpasses
Study Area
Urban Channel
Roads by Surface Type
Compacted Earth
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Existing Trails
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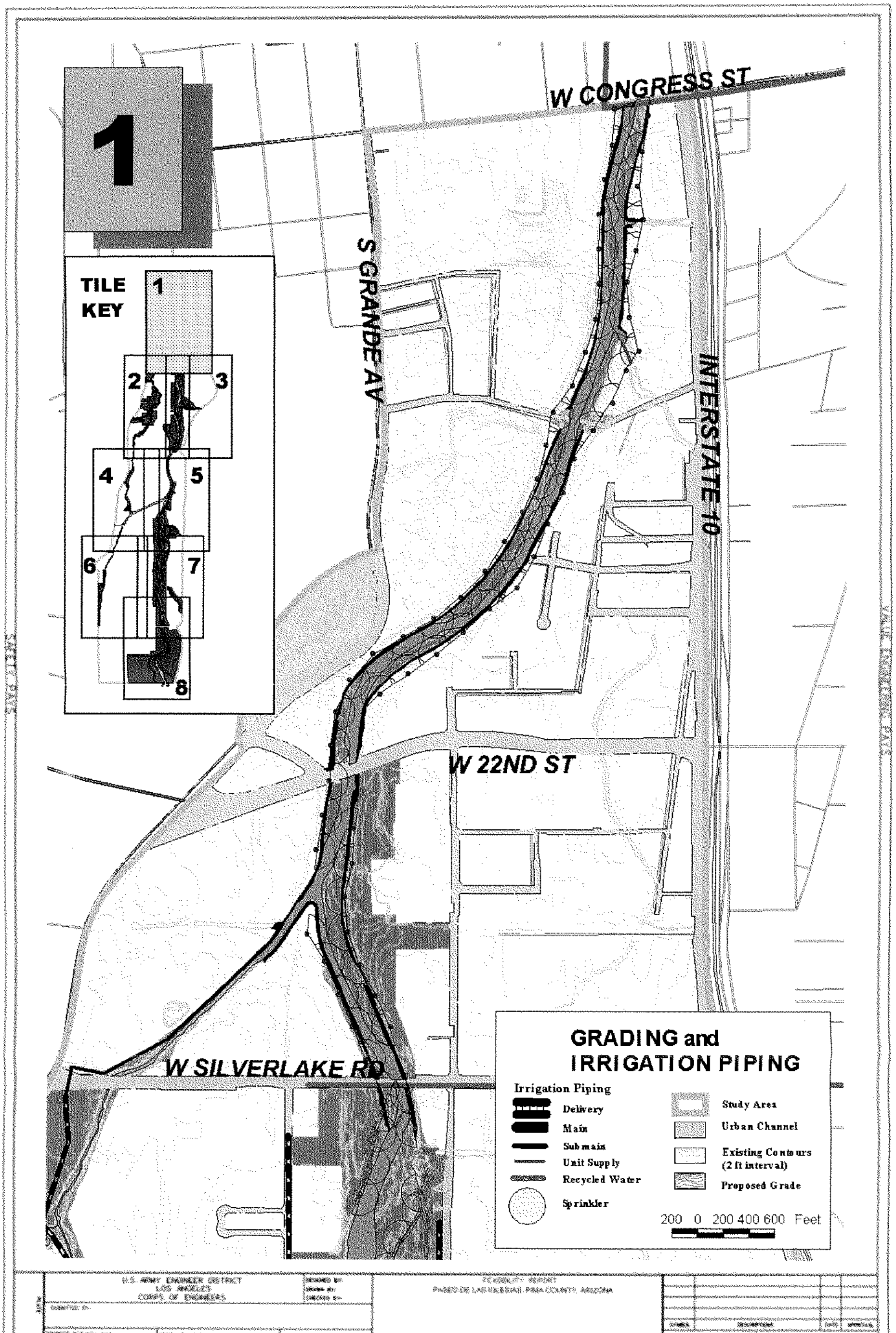
Figure 23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W SILVERLAKE RD
GRADING and IRRIGATION PIPING
Irrigation Piping
Delivery
Main
Submain
Unit Supply
Recycled Water
Sprinkler
Study Area
Urban Channel
Existing Contours (2 ft interval)
Proposed Grade
200 0 200 400 600 Feet
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
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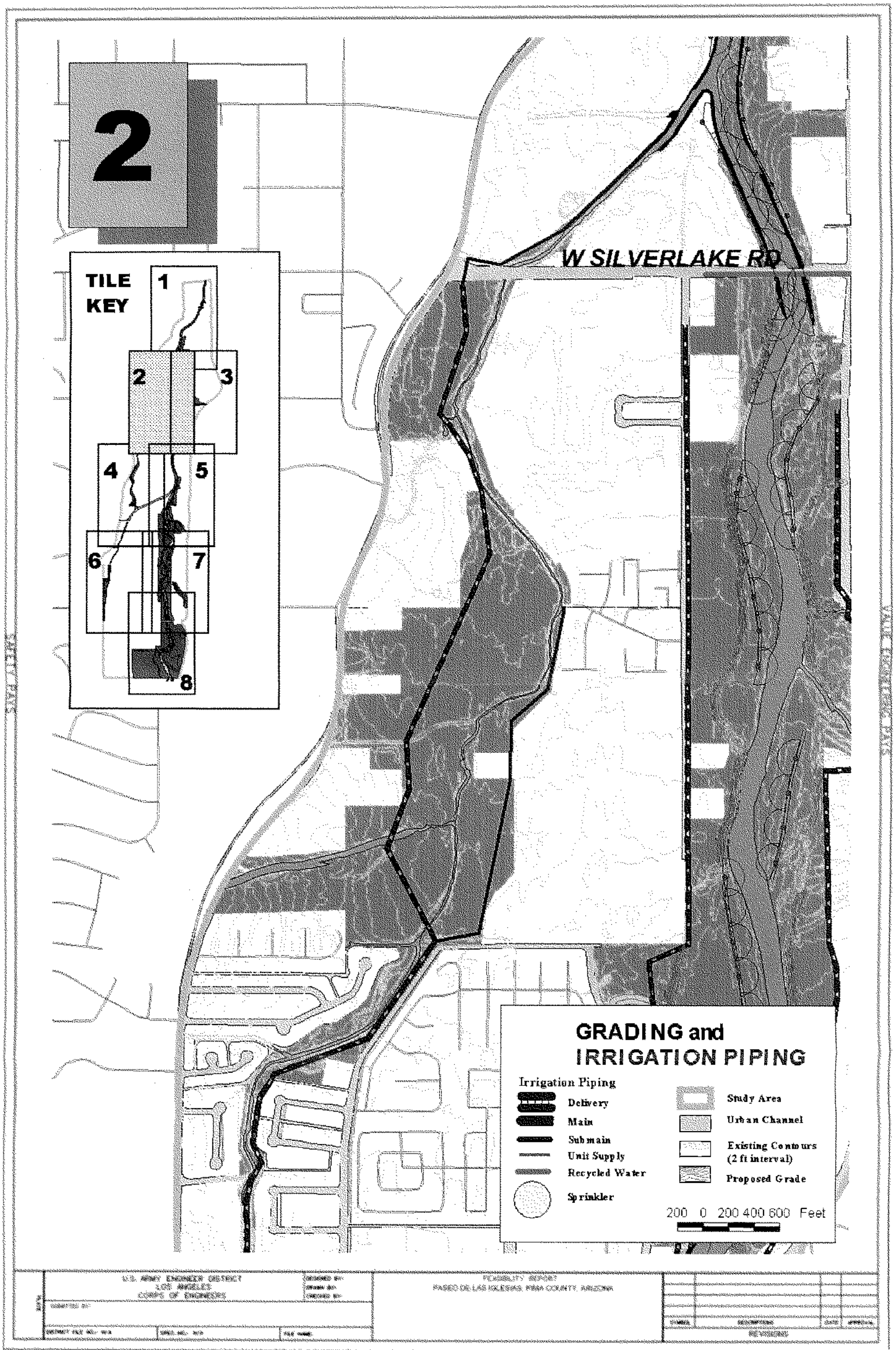
PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA
REVISIONS

Figure 24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GRADING and IRRIGATION PIPING
Irrigation Piping
Delivery
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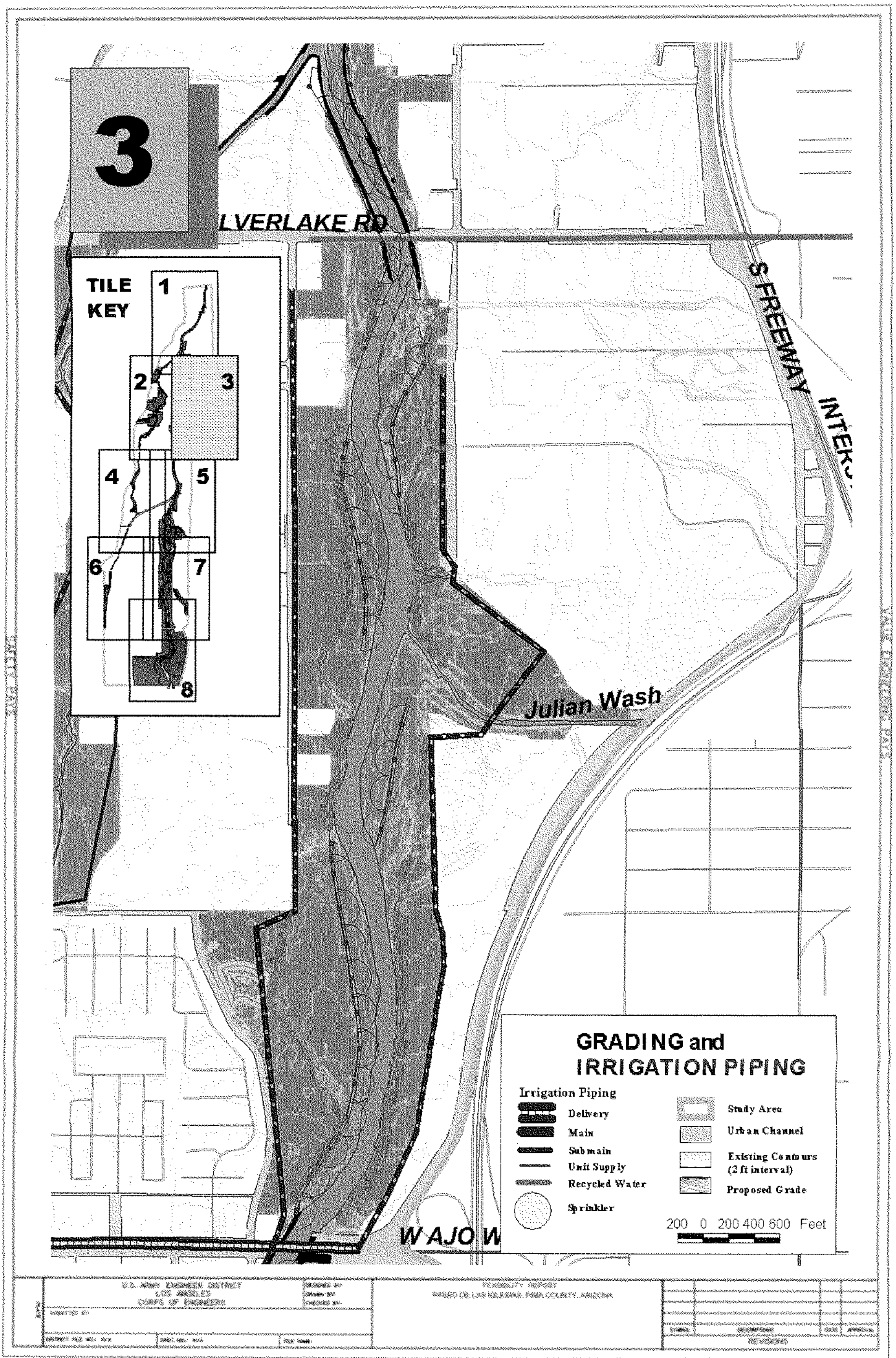
Submain
Unit Supply
Recycled Water
Sprinkler
Study Area
Urban Channel
Existing Contours (2 ft interval)
Proposed Grade
200 0 200 400 600 Feet

Figure 25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Delivery
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Unit Supply
Recycled Water
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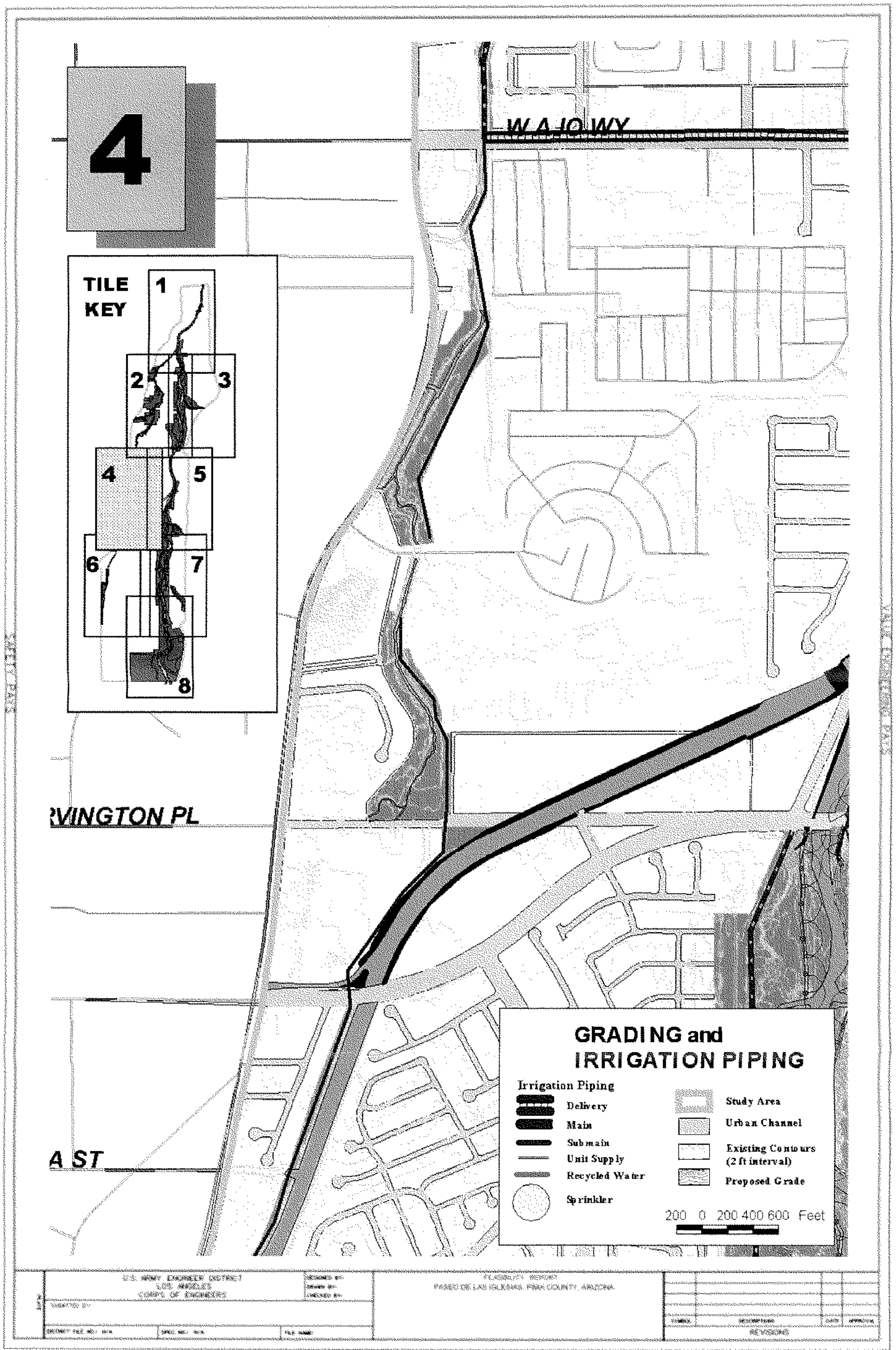
Study Area
Urban Channel
Existing Contours (2 ft interval)
Proposed Grade
200 0 200 400 600 Feet
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
FEASIBILITY REPORT
PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA
REVISIONS

Figure 26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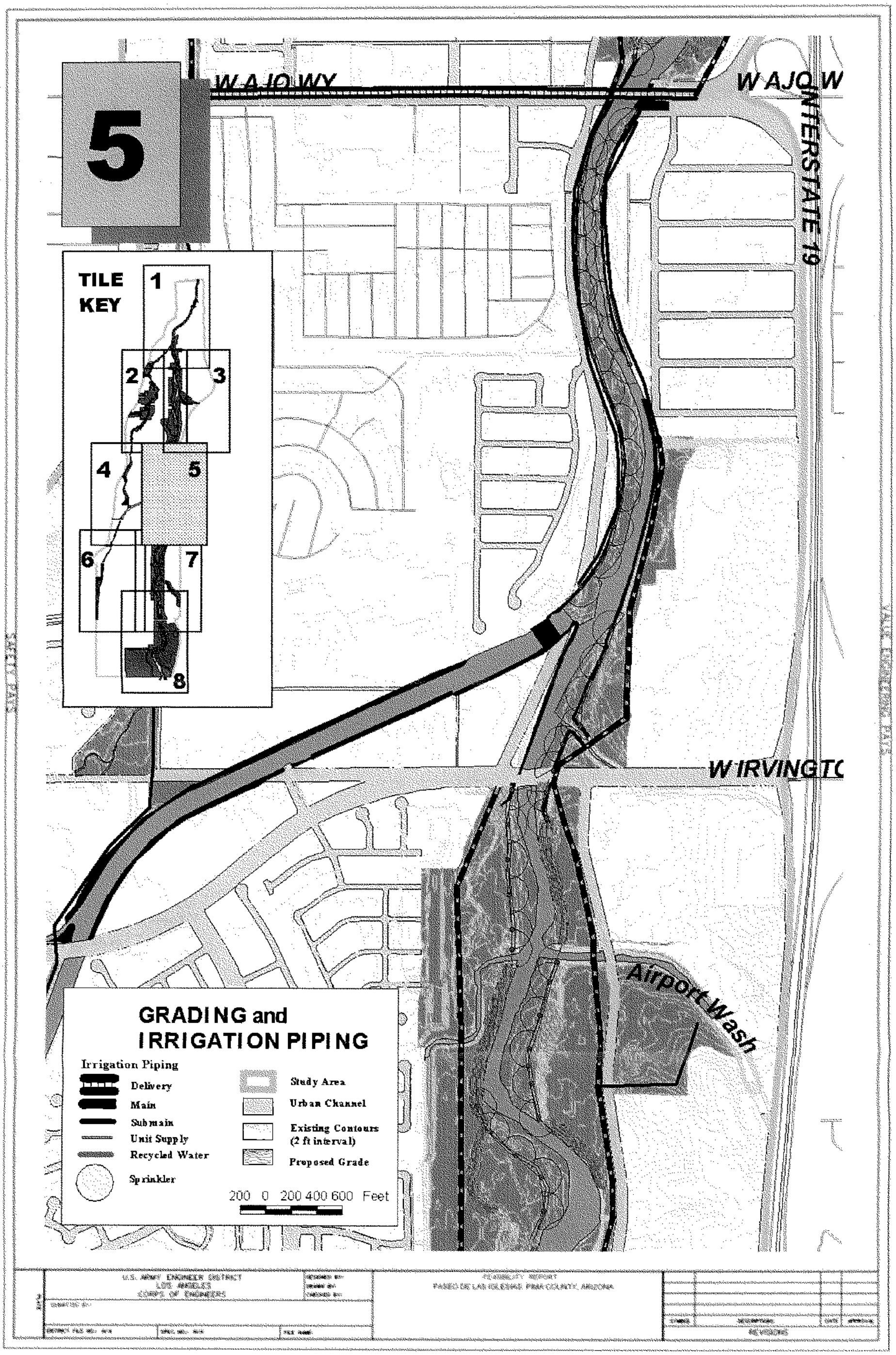
Delivery
Main
Submain
Unit Supply
Recycled Water
Sprinkler
Study Area
Urban Channel
Existing Contours (2 ft interval)
Proposed Grade
200 0 200 400 600 Feet

Figure 27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Airport Wash
GRADING and IRRIGATION PIPING
Irrigation Piping
Delivery
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Submain
Unit Supply
Recycled Water
Sprinkler
Study Area
Urban Channel
Existing Contours (2 ft interval)
Proposed Grade
200 0 200 400 600 Feet
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
FEASIBILITY REPORT
PASEO DE LAS IGLESIAS, PIMA COUNTY, ARIZONA
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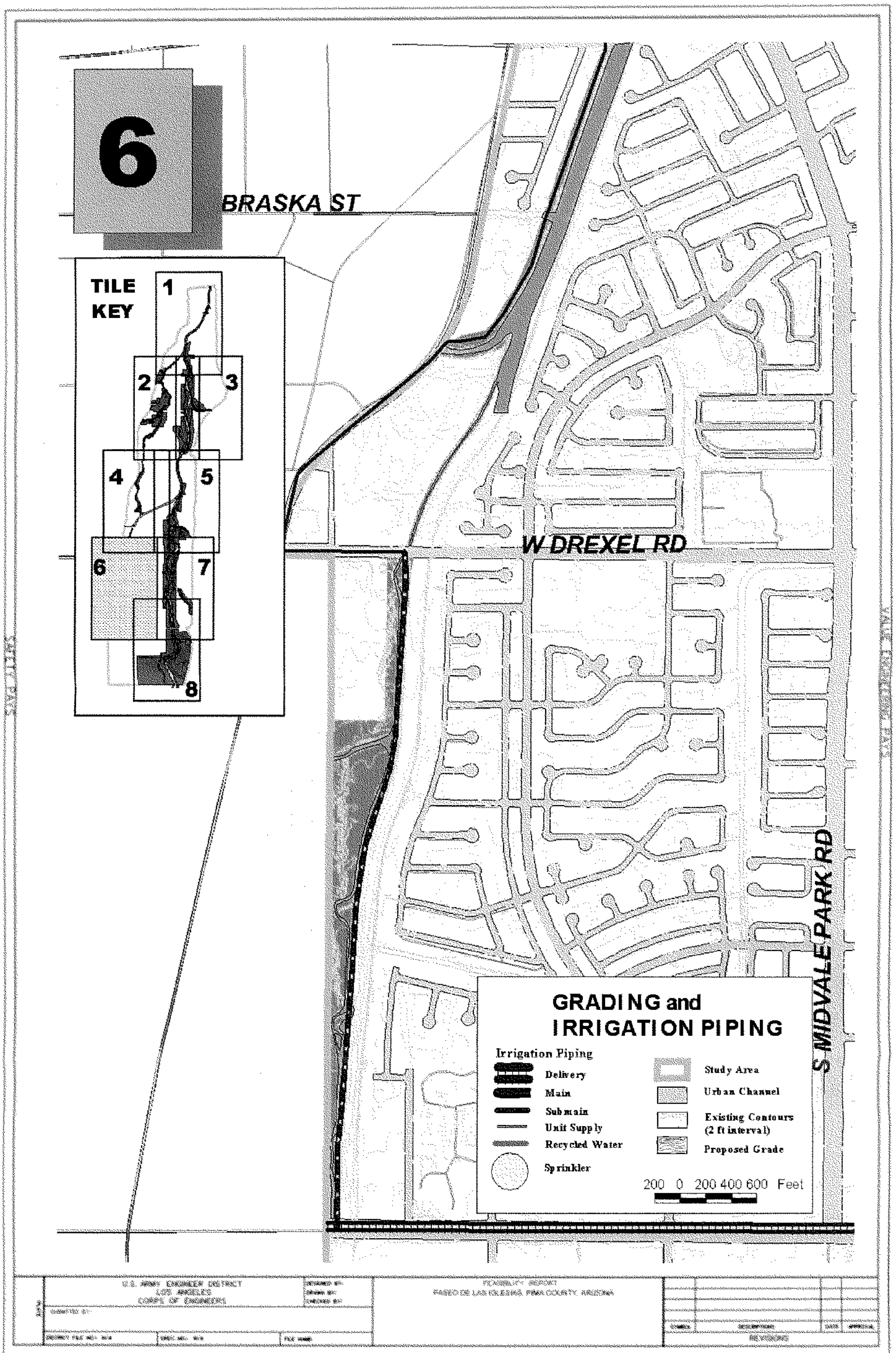
Figure 28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Delivery
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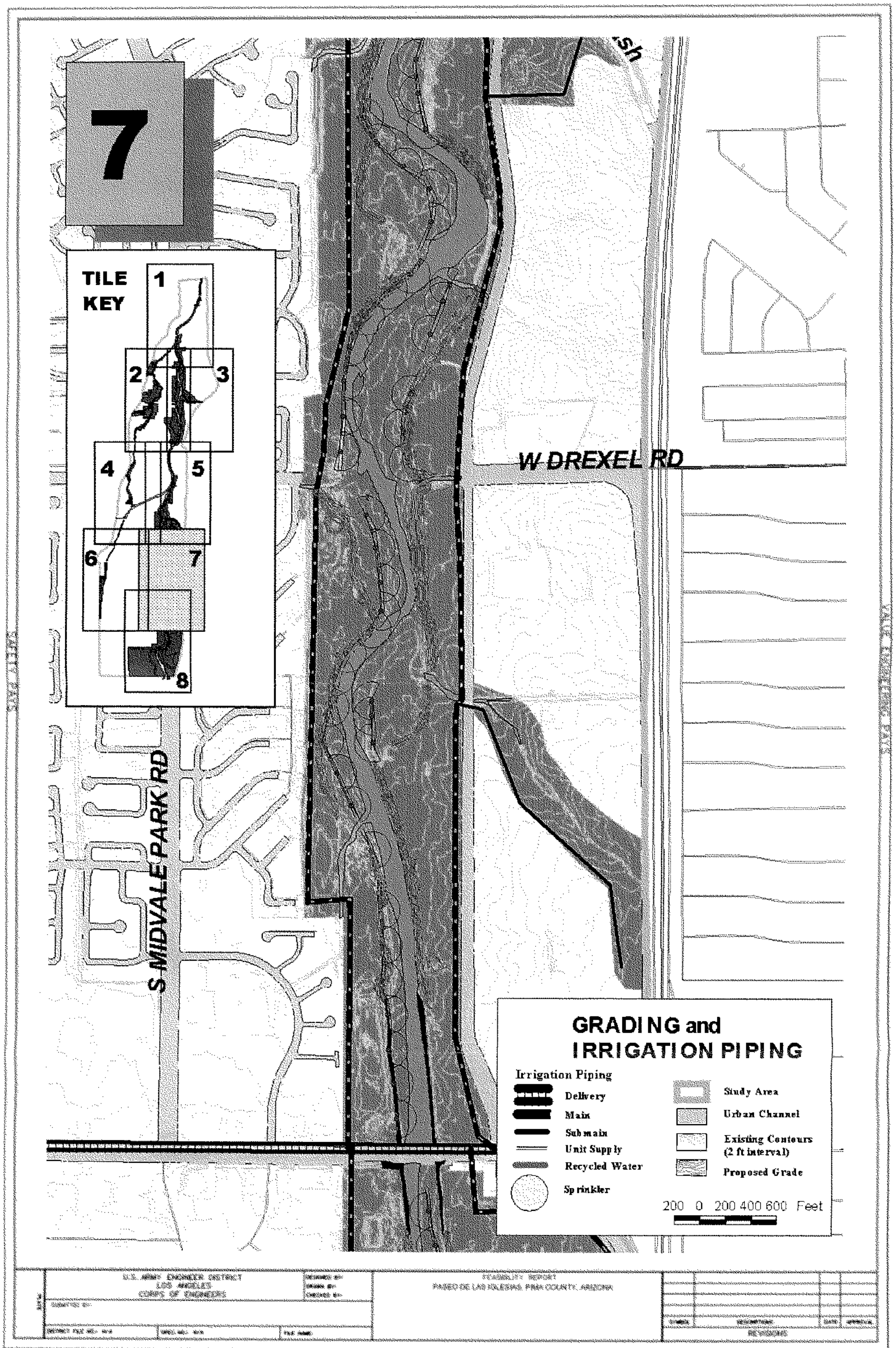
Unit Supply
Recycled Water
Sprinkler
Study Area
Urban Channel
Existing Contours (2 ft interval)
Proposed Grade
200 0 200 400 600 Feet

Figure 29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Irrigation Piping
Delivery
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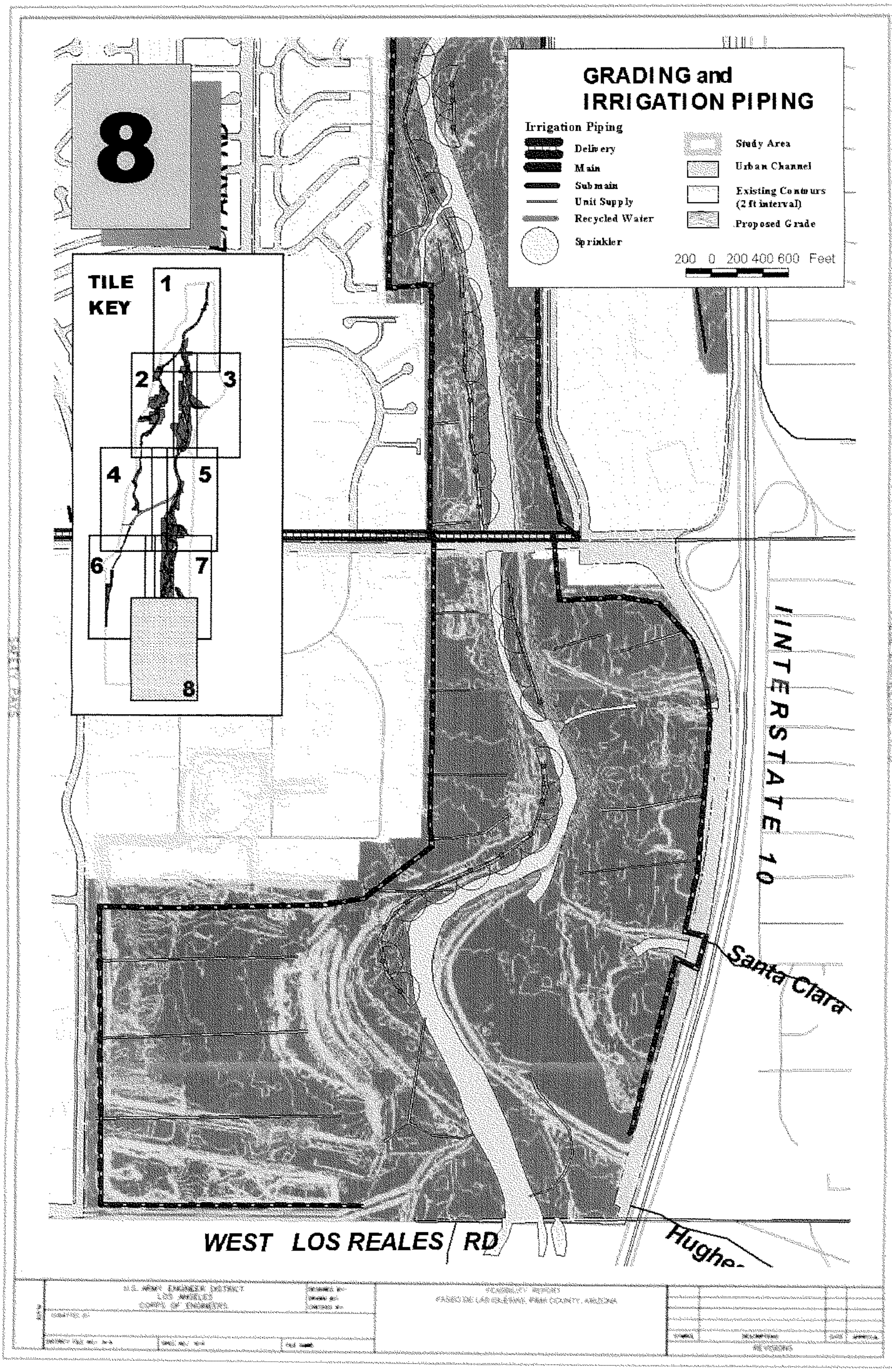
Submain
Unit Supply
Recycled Water
Sprinkler
Study Area
Urban Channel
Existing Contours (2 ft interval)
Proposed Grade
200 0 200 400 600 Feet

Figure 30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IRRIGATION PIPING
Irrigation Piping
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Unit Supply
Recycled Water
Sprinkler
Study Area
Urban Channel
Existing Contours
(2 ft interval)
Proposed Grade
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Santa Clara
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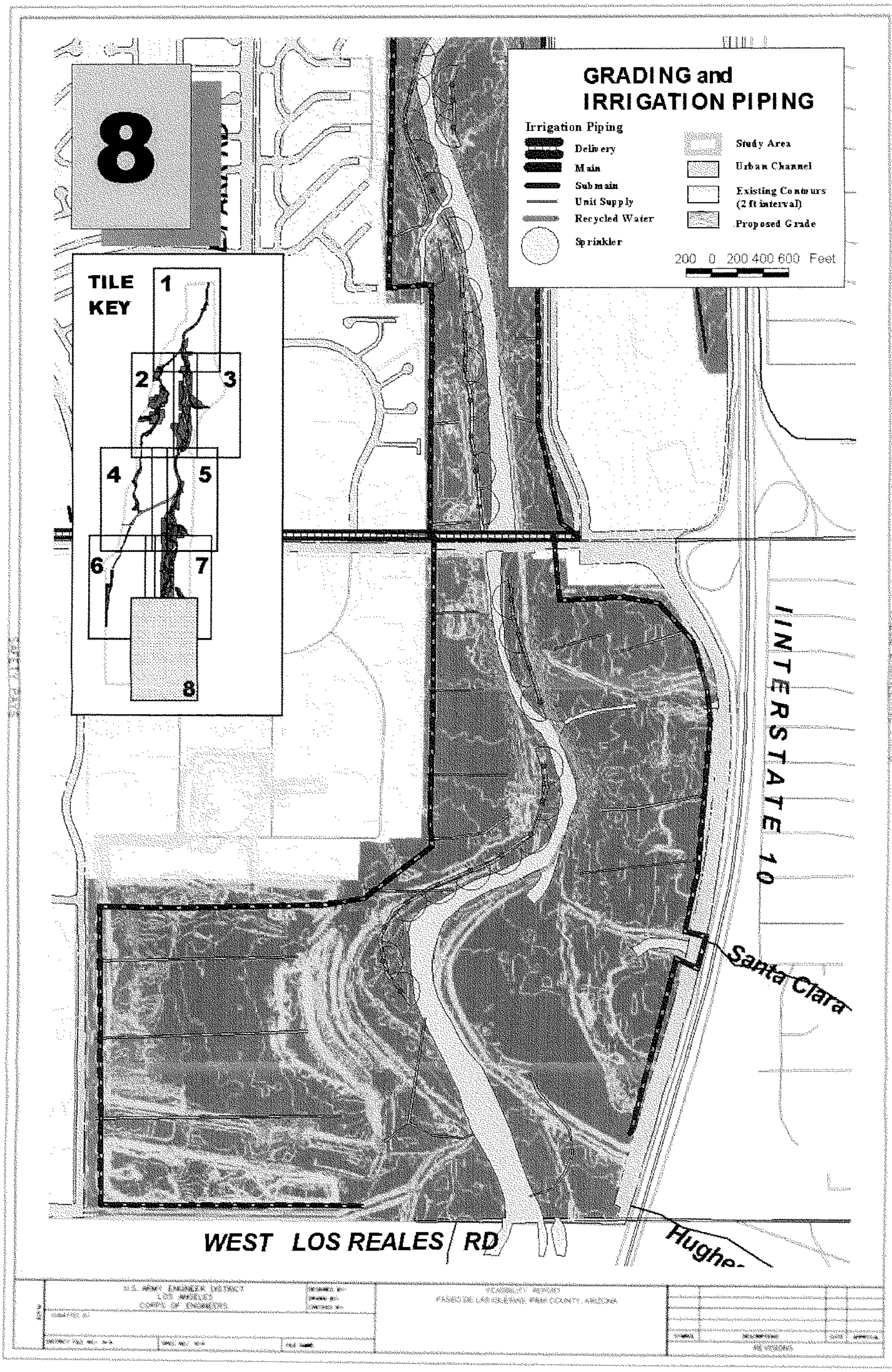
Figure 31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Unit Supply
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Study Area
Urban Channel
Existing Contours
(2 ft interval)
Proposed Grade
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INTERSTATE 10
Santa Clara
WEST LOS REALES RD

Figure 31

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report and

Environmental Impact Statement

APPENDIX D
HABITAT ANALYSIS

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Study

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July 2005

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LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX F

GEOTECHNICAL

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

APPENDIX F
GEOTECHNICAL EVALUATION
FEASIBILITY REPORT
FOR
PASEO DE LAS IGLESIAS, FEASIBILITY STUDY
PIMA COUNTY, ARIZONA

CONTENTS

1.0 STUDY OBJECTIVE

The objective of the Paseo de las Iglesias Feasibility Study is to evaluate environmental restoration alternatives along the Santa Cruz in eastern Pima County. The appendix presents an evaluation performed by the U.S. Army Corps of Engineers, Los Angeles District Geotechnical Branch to assess general geotechnical issues, including HTRW that may impact the array of final alternatives under consideration. This evaluation is based on data and information provided by the non-Federal Sponsor and the final array of alternatives (and measures) that were developed during plan formulation to provide a basis design leading to the development of the construction plans and specifications.

2.0 STUDY AREA

The Paseo de las Iglesias study area is located in eastern Pima County, Arizona. The study area extends along the Santa Cruz River between Congress Street (downstream limit) to Los Reales Road (upstream limit) for a total length of approximately 7.5 miles. The study area varies from 0.5 miles to 1.6 miles wide and encompasses approximately 5005 acres.

3.0 SOURCES OF INFORMATION

Sources if information used in this geotechnical evaluation included:

- *Paseo de las Iglesias Draft Feasibility Report*, May 2004.
- *Paseo de las Iglesias F-3 Geotechnical Appendix*, February 27, 2002, by LMT Engineering, Inc. dated 27 February 2002 (under contract for Pima County Flood Control District).
- *Appendix G, Phase I Environmental Site Assessment for Paseo de las Iglesias Feasibility Report,* September 24, 2002, by SWCA, Inc. Environmental Consultants.

The final array consisted of the fourteen (14) of alternatives were obtained from Chapters 5 and 6 of the Draft Feasibility Report and are identified below:

Table 1: Alternative Names

Screening	Alternative Name	Screening	Alternative Name
NMX	1A	MMM	3E
NMM	1B	HNN	4A
XXX	2A	HXN	4B
MXN	3A	HXX	4C
MXX	3B	HHN	4D
MMN	3C	HHX	4E
MMX	3D	HHM	4F

The letter designations refer to what will be done within the active low flow channel (first letter), the terraces (second letter), and the over bank historic floodplain (third letter). "H" stands for "hydroriparian", which will carry the greatest water requirements; "M" stands for "mesoriprarian", which connotes lesser water requirements; "X" stands for "xeroriprarian", which connotes still less water requirements, and "N" stands for "none" (for example, in alternative HNN, there are no water requirements for either the terrace, or the floodplain).

4.0 POTENTIAL ISSUES

4.1 Slope Stability. The issue of slope stability will needs to be addressed, particularly for the sand and gravel pits at the southern end of the project area, for all of the alternatives that include floodplain restoration encompassing the large areas described in the Phase I Environmental Site Assessment (ESA) as being a sand and gravel mine, or as implied as such on the topographic map in the Phase I ESA (p. 8). These alternatives are 1A, 1B, 2A, 3B, 3D, 3E, 4B, 4C, 4D, 4E, and 4F.

Alternatives from the list above that include the maintaining a perennial channel and / or a hydroriparian zone deserve the most attention, since, presumably, the most water would be added to the system to maintain these features. Those alternatives include 4A, 4B, 4C, 4D, 4E, and 4F.

The lake adjoining Interstate 19 is related to the sand and gravel mining operation. Most of the alternatives show at least some part of that lake continuing to exist into the development of a restoration project as an off-channel basin, and also, the existence of several new off-channel basins. In alternatives where off-channel basins are to exist or be constructed, the potential issue of slope stability of the sand and gravel pit is even more important, as the stability may be affected by water saturation. These alternatives are 1A, 2A, 3B, 3D, 4C, and 4E.

For all of the mentioned alternatives, slope stability considerations will need to be addressed. A slope stability analysis for the sand and gravel site will be conducted during the Pre-Construction Engineering and Design Phase. In addition to in-channel erosion, non-structurally stabilized earthen slopes used for restoration could experience localized erosion, rilling, and head cutting caused by over bank runoff, therefore the slope stability analysis should included these areas as well.

4.2 Groundwater. In most alternatives, groundwater elevation may be raised, at least locally. In some alternatives, aquitards or water harvesting basins are included. Where no basins will be constructed, the mechanism of maintaining groundwater elevation increases is not apparent, therefore it is surmised that some local areas of perched groundwater will experience an increase in elevation. The groundwater data presented in the F-3 Geotechnical Appendix, plus other data that may be available, should be assessed further to look for trends in the perched groundwater areas, including locations, depths and directions of flow. At least some of this information could be obtained from EDR. Specifically, how much will each element of each alternatives feature cause the groundwater elevation to increase, and over what areas? A map of these results should then be developed. Once this area of impact is known, the issue regarding the relationship between the final alternative, groundwater, and landfills can be addressed. Where groundwater level is to be increased in the vicinity of any of the seven landfills in or near the study area, the question of whether or not the projected new groundwater elevation will inundate any part of any of the existing landfills can be addressed. State and or other applicable criteria for such a situation should also be ascertained.

Because the Phase I Environmental Site Assessment summarizes the landfills in this manner (see Table 2 below), it would appear that inundation of the bottom of the landfill from rising groundwater elevations, including that of perched groundwater areas, will be a main issue. The anticipated impacts or lack thereof should be documented in one of the study reports, preferably the main report and a supplement to the geotechnical appendix.

Table 2: Landfill Data

Landfill Name	Cap? / Liner?	Depth of landfill (ft) / Quantity landfilled	Methane? / VOCs?	Ground-water contamination?	Remediation Status
Congress (part of Rio Nuevo South)	No report	10-35 / 384,000 yds^3	No data / yes (soil gas)	No	Slated for in-situ aerobic degradation to reduce methane, then redevelopment by City. Note: "on west river bank"
Nearmont (part of Rio Nuevo South)	No report	15-40 / 264,000 yds^3	Yes (bigh levels) / yes (soil gas)	No	Slated for in-situ aerobic degradation to reduce methane, then redevelopment by City. Note: "on west river bank"
"A" Mountain (part of Rio Nuevo South)	No report	15-50 / 2,000,000 yds^3	Yes (high levels) / yes (soil gas)	No	Slated for in-situ aerobic degradation to reduce methane, then redevelopment by City.
Mission	No report	10 / 32,872 tons	No (very limited testing) / no report	No report	Possibly NO HOUSEHOLD WASTE, only green waste , newspaper, and construction debris. Has been landscaped, drainage installed; incorp. into Santa Cruz River Park (Pima Co.). Apparently adjoins west river bank
29th St.	No / no	50 ?? / 41,090 tons	Yes (and venting system at southern end where more trash was dumped) / yes (trace, soil gas)	No report	Extends N. to confluence of West Fork, Santa Cruz R. and mainstem, Santa Cruz R. Debris unearthed during soil cement bank stabilization. Gasses thought to be rapidly dissipating through soil from center of deposit and little gas accumulation on perimeters.
Ryland	No / no	50 ?? / 365,250 tons	No report but methane and leachate apparently are suspected	No report	Adjoins east river bank or Julian Wash bank. Debris unearthed during flooding. City, as of 2001, plans to excavate, repair, install drainage, remove any trash encountered during this work
Cottonwood	Yes (good condition)	unknown / no tabulated	Yes (can be high);	No (unrelated	Residences and drinking water supply well on site

Landfill Name	Cap? / Liner?	Depth of landfill (ft) / Quantity landfilled	Methane? / VOCs?	Ground-water contaminat ion?	Remediation Status
			extraction system was in place / no report	coliform bacteria and nitrate)	
Barnett & Shore	No report	No report	No report	No report	Possibly contains only brick and concrete and, if so, is a non-issue

A different subject, but still under the topic of groundwater issues, is the Tucson International Airport (TIA) Trichloroethylene (TCE) environmental site. Some research needs to be done regarding what the groundwater elevation manipulations of the study will or will not do to impact the TIA site, at which contaminants are groundwater-borne. The site borders the study area at the location where the greatest concentrations of off-channel basins will be, thus it is at the locations where the study features presumably could impact groundwater levels the most. Potential impacts will need to be addressed assessed during the design phase.

4.3 Landfills. The Phase I ESA identified five (5) primary landfills, based on review of City of Tucson files, these are: 1) Rio Nuevo South [which includes Nearmont, Congress, and "A" Mountain landfills], 2) Mission, 3) 29th Street, 4) Ryland, and 5) Cottonwood. In addition to the groundwater / landfill inundation issue addressed above under Section 4.2, there is the prospect of encountering landfill materials during construction or project excavation. A system of identifying the possible encountered materials and a plan for dealing with each type should be developed. Rather than non-specific "dot on the map" method of identifying the landfill locations, which is what has been presented to date, an effort should be made to show the full landfill perimeter, as known or as suspected. This will be a guide to the areas in which landfill materials may be encountered.

Regarding what might be encountered, the sum total of the reports reviewed to date suggests a rather benign set of candidates including but not limited to: green materials, construction debris, tires, and household trash. Tires may be one of the worst contaminants, but usually are rather intact and highly recognizable, so they should be relatively easy to segregate, when encountered. Household trash might be somewhat of a problem due to unknown contents. Green materials and construction debris likely can just be shipped to facilities that take similar materials now. But a plan needs to be developed and presented for review that addresses what is to be done with each expected debris type. Estimates of quantities should be developed for costing purposes. The importance of showing the true boundaries, rather than map dots, becomes more important. Without such boundaries, some cost estimates could be made.

4.4 Other HTRW Concerns. As shown in the previously supplied examples of Corps work on HTRW, a complete listing of RCRIS sites, HAZMAT sites, and USTs that are in or adjoining the potential construction reaches needs to be tabulated and made available to the construction team. After examining the Phase I ESA and the raw EDR data, it appears this list will be a short one. A preliminary review suggests the list will include the Honeywell and Pima school sites at Drexel, the Chevron and Conoco sites (for USTs) at Ajo Way, and other UST sites numbered

A check should also be made to see if the "unlocatable" EDR listing for "Your Cleaners", at the intersection of Valencia and Midvale Park, does on site dry cleaning. If not, this site may be a non-issue.

5.0 RECOMMENDED PLAN

He recommended plan as identified in Draft Feasibility Report and Environmental Impact Statement is Alternative 3E. Based on the issues identified herein, the following summarizes recommendations for Alternative 3E:

- Slope stability issues, particularly at the sand and gravel site(s) warrant additional analysis during the PED Phase. The same applies to new earthen slopes created for habitat restoration that could experience localized erosion, rilling, and head cutting caused by over bank runoff.
- The groundwater data collected to date, plus other new data that may become available, should be assessed further to look for trends in the perched groundwater areas, including locations, depths and directions of flow. Specifically, how much will each element of each alternatives feature cause the groundwater elevation to increase, and over what areas? A map of these results should then be developed.
- Where groundwater level is to be increased in the vicinity of any of the seven landfills in or near the study area, the question of whether or not the projected new groundwater elevation will inundate any part of any of the existing landfills can be addressed. State and or other applicable criteria for such a situation should also be ascertained.
- Some research needs to be done regarding what the groundwater elevation manipulations of the study will or will not do to impact the TIA site, at which contaminants are groundwater-borne. The site borders the study area at the location where the greatest concentrations of off-channel basins will be, thus it is at the locations where the study features presumably will impact groundwater levels the most. Potential impacts need to be addressed.
- An effort should be made to show the full landfill perimeter(s), as known or as suspected. This will be a guide to the areas in which landfill materials may be encountered during excavation.
- Estimates of quantities of potential landfill materials should be developed for costing purposes.
- A complete listing of RCRIS sites, HAZMAT sites, and USTs that are in or adjoining the potential construction reaches needs to be tabulated and made available to the design and construction team(s).

The above recommendations are not intended to be a comprehensive list. Additional recommendations and data collection may be required based on refinement of the final recommended plan into the design and construction phases.

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February 27, 2002

Mr. Thomas J. Helfrich
Chief Hydrologist
Pima County Floodplain Management Division
201 N. Stone Ave., 4th Floor
Tucson, AZ 85701-1207

Re: Paseo de las Iglesias Environmental Restoration Study
Santa Cruz River, Congress to Los Reales
Pima County, Arizona
Pima County WO#: 4FPDLI
LMT Project No. 21563

Attached is our report for the referenced study. This report presents the results of our soils, materials and geologic investigations to verify feasibility of alternative solutions for erosion control and bank stabilization along the Santa Cruz River. The study area extends along both sides of the Santa Cruz River from Congress Street on the north to Los Reales Road on the south. The report was prepared in collaboration with Robert L. Sogge, P.E., Ph.D.

This report is the initial phase of the scope of the study to evaluate alternative methods of erosion prevention/control for the Santa Cruz.

If you have any questions or comments about the report, please contact us.

Sincerely,
LMT Engineering, Inc.

Registered Professional Engineer (Civil)
Certificate No. 9674
LYLE M. TWEET
Arizona U.S.A.
2/27/02

Lyle M. Tweet, P.E.
President

Robert L. Sogge, P.E., Ph.D.
Consultant

Dist: Addressee (6)

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1. INTRODUCTION

PURPOSE AND SCOPE

1.1. This report presents the results of the initial phase of our geologic, soils, and materials evaluation for the Paseo de las Iglesias study. Our services evaluated the existing bed and bank conditions and the types and physical properties of the materials in the bed and banks of the Santa Cruz River and West Branch of the Santa Cruz. In addition, we researched information relating to the geologic and seismic conditions of the area, groundwater conditions, and landfill conditions along the designated stretch of the Santa Cruz River and West Branch in order to provide information to evaluate potential methods of stabilizing the banks along the study alignment.

This report describes the geologic and seismic setting, the field and laboratory tests performed and their results, the results of field studies, the extent and type of trash and debris that were identified and our opinions regarding use of the native soils for construction of soil-cement bank protection.

SITE LOCATION AND DESCRIPTION

1.2. The proposed Paseo de las Iglesias Environmental Restoration Study is located along two northward flowing branches of the Santa Cruz River extending from the central downtown area, specifically Congress St., directly south seven miles to its southern extent at Los Reales Rd in the Tucson, Arizona, metropolitan area in central Pima County. This area is the cradle of modern day Tucson and has a lineage of continued inhabitance dating back to settlement by the Spanish missionaries. San Xavier Mission was developed near the southern extent of the study and a convent was established near the northern end of the study, thus the name "Paseo de las Iglesias", or "passage between the churches."

1.3. The main channel of the Santa Cruz River flows in a relatively straight northerly direction from the south to the north ends of the study area. The West Branch of the Santa Cruz River currently extends from the southern border of the study north approximately 3.5 miles to where it flows into the main Santa Cruz River just north of Irvington Road. The portion of this channel just north of Irvington Road has been re-routed. The former channel (before it was re-routed) extends from just north of Irvington to just south of 22nd St. where it joins the main branch of the Santa Cruz River. The Site Plan accompanying this report displays these channels and the general location of the study. The area between the two branches of the Santa Cruz encompasses a relatively flat, alluvial plain. Over much of the study length, a highly urbanized area abuts both sides of the river. In these regions many of its bank sections have been stabilized with soil cement (reference photos 6 through 12 in Appendix A of this report). (Note that the photos in Appendix A are for this study. The "Landfills and Waste Disposal Sites along the Santa Cruz River from Grant Road to Pima Mine Road" report by the Pima Association of Governments in Appendix E of this report also has photos which have the same numbers. Photo references in the body of this report relate tothe photos in Appendix A.)

STUDY DESCRIPTION

1.4 Improvements proposed for the river consist of an environmental restoration of the river and its surrounding overbanks consistent with the population and development extant in the study domain. Alternative restoration types may consist of different types of bank protection having varying levels of resistance to erosion and varying locations within the overbank areas as well as invert stabilizers or grade-control structures.

2. GEOLOGY

TOPOGRAPHY

2.1 The study area is located near the central portion of the Tucson basin, a broad 1,000 sq mi valley in the Santa Cruz River drainage basin. The topography of this basin is typical of the Basin and Range Physiographic Province. Northwestward trending, steep, rugged fault block mountains border the broad, gently northwestward sloping alluvium-filled valley. The basin is about 50 miles long and is approximately 20 miles wide in the southern and central parts, narrowing to 4 miles wide at the northwest outlet. The basin is bounded on the north and east by the Tortolita, Santa Catalina, Tanque Verde, Rincon, Empire and Santa Rita Mountains, and on the west by the Tucson, Black and Sierrita Mountains. The mountains on the west side of the basin range from 3000 to 6000 ft elevation, and those on the north and east side have elevations generally ranging from 6000 to 8000 ft, with peaks rising to elevations of 9400 ft. The metropolitan City of Tucson resides at the approximate center of this basin at an elevation of about 2400 ft. The Santa Cruz River channel extends north from Mexico into the south-central portion of this basin and exits north of the basin where it eventually terminates into the Gila River. Flow occurs in the channel during most of the year south of the Tucson Basin. The flow during dry times of the year is a result of discharges from the Nogales, Arizona, and Nogales, Sonora, Mexico, sewage treatment plants. During dry times of the year, such flow does not normally extend further north than Green Valley, Arizona, approximately 15 to 20 miles south of the study area.

Along the extent of this study area, sixteen tributaries flow into the main Santa Cruz River (including the South Channel), historic and diverted West Branch(es) of the Santa Cruz, Tucson Diversion Channel, and many others. The main channel, west branch(es) and all of these tributaries are ephemeral and generally only flow in direct response to rainfall and/or snow melt in the region and nearby mountains.

REGIONAL GEOLOGY

2.2 The complex geological history of Arizona has resulted in the formation of three geologic physiographical provinces. The three provinces consist of the Colorado Plateau (in the northern area of the state), the Basin and Range Province (encompassing southern and western Arizona), and the Central Highlands or Transitional Zone (encompassing the central part of the state). The Santa Cruz River Watershed lies within the Sonoran Desert of the Basin and Range Physiographic Province. The north to northwest trending alluvial basin is characterized by a semi-arid to arid broad valley.

The Santa Cruz River Basin is paralleled by steep mountain ranges composed of igneous, metamorphic, and sedimentary rocks of Precambrian (over 600 million years old) to Tertiary (63 to 2 million years ago) age. (Anderson 1987) The mountains lie upon a Precambrian igneous and metamorphic basement complex that is composed predominantly of granite and diorite, schist and gneiss, and volcanics.

The present relief of the Santa Cruz River Basin is a direct result of a period of regional uplifting due to block faulting that took place during the late Tertiary (63 to 2 million years ago) or early Quaternary (2 million years ago to present). Concurrent with the uplifting of the regional mountains, large amounts of alluvium from the surrounding mountains have been deposited within the basin (at the center of the Santa Cruz River basin, bedrock is currently buried by more than 11,000 feet of alluvial sediments). The Tucson basin, a structural depression, is filled primarily with unconsolidated to indurated Tertiary and Quaternary age sedimentary deposits, with lesser amounts of intercalated evaporites and volcanic rocks.

The alluvial sediments deposited within the basin have been divided into four geologic units that are, in descending order of depth: surficial or recent alluvial deposits, the Fort Lowell Formation, the Tinaja Beds, and the Pantano Formation (ADWR 1996). The extent of these layers in the study area is shown in Table 9 in this section of the report. The surficial deposits occupy the streambed channels and are generally less than 100 feet thick. The coarse surficial deposits allow the infiltration of surface water to recharge the underlying units. The Fort Lowell Formation underlies the recent alluvial deposits and consists of unconsolidated to moderately consolidated sands and silts 300 to 400 feet thick throughout most of the basin (AMA 1998). The Tinaja Beds lie under the Fort Lowell Formation and are composed of sandstones and conglomerates with a total thickness of up to 5,000 feet at the center of the basin (AMA 1998). The Pantano Formation, which underlies the Tinaja Beds, is up to 6,400 feet thick near Davidson Canyon, which is about 20 miles southeast of Tucson along I-10. This formation consists of consolidated sandstones, conglomerates and mudstones. In addition to these sediments, as a result of intermittent periods of volcanism, there are areas of extrusive igneous rocks interbedded within the valley alluvium layers. Below the alluvial units and beds of volcanic rock, there is an impermeable basement complex, which extends to the surrounding mountainsides.

Table 9 - Stratigraphic Sediment Layers (from Well Logs) *

At Marana	
Fort Lowell Formation and Recent Alluvium	73 m-thick (240 ft) layer
Upper Tinaja Beds	73 m-thick (240 ft) layer
Volcanic Bedrock	Top at - 146 m (-480 ft)
Near Grant Road Crossing	
Fort Lowell Formation and Recent Alluvium	24 m-thick (80 ft) layer
Upper Tinaja Beds	73 m-thick (240 ft) layer
Middle Tinaja Beds	49 m-thick (160 ft) layer
Volcanic Bedrock	Top at - 146 m (-480 ft)
½ Mile South of I-19/I-10 Interchange	
Fort Lowell Formation and Recent Alluvium	46 m-thick (150 ft) layer
Upper Tinaja Beds	46 m-thick (150 ft) layer
Volcanic Bedrock	Top at - 91 m (-300 ft)
1.5 Miles South of San Xavier Mission	
Fort Lowell Formation and Recent Alluvium	49 m-thick (160 ft) layer
Upper Tinaja Beds	37 m-thick (120 ft) layer
Lower Tinaja Beds	24 m, minimum (80 ft)
1.5 Miles North of Sahuarita/I-19 Interchange	
Fort Lowell Formation and Recent Alluvium	52 m-thick (170 ft) layer
Upper Tinaja Beds	43 m-thick (140 ft) layer
Lower Tinaja Beds	195 m, minimum (640 ft)
1 Mile North of Green Valley	
Fort Lowell Formation and Recent Alluvium	73 m-thick (240 ft) layer
Upper Tinaja Beds	37 m-thick (120 ft) layer
Lower Tinaja Beds	180 m, minimum (600 ft)

* logs adapted from Anderson 1987

Poorly developed drainage systems gave rise to numerous pluvial lakes during the middle Tertiary, which accounted for rapid sediment filling of the basins. During the

Pleistocene (2 million to 10,000 years ago) drainage was established westward by the Gila River and its tributaries (including the Santa Cruz River). During high erosion and deposition periods, the Santa Cruz River basin floor developed numerous bajadas (smooth slopes originating at the base of the mountains) which extended outward into the Santa Cruz River channel. In more recent geologic time, during the Quaternary Period (present to 2 million years ago), climatic changes and regional uplift accelerated erosion, resulting in the upper bajada slopes being deeply dissected by lateral washes, causing development of terraces along the main drainage systems including the Santa Cruz River Basin.

The Santa Cruz River main channel through Tucson flows on the far west side of the Basin over the relatively thin, peripheral parts of the basin fill sediments. Typical sections, derived from well logs identify specific stratigraphic sediment layers underlying the Santa Cruz River.

SITE GEOLOGY

2.3 The alluvial deposits in the study area consist mainly of recent stream channel and floodplain deposits. These alluvial basin sediments are generally gravel and gravelly sand. Locally, the sediments in the study area are sand to sandy silt of fluvial origin. Lithified sediments do not crop out along the Santa Cruz River and generally they should not be present within excavation depths of the channel for structure installation, though such formations do approach the riverbed elevation in the vicinity of 22nd Street. The nearest rock exposures, classified as the Pantano Formation, occur in the foothills of the Santa Catalina Mountains to the north and east of the study. Rocks of this formation consist of highly faulted and tilted beds of conglomerate, sandstone and mudstone, interbedded in places with volcanic flows and tuffs and locally containing landslide debris and lenses of megabreccia (Anderson 1987a). Other subsurface information is presented in the Subsurface Investigations section of this report.

2.4 The surficial soil deposits as classified by the National Resource Conservation Service (previously Soil Conservation Service) are a Grabe-Anthony-Gila association consisting of level and nearly level to gently sloping soils that are dominantly loam to gravelly sandy loam, on flood plains and alluvial fans in the main channel of the river and Cave-Rillito-Mohave association consisting of nearly level to gently rolling soils that are dominantly gravelly loam and gravelly sandy loam, on low dissected terraces in portions of the banks away from the main channel (U. S. Dept of Agriculture, Soil Conservation Service, U of A Agricultural Experiment Station, Soil Survey of Tucson-Avra Valley Area, Arizona, April 1972).

A study by Jackson classified the soils in the channel as part of the T2 terrace, one of five terraces that exist in the Tucson Basin. The T2 terrace is defined as historically abandoned stream terraces occurring on the Santa Cruz River and Pantano Wash. Forms wide floodplain inset into stream valley. Soils are weakly developed (Torrifluvents). Topographically the T2 terrace is higher than T1 but several meters below T3. Gravelly sand dominates the sediments. Banks are unstable; recent incision and lateral erosion has left banks standing at an angle greater than the angle of repose, often vertical. Middle to late Holocene in age (Jackson, 1989).

FAULTING

2.4 The Tucson basin was formed during the Basin and Range disturbance of middle Miocene time (23 to 5 million years ago). A tectonic event was responsible for producing the deep basins and high ranges characteristic of present-day Basin and Range physiography. This extreme relief resulted from movement along deep-seated, high-angle normal faults. Anderson's (1987a) structural interpretation of the Tucson basin infers two major north to northwest-trending basin-bounding faults: the Santa Cruz fault and a segmented subparallel fault system on the north and east edges of the basin and a secondary, oblique, and generally northeast-trending fault system. The large-scale, low-angle structural feature that extends along a sinuous trace on the south and west flanks of the Santa Catalina and Rincon Mountains, respectively, is referred to as the Catalina detachment fault (Dickenson 1988). This feature represents a stage in the development of the Santa Catalina-Rincon Mountain metamorphic core complex during the mid-Tertiary Orogeny, which preceded the Basin and Range disturbance.

2.5 The concealed basin faults and the detachment fault are not considered to be active or capable faults and are not underlying this study area. The Basin and Range province in southwestern Arizona has been considered tectonically inactive since the waning of the Basin and Range disturbance during the early Pliocene (Anderson 1987a), due in part to the low levels of historical seismicity and the extensive pedimentation of mountain blocks (Pearthree et al. 1983). Quaternary faults are rare in southwestern Arizona and none have been identified in the Tucson metropolitan area (Menges and Pearthree 1983; Scarborough et al. 1986). The nearest concentration of Quaternary faults occurs along the western edge of the Santa Rita Mountains in southeastern Arizona, approximately 20 miles southeast of the study area. Pearthree (1986) estimated that the most recent movement along the Santa Rita fault occurred during the late Pleistocene. The Quaternary faulting observed in southeastern Arizona may represent minor reactivation of older Basin and Range structures or may be related to the Rio Grande Rift system of New Mexico (Pearthree et al. 1983).

SEISMICITY

2.6 The Tucson metropolitan area straddles the boundary between Zone 1 and Zone 2A of the Seismic Zone Map of the Contiguous States (Uniform Building Code, 1994 and USACE ER 1110-2-1806, dated 31 July 1995) and thus is located in a region of low to moderate seismic potential. Seismic activity has occurred throughout Arizona but southeastern Arizona (part of Zones 2A and 2B) is one of three regions where more frequent activity and earthquake epicenters with intensities greater than VI on the Modified Mercalli Scale and magnitudes greater than 4.0 have been concentrated (DuBois and Smith, et al. 1982). Estimates of average regional recurrence intervals between surface-rupturing earthquakes over the last 20,000 years for this portion of the state range from 3000 to 4000 years (Pearthree 1986). The report by Pearthree also contains a map of earthquake epicenters in the vicinity of Tucson.

2.7 The largest historical earthquake known to have affected the study area was the 1887 Sonora, Mexico, event with a maximum epicentral intensity of XII and an estimated magnitude of 7.2. An isoseismic map of the earthquake area in DuBois and Smith (1982) indicates an intensity of VII was experienced in the Tucson area. This event, although 130 miles southeast of the study area, resulted in rock falls and landslides in the Santa Catalina Mountains and caused widespread damage in Arizona as far north as Phoenix. A seismicity map of the State of Arizona compiled by Stover et al. (1986) indicates that the largest known historical earthquakes within 100 miles of the study area occurred near Nogales, Arizona, in 1916; in western Pima County in 1961; and near Globe, Arizona, in 1969. The 1916 event, approximately 60 miles south of Tucson, had a maximum epicentral intensity of VI. The 1961 event, about 90 miles west-northwest of Tucson, had a magnitude of 4.7, while the 1969 event, approximately 85 miles northeast of Tucson, had a magnitude of 4.4. Only three earthquakes have been reported within a 25-miles radius of the study area. Two of these events, with maximum epicentral intensities of IV, occurred in 1888, approximately 3 miles southwest of Tucson. The third, a magnitude 4.4 event, occurred in 1965 about 25 miles west of Tucson.

2.8 Using Schnabel and Seed's (1973) attenuation curves for horizontal acceleration in rock (USACE, South Pacific Division, 1979), the previously mentioned earthquakes would have produced maximum bedrock accelerations of less than 0.1g at the study site. By contrast, a maximum credible earthquake of magnitude 6.7 to 7.2 generated by movement on the 12 to 36-mile long Santa Rita fault would produce a maximum bedrock acceleration of approximately 0.2g at the study site. The Uniform Building Code and International Building Code both recommend accelerations of 0.2g for the Tucson metropolitan area.

GROUNDWATER

2.9 The main groundwater in the Tucson basin occurs in the sedimentary rocks and alluvium that form a single aquifer. The aquifer consists of the Pantano Formation, the Tinaja Beds, and the Fort Lowell Formation (from bottom to top) (Anderson 1987b). The Pantano Formation yields small to moderate amounts of water to wells while the Tinaja beds yield small to large amounts of water to wells, frequently in excess of 1000 gal/min (Anderson 1987b). The water table for this main aquifer is within 350 ft of the ground surface throughout most of the basin. Due to localized and/or perched water tables, the depth to groundwater ranges from less than 20 feet to about 170 ft below the ground surface along the Santa Cruz and Rillito Rivers (Babcock et al. 1988; City of Tucson 1996). Groundwater is generally under unconfined conditions. However, it may occur locally under confined or perched conditions. Groundwater movement is typically in a west-northwest direction, away from the basin margins toward the narrow northwest outlet (Osterkamp 1974). A groundwater contour map prepared by Tucson Water is attached to this report. This map shows the depth to groundwater throughout the Tucson Basin and in this study area.

2.10 We obtained information from the Arizona Department of Water Resources (ADWR) regarding depth of groundwater in wells in this study area. This information is included in Appendix C of this report. The key to the locations of the wells is also included in this Appendix. The wells with current water level readings are denoted with letters "A" through "K" on the right side of the well data sheets. These well locations are noted as ADWR Well Locations A through K on the aerial photo of the study region included with this report. The current well information included in this report indicates that depths to groundwater in the wells generally ranged from about 100 to 200 feet below ground surface in areas close to the Santa Cruz channel. Groundwater data were also obtained from soil borings made for bridges along the Santa Cruz River. Reports for the bridges at Congress, 22nd St., Irvington, and Valencia were reviewed. Information in these reports indicates groundwater (perched) was encountered at depths ranging from about 5 to 35 feet at Congress, Irvington, and Valencia. No groundwater was encountered in the test boring for the 22nd St. Bridge where the borings were advanced to depths of 45 to 60 feet. Due to the perched and/or localized nature of the groundwater along the Santa Cruz channel, these groundwater conditions are expected to vary in relation to flows in the River, well pumping, subsurface stratification, and other factors.

2.11 Long-term groundwater withdrawal has resulted in a general decline in water levels in the Tucson area since the 1900's. This groundwater decline can be noted in the ADWR data for the depth to groundwater for the wells in this vicinity.

2.12 Large-scale pumping of groundwater in the Tucson basin began about 1900 and increased dramatically in the 1940's. Most of the groundwater pumped in 1940 was used for irrigation. Later, groundwater pumpage was approximately equally divided among irrigation, municipal, and industrial uses (Anderson et al. 1982). The centers of greatest water-level decline are along the Santa Cruz River near Sahuarita and in the City of Tucson. Declines exceeding 100 ft have occurred in Tucson and portions of the study area, while to the south along the river, the maximum decline has been about 150 ft (Schumann and Genualdi 1986). This difference has resulted in the formation of two distinct cones of depression in the groundwater table.

2.13 Infiltration of storm runoff in the stream channels during the rainy seasons is the major source of recharge to the groundwater basin (Davidson 1973). Seepage of runoff along the mountain fronts constitutes the second largest source of recharge. This natural system recharges about 100,000 acre-ft/yr; however, there is currently a demand for 300,000 to 400,000 acre-ft annually. The resulting deficit is causing the water table to decline at an approximate average annual rate of 2.7 ft (PCDOT 1986).

2.14 Several studies have been performed to evaluate the rate of recharge for both the Santa Cruz and Rillito Rivers (Wilson 1979; Katz 1987; Wilson and Newman 1987; Cluff et al. 1987). These studies attempted to evaluate the recharge rate using primarily empirical methods. The study by Katz indicated that the infiltration rates for all the studies ranged from 286 to 551 acre-feet/day for the Santa Cruz River and from 272 to 1,262 acre-feet/day for the Rillito. The studies by Cluff, et. al., and Wilson and Newman, evaluate the effects of channel stabilization on infiltration and ground water recharge. These reports are available at the Pima County Flood Control in-house library.

SUBSIDENCE, FISSURING AND COLLAPSING SOILS

2.15 Groundwater depletion in the Tucson basin has caused the aquifer system to compact. This compaction, in turn, has resulted in large areas of land subsidence, a problem that exists in other parts of the Basin and Range province of southern Arizona. The U.S. Geological Survey (USGS) is currently using seven vertical extensometer installations (VEIs) to measure and monitor aquifer compaction and water-level changes in the Tucson Basin. The VEIs are located in areas where the potential for land subsidence is believed to be large. Measurements made by the USGS from 1980 to the end of 1987 indicate that approximately 0.01 to 0.1 ft of compaction has occurred in the aquifer-system deposits underlying the basin during this period (Babcock et al. 1988). The amount of land subsidence resulting from aquifer compaction would be equal to the amount of compaction in all the compressible deposits of the aquifer. Since the water wells used in the USGS study do not fully penetrate the aquifer, measured aquifer compaction would be less than or equal to the amount of land subsidence (Anderson et al. 1982). Thus, the greatest amount of land subsidence that has occurred in the Tucson basin between 1980 and 1987 is approximately 0.1 ft. This would equate to a subsidence rate of about 0.01 ft/yr. The closest VEI to the study area is located at well D-13-14 31cac, about 2-1/4 miles south of the Rillito River at First Avenue and about 2-1/2 miles northeast of the north end of this study area. A total of about 0.04 ft of aquifer compaction was measured at this installation. From 1982, this amount would correspond to a minimum subsidence rate of less than 0.01 ft/yr. An aquifer compaction study near the town of Eloy, Arizona, in the lower Santa Cruz basin, revealed that compaction and expansion of the aquifer materials corresponds to seasonal trends in water-level fluctuations, while measured land subsidence corresponds to net annual water-level declines (Schumann et al. 1986).

2.16 Land subsidence was also identified and measured by National Geodetic Survey releveling in the Tucson basin in 1980 (Anderson 1987b; Winikka 1984). Results indicated that from 1951-54 to 1979-80, land subsidence ranged from less than 0.1 ft to almost 0.5 ft; the largest amount occurred southeast of Tucson in an area south of Davis-Monthan Air Force Base, approximately 7 to 10 miles east of the Santa Cruz River channel. Subsidence generally was small in relation to water-level decline in the basin during this period. Long-term data indicate a ratio of subsidence to water-level decline of generally less than 0.003 foot per foot (Anderson 1987b).

2.1. The area of greatest potential land subsidence in the Tucson basin is from the Davis-Monthan Air Force Base area to south of Sahuarta, where water-level declines have been large (Anderson 1987b). Anderson (1987b) indicates that by the year 2030, approximately 3 to 10-plus feet of potential subsidence may result from a 200 to 400 foot decline in 1940 water levels in this region.

2.18 Earth fissures, produced in alluvial deposits by differential land subsidence, have not yet been reported in the Tucson basin but have been mapped near seven groundwater areas in southern Arizona where maximum water-level declines have equaled or exceeded 200 ft (Schumann et al. 1986). The greatest concentration of fissures is found about 30 miles north of Tucson in the lower Santa Cruz basin, which has experienced the most severe groundwater depletion. The closest earth-fissure sites to the study area are in the Avra Valley, approximately 20 miles west of Tucson.

2.19 Earth fissures, which generally occur on the periphery of subsidence areas, may eventually develop in the Tucson basin if the magnitude of groundwater depletion approaches that found in the areas noted above that presently contain fissures. Anderson (1987b) delineated zones of potential severe localized differential land subsidence in the Tucson basin and noted that geohydrologic similarities with the Eloy-Picacho area in the lower Santa Cruz basin strongly indicate that earth fissures may occur in the Tucson basin by the year 2030, or perhaps sooner, assuming further ground water overdraft in the Tucson basin. The area from south of the Tucson International Airport to southeast of Sahuarita, which parallels a 15-mile segment of the Santa Cruz fault, was identified as the area most likely to be seriously affected by fissuring. However, a recent U.S. Geological Survey assessment of potential surface subsidence in response to overdraft in the Tucson area (Tucson Water et al. 1998) indicates that the Santa Cruz Mainstem in the Tucson Vicinity has potential to subside "less than two feet (0.6 m) to the north of the Interstate 19/I-10 interchange (the lowest number assigned in the potential ranking scheme) and no potential to subside south of that interchange." Those subsidence potential numbers represent a significant decrease in estimated subsidence potential from earlier U.S. Geological Survey work. The decrease is related to local control of groundwater pumping instituted in the interim between the two U.S. Geological Survey studies (Anderson 1987).

2.20 The ADWR well data indicate water-level declines exceeding 100 ft in the wells in the vicinity of this study. Therefore, this vicinity and the Tucson metropolitan area in general will likely to continue to be affected by subsidence as long as groundwater overdraft continues. Efforts are being made to reduce groundwater overdraft through water conservation and groundwater replacement. Specifically, the goal of the Tucson Active Management Area is to achieve a long-term balance of groundwater withdrawal with natural and artificial recharge by the year 2025 (USACE, 1986).

2.21 Collapsible soils are common in the southwestern desert environments where the natural evaporation greatly exceeds the precipitation. Collapsible soil deposits are formed when the alluvially deposited soils dry and form chemical bonds between the soil particles. These chemical bonds "tack weld" the soil particles together and give the soil a high dry strength. However, when these soils become wet, the chemical bonds weaken or dissolve and the soil structure reaches a point when it cannot withstand the applied overburden stress and the soil structure collapses. Structures supported on collapsing soils that undergo this collapsing phenomenon can undergo significant settlements and damage. Collapsing soils are typically composed of sands, silts and clays of low plasticity. These soils types and soils with collapsing potentials are known to exist within this vicinity. Usually, such collapsing soils occur at a distance of _ to 1 mile from the main channel of a river where silts and clays are deposited by channel overflows. Specific studies should be undertaken once the type of remedial measures have been determined to evaluate the existence of collapsing soils.

3. SUBSURFACE INVESTIGATIONS AND RESULTS

SUBSURFACE INVESTIGATIONS

3.1. The subsurface investigation for this study consisted of excavating shallow pits in the banks and bed of the rivers using a standard, wheel-mounted backhoe. These pits were excavated to maximum depths of about 10 feet below existing grade to obtain samples of the bed and bank materials to perform laboratory classification tests. The laboratory tests were performed to determine the gradation of the soil samples. Locations of the samples are noted on the site plan included with the maps in the jacket at the end of this report. Results of laboratory tests on these samples are presented in Appendix B of this report.

3.2. In addition to the sampling performed for this study, information from geotechnical engineering studies for several of the bridges along the Santa Cruz channel was reviewed - specifically the bridges at Congress, 22nd St., Irvington, and Valencia. Based on the information available in these reports and the authors' personal experience on other projects in this vicinity, the subsurface materials below the channels generally consist of sands and gravels, with some cobble layers. These soils generally become more granular and denser with increasing depth. However, some interbedded layers of silt and clay were also encountered in the borings for the Congress Bridge. These silt and clay layers existed at various depths in the borings, generally between about 15 and 50 feet. The perched water encountered in these borings appears to sit on top of the silt/clay layers. The subsurface soils are generally not cemented, although there is a heavily cemented layer approximately 25 feet below the riverbed at the site of the 22nd Street Bridge.

4. LABORATORY TESTING AND TEST RESULTS

4.1. Samples obtained in the backhoe test pits for this study were transported to the laboratory. Tests were performed on the samples to determine the gradation of all the samples. Atterberg Limits tests were performed on those samples determined to have significant portions of silt and clay.

4.2. Results of the laboratory tests are included in Appendix B of this report. The tests indicate that most of the soils sampled from the riverbed were sands with some gravel and relatively small percentages of silts and clays. The soils from the banks tend to be finer grained, especially toward the southern end of the study, specifically test locations

6, 7 and 8. The gradation test result plots have been separated for the materials obtained from the bed and banks of the river.

4.3. Pima County DOT specifications for soil cement mixtures to be used for soil-cement bank protection call for less than 15% passing the #200 sieve (0.074 mm) and a maximum aggregate size of 2 inches (50.8 mm) with a compressive strength of 750 psi (5,170 kPa) in 7 days. Their experience has shown that the required cement content is reduced if the percent soil passing the #200 sieve (0.06 mm) is in the range of 6 to 8 percent and the material is a well-graded sand. Therefore, most of the bed material samples obtained for this study could be used for soil cement, although some screening and blending of some of the materials would be required to achieve a gradation that would reduce the required cement content and increase the strength.

5. RESULTS OF THE VISUAL OBSERVATIONS

OBSERVATIONS

5.1. The photos included in Appendix A of this report are representative of the conditions along the Santa Cruz and West Branch of the Santa Cruz at the time of our field work. As shown (reference photos 6 – 12), soil cement bank protection extends along both sides of the Santa Cruz channel from Congress to approximately 300 feet south of Silverlake Road (29th St.). From that point south, sections of the bank of the main channel are protected by soil cement, but large sections of the channel are natural (reference photos 17 – 34). Many of these natural banks are nearly vertical (photos 17 – 23, 25, 26, 28) and some have developed tension cracks along the banks (photos 26, 28). There are also some soil cement grade control structures in the bed of the channel (photos 2, 3, 4). We also noted a soil cement apron across the main channel just north of Mission Lane. It appeared this apron was constructed to protect a fiber optics cable that crossed beneath the channel at this location.

5.2. The channel of the West Branch of the Santa Cruz north of Irvington was re-aligned. The original alignment extended roughly parallel to the main channel to the point of confluence near the site of the existing Pima County Jail (near 29th Street). Portions of the original alignment of this channel are shown in photos 31 – 34. The channel was diverted into the main branch of the Santa Cruz River just north of Irvington Road, as shown on the site plan accompanying this report. The diverted portion of the West Branch channel intersects the main channel just north of Irvington Road, at which point an energy dissipation structure has been constructed (reference photos 27 - 29). Some sections of the northern portion of this channel have bank protection consisting of vertical, driven railroad rails connected with cable interlaced through a wire mesh filled with gravel and cobbles. Other portions of the banks of the West Branch, particularly near the southern end of the study area, are protected by shotcrete lining. Much of the bed of the diverted channel supports a dense growth of grass (photos 26 - 28). The portion of the channel extending from just north of Irvington Road currently carries only the flow from the tributary washes, primarily from the west, and much of the channel supports a dense growth of vegetation. The bed of the main channel of the Santa Cruz supports varying amounts and types of vegetation, depending on the amount of water available and the amount of water flow in that particular portion of the channel. As shown on most of the photos of the main channel, a relatively dense growth of grass, weeds, bushes (mainly desert broom) and some small trees (primarily salt cedars and mesquites) grow in the bed of the river. However, as illustrated on photos 1 – 25, 30, sparse to no vegetation exists in the low-flow channel.

LANDFILLS

5.3. Several previous studies have been conducted to locate landfills along the Santa Cruz River and its tributaries. One of these studies, *LANDFILLS AND WASTE DISPOSAL SITES ALONG THE SANTA CRUZ RIVER FROM GRANT ROAD TO PIMA MINE ROAD*, July 1996, summarizes the information in these studies and is included in the Appendix of this report. As noted in this report, landfills along the channels range from major landfills, such as the Rio Nuevo South and A Mountain areas, which were former City of Tucson landfills, to miscellaneous wildcat dumping. In addition to the landfills noted in this report, we noted additional wildcat surface dumping on the east bank of the main Santa Cruz channel just south of Drexel Road. Also, the landfill at Site 21, the 29th St. landfill, appeared to extend farther to the west and north than indicated on the site plan in that report.

6. BANK SLOPE STABILITY

6.1 The material generally encountered within the banks was typically a fine sandy silt. This material is not layered and has little plasticity but is cemented. There are very few cobble-sized rocks within this sandy silt material. As the cementation is readily broken down by water the material, due to its small grain size, enters a state where it is very susceptible to piping. Some areas of piping and surface sinkholes were noted along the alignment. Specifically, two-foot-diameter sinkholes were noted along the bank of the West Branch north of Irvington.

6.2 The stability of the existing native embankments is marginal due to the existence of two conditions. One, the natural cementation of the soils allows the banks to stand at a near vertical inclination at many locations along the reaches of the study (reference photos 14 - 16 and 23-25). The vertical banks, when impacted by the any significant streamflow, are susceptible to being undercut at the bottom and collapsing into the streambed. The undercutting occurs mainly by the water breaking down the weak cementation present in the silty material. The second form of stream bank erosion is piping. As previously noted, the particle size of the slope embankment material is such that it is very susceptible to piping. Either surface or subsurface water flowing over or beneath the banks form large cavities or cave-like structures as the material is removed by piping thru the embankment and out its face.

7. BED DEGRADATION

7.1 Entrenchment of the channel into the previously unincised flood plain during the late 19th and early 20th centuries caused the greatest channel change on the Santa Cruz River in historical times. Vertical channel change has continued in entrenched and unentrenched reaches of the river over the past few decades. Scour and fill are transient changes in bed elevation that occur during floods. Degradation and aggradation occur over years to decades and may reflect climatic change, adjustments of channel widening or narrowing, sediment storage and episodic transport, and natural or artificial changes in channel-hydraulic properties. Degradation and aggradation can alternate in time and space. Most vertical channel change on the Santa Cruz River near Tucson has been degradational since the late 1950's. The most pronounced channel incision on the Santa Cruz channel has been from Ajo Way in the lower San Xavier reach to Grant Road in the middle of the Tucson reach where 10 to 15 feet of streambed lowering has occurred. The general pattern suggests stable or aggrading conditions through the mid-1950's, and limited evidence suggests that his period of vertical stability may have spanned the preceding 40 years. In the mid 1950's, the streambed at Ajo Way and 1.6 miles downstream at Silverlake Road rose 4 feet. (U.S. Geological Survey 1993). The period of most rapid degradation occurred between 1954 and 1972, when the Santa Cruz channel bed lowered between three to six feet. The cause of this historical channel bed degradation appears to be most directly related to the effects of urbanization such as encroachment along the channel banks, which limits the channel's natural meandering processes, and to the excavation of sand and gravel materials from the channel bed, which disturbs the natural sediment transport continuity of the system. The process of confining a natural, braided channel system into a single, well-defined channel has created increased flow velocities and correspondingly higher sediment transport capacities. As a direct consequence, the Santa Cruz River has responded, in general, by degrading. (Simons Li 1986).

8. CONSTRUCTION CONSIDERATIONS

8.1 Any plan to stabilize the slopes would have to be implemented during the dry season when the Santa Cruz River is not flowing. Wet seasonal times and, consequently, stream flow can be expected to occur during the monsoons of late July and August, the early fall time of late September and October, and during the December and January winter rains. During these times the channel can fill up with flow extending from bank to bank. As the predominate material comprising the channel bed is a fine gravelly sand, significant bed infiltration during flows and quick drainage of the bed material occurs once the stream flow subsides. Deep borings for the bridges have shown the presence of clay layers on which perched water could and, in some cases, does reside. Also, there are cemented soils and/or rock at relatively shallow depths in the vicinity of 22nd and 29th (Silverlake) Streets. The depth of such formations is typically more than 20 ft below the streambed elevation and, thus, would not impact the construction of even the deepest toe-down structures constructed in a soil-cement stabilization program.

11. FLOODING ON THE SANTA CRUZ RIVER

9.1 The greatest flooding that has occurred on the Santa Cruz River was in Sept. – Oct. 1983 when 7.5 inches (19 cm) of rain fell over Pima County within a 7-day period (4 inches (10 cm) fell on a single day). Peak gauged discharge at Congress Street was approximately 53,000 cfs. During this time the Santa Cruz River met and flowed into the Gila River, 50 miles to the north of Tucson.

During this flood event, people were killed, injured, had to be rescued or evacuated, and substantial property damage (> $200 million) occurred. Most of the damage resulted from bank erosion. Soil cement bank protection along the river prevented losses of at least four times the cost of such protection. Almost all of the flood damage was to structures constructed prior to floodplain management in Pima County.

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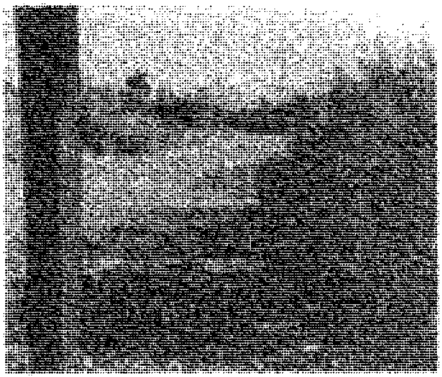
APPENDIX A

Sitc Photographs



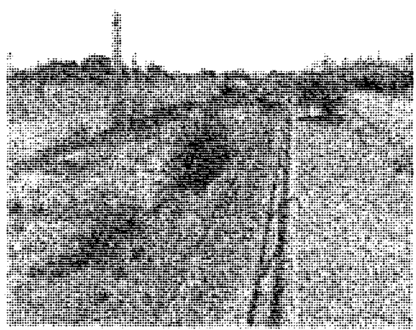
#1: Santa Cruz channel just S. of Congress

#2. Grade control structure S. of Congress in the main channel

#3: Grade control structure S of Congress in the main channel

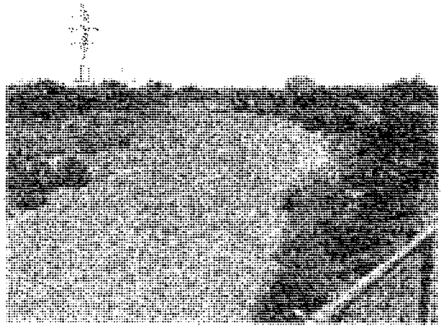
#4: Grade control structure S of Congress in the main channel

#5: Santa Cruz channel S of Congress



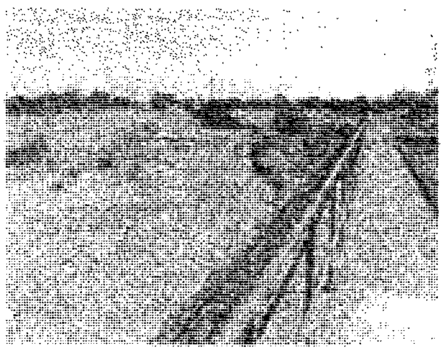
#6. Santa Cruz channel just N of A Mtn

#7: Santa Cruz channel view S from Congress Bridge



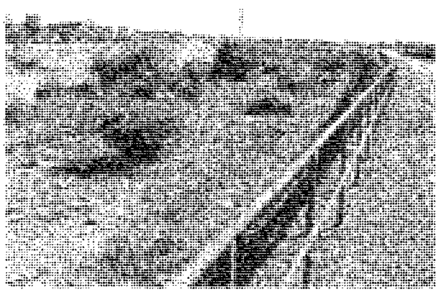
#8: View to S. of main channel (22nd St Bridge in background)

#9: Santa Cruz channel - view N. of 22nd St. toward downtown

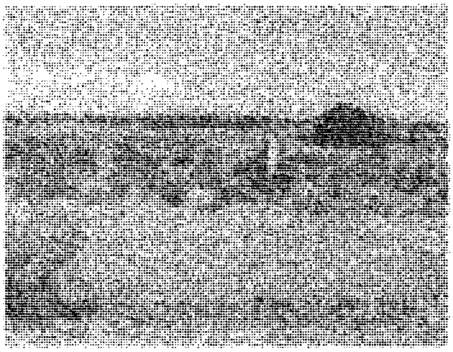


#10: View to S. of the main channel and the 29th St. Bridge

#11: View to S. of Santa Cruz channel S of Ajo



#12: View to S. of Santa Cruz channel 1/4 mile S of Ajo



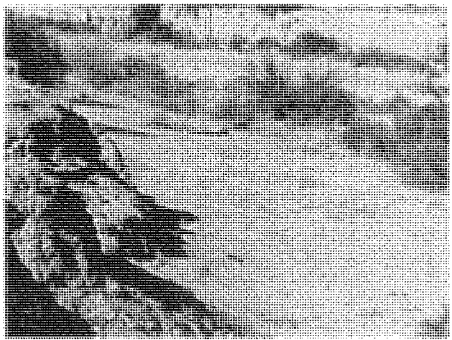
#13: Power pole base in Santa Cruz channel just S. of Drexel

#14: Same pole foundation as previous showing bed degradation

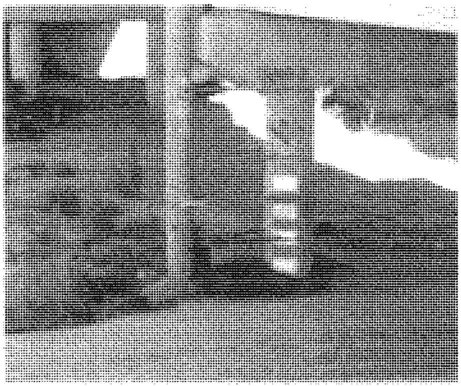
#15: East bank of Santa Cruz channel just N. of Valencia

#16: East bank of Santa Cruz channel north of Valencia

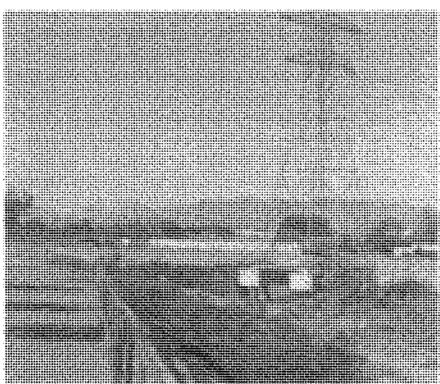
#17: Santa Cruz channel N of Valencia

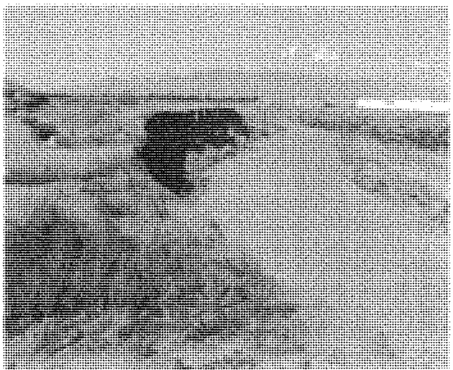

#18: Santa Cruz channel N of Valencia


#19: Tension Cracks in W. bank, just S. of Valencia

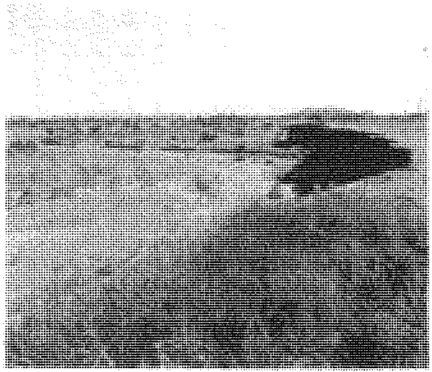

#20: Valencia Bridge


#21: Tension Cracks in W. Bank just S. of Valencia

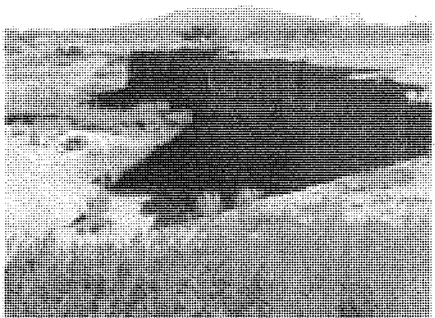

#22: Power pole base in Santa Cruz channel



#23: Santa Cruz channel west bank, south of Irvington (view to north)

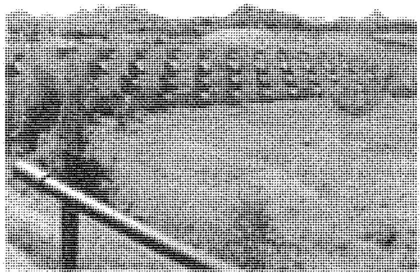


#24: Santa Cruz channel bank, south of Irvington (view to south)

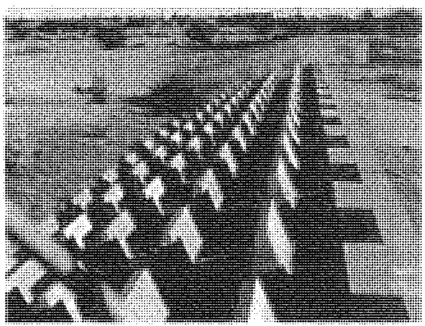


#25: Santa Cruz Riv. bank, south of Irvington (view to south) (closeup of previous photo)

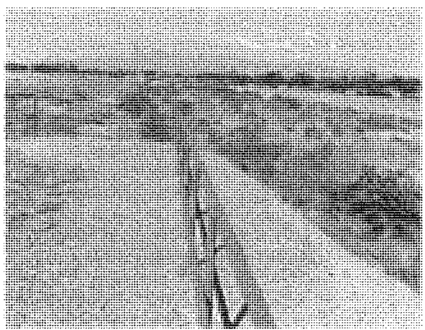
#26: View Upstream of West Branch, just W. of the Santa Cruz channel intersection



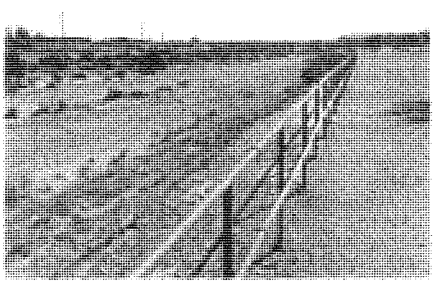
#27: Energy dissipation structure @ W. Branch just upstream of Santa Cruz River



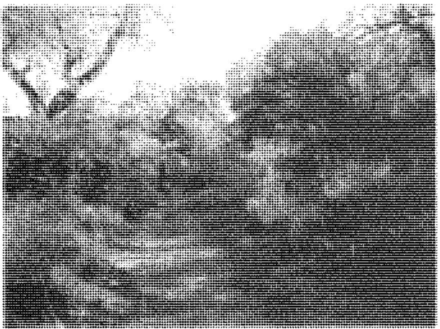
#28: Energy dissipators @ West Branch and Santa Cruz intersection (view to S)



#29: Intersection of W. Branch and Santa Cruz channels (view to N)



#30: Santa Cruz channel - view to S. just below W. Branch intersection



#31: W. Branch Santa Cruz south of Ajo near Mission (view to south)

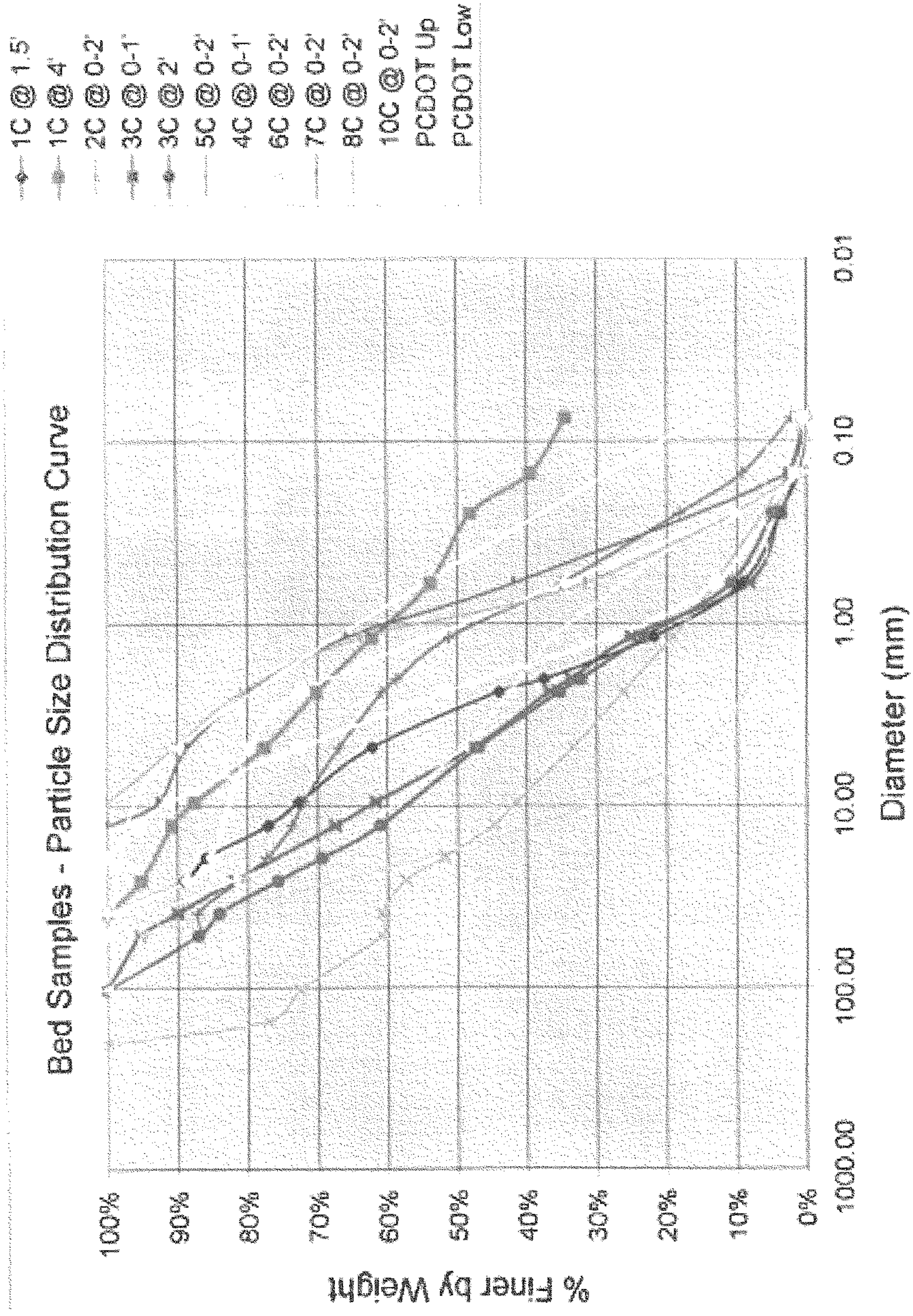
#32: W. Branch of Santa Cruz south of Ajo near Mission (view to south)

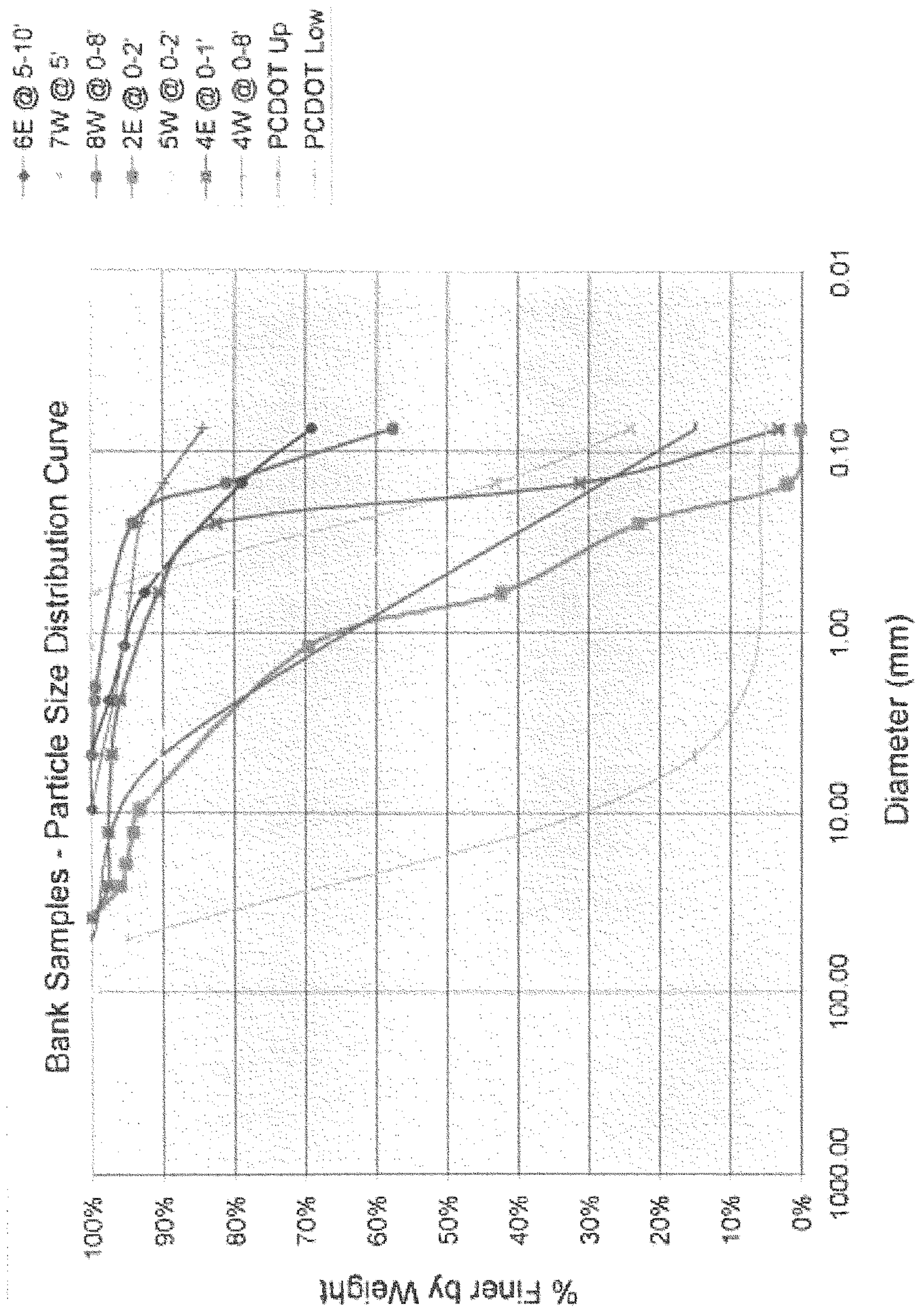
#33: View to south of the old (near) and new/diverted (distance) W. Branch channels

#34: View to north of the diverted (old) W Branch Channel

APPENDIX B

Laboratory Test Results


Bed Samples - Particle Size Distribution Curve
% Finer by Weight
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1000.00
100.00
10.00
1.00
0.10
0.01
Diameter (mm)
1C @ 1.5'
1C @ 4'
2C @ 0-2'
3C @ 0-1'
3C @ 2'
5C @ 0-2'
4C @ 0-1'
6C @ 0-2'
7C @ 0-2'
8C @ 0-2'
10C @ 0-2'
PCDOT Up
PCDOT Low


Bank Samples - Particle Size Distribution Curve
% Finer by Weight
Diameter (mm)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1000.00
100.00
10.00
1.00
0.10
0.01
6E @ 5-10'
7W @ 5'
8W @ 0-8'
2E @ 0-2'
5W @ 0-2'
4E @ 0-1'
4W @ 0-8'
PCDOT Up
PCDOT Low

APPENDIX C

ADWR Well Data

11 Well Site Locations Selected

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1	D-14-13 11BAD	55-620304	321400110592101	01/08/60	77	2258
2		55-620304	321400110592101	01/29/62	82	2253
3		55-620304	321400110592101	02/01/63	87	2248
4		55-620304	321400110592101	01/29/64	90	2245
5		55-620304	321400110592101	02/02/65	90	2245
6		55-620304	321400110592101	07/26/65	96	2239
7		55-620304	321400110592101	02/01/68	89	2246
8		55-620304	321400110592101	02/10/69	89	2246
9		55-620304	321400110592101	05/01/70	93	2242
10		55-620304	321400110592101	02/01/71	94	2241
11		55-620304	321400110592101	02/01/72	97	2238
12		55-620304	321400110592101	02/01/73	99	2236
13		55-620304	321400110592101	12/28/81	120	2215
14		55-620304	321400110592101	12/01/82	120	2215
15		55-620304	321400110592101	01/06/84	113	2222
16		55-620304	321400110592101	01/06/85	113	2222
17		55-620304	321400110592101	12/30/85	110	2226
18		55-620304	321400110592101	12/30/86	111	2224
19		55-620304	321400110592101	12/28/87	114	2221
20		55-620304	321400110592101	01/06/89	116	2219
21		55-620304	321400110592101	12/26/90	122	2213
22		55-620304	321400110592101	12/18/91	124	2211
23		55-620304	321400110592101	01/21/94	127	2208
24		55-620304	321400110592101	02/03/95	129	2206
25		55-620304	321400110592101	01/09/97	133	2202
26		55-620304	321400110592101	02/11/98	136	2199
27		55-620304	321400110592101	12/02/98	137	2198
28		55-620304	321400110592101	01/03/00	149	2186
29	D-14-13 11BBB1	55-620302	321403110594201	01/21/94	130	2205
30	D-14-13 11DAA		321339110584201	01/01/65	60	2285
31	D-14-13 11DBB		321338110590701	03/12/53	59	2282
32			321338110590701	03/01/54	68	2273
33			321338110590701	02/04/55	67	2274
34			321338110590701	01/27/58	73	2268

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
35			321338110590701	01/29/59	73	2268
36			321338110590701	01/30/61	79	2262
37			321338110590701	01/29/62	82	2259
38			321338110590701	01/31/63	90	2251
39			321338110590701	01/24/64	89	2252
40			321338110590701	02/02/65	89	2252
41			321338110590701	02/17/66	89	2252
42			321338110590701	01/25/67	87	2254
43			321338110590701	02/01/68	86	2255
44			321338110590701	02/01/69	89	2252
45			321338110590701	02/06/70	93	2248
46			321338110590701	02/18/71	93	2248
47			321338110590701	02/06/72	96	2245
48			321338110590701	02/15/73	98	2243
49			321338110590701	01/04/74	99	2242
50			321338110590701	01/03/75	109	2233
51			321338110590701	02/18/76	110	2231
52			321338110590701	02/01/77	111	2230
53			321338110590701	02/01/78	107	2234
54			321338110590701	02/01/79	105	2236
55			321338110590701	12/29/81	121	2220
56			321338110590701	12/15/83	108	2233
57			321338110590701	01/04/84	112	2229
58			321338110590701	12/10/84	110	2231
59			321338110590701	06/19/85	109	2232
60			321338110590701	12/03/85	110	2231
61			321338110590701	05/28/86	110	2231
62			321338110590701	06/03/87	115	2226
63	D-14-13 14CAB		321247110592001	09/11/39	28	2422
64			321247110592001	09/25/39	28	2422
65			321247110592001	11/13/39	28	2422
66			321247110592001	12/30/39	28	2422
67			321247110592001	02/19/40	27	2423
68	D-14-13 23ACA	55-619926	321209110585401	01/05/82	87	2283

A

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
69		55-619926	321209110585401	01/09/84	82	2288
70		55-619926	321209110585401	01/09/85	74	2296
71		55-619926	321209110585401	12/30/85	66	2304
72		55-619926	321209110585401	12/30/86	70	2300
73		55-619926	321209110585401	12/30/87	75	2295
74		55-619926	321209110585401	01/10/89	78	2292
75		55-619926	321209110585401	12/26/90	85	2285
76		55-619926	321209110585401	12/18/91	90	2280
77		55-619926	321209110585401	01/21/94	93	2277
78		55-619926	321209110585401	02/03/95	90	2280
79		55-619926	321209110585401	01/09/97	103	2267
80		55-619926	321209110585401	02/10/98	116	2254
81		55-619926	321209110585401	01/08/99	120	2250
82		55-619926	321209110585401	12/29/99	123	2247
83	D-14-13 23ACC	55-646738	321158110590101	12/30/81	82	2289
84		55-646738	321158110590101	01/05/84	85	2286
85		55-646738	321158110590101	11/30/87	78	2293
86		55-646738	321158110590101	01/16/95	92	2279
87		55-646738	321158110590101	02/28/00		
88	D-14-13 23ADC		321202110584901	09/29/39	19	2357
89	D-14-13 23BDA	55-619925	321207110591201	07/31/50	24	2339
90		55-619925	321207110591201	10/05/50	25	2338
91		55-619925	321207110591201	02/23/51	26	2337
92		55-619925	321207110591201	10/24/51	29	2334
93		55-619925	321207110591201	02/04/52	26	2337
94		55-619925	321207110591201	02/05/53	32	2331
95		55-619925	321207110591201	02/04/54	34	2329
96		55-619925	321207110591201	02/04/55	28	2335
97		55-619925	321207110591201	02/02/56	27	2336
98		55-619925	321207110591201	02/06/57	27	2336
99		55-619925	321207110591201	01/27/58	29	2334
100		55-619925	321207110591201	01/29/59	29	2334
101		55-619925	321207110591201	01/29/60	28	2335
102		55-619925	321207110591201	01/26/61	32	2331

A

B

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B

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
103		55-619925	321207110591201	01/25/62	31	2332
104		55-619925	321207110591201	01/29/63	35	2328
105		55-619925	321207110591201	02/05/64	41	2322
106		55-619925	321207110591201	02/03/65	38	2325
107		55-619925	321207110591201	06/10/65	40	2323
108		55-619925	321207110591201	08/12/65	43	2320
109		55-619925	321207110591201	09/27/65	41	2322
110		55-619925	321207110591201	10/15/65	42	2321
111		55-619925	321207110591201	12/15/65	38	2325
112		55-619925	321207110591201	01/15/66	36	2327
113		55-619925	321207110591201	02/17/66	32	2331
114		55-619925	321207110591201	03/04/66	33	2330
115		55-619925	321207110591201	03/17/66	33	2330
116		55-619925	321207110591201	04/19/66	36	2327
117		55-619925	321207110591201	06/22/66	35	2328
118		55-619925	321207110591201	08/22/66	35	2329
119		55-619925	321207110591201	10/15/66	34	2329
120		55-619925	321207110591201	11/18/66	34	2330
121		55-619925	321207110591201	12/28/66	34	2329
122		55-619925	321207110591201	01/15/67	32	2331
123		55-619925	321207110591201	02/20/67	31	2332
124		55-619925	321207110591201	03/01/67	31	2332
125		55-619925	321207110591201	04/17/67	32	2331
126		55-619925	321207110591201	06/20/67	36	2327
127		55-619925	321207110591201	08/23/67	34	2329
128		55-619925	321207110591201	09/01/67	35	2328
129		55-619925	321207110591201	10/01/67	35	2328
130		55-619925	321207110591201	11/01/67	34	2329
131		55-619925	321207110591201	12/01/67	33	2330
132		55-619925	321207110591201	01/18/68	31	2332
133		55-619925	321207110591201	02/01/68	33	2330
134		55-619925	321207110591201	02/16/68	32	2331
135		55-619925	321207110591201	03/01/68	32	2331
136		55-619925	321207110591201	04/19/68	32	2331

E

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
137		55-619925	321207110591201	05/16/68	32	2331
138		55-619925	321207110591201	06/17/68	34	2329
139		55-619925	321207110591201	02/11/69	35	2328
140		55-619925	321207110591201	04/23/70	41	2322
141		55-619925	321207110591201	01/05/82	87	2276
142		55-619925	321207110591201	12/01/82	89	2274
143		55-619925	321207110591201	12/30/85	66	2297
144		55-619925	321207110591201	12/30/86	69	2294
145		55-619925	321207110591201	12/30/87	75	2288
146		55-619925	321207110591201	12/26/90	85	2278
147		55-619925	321207110591201	12/18/91	89	2274
148		55-619925	321207110591201	01/21/94	93	2270
149		55-619925	321207110591201	12/24/97	105	2258
150		55-619925	321207110591201	04/28/98	135	2228
151	D-14-13 23CAA1		321154110591201	01/23/46	55	2505
152	D-14-13 23CDD	55-802875	321134110591301	01/09/89	86	2299
153		55-802875	321134110591301	12/28/90	94	2291
154	D-14-13 26ACA	55-619921	321108110590901	12/06/30	21	2374
155		55-619921	321108110590901	12/16/31	17	2378
156		55-619921	321108110590901	02/15/32	16	2379
157		55-619921	321108110590901	02/01/33	16	2379
158		55-619921	321108110590901	01/01/34	16	2379
159		55-619921	321108110590901	01/01/35	18	2377
160		55-619921	321108110590901	01/21/36	17	2378
161		55-619921	321108110590901	02/24/37	18	2377
162		55-619921	321108110590901	01/18/38	20	2375
163		55-619921	321108110590901	01/01/39	21	2374
164		55-619921	321108110590901	02/01/40	21	2374
165		55-619921	321108110590901	01/01/41	22	2373
166		55-619921	321108110590901	02/28/47	78	2317
167		55-619921	321108110590901	02/10/49	32	2363
168		55-619921	321108110590901	02/10/50	35	2360
169		55-619921	321108110590901	02/22/51	37	2358
170		55-619921	321108110590901	02/08/52	36	2359

C

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
171		55-619921	321108110590901	02/05/53	40	2355
172		55-619921	321108110590901	02/04/54	40	2355
173		55-619921	321108110590901	02/07/55	36	2359
174		55-619921	321108110590901	02/29/56	33	2362
175		55-619921	321108110590901	02/07/57	36	2359
176		55-619921	321108110590901	01/27/58	37	2358
177		55-619921	321108110590901	01/29/59	38	2357
178		55-619921	321108110590901	01/29/60	37	2358
179		55-619921	321108110590901	01/26/61	42	2353
180		55-619921	321108110590901	01/24/62	42	2353
181		55-619921	321108110590901	01/29/63	47	2348
182		55-619921	321108110590901	01/28/64	50	2345
183		55-619921	321108110590901	02/03/65	48	2347
184	D-14-13 26BBC1	55-807626	321119110593601	09/30/81		
185	D-14-13 26BBC3	55-619908	321129110593401	01/21/52	37	2353
186		55-619908	321129110593401	02/02/53	38	2352
187		55-619908	321129110593401	02/08/54	39	2351
188		55-619908	321129110593401	02/04/55	36	2354
189		55-619908	321129110593401	02/08/56	32	2358
190		55-619908	321129110593401	02/08/57	36	2354
191		55-619908	321129110593401	01/28/58	37	2353
192		55-619908	321129110593401	01/28/59	37	2353
193		55-619908	321129110593401	01/29/60	37	2353
194		55-619908	321129110593401	01/31/61	40	2350
195		55-619908	321129110593401	01/30/62	40	2350
196		55-619908	321129110593401	02/01/63	46	2344
197		55-619908	321129110593401	01/27/64	49	2341
198		55-619908	321129110593401	02/05/68	48	2342
199		55-619908	321129110593401	01/11/69	50	2340
200		55-619908	321129110593401	12/28/81	97	2293
201		55-619908	321129110593401	12/30/81	97	2293
202		55-619908	321129110593401	12/01/82	103	2287
203		55-619908	321129110593401	01/09/84	94	2296
204		55-619908	321129110593401	01/08/85	83	2307

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
205		55-619908	321129110593401	12/31/85	80	2310
206		55-619908	321129110593401	01/02/87	82	2309
207		55-619908	321129110593401	12/30/87	85	2305
208		55-619908	321129110593401	12/26/90	99	2291
209		55-619908	321129110593401	01/21/94	105	2285
210		55-619908	321129110593401	02/02/95	105	2285
211	D-14-13 26BCA2		321118110592801	12/22/81		
212	D-14-13 26CDC		321045110592301	12/30/81	116	2285
213	D-14-13 26DBB	55-619920	321107110590801	01/17/30	22	2373
214		55-619920	321107110590801	12/01/30	24	2371
215		55-619920	321107110590801	02/15/32	19	2376
216		55-619920	321107110590801	02/01/33	18	2377
217		55-619920	321107110590801	01/01/34	19	2376
218		55-619920	321107110590801	01/01/35	20	2375
219		55-619920	321107110590801	01/21/36	20	2375
220		55-619920	321107110590801	01/01/37	22	2373
221		55-619920	321107110590801	01/18/38	23	2372
222		55-619920	321107110590801	01/01/39	24	2371
223		55-619920	321107110590801	02/01/40	24	2371
224		55-619920	321107110590801	01/01/41	25	2370
225		55-619920	321107110590801	02/28/47	32	2363
226		55-619920	321107110590801	02/10/49	35	2360
227		55-619920	321107110590801	02/10/50	37	2358
228		55-619920	321107110590801	02/22/51	39	2356
229		55-619920	321107110590801	02/08/52	39	2356
230		55-619920	321107110590801	02/05/53	43	2352
231		55-619920	321107110590801	02/09/54	43	2352
232		55-619920	321107110590801	02/07/55	41	2354
233		55-619920	321107110590801	02/29/56	36	2359
234		55-619920	321107110590801	02/07/57	39	2356
235		55-619920	321107110590801	01/27/58	40	2355
236		55-619920	321107110590801	01/29/59	42	2353
237		55-619920	321107110590801	01/29/60	41	2355
238		55-619920	321107110590801	01/26/61	45	2350

C

D

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
239		55-619920	321107110590801	01/24/62	46	2349
240		55-619920	321107110590801	01/29/63	51	2344
241		55-619920	321107110590801	01/27/64	55	2340
242		55-619920	321107110590801	02/03/65	54	2341
243		55-619920	321107110590801	02/17/66	51	2344
244		55-619920	321107110590801	02/02/68	50	2345
245		55-619920	321107110590801	02/11/69	55	2340
246		55-619920	321107110590801	01/03/75	90	2305
247		55-619920	321107110590801	01/05/82	108	2287
248		55-619920	321107110590801	01/06/84	103	2292
249		55-619920	321107110590801	01/09/85	91	2304
250		55-619920	321107110590801	12/30/85	90	2305
251		55-619920	321107110590801	12/30/87	94	2302
252		55-619920	321107110590801	01/09/89	99	2296
253		55-619920	321107110590801	12/26/90	108	2287
254		55-619920	321107110590801	12/18/91	112	2283
255		55-619920	321107110590801	01/21/94	114	2281
256		55-619920	321107110590801	02/02/95	116	2279
257		55-619920	321107110590801	01/09/97	136	2259
258		55-619920	321107110590801	02/10/98	144	2251
259		55-619920	321107110590801	01/09/99	147	2248
260		55-619920	321107110590801	12/29/99	152	2243
261	D-14-13 34ACA		321027110595501	02/07/55	52	2350
262			321027110595501	02/10/56	46	2357
263			321027110595501	02/11/57	52	2351
264			321027110595501	01/29/58	53	2349
265			321027110595501	01/30/59	53	2349
266			321027110595501	01/29/60	53	2349
267			321027110595501	01/30/61	57	2345
268			321027110595501	01/25/62	59	2343
269			321027110595501	01/28/63	62	2340
270	D-14-13 34AD		321020110594801	03/24/42	34	2391
271	D-14-13 34ADC		321017110595001	12/08/30	29	2386
272			321017110595001	02/07/31	28	2387

D

E

E

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
273			321017110595001	03/06/31	28	2387
274			321017110595001	01/19/32	25	2390
275			321017110595001	02/24/32	25	2390
276			321017110595001	08/01/32	27	2388
277			321017110595001	09/01/32	27	2388
278			321017110595001	10/01/32	27	2388
279			321017110595001	11/01/32	27	2388
280			321017110595001	12/01/32	26	2389
281			321017110595001	01/01/33	25	2390
282			321017110595001	09/01/34	30	2385
283			321017110595001	11/01/34	30	2385
284			321017110595001	12/01/34	29	2386
285			321017110595001	01/01/35	28	2387
286			321017110595001	09/01/35	33	2382
287			321017110595001	12/01/35	28	2387
288			321017110595001	02/05/36	28	2387
289			321017110595001	04/01/36	28	2387
290			321017110595001	02/24/37	29	2386
291			321017110595001	09/01/37	32	2383
292			321017110595001	10/13/37	32	2383
293			321017110595001	11/17/37	32	2383
294			321017110595001	12/21/37	32	2383
295			321017110595001	01/18/38	31	2384
296			321017110595001	03/16/38	30	2385
297			321017110595001	04/14/38	31	2384
298			321017110595001	05/16/38	32	2383
299			321017110595001	10/01/38	34	2381
300			321017110595001	11/01/38	33	2382
301			321017110595001	12/01/38	33	2382
302			321017110595001	01/01/39	32	2383
303			321017110595001	02/01/39	31	2384
304			321017110595001	09/01/39	34	2381
305			321017110595001	11/01/39	32	2383
306			321017110595001	02/01/40	31	2384

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
307			321017110595001	03/01/40	30	2385
308			321017110595001	07/01/40	34	2381
309			321017110595001	10/01/40	34	2381
310			321017110595001	01/01/41	32	2383
311			321017110595001	03/01/41	30	2385
312			321017110595001	06/16/41	33	2382
313			321017110595001	02/26/42	32	2383
314			321017110595001	10/20/42	38	2377
315			321017110595001	02/05/52	52	2363
316			321017110595001	02/05/53	55	2360
317			321017110595001	02/09/54	58	2357
318			321017110595001	02/07/55	52	2363
319			321017110595001	02/10/56	47	2368
320			321017110595001	02/11/57	53	2362
321			321017110595001	01/29/58	54	2361
322			321017110595001	02/02/59	54	2361
323			321017110595001	01/29/60	58	2357
324			321017110595001	01/31/61	58	2357
325			321017110595001	01/30/62	59	2356
326			321017110595001	02/04/63	63	2352
327			321017110595001	01/29/64	68	2348
328			321017110595001	02/04/65	65	2350
329			321017110595001	01/26/67	62	2353
330			321017110595001	02/09/70	76	2339
331			321017110595001	12/30/81	131	2285
332			321017110595001	11/30/87	113	2302
333			321017110595001	01/16/95	140	2275
334			321017110595001	02/28/00		
335	D-14-13 34DCD		320950110595801	09/28/39	33	2392
336			320950110595801	11/06/39	33	2392
337			320950110595801	12/26/39	32	2393
338			320950110595801	02/11/40	31	2394
339			320950110595801	03/18/40	32	2393
340			320950110595801	05/01/40	32	2393

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
341			320950110595801	05/28/40	33	2392
342			320950110595801	08/13/40	19	2406
343			320950110595801	10/04/40	18	2407
344	D-14-13 34DDC		320951110595001	09/28/39	33	2392
345			320951110595001	10/04/40	36	2389
346			320951110595001	11/05/40	37	2388
347			320951110595001	02/24/41	34	2391
348			320951110595001	03/25/41	34	2391
349			320951110595001	04/28/41	35	2390
350			320951110595001	09/30/41	38	2387
351			320951110595001	11/13/41	37	2388
352			320951110595001	12/29/41	36	2389
353			320951110595001	03/24/42	35	2390
354			320951110595001	12/23/42	38	2387
355			320951110595001	10/26/43	41	2384
356			320951110595001	11/18/43	40	2385
357			320951110595001	01/14/44	38	2387
358			320951110595001	10/13/44	46	2379
359			320951110595001	12/11/44	42	2383
360			320951110595001	03/10/45	41	2384
361			320951110595001	10/12/45	48	2377
362			320951110595001	10/15/45	47	2378
363			320951110595001	12/06/45	45	2380
364			320951110595001	05/08/46	46	2379
365			320951110595001	07/23/46	50	2375
366			320951110595001	09/30/46	47	2378
367			320951110595001	10/11/46	46	2379
368			320951110595001	10/12/46	48	2377
369			320951110595001	12/02/46	44	2381
370			320951110595001	12/06/46	45	2380
371			320951110595001	03/31/47	45	2380
372			320951110595001	04/29/47	46	2379
373			320951110595001	07/14/47	52	2373
374			320951110595001	07/15/47	52	2373

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
375			320951110595001	09/26/47	52	2373
376			320951110595001	10/01/47	51	2375
377			320951110595001	10/28/47	50	2375
378			320951110595001	05/21/48	52	2373
379			320951110595001	06/18/48	54	2371
380			320951110595001	07/28/48	56	2369
381			320951110595001	08/24/48	56	2369
382			320951110595001	09/30/48	56	2369
383			320951110595001	10/11/48	56	2369
384			320951110595001	10/25/48	55	2370
385			320951110595001	11/26/48	53	2372
386			320951110595001	01/27/49	49	2376
387			320951110595001	02/07/49	49	2376
388			320951110595001	09/26/49	58	2367
389			320951110595001	10/13/49	57	2368
390			320951110595001	12/16/49	54	2371
391			320951110595001	02/06/50	55	2370
392			320951110595001	09/19/50	59	2366
393			320951110595001	09/26/50	59	2366
394			320951110595001	11/30/50	58	2367
395			320951110595001	12/16/50	52	2373
396			320951110595001	01/18/51	56	2369
397			320951110595001	02/23/51	54	2371
398			320951110595001	12/17/51	58	2367
399			320951110595001	02/08/52	58	2367
400			320951110595001	05/19/52	57	2368
401			320951110595001	11/13/52	63	2362
402			320951110595001	02/03/53	58	2367
403			320951110595001	02/05/53	58	2357
404			320951110595001	04/23/53	59	2366
405			320951110595001	10/21/53	57	2368
406			320951110595001	02/08/54	63	2362
407			320951110595001	05/17/54	63	2362
408			320951110595001	08/04/54	67	2358

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
409			320951110595001	11/08/54	62	2363
410			320951110595001	01/04/55	61	2364
411			320951110595001	02/07/55	57	2368
412			320951110595001	03/25/55	59	2367
413			320951110595001	10/28/55	55	2370
414			320951110595001	01/04/56	51	2374
415			320951110595001	02/10/56	50	2375
416			320951110595001	08/10/56	60	2365
417			320951110595001	02/01/57	55	2370
418			320951110595001	02/11/57	56	2369
419			320951110595001	07/19/57	62	2363
420			320951110595001	12/27/57	58	2367
421			320951110595001	01/29/58	58	2367
422			320951110595001	02/02/59	59	2366
423			320951110595001	01/05/60	61	2364
424			320951110595001	01/29/60	59	2366
425			320951110595001	01/30/61	63	2362
426			320951110595001	02/02/61	63	2362
427			320951110595001	01/25/62	65	2360
428			320951110595001	02/21/62	65	2360
429			320951110595001	10/10/62	74	2351
430			320951110595001	01/31/63	71	2354
431			320951110595001	02/04/63	71	2354
432			320951110595001	01/27/64	74	2351
433			320951110595001	03/05/64	79	2346
434			320951110595001	01/12/65	79	2346
435			320951110595001	02/04/65	72	2353
436			320951110595001	01/10/66	72	2353
437			320951110595001	02/17/66	70	2355
438			320951110595001	03/23/67	75	2350
439			320951110595001	12/11/74	112	2313
440			320951110595001	12/30/81		
441	D-14-13 34DDD		320947110594001	10/26/43	41	2382
442			320947110594001	10/13/44	46	2377

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
443			320947110594001	12/11/44	42	2381
444			320947110594001	03/10/45	41	2382
445			320947110594001	10/15/45	47	2376
446			320947110594001	05/08/46	44	2379
447			320947110594001	07/23/46	48	2375
448			320947110594001	09/30/46	46	2377
449			320947110594001	10/11/46	44	2379
450			320947110594001	10/23/46	45	2378
451			320947110594001	12/02/46	42	2381
452			320947110594001	12/24/46	42	2381
453			320947110594001	03/31/47	43	2380
454			320947110594001	04/29/47	44	2379
455			320947110594001	09/26/47	50	2373
456			320947110594001	10/27/47	50	2373
457			320947110594001	10/28/47	48	2375
458			320947110594001	05/02/48	52	2371
459			320947110594001	06/18/48	54	2369
460			320947110594001	07/28/48	56	2367
461			320947110594001	08/24/48	56	2367
462			320947110594001	09/30/48	56	2367
463			320947110594001	10/11/48	55	2368
464			320947110594001	10/28/48	55	2368
465			320947110594001	11/26/48	53	2370
466			320947110594001	02/07/49	55	2368
467			320947110594001	09/19/50	59	2364
468			320947110594001	02/23/51	54	2369
469			320947110594001	02/08/52	58	2365
470			320947110594001	02/05/53	59	2364
471			320947110594001	02/11/54	62	2361
472			320947110594001	02/07/55	57	2366
473			320947110594001	02/10/56	50	2373
474			320947110594001	02/11/57	56	2367
475			320947110594001	01/29/58	58	2365
476			320947110594001	02/02/59	58	2365

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
477			320947110594001	01/29/60	60	2363
478			320947110594001	01/30/61	63	2360
479			320947110594001	01/25/62	65	2358
480			320947110594001	02/04/63	69	2354
481			320947110594001	01/27/64	74	2349
482			320947110594001	02/04/65	72	2351
483			320947110594001	01/26/67	69	2354
484			320947110594001	02/01/72	84	2339
485			320947110594001	01/24/73	86	2337
486			320947110594001	02/01/78	116	2307
487			320947110594001	02/01/79	113	2310
488	D-14-13 35AAC	55-620202	321030110584901	02/28/68	87	2345
489		55-620202	321030110584901	01/01/82	147	2285
490		55-620202	321030110584901	08/13/84	138	2295
491		55-620202	321030110584901	12/30/85	126	2306
492	D-14-13 35ADA	55-620202	321025110584801	10/10/85	141	2207
493		55-620202	321025110584801	12/30/85	126	2312
494		55-620202	321025110584801	05/20/86	137	2301
495		55-620202	321025110584801	11/17/86	141	2297
496		55-620202	321025110584801	05/26/87	140	2298
497		55-620202	321025110584801	05/16/91	166	2272
498		55-620202	321025110584801	12/23/91	150	2288
499		55-620202	321025110584801	12/16/94	157	2281
500		55-620202	321025110584801	01/16/97	183	2255
501		55-620202	321025110584801	12/05/97	183	2255
502		55-620202	321025110584801	04/30/98	216	2222
503		55-620202	321025110584801	01/27/99	183	2255
504		55-620202	321025110584801	02/02/00	194	2244
505	D-14-13 35ADC		321014110584501	02/10/49	70	2374
506			321014110584501	10/13/49	78	2366
507			321014110584501	02/09/50	74	2370
508			321014110584501	02/26/51	75	2369
509			321014110584501	10/24/51	82	2362
510			321014110584501	02/01/52	77	2367

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
511			321014110584501	02/01/53	80	2364
512			321014110584501	02/08/54	81	2363
513			321014110584501	02/09/55	78	2366
514			321014110584501	02/10/56	71	2374
515			321014110584501	02/11/57	76	2368
516			321014110584501	01/29/58	78	2366
517			321014110584501	01/30/59	79	2365
518			321014110584501	02/01/60	80	2364
519			321014110584501	01/27/61	83	2361
520			321014110584501	01/25/62	86	2358
521			321014110584501	02/04/63	90	2354
522			321014110584501	01/28/64	94	2350
523			321014110584501	02/03/65	93	2351
524			321014110584501	02/20/66	90	2354
525			321014110584501	01/26/67	88	2356
526			321014110584501	02/02/68	87	2357
527			321014110584501	02/14/69	96	2348
528			321014110584501	02/09/70	109	2335
529	D-14-13 35BAB	55-619930	321033110592101	06/01/66	60	2340
530		55-619930	321033110592101	12/01/82	127	2273
531		55-619930	321033110592101	01/06/84	114	2286
532		55-619930	321033110592101	01/08/85	99	2301
533		55-619930	321033110592101	12/30/85	98	2302
534		55-619930	321033110592101	01/09/89	110	2291
535		55-619930	321033110592101	12/26/90	118	2282
536		55-619930	321033110592101	02/03/95	129	2271
537		55-619930	321033110592101	12/16/96	142	2258
538		55-619930	321033110592101	12/24/97	150	2250
539		55-619930	321033110592101	05/19/98	172	2229
540		55-619930	321033110592101	11/18/98	150	2250
541		55-619930	321033110592101	12/28/99	160	2240
542	D-14-13 35BDC		321017110591901	09/29/39	34	2378
543			321017110591901	10/04/40	35	2377
544			321017110591901	09/30/41	35	2377

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
545			321017110591901	09/29/42	39	2373
546			321017110591901	09/29/43	41	2371
547			321017110591901	09/28/44	44	2368
548			321017110591901	10/22/45	44	2368
549			321017110591901	10/11/46	43	2369
550			321017110591901	09/26/47	49	2363
551	D-14-13 35CAA	55-619922	321008110590801	02/10/50	61	2364
552		55-619922	321008110590801	02/06/52	62	2363
553		55-619922	321008110590801	02/06/53	66	2359
554		55-619922	321008110590801	02/11/54	67	2358
555		55-619922	321008110590801	02/10/55	63	2362
556		55-619922	321008110590801	02/10/56	57	2368
557		55-619922	321008110590801	02/07/57	62	2363
558		55-619922	321008110590801	01/28/58	64	2361
559		55-619922	321008110590801	01/30/59	64	2361
560		55-619922	321008110590801	02/01/60	65	2360
561		55-619922	321008110590801	01/27/61	69	2356
562		55-619922	321008110590801	01/25/62	71	2354
563		55-619922	321008110590801	01/29/63	76	2349
564		55-619922	321008110590801	01/27/64	81	2344
565		55-619922	321008110590801	02/03/65	82	2343
566		55-619922	321008110590801	06/11/65	86	2339
567		55-619922	321008110590801	02/02/68	86	2339
568		55-619922	321008110590801	02/14/69	89	2336
569		55-619922	321008110590801	04/23/70	88	2337
570		55-619922	321008110590801	01/05/82	139	2286
571		55-619922	321008110590801	01/09/84	132	2293
572		55-619922	321008110590801	01/08/85	118	2307
573		55-619922	321008110590801	12/30/85	117	2308
574		55-619922	321008110590801	01/02/87	116	2309
575		55-619922	321008110590801	12/30/87	121	2304
576		55-619922	321008110590801	12/28/90	137	2288
577		55-619922	321008110590801	12/23/91	141	2284
578		55-619922	321008110590801	02/02/95	153	2272

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
579		55-619922	321008110590801	12/30/96	174	2251
580		55-619922	321008110590801	02/10/98	180	2245
581		55-619922	321008110590801	12/24/98	184	2241
582		55-619922	321008110590801	12/29/99	187	2238
583	D-14-13 35CAB	55-619919	321008110592001	03/16/31	30	2380
584		55-619919	321008110592001	04/15/31	31	2379
585		55-619919	321008110592001	06/16/31	33	2377
586		55-619919	321008110592001	07/15/31	33	2377
587		55-619919	321008110592001	09/15/31	30	2380
588		55-619919	321008110592001	11/16/31	30	2380
589		55-619919	321008110592001	01/16/32	28	2382
590		55-619919	321008110592001	02/15/32	28	2382
591		55-618919	321008110592001	07/01/32	29	2381
592		55-619919	321008110592001	11/01/32	30	2380
593		55-619919	321008110592001	01/01/34	29	2381
594		55-619919	321008110592001	03/01/34	30	2380
595		55-619919	321008110592001	04/01/34	30	2380
596		55-619919	321008110592001	05/01/34	31	2379
597		55-619919	321008110592001	06/01/34	32	2378
598		55-619919	321008110592001	09/01/34	32	2378
599		55-619919	321008110592001	01/01/35	30	2380
600		55-619919	321008110592001	03/01/35	30	2380
601		55-619919	321008110592001	08/01/35	31	2379
602		55-619919	321008110592001	09/01/35	31	2379
603		55-619919	321008110592001	10/01/35	31	2379
604		55-619919	321008110592001	12/01/35	30	2380
605		55-619919	321008110592001	01/21/36	30	2380
606		55-619919	321008110592001	04/01/36	31	2379
607		55-619919	321008110592001	02/24/37	31	2379
608		55-619919	321008110592001	04/23/37	33	2377
609		55-619919	321008110592001	06/10/37	33	2378
610		55-619919	321008110592001	07/15/37	34	2376
611		55-619919	321008110592001	08/19/37	34	2376
612		55-619919	321008110592001	10/13/37	34	2376

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
613		55-619919	321008110592001	11/17/37	34	2376
614		55-619919	321008110592001	12/21/37	33	2377
615		55-619919	321008110592001	01/18/38	33	2377
616		55-619919	321008110592001	02/17/38	32	2378
617		55-619919	321008110592001	03/16/38	33	2377
618		55-619919	321008110592001	04/14/38	33	2377
619		55-619919	321008110592001	05/16/38	35	2375
620		55-619919	321008110592001	08/18/38	31	2379
621		55-619919	321008110592001	10/01/38	36	2374
622		55-619919	321008110592001	12/01/38	35	2375
623		55-619919	321008110592001	01/01/39	34	2376
624		55-619919	321008110592001	02/01/39	33	2377
625		55-619919	321008110592001	03/01/40	32	2378
626		55-619919	321008110592001	10/01/40	36	2374
627		55-619919	321008110592001	01/01/41	33	2377
628		55-619919	321008110592001	02/28/47	45	2365
629		55-619919	321008110592001	10/28/47	49	2361
630		55-619919	321008110592001	02/10/50	53	2357
631		55-619919	321008110592001	02/05/52	54	2356
632		55-619919	321008110592001	02/05/53	56	2354
633		55-619919	321008110592001	02/11/54	58	2352
634		55-619919	321008110592001	02/10/55	54	2356
635		55-619919	321008110592001	02/10/56	47	2363
636		55-619919	321008110592001	02/07/57	54	2356
637		55-619919	321008110592001	01/28/58	55	2355
638		55-619919	321008110592001	01/30/59	56	2354
639		55-619919	321008110592001	02/01/60	56	2354
640		55-619919	321008110592001	01/27/61	60	2350
641		55-619919	321008110592001	01/24/62	62	2348
642		55-619919	321008110592001	01/28/63	66	2344
643		55-619919	321008110592001	01/27/64	70	2340
644		55-619919	321008110592001	02/02/65	69	2341
645		55-619919	321008110592001	06/09/65	72	2338
646		55-619919	321008110592001	07/15/65	75	2335

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
647		55-619919	321008110592001	08/10/65	76	2334
648		55-619919	321008110592001	09/21/65	74	2336
649		55-619919	321008110592001	10/15/65	75	2335
650		55-619919	321008110592001	12/15/65	73	2338
651		55-619919	321008110592001	01/15/66	73	2338
652		55-619919	321008110592001	04/19/66	69	2341
653		55-619919	321008110592001	08/28/67	72	2338
654		55-619919	321008110592001	09/01/67	72	2338
655		55-619919	321008110592001	10/25/67	70	2340
656		55-619919	321008110592001	11/20/67	73	2338
657		55-619919	321008110592001	12/20/67	70	2340
658		55-619919	321008110592001	01/18/68	69	2342
659		55-619919	321008110592001	02/02/68	75	2335
660		55-619919	321008110592001	02/16/68	68	2342
661		55-619919	321008110592001	03/01/68	66	2344
662		55-619919	321008110592001	04/11/68	68	2342
663		55-619919	321008110592001	05/16/68	70	2341
664		55-619919	321008110592001	06/17/68	70	2340
665		55-619919	321008110592001	04/23/70	80	2330
666		55-619919	321008110592001	01/05/82	131	2279
667		55-619919	321008110592001	01/09/84	124	2286
668		55-619919	321008110592001	01/08/85	109	2301
669		55-619919	321008110592001	12/30/85	109	2301
670		55-619919	321008110592001	01/02/87	108	2302
671		55-619919	321008110592001	12/30/87	113	2297
672		55-619919	321008110592001	01/09/89	121	2289
673		55-619919	321008110592001	12/28/90	129	2281
674		55-619919	321008110592001	12/23/91	133	2277
675		55-619919	321008110592001	02/02/95	143	2267
676	D-14-13 35CAC1	55-619910	321003110592101	05/15/31	29	2386
677		55-619910	321003110592101	09/15/31	28	2387
678		55-619910	321003110592101	11/16/31	27	2388
679		55-619910	321003110592101	04/01/32	25	2390
680		55-619910	321003110592101	05/01/32	26	2389

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
681		55-619910	321003110592101	06/01/32	27	2388
682		55-619910	321003110592101	08/01/32	25	2390
683		55-619910	321003110592101	09/01/32	27	2388
684		55-619910	321003110592101	11/01/32	26	2389
685		55-619910	321003110592101	12/01/32	26	2389
686		55-619910	321003110592101	03/01/33	29	2386
687		55-619910	321003110592101	07/01/33	28	2387
688		55-619910	321003110592101	01/01/34	22	2393
689		55-619910	321003110592101	02/01/34	23	2392
690		55-619910	321003110592101	03/01/34	24	2391
691		55-619910	321003110592101	04/01/34	23	2392
692		55-619910	321003110592101	06/01/34	25	2390
693		55-619910	321003110592101	07/01/34	27	2388
694		55-619910	321003110592101	10/01/34	26	2389
695		55-619910	321003110592101	01/01/35	24	2391
696		55-619910	321003110592101	04/01/35	25	2390
697		55-619910	321003110592101	04/01/36	29	2386
698		55-619910	321003110592101	06/10/37	32	2383
699		55-619910	321003110592101	07/15/37	32	2383
700		55-619910	321003110592101	08/19/37	32	2383
701		55-619910	321003110592101	09/16/37	32	2383
702		55-619910	321003110592101	10/13/37	32	2383
703		55-619910	321003110592101	11/17/37	32	2383
704		55-619910	321003110592101	12/21/37	31	2384
705		55-619910	321003110592101	01/18/38	31	2384
706		55-619910	321003110592101	02/17/38	31	2384
707		55-619910	321003110592101	03/16/38	31	2385
708		55-619910	321003110592101	04/14/38	31	2384
709		55-619910	321003110592101	05/16/38	33	2382
710		55-619910	321003110592101	08/18/38	34	2381
711		55-619910	321003110592101	10/01/38	34	2381
712		55-619910	321003110592101	11/01/38	34	2381
713		55-619910	321003110592101	12/01/38	33	2382
714		55-619910	321003110592101	01/01/39	32	2383

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
715		55-619910	321003110592101	02/01/39	31	2384
716		55-619910	321003110592101	03/01/40	32	2383
717		55-619910	321003110592101	10/01/40	34	2381
718		55-619910	321003110592101	01/01/41	32	2383
719		55-619910	321003110592101	10/13/49	57	2358
720		55-619910	321003110592101	02/10/50	50	2365
721		55-619910	321003110592101	02/06/52	51	2364
722		55-619910	321003110592101	02/05/53	55	2360
723		55-619910	321003110592101	02/11/54	56	2359
724		55-619910	321003110592101	02/10/55	52	2363
725		55-619910	321003110592101	02/01/56	45	2370
726		55-619910	321003110592101	02/07/57	51	2364
727		55-619910	321003110592101	01/28/58	53	2362
728		55-619910	321003110592101	01/30/59	54	2361
729		55-619910	321003110592101	01/29/60	53	2362
730		55-619910	321003110592101	01/27/61	61	2354
731		55-619910	321003110592101	01/24/62	60	2355
732		55-619910	321003110592101	01/28/63	64	2351
733		55-619910	321003110592101	01/27/64	68	2347
734		55-619910	321003110592101	02/02/65	67	2348
735		55-619910	321003110592101	06/09/65	72	2343
736		55-619910	321003110592101	10/29/65	75	2340
737		55-619910	321003110592101	02/02/68	73	2342
738		55-619910	321003110592101	02/01/69	73	2342
739		55-619910	321003110592101	04/23/70	81	2334
740		55-619910	321003110592101	01/05/82	133	2282
741		55-619910	321003110592101	12/01/82	140	2275
742		55-619910	321003110592101	01/09/84	126	2290
743		55-619910	321003110592101	01/08/85	110	2305
744		55-619910	321003110592101	12/30/85	110	2305
745		55-619910	321003110592101	01/02/87	110	2305
746		55-619910	321003110592101	12/30/87	114	2301
747		55-619910	321003110592101	01/09/89	123	2292
748		55-619910	321003110592101	12/28/90	130	2285

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
749		55-619910	321003110592101	12/31/91	136	2279
750		55-619910	321003110592101	02/02/95	145	2270
751		55-619910	321003110592101	12/13/96	166	2249
752		55-619910	321003110592101	02/02/99	170	2245
753		55-619910	321003110592101	12/22/99	180	2235
754	D-14-13 35CCC		320950110593501	02/20/48	46	2378
755			320950110593501	03/19/48	47	2377
756			320950110593501	06/18/48	52	2372
757			320950110593501	10/11/48	54	2371
758			320950110593501	02/07/49	46	2378
759			320950110593501	06/27/49	56	2368
760			320950110593501	10/13/49	55	2369
761			320950110593501	02/23/51	51	2373
762			320950110593501	01/21/52	56	2368
763			320950110593501	02/05/52	54	2370
764			320950110593501	02/09/54	58	2366
765			320950110593501	02/07/55	54	2370
766			320950110593501	02/10/56	47	2377
767			320950110593501	02/11/57	53	2371
768			320950110593501	01/29/58	55	2369
769			320950110593501	02/02/59	55	2369
770			320950110593501	01/29/60	57	2367
771			320950110593501	01/30/61	60	2365
772			320950110593501	01/25/62	62	2362
773			320950110593501	02/04/63	65	2359
774			320950110593501	01/27/64	70	2354
775			320950110593501	02/02/65	68	2356
776			320950110593501	02/02/68	56	2368
777			320950110593501	02/09/70	82	2342
778			320950110593501	02/19/71	81	2343
779			320950110593501	02/01/72	85	2340
780			320950110593501	01/24/73	88	2336
781			320950110593501	01/15/74	86	2338
782			320950110593501	02/18/76	110	2314

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
783			320950110593501	02/01/77	116	2308
784			320950110593501	02/01/78	130	2295
785			320950110593501	02/01/79	127	2297
786			320950110593501	09/30/81	134	2290
787	D-14-13 35CDB	55-619915	320957110591801	09/15/31	32	2393
788		55-619915	320957110591801	11/16/31	31	2394
789		55-619915	320957110591801	12/15/31	29	2396
790		55-619915	320957110591801	01/16/32	29	2396
791		55-619915	320957110591801	02/15/32	29	2396
792		55-619915	320957110591801	05/01/32	30	2395
793		55-619915	320957110591801	06/01/32	32	2393
794		55-619915	320957110591801	07/01/32	31	2394
795		55-619915	320957110591801	08/01/32	30	2395
796		55-619915	320957110591801	09/01/32	32	2393
797		55-619915	320957110591801	10/01/32	32	2393
798		55-619915	320957110591801	11/01/32	31	2394
799		55-619915	320957110591801	05/01/33	31	2394
800		55-619915	320957110591801	07/01/33	32	2394
801		55-619915	320957110591801	01/01/34	30	2395
802		55-619915	320957110591801	04/01/34	31	2394
803		55-619915	320957110591801	07/01/34	35	2390
804		55-619915	320957110591801	10/01/34	34	2391
805		55-619915	320957110591801	02/01/35	32	2393
806		55-619915	320957110591801	03/01/35	31	2394
807		55-619915	320957110591801	04/01/35	33	2392
808		55-619915	320957110591801	06/01/35	34	2391
809		55-619915	320957110591801	04/01/36	32	2393
810		55-619915	320957110591801	07/17/36	35	2390
811		55-619915	320957110591801	02/24/37	32	2393
812		55-619915	320957110591801	04/23/37	34	2391
813		55-619915	320957110591801	07/15/37	35	2390
814		55-619915	320957110591801	08/19/37	35	2390
815		55-619915	320957110591801	09/16/37	37	2388
816		55-619915	320957110591801	10/13/37	35	2390

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
817		55-619915	320957110591801	11/17/37	35	2390
818		55-619915	320957110591801	12/21/37	34	2391
819		55-619915	320957110591801	01/18/38	35	2391
820		55-619915	320957110591801	02/17/38	34	2391
821		55-619915	320957110591801	03/16/38	34	2391
822		55-619915	320957110591801	04/14/38	34	2391
823		55-619915	320957110591801	05/16/38	36	2389
824		55-619915	320957110591801	03/01/40	34	2391
825		55-619915	320957110591801	10/01/40	37	2388
826		55-619915	320957110591801	01/01/41	34	2391
827		55-619915	320957110591801	10/13/49	58	2367
828		55-619915	320957110591801	02/09/50	54	2371
829		55-619915	320957110591801	02/05/52	57	2368
830		55-619915	320957110591801	02/09/54	63	2362
831		55-619915	320957110591801	02/10/55	56	2369
832		55-619915	320957110591801	02/15/56	50	2375
833		55-619915	320957110591801	02/07/57	56	2369
834		55-619915	320957110591801	01/28/58	58	2367
835		55-619915	320957110591801	01/30/59	58	2367
836		55-619915	320957110591801	01/01/60	59	2366
837		55-619915	320957110591801	01/27/61	63	2362
838		55-619915	320957110591801	01/24/62	65	2360
839		55-619915	320957110591801	01/28/63	68	2357
840		55-619915	320957110591801	01/27/64	73	2352
841		55-619915	320957110591801	02/02/65	71	2354
842		55-619915	320957110591801	06/09/65	76	2349
843		55-619915	320957110591801	08/13/65	79	2346
844		55-619915	320957110591801	09/27/65	79	2346
845		55-619915	320957110591801	10/15/65	79	2346
846		55-619915	320957110591801	12/15/65	76	2350
847		55-619915	320957110591801	01/15/66	72	2353
848		55-619915	320957110591801	03/04/66	69	2356
849		55-619915	320957110591801	03/17/66	70	2355
850		55-619915	320957110591801	01/05/67	70	2355

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
851		55-619915	320957110591801	02/01/67	69	2356
852		55-619915	320957110591801	07/20/67	77	2348
853		55-619915	320957110591801	08/28/67	76	2349
854		55-619915	320957110591801	09/01/67	78	2347
855		55-619915	320957110591801	10/25/67	79	2346
856		55-619915	320957110591801	02/02/68	76	2349
857		55-619915	320957110591801	02/14/69	76	2349
858		55-619915	320957110591801	04/23/70	84	2341
859		55-619915	320957110591801	01/05/82	135	2290
860		55-619915	320957110591801	12/01/82	141	2284
861		55-619915	320957110591801	01/09/84	127	2298
862		55-619915	320957110591801	01/08/85	111	2314
863		55-619915	320957110591801	12/30/85	111	2314
864		55-619915	320957110591801	01/02/87	110	2315
865		55-619915	320957110591801	12/30/87	115	2310
866		55-619915	320957110591801	01/09/89	124	2301
867		55-619915	320957110591801	12/28/90	131	2294
868		55-619915	320957110591801	12/23/91	135	2290
869		55-619915	320957110591801	12/16/03	139	2286
870	D-14-13 35CDC1	55-619914	320947110591801	03/16/31	31	2394
871		55-619914	320947110591801	04/15/31	32	2393
872		55-619914	320947110591801	05/15/31	32	2393
873		55-619914	320947110591801	06/16/31	34	2391
874		55-619914	320947110591801	07/15/31	34	2391
875		55-619914	320947110591801	08/17/31	31	2394
876		55-619914	320947110591801	09/15/31	31	2394
877		55-619914	320947110591801	10/15/31	31	2394
878		55-619914	320947110591801	11/16/31	30	2395
879		55-619914	320947110591801	12/15/31	28	2397
880		55-619914	320947110591801	01/16/32	28	2397
881		55-619914	320947110591801	02/15/32	28	2397
882		55-619914	320947110591801	03/15/32	28	2397
883		55-619914	320947110591801	04/01/32	29	2396
884		55-619914	320947110591801	05/01/32	29	2396

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
885		55-619914	320947110591801	06/01/32	31	2394
886		55-619914	320947110591801	07/01/32	31	2394
887		55-619914	320947110591801	08/01/32	30	2395
888		55-619914	320947110591801	09/01/32	31	2394
889		55-619914	320947110591801	10/01/32	32	2393
890		55-619914	320947110591801	11/01/32	31	2394
891		55-619914	320947110591801	12/01/32	30	2395
892		55-619914	320947110591801	02/01/33	29	2396
893		55-619914	320947110591801	03/01/33	30	2395
894		55-619914	320947110591801	04/01/33	30	2395
895		55-619914	320947110591801	05/01/33	30	2395
896		55-619914	320947110591801	06/01/33	31	2394
897		55-619914	320947110591801	07/01/33	31	2394
898		55-619914	320947110591801	11/01/33	31	2394
899		55-619914	320947110591801	12/01/33	31	2394
900		55-619914	320947110591801	01/01/34	30	2395
901		55-619914	320947110591801	02/01/34	30	2395
902		55-619914	320947110591801	03/01/34	31	2394
903		55-619914	320947110591801	04/01/34	31	2394
904		55-619914	320947110591801	05/01/34	32	2393
905		55-619914	320947110591801	06/01/34	33	2392
906		55-619914	320947110591801	07/01/34	34	2391
907		55-619914	320947110591801	08/01/34	34	2392
908		55-619914	320947110591801	10/01/34	34	2391
909		55-619914	320947110591801	11/01/34	34	2391
910		55-619914	320947110591801	12/01/34	32	2393
911		55-619914	320947110591801	02/01/35	31	2394
912		55-619914	320947110591801	03/01/35	31	2394
913		55-619914	320947110591801	04/01/35	33	2392
914		55-619914	320947110591801	06/01/35	34	2392
915		55-619914	320947110591801	09/01/35	33	2392
916		55-619914	320947110591801	10/01/35	33	2392
917		55-619914	320947110591801	12/01/35	31	2394
918		55-619914	320947110591801	01/21/36	31	2394

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
919		55-619914	320947110591801	04/01/36	31	2394
920		55-619914	320947110591801	07/17/36	34	2391
921		55-619914	320947110591801	01/12/37	32	2393
922		55-619914	320947110591801	02/24/37	32	2393
923		55-619914	320947110591801	04/23/37	33	2392
924		55-619914	320947110591801	06/10/37	34	2391
925		55-619914	320947110591801	07/15/37	34	2391
926		55-619914	320947110591801	08/19/37	35	2390
927		55-619914	320947110591801	10/13/37	35	2390
928		55-619914	320947110591801	11/17/37	34	2391
929		55-619914	320947110591801	12/21/37	33	2392
930		55-619914	320947110591801	01/18/38	33	2392
931		55-619914	320947110591801	02/17/38	31	2394
932		55-619914	320947110591801	04/14/38	32	2393
933		55-619914	320947110591801	06/16/38	37	2388
934		55-619914	320947110591801	10/01/38	36	2389
935		55-619914	320947110591801	11/01/38	36	2389
936		55-619914	320947110591801	01/01/39	40	2385
937		55-619914	320947110591801	03/01/40	33	2392
938		55-619914	320947110591801	06/25/46	51	2374
939		55-619914	320947110591801	02/28/47	46	2379
940		55-619914	320947110591801	10/28/47	50	2375
941		55-619914	320947110591801	02/23/48	48	2377
942		55-619914	320947110591801	06/18/48	56	2369
943		55-619914	320947110591801	10/14/48	55	2370
944		55-619914	320947110591801	02/10/49	49	2376
945		55-619914	320947110591801	06/29/49	58	2367
946		55-619914	320947110591801	10/13/49	57	2368
947		55-619914	320947110591801	02/09/50	54	2371
948		55-619914	320947110591801	11/06/50	58	2367
949		55-619914	320947110591801	02/23/51	54	2371
950		55-619914	320947110591801	07/13/51	65	2360
951		55-619914	320947110591801	02/05/52	56	2369
952		55-619914	320947110591801	02/06/53	61	2364

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
953		55-619914	320947110591801	02/08/54	60	2365
954		55-619914	320947110591801	12/30/96	167	2259
955		55-619914	320947110591801	02/10/98	172	2253
956		55-619914	320947110591801	12/24/98	177	2248
957		55-619914	320947110591801	12/29/99	180	2245
958	D-14-13 35DAD	55-620146	321000110584901	12/28/81	160	2292
959		55-620146	321000110584901	12/01/82	166	2285
960		55-620146	321000110584901	01/06/84	152	2299
961		55-620146	321000110584901	01/07/85	138	2313
962		55-620146	321000110584901	07/09/85	146	2305
963		55-620146	321000110584901	10/10/85	149	2302
964		55-620146	321000110584901	12/30/85	136	2315
965		55-620146	321000110584901	02/20/86	140	2311
966		55-620146	321000110584901	05/20/86	142	2309
967		55-620146	321000110584901	08/26/86	147	2304
968		55-620146	321000110584901	11/17/86	146	2305
969		55-620146	321000110584901	01/02/87	136	2315
970		55-620146	321000110584901	02/23/87	142	2309
971		55-620146	321000110584901	05/26/87	145	2306
972		55-620146	321000110584901	12/23/87	142	2309
973		55-620146	321000110584901	01/09/89	150	2301
974		55-620146	321000110584901	12/23/91	161	2290
975		55-620146	321000110584901	01/21/94	164	2287
976		55-620146	321000110584901	01/10/95	172	2279
977		55-620146	321000110584901	12/19/96	187	2264
978		55-620146	321000110584901	02/10/98	206	2245
979		55-620146	321000110584901	01/19/99	209	2242
980		55-620146	321000110584901	12/29/99	207	2244
981	D-14-13 35DCB	55-619924	320958110590201	01/05/82	152	2283
982		55-619924	320958110590201	12/01/82	158	2277
983		55-619924	320958110590201	01/09/84	144	2291
984		55-619924	320958110590201	01/07/85	130	2305
985		55-619924	320958110590201	10/10/85	142	2293
986		55-619924	320958110590201	12/30/85	128	2307

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
987		55-619924	320958110590201	05/20/86	136	2299
988		55-619924	320958110590201	11/17/86	139	2296
989		55-619924	320958110590201	01/02/87	127	2308
990		55-619924	320958110590201	12/30/87	133	2302
991		55-619924	320958110590201	01/09/89	142	2293
992		55-619924	320958110590201	12/28/90	149	2286
993		55-619924	320958110590201	12/23/91	152	2283
994		55-619924	320958110590201	01/21/94	155	2280
995		55-619924	320958110590201	01/10/95	163	2272
996		55-619924	320958110590201	12/19/96	187	2248
997		55-619924	320958110590201	02/10/98	194	2241
998		55-619924	320958110590201	01/19/99	198	2237
999		55-619924	320958110590201	12/29/99	198	2237
1000	D-14-13 35DDA	55-533858	320954110584201	04/27/98	230	2224
1001		55-533858	320954110584201	11/10/98	201	2252
1002		55-533858	320954110584201	12/27/99	208	2245
1003	D-14-13 35DDB1	55-533856	320957110585101	11/09/98	200	2248
1004		55-533856	320957110585101	12/27/99	203	2245
1005	D-14-13 35DDB2	55-533857	320956110584901	04/24/98	228	2220
1006		55-533857	320956110584901	05/08/98	223	2225
1007		55-533857	320956110584901	11/09/98	200	2248
1008		55-533857	320956110584901	12/27/99	204	2244
1009	D-15-13 11AAB	55-507256	320853110584601	07/10/85	151	2329
1010		55-507256	320853110584601	07/10/85	168	2312
1011		55-507256	320853110584601	10/09/85	151	2329
1012		55-507256	320853110584601	02/18/86	146	2334
1013		55-507256	320853110584601	02/18/86	164	2316
1014		55-507256	320853110584601	05/19/86	146	2334
1015		55-507256	320853110584601	05/19/86	163	2318
1016		55-507256	320853110584601	08/26/86	150	2330
1017		55-507256	320853110584601	08/26/86	166	2314
1018		55-507256	320853110584601	11/19/86	149	2331
1019		55-507256	320853110584601	11/19/86	166	2314
1020		55-507256	320853110584601	12/23/86	148	2333

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1021		55-507256	320853110584601	02/24/87	146	2334
1022		55-507256	320853110584601	02/24/87	164	2316
1023		55-507256	320853110584601	05/26/87	147	2333
1024		55-507256	320853110584601	05/26/87	165	2315
1025		55-507256	320853110584601	11/17/87	152	2328
1026		55-507256	320853110584601	11/17/87	169	2311
1027		55-507256	320853110584601	12/21/87	153	2327
1028		55-507256	320853110584601	03/01/88	142	2338
1029		55-507256	320853110584601	03/01/88	170	2310
1030		55-507256	320853110584601	03/01/88	170	2310
1031		55-507256	320853110584601	03/01/88	142	2338
1032		55-507256	320853110584601	05/25/88	155	2325
1033		55-507256	320853110584601	05/25/88	172	2308
1034		55-507256	320853110584601	08/10/88	158	2322
1035		55-507256	320853110584601	08/10/88	176	2304
1036		55-507256	320853110584601	10/19/88	159	2321
1037		55-507256	320853110584601	10/19/88	176	2304
1038		55-507256	320853110584601	01/23/89	159	2321
1039		55-507256	320853110584601	01/23/89	178	2302
1040		55-507256	320853110584601	04/24/89	162	2318
1041		55-507256	320853110584601	04/24/89	177	2303
1042		55-507256	320853110584601	02/25/92	172	2308
1043		55-507256	320853110584601	02/01/94	174	2306
1044		55-507256	320853110584601	01/30/95	177	2303
1045	D-15-13 11AAD1	55-505575	320846110583801	10/09/85	152	2329
1046		55-505575	320846110583801	10/09/85	156	2325
1047		55-505575	320846110583801	05/21/86	149	2332
1048		55-505575	320846110583801	05/21/86	152	2329
1049		55-505575	320846110583801	11/18/86	151	2330
1050		55-505575	320846110583801	11/18/86	154	2327
1051		55-505575	320846110583801	12/23/86	150	2332
1052		55-505575	320846110583801	11/16/87	156	2326
1053		55-505575	320846110583801	11/16/87	159	2322
1054		55-505575	320846110583801	12/21/87	155	2326

11/08/01

Arizona Department of Water Resources
GWSI Water Level Measurements

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1055		55-505575	320846110583801	05/23/88	160	2322
1056		55-505575	320846110583801	05/23/88	163	2319
1057		55-505575	320846110583801	10/17/88	164	2317
1058		55-505575	320846110583801	10/17/88	167	2315
1059		55-505575	320846110583801	02/25/92	174	2307
1060		55-505575	320846110583801	02/01/94	171	2310
1061		55-505575	320846110583801	01/10/95	180	2302
1062		55-505575	320846110583801	12/30/96	196	2285
1063		55-505575	320846110583801	02/25/97	196	2285
1064		55-505575	320846110583801	12/24/97	202	2280
1065		55-505575	320846110583801	12/27/99	211	2271
1066	D-15-13 11AAD2	55-505576	320845110583801	07/11/85	100	2382
1067		55-505576	320845110583801	07/11/85	118	2365
1068		55-505576	320845110583801	10/09/85	99	2383
1069		55-505576	320845110583801	10/09/85	117	2366
1070		55-505576	320845110583801	02/19/86	99	2383
1071		55-505576	320845110583801	02/19/86	120	2362
1072		55-505576	320845110583801	05/21/86	100	2382
1073		55-505576	320845110583801	05/21/86	118	2364
1074		55-505576	320845110583801	08/27/86	100	2382
1075		55-505576	320845110583801	08/27/86	118	2364
1076		55-505576	320845110583801	11/18/86	100	2382
1077		55-505576	320845110583801	11/18/86	118	2364
1078		55-505576	320845110583801	12/23/86	99	2383
1079		55-505576	320845110583801	02/24/87	99	2383
1080		55-505576	320845110583801	02/24/87	117	2366
1081		55-505576	320845110583801	05/24/87	118	2364
1082		55-505576	320845110583801	05/25/87	101	2381
1083		55-505576	320845110583801	11/16/87	101	2381
1084		55-505576	320845110583801	11/16/87	118	2364
1085		55-505576	320845110583801	12/21/87	100	2382
1086		55-505576	320845110583801	03/01/88	102	2381
1087		55-505576	320845110583801	03/01/88	118	2364
1088		55-505576	320845110583801	03/01/88	119	2364

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1089		55-505576	320845110583801	03/01/88	102	2381
1090		55-505576	320845110583801	05/23/88	102	2381
1091		55-505576	320845110583801	05/23/88	119	2364
1092		55-505576	320845110583801	08/10/88	102	2380
1093		55-505576	320845110583801	08/10/88	118	2364
1094		55-505576	320845110583801	10/17/88	102	2380
1095		55-505576	320845110583801	10/17/88	118	2364
1096		55-505576	320845110583801	01/23/89	102	2380
1097		55-505576	320845110583801	01/23/89	118	2364
1098		55-505576	320845110583801	04/24/89	103	2379
1099		55-505576	320845110583801	04/24/89	119	2363
1100		55-505576	320845110583801	02/25/92	101	2381
1101		55-505576	320845110583801	02/01/94	100	2383
1102		55-505576	320845110583801	01/10/95	105	2377
1103		55-505576	320845110583801	12/30/96	115	2367
1104		55-505576	320845110583801	02/25/97	114	2368
1105		55-505576	320845110583801	12/24/97	115	2368
1106		55-505576	320845110583801	12/27/99	106	2376
1107	D-15-13 11ADB	55-620160	320837110585001	02/05/59	64	2417
1108		55-620160	320837110585001	02/08/60	65	2415
1109		55-620160	320837110585001	02/02/61	65	2415
1110		55-620160	320837110585001	02/01/62	98	2382
1111		55-620160	320837110585001	02/13/63	104	2376
1112		55-620160	320837110585001	02/06/64	111	2369
1113		55-620160	320837110585001	02/05/65	109	2371
1114		55-620160	320837110585001	04/25/66	109	2371
1115		55-620160	320837110585001	11/02/66	110	2370
1116		55-620160	320837110585001	01/26/67	110	2371
1117		55-620160	320837110585001	11/01/67	117	2363
1118		55-620160	320837110585001	11/01/68	119	2361
1119		55-620160	320837110585001	12/28/81	147	2333
1120		55-620160	320837110585001	12/01/82	140	2340
1121		55-620160	320837110585001	01/05/84	149	2331
1122		55-620160	320837110585001	01/04/85	157	2323

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1123		55-620160	320837110585001	01/10/86	102	2378
1124		55-620160	320837110585001	12/31/87	142	2338
1125		55-620160	320837110585001	01/17/89	147	2334
1126		55-620160	320837110585001	01/08/91	139	2341
1127		55-620160	320837110585001	02/28/92	138	2342
1128		55-620160	320837110585001	12/17/93	113	2367
1129		55-620160	320837110585001	02/01/95	127	2353
1130		55-620160	320837110585001	12/19/96	122	2358
1131		55-620160	320837110585001	02/11/98	123	2357
1132		55-620160	320837110585001	12/23/98	124	2356
1133		55-620160	320837110585001	12/28/99	114	2366
1134	D-15-13 11ADC	55-801435	320828110585201	12/22/81	101	2384
1135		55-801435	320828110585201	01/05/84	93	2392
1136		55-801435	320828110585201	12/01/87	94	2391
1137		55-801435	320828110585201	01/17/95	97	2388
1138		55-801435	320828110585201	02/28/00	89	2397
1139	D-15-13 11BAA	55-807326	320850110591201	05/01/62	65	2400
1140	D-15-13 11CBA	55-619918	320824110593001	07/15/31	37	2421
1141		55-619918	320824110593001	09/15/31	33	2425
1142		55-619918	320824110593001	11/16/31	33	2425
1143		55-619918	320824110593001	12/15/31	31	2426
1144		55-619918	320824110593001	01/16/32	31	2426
1145		55-619918	320824110593001	02/15/32	31	2427
1146		55-619918	320824110593001	03/15/32	31	2427
1147		55-619918	320824110593001	05/01/32	32	2426
1148		55-619918	320824110593001	06/01/32	32	2425
1149		55-619918	320824110593001	08/01/32	33	2424
1150		55-619918	320824110593001	10/01/32	34	2424
1151		55-619918	320824110593001	11/01/32	34	2424
1152		55-619918	320824110593001	12/01/32	34	2424
1153		55-619918	320824110593001	02/01/33	33	2425
1154		55-619918	320824110593001	03/01/33	33	2424
1155		55-619918	320824110593001	04/01/33	34	2424
1156		55-619918	320824110593001	05/01/33	34	2424

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1157		55-619918	320824110593001	11/01/33	34	2423
1158		55-619918	320824110593001	12/01/33	34	2424
1159		55-619918	320824110593001	01/01/34	34	2424
1160		55-619918	320824110593001	02/01/34	34	2424
1161		55-619918	320824110593001	03/01/34	34	2424
1162		55-619918	320824110593001	05/01/34	35	2422
1163		55-619918	320824110593001	07/01/34	36	2421
1164		55-619918	320824110593001	08/01/34	36	2422
1165		55-619918	320824110593001	10/01/34	36	2422
1166		55-619918	320824110593001	11/01/34	36	2421
1167		55-619918	320824110593001	12/01/34	36	2422
1168		55-619918	320824110593001	01/01/35	35	2423
1169		55-619918	320824110593001	02/01/35	34	2423
1170		55-619918	320824110593001	03/01/35	34	2423
1171		55-619918	320824110593001	04/01/35	35	2423
1172		55-619918	320824110593001	08/01/35	36	2422
1173		55-619918	320824110593001	12/01/35	36	2422
1174		55-619918	320824110593001	01/21/36	36	2422
1175		55-619918	320824110593001	01/01/37	35	2423
1176		55-619918	320824110593001	02/24/37	34	2423
1177		55-619918	320824110593001	04/23/37	34	2423
1178		55-619918	320824110593001	07/15/37	37	2420
1179		55-619918	320824110593001	08/19/37	38	2419
1180		55-619918	320824110593001	09/16/37	38	2419
1181		55-619918	320824110593001	10/13/37	37	2421
1182		55-619918	320824110593001	11/17/37	37	2421
1183		55-619918	320824110593001	12/21/37	36	2421
1184		55-619918	320824110593001	01/18/38	36	2421
1185		55-619918	320824110593001	02/17/38	36	2422
1186		55-619918	320824110593001	03/16/38	36	2422
1187		55-619918	320824110593001	04/14/38	37	2421
1188		55-619918	320824110593001	05/16/38	40	2418
1189		55-619918	320824110593001	06/16/38	38	2419
1190		55-619918	320824110593001	08/18/38	38	2420

Arizona Department of Water Resources
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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1191		55-619918	320824110593001	10/01/38	39	2419
1192		55-619918	320824110593001	11/01/38	38	2420
1193		55-619918	320824110593001	12/01/38	37	2420
1194		55-619918	320824110593001	01/01/39	37	2421
1195		55-619918	320824110593001	02/01/39	36	2421
1196		55-619918	320824110593001	04/01/39	37	2420
1197		55-619918	320824110593001	05/01/39	38	2419
1198		55-619918	320824110593001	07/01/39	39	2419
1199		55-619918	320824110593001	08/01/39	36	2421
1200		55-619918	320824110593001	11/01/39	37	2420
1201		55-619918	320824110593001	01/01/40	35	2422
1202		55-619918	320824110593001	02/01/40	36	2421
1203		55-619918	320824110593001	03/01/40	39	2419
1204		55-619918	320824110593001	10/01/40	40	2417
1205		55-619918	320824110593001	06/25/46	46	2412
1206		55-619918	320824110593001	02/26/47	44	2413
1207		55-619918	320824110593001	06/12/47	47	2411
1208		55-619918	320824110593001	10/28/47	47	2411
1209		55-619918	320824110593001	02/23/48	46	2411
1210		55-619918	320824110593001	06/26/48	49	2408
1211		55-619918	320824110593001	10/15/48	49	2409
1212		55-619918	320824110593001	02/07/49	48	2409
1213		55-619918	320824110593001	06/29/49	53	2405
1214		55-619918	320824110593001	10/13/49	52	2405
1215		55-619918	320824110593001	02/09/50	50	2407
1216		55-619918	320824110593001	11/07/50	52	2405
1217		55-619918	320824110593001	02/26/51	52	2406
1218		55-619918	320824110593001	07/13/51	59	2398
1219		55-619918	320824110593001	02/08/52	54	2404
1220		55-619918	320824110593001	02/09/53	58	2399
1221		55-619918	320824110593001	02/09/54	62	2395
1222		55-619918	320824110593001	02/14/55	59	2399
1223		55-619918	320824110593001	02/13/56	51	2406
1224		55-619918	320824110593001	02/09/57	62	2395

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1225		55-619918	320824110593001	01/29/58	61	2397
1226		55-619918	320824110593001	02/02/59	63	2394
1227		55-619918	320824110593001	02/01/60	65	2393
1228		55-619918	320824110593001	01/30/61	70	2388
1229		55-619918	320824110593001	01/30/62	72	2386
1230		55-619918	320824110593001	01/28/63	77	2380
1231		55-619918	320824110593001	01/29/64	83	2374
1232		55-619918	320824110593001	02/05/65	83	2375
1233		55-619918	320824110593001	06/11/65	86	2371
1234		55-619918	320824110593001	08/06/65	88	2369
1235		55-619918	320824110593001	09/27/65	89	2369
1236		55-619918	320824110593001	10/15/65	90	2367
1237		55-619918	320824110593001	12/15/65	88	2370
1238		55-619918	320824110593001	01/15/66	85	2372
1239		55-619918	320824110593001	03/17/66	82	2376
1240		55-619918	320824110593001	04/19/66	84	2374
1241		55-619918	320824110593001	01/01/67	81	2377
1242		55-619918	320824110593001	02/01/67	79	2378
1243		55-619918	320824110593001	03/01/67	81	2376
1244		55-619918	320824110593001	10/25/67	89	2368
1245		55-619918	320824110593001	01/22/68	84	2374
1246		55-619918	320824110593001	02/21/68	83	2374
1247		55-619918	320824110593001	03/22/68	84	2374
1248		55-619918	320824110593001	04/22/68	85	2373
1249		55-619918	320824110593001	05/22/68	85	2372
1250		55-619918	320824110593001	06/20/68	87	2370
1251		55-619918	320824110593001	07/19/68	90	2368
1252		55-619918	320824110593001	08/22/68	89	2368
1253		55-619918	320824110593001	09/23/68	90	2367
1254		55-619918	320824110593001	10/23/68	89	2368
1255		55-619918	320824110593001	11/21/68	88	2369
1256		55-619918	320824110593001	12/24/68	88	2370
1257		55-619918	320824110593001	01/24/69	87	2370
1258		55-619918	320824110593001	02/26/69	88	2369

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1259		55-619918	320824110593001	03/25/69	92	2366
1260		55-619918	320824110593001	04/25/69	92	2366
1261		55-619918	320824110593001	05/23/69	93	2364
1262		55-619918	320824110593001	06/25/69	95	2362
1263		55-619918	320824110593001	07/24/69	97	2361
1264		55-619918	320824110593001	08/22/69	97	2360
1265		55-619918	320824110593001	09/23/69	98	2359
1266		55-619918	320824110593001	10/24/69	98	2360
1267		55-619918	320824110593001	11/25/69	96	2362
1268		55-619918	320824110593001	12/23/69	95	2363
1269		55-619918	320824110593001	01/23/70	94	2363
1270		55-619918	320824110593001	02/19/70	94	2364
1271		55-619918	320824110593001	03/20/70	94	2364
1272		55-619918	320824110593001	04/21/70	95	2362
1273		55-619918	320824110593001	05/25/70	97	2360
1274		55-619918	320824110593001	06/25/70	99	2359
1275		55-619918	320824110593001	07/27/70	99	2358
1276		55-619918	320824110593001	08/26/70	100	2357
1277		55-619918	320824110593001	09/24/70	100	2358
1278		55-619918	320824110593001	10/28/70	99	2358
1279		55-619918	320824110593001	11/24/70	99	2359
1280		55-619918	320824110593001	12/28/70	98	2359
1281		55-619918	320824110593001	01/26/71	97	2361
1282		55-619918	320824110593001	02/25/71	96	2361
1283		55-619918	320824110593001	03/25/71	97	2361
1284		55-619918	320824110593001	04/26/71	98	2359
1285		55-619918	320824110593001	05/24/71	100	2357
1286		55-619918	320824110593001	06/24/71	101	2356
1287		55-619918	320824110593001	07/26/71	103	2355
1288		55-619918	320824110593001	08/24/71	104	2354
1289		55-619918	320824110593001	09/27/71	102	2355
1290		55-619918	320824110593001	10/26/71	104	2354
1291		55-619918	320824110593001	11/23/71	101	2356
1292		55-619918	320824110593001	12/21/71	101	2357

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1293		55-619918	320824110593001	01/24/72	100	2358
1294		55-619918	320824110593001	02/22/72	100	2357
1295		55-619918	320824110593001	03/22/72	102	2356
1296		55-619918	320824110593001	04/27/72	104	2353
1297		55-619918	320824110593001	05/25/72	106	2352
1298		55-619918	320824110593001	06/27/72	107	2350
1299		55-619918	320824110593001	07/26/72	109	2348
1300		55-619918	320824110593001	08/25/72	110	2347
1301		55-619918	320824110593001	09/25/72	111	2346
1302		55-619918	320824110593001	10/26/72	111	2347
1303		55-619918	320824110593001	11/27/72	109	2348
1304		55-619918	320824110593001	12/21/72	109	2349
1305		55-619918	320824110593001	01/24/73	110	2348
1306		55-619918	320824110593001	02/27/73	110	2347
1307		55-619918	320824110593001	03/21/73	110	2348
1308		55-619918	320824110593001	04/26/73	110	2347
1309		55-619918	320824110593001	05/29/73	112	2345
1310		55-619918	320824110593001	06/25/73	113	2344
1311		55-619918	320824110593001	07/24/73	115	2342
1312		55-619918	320824110593001	08/28/73	118	2340
1313		55-619918	320824110593001	09/26/73	119	2338
1314		55-619918	320824110593001	10/25/73	120	2337
1315		55-619918	320824110593001	11/26/73	120	2337
1316		55-619918	320824110593001	12/20/73	120	2337
1317		55-619918	320824110593001	01/28/74	119	2338
1318		55-619918	320824110593001	02/25/74	119	2339
1319		55-619918	320824110593001	03/26/74	120	2338
1320		55-619918	320824110593001	04/26/74	122	2336
1321		55-619918	320824110593001	05/22/74	123	2334
1322		55-619918	320824110593001	07/24/74	128	2330
1323		55-619918	320824110593001	08/26/74	130	2328
1324		55-619918	320824110593001	09/26/74	131	2326
1325		55-619918	320824110593001	10/22/74	131	2327
1326		55-619918	320824110593001	11/26/74	131	2327

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1327		55-619918	320824110593001	12/23/74	129	2328
1328		55-619918	320824110593001	01/27/75	129	2329
1329		55-619918	320824110593001	02/24/75	129	2328
1330		55-619918	320824110593001	03/24/75	130	2327
1331		55-619918	320824110593001	04/22/75	132	2326
1332		55-619918	320824110593001	05/22/75	131	2327
1333		55-619918	320824110593001	06/23/75	134	2324
1334		55-619918	320824110593001	08/25/75	136	2321
1335		55-619918	320824110593001	09/25/75	137	2321
1336		55-619918	320824110593001	10/28/75	138	2320
1337		55-619918	320824110593001	11/24/75	138	2320
1338		55-619918	320824110593001	12/22/75	138	2320
1339		55-619918	320824110593001	01/27/76	137	2320
1340		55-619918	320824110593001	02/23/76	137	2320
1341		55-619918	320824110593001	03/25/76	138	2320
1342		55-619918	320824110593001	04/22/76	138	2320
1343		55-619918	320824110593001	05/26/76	138	2319
1344		55-619918	320824110593001	06/24/76	139	2318
1345		55-619918	320824110593001	07/26/76	141	2316
1346		55-619918	320824110593001	08/25/76	141	2316
1347		55-619918	320824110593001	09/22/76	142	2316
1348		55-619918	320824110593001	11/24/76	142	2316
1349		55-619918	320824110593001	12/23/76	141	2316
1350		55-619918	320824110593001	01/02/77	141	2316
1351		55-619918	320824110593001	01/25/77	140	2317
1352		55-619918	320824110593001	02/23/77	135	2322
1353		55-619918	320824110593001	03/28/77	139	2318
1354		55-619918	320824110593001	04/27/77	140	2318
1355		55-619918	320824110593001	05/25/77	142	2316
1356		55-619918	320824110593001	06/28/77	142	2315
1357		55-619918	320824110593001	07/28/77	143	2315
1358		55-619918	320824110593001	08/26/77	144	2314
1359		55-619918	320824110593001	09/23/77	144	2313
1360		55-619918	320824110593001	10/27/77	144	2313

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1361		55-619918	320824110593001	11/28/77	144	2314
1362		55-619918	320824110593001	12/21/77	144	2314
1363		55-619918	320824110593001	01/25/78	147	2311
1364		55-619918	320824110593001	02/23/78	144	2314
1365		55-619918	320824110593001	03/21/78	141	2316
1366		55-619918	320824110593001	04/21/78	146	2311
1367		55-619918	320824110593001	05/25/78	140	2317
1368		55-619918	320824110593001	06/23/78	141	2317
1369		55-619918	320824110593001	07/25/78	143	2315
1370		55-619918	320824110593001	08/28/78	144	2313
1371		55-619918	320824110593001	09/25/78	146	2312
1372		55-619918	320824110593001	10/26/78	146	2311
1373		55-619918	320824110593001	11/22/78	147	2310
1374		55-619918	320824110593001	12/26/78	148	2310
1375		55-619918	320824110593001	01/24/79	145	2312
1376		55-619918	320824110593001	02/22/79	140	2317
1377		55-619918	320824110593001	03/26/79	138	2319
1378		55-619918	320824110593001	04/23/79	138	2320
1379		55-619918	320824110593001	05/23/79	136	2321
1380		55-619918	320824110593001	06/25/79	139	2319
1381		55-619918	320824110593001	07/24/79	140	2318
1382		55-619918	320824110593001	08/24/79	141	2317
1383		55-619918	320824110593001	09/24/79	142	2315
1384		55-619918	320824110593001	10/23/79	154	2304
1385		55-619918	320824110593001	10/25/79	144	2314
1386		55-619918	320824110593001	11/21/79	143	2314
1387		55-619918	320824110593001	12/20/79	142	2315
1388		55-619918	320824110593001	01/24/80	141	2317
1389		55-619918	320824110593001	02/22/80	140	2317
1390		55-619918	320824110593001	03/25/80	139	2318
1391		55-619918	320824110593001	04/24/80	140	2318
1392		55-619918	320824110593001	05/25/80	140	2318
1393		55-619918	320824110593001	06/24/80	141	2317
1394		55-619918	320824110593001	07/25/80	142	2315

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1395		55-619918	320824110593001	08/26/80	144	2314
1396		55-619918	320824110593001	09/22/80	145	2313
1397		55-619918	320824110593001	10/24/80	148	2309
1398		55-619918	320824110593001	11/24/80	145	2313
1399		55-619918	320824110593001	12/23/80	144	2313
1400		55-619918	320824110593001	01/27/81	145	2312
1401		55-619918	320824110593001	02/24/81	143	2314
1402		55-619918	320824110593001	03/25/81	143	2314
1403		55-619918	320824110593001	04/24/81	144	2313
1404		55-619918	320824110593001	05/22/81	145	2313
1405		55-619918	320824110593001	06/25/81	148	2309
1406		55-619918	320824110593001	07/30/81	150	2308
1407		55-619918	320824110593001	08/27/81	150	2308
1408		55-619918	320824110593001	09/24/81	148	2309
1409		55-619918	320824110593001	10/27/81	151	2306
1410		55-619918	320824110593001	11/25/81	155	2303
1411		55-619918	320824110593001	12/28/81	155	2302
1412		55-619918	320824110593001	01/04/82	149	2308
1413		55-619918	320824110593001	01/28/82	152	2306
1414		55-619918	320824110593001	02/24/82	150	2307
1415		55-619918	320824110593001	03/29/82	151	2307
1416		55-619918	320824110593001	04/27/82	151	2306
1417		55-619918	320824110593001	12/30/83	146	2312
1418		55-619918	320824110593001	12/30/84	130	2328
1419		55-619918	320824110593001	01/13/86	124	2334
1420		55-619918	320824110593001	12/23/86	124	2334
1421		55-619918	320824110593001	12/30/87	128	2330
1422		55-619918	320824110593001	01/04/89	134	2323
1423		55-619918	320824110593001	01/09/91	141	2316
1424		55-619918	320824110593001	12/26/91	145	2313
1425		55-619918	320824110593001	12/16/93	146	2311
1426		55-619918	320824110593001	02/01/95	149	2308
1427		55-619918	320824110593001	12/19/96	162	2295
1428		55-619918	320824110593001	02/11/98	169	2289

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1429		55-619918	320824110593001	12/24/98	173	2285
1430		55-619918	320824110593001	12/28/99	177	2280
1431	D-15-13 11DDB1	55-619969	320815110585201	06/04/52	54	2436
1432		55-619969	320815110585201	02/09/53	56	2434
1433		55-619969	320815110585201	02/11/54	56	2434
1434		55-619969	320815110585201	02/10/55	55	2435
1435		55-619969	320815110585201	02/13/56	54	2436
1436		55-619969	320815110585201	02/15/57	55	2435
1437		55-619969	320815110585201	02/05/58	55	2435
1438		55-619969	320815110585201	02/05/59	57	2433
1439		55-619969	320815110585201	02/08/60	58	2432
1440		55-619969	320815110585201	02/02/61	59	2431
1441		55-619969	320815110585201	02/02/62	59	2431
1442		55-619969	320815110585201	02/05/63	60	2430
1443		55-619969	320815110585201	02/06/64	61	2429
1444		55-619969	320815110585201	02/05/65	61	2429
1445		55-619969	320815110585201	04/25/66	65	2425
1446		55-619969	320815110585201	11/02/66	62	2428
1447		55-619969	320815110585201	01/26/67	62	2428
1448		55-619969	320815110585201	11/01/67	62	2428
1449		55-619969	320815110585201	02/06/68	60	2430
1450		55-619969	320815110585201	12/22/81	67	2423
1451		55-619969	320815110585201	12/01/82	67	2423
1452		55-619969	320815110585201	01/05/84	65	2425
1453		55-619969	320815110585201	01/04/85	66	2424
1454		55-619969	320815110585201	01/09/86	54	2436
1455		55-619969	320815110585201	12/21/87	64	2426
1456		55-619969	320815110585201	01/08/91	65	2425
1457		55-619969	320815110585201	01/21/94	66	2424
1458		55-619969	320815110585201	02/01/95	65	2425
1459		55-619969	320815110585201	12/19/96	67	2423
1460		55-619969	320815110585201	02/11/98	67	2423
1461		55-619969	320815110585201	12/23/98	67	2423
1462		55-619969	320815110585201	12/28/99	68	2422

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1463	D-15-13 11DDB2	55-619970	320810110585001	02/10/55	65	2426
1464		55-619970	320810110585001	02/13/56	61	2430
1465		55-619970	320810110585001	02/07/57	61	2430
1466		55-619970	320810110585001	02/05/58	61	2430
1467		55-619970	320810110585001	02/05/59	59	2432
1468		55-619970	320810110585001	02/08/60	58	2433
1469		55-619970	320810110585001	02/02/61	94	2397
1470		55-619970	320810110585001	01/30/62	101	2391
1471		55-619970	320810110585001	02/05/63	107	2384
1472		55-619970	320810110585001	02/06/64	113	2378
1473		55-619970	320810110585001	02/05/65	113	2378
1474		55-619970	320810110585001	11/01/68	123	2368
1475		55-619970	320810110585001	11/01/69	124	2367
1476		55-619970	320810110585001	12/01/70	129	2362
1477		55-619970	320810110585001	01/17/72	130	2361
1478		55-619970	320810110585001	01/04/73	141	2350
1479		55-619970	320810110585001	12/26/73	146	2345
1480		55-619970	320810110585001	12/11/74	159	2332
1481		55-619970	320810110585001	12/01/76	168	2324
1482		55-619970	320810110585001	01/01/77	171	2320
1483		55-619970	320810110585001	12/22/81	172	2319
1484		55-619970	320810110585001	12/01/82	174	2317
1485		55-619970	320810110585001	01/04/85	157	2334
1486		55-619970	320810110585001	01/05/85	165	2326
1487		55-619970	320810110585001	01/09/86	146	2345
1488		55-619970	320810110585001	12/23/86	148	2343
1489		55-619970	320810110585001	12/21/87	152	2339
1490		55-619970	320810110585001	12/17/88	157	2334
1491		55-619970	320810110585001	01/08/91	157	2334
1492		55-619970	320810110585001	01/21/94	156	2335
1493		55-619970	320810110585001	02/01/95	156	2335
1494		55-619970	320810110585001	12/19/96	165	2326
1495		55-619970	320810110585001	02/11/98	168	2323
1496		55-619970	320810110585001	12/23/98	169	2322

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1497		55-610970	320810110565001	12/28/99	170	2321
1498	D-15-13 11DDC		320805110585001	06/16/72	144	2357
1499	D-15-13 14ACA		320746110585601	02/09/53	52	2438
1500			320746110585601	02/11/54	53	2437
1501			320746110585601	02/10/55	50	2440
1502			320746110585601	02/13/56	48	2442
1503			320746110585601	02/13/57	51	2439
1504			320746110585601	02/05/58	51	2439
1505			320746110585601	02/05/59	52	2438
1506			320746110585601	02/08/60	53	2437
1507			320746110585601	02/02/61	55	2435
1508			320746110585601	01/20/62	56	2434
1509			320746110585601	02/05/63	57	2433
1510			320746110585601	02/06/64	58	2432
1511			320746110585601	02/05/65	62	2428
1512			320746110585601	02/06/68	63	2427
1513			320746110585601	02/14/69	71	2419
1514			320746110585601	11/01/69	76	2414
1515			320746110585601	12/01/70	77	2413
1516	D-15-13 14BCC1	55-625411	320735110593701	12/23/81	114	2358
1517		55-625411	320735110593701	01/07/84	69	2403
1518	D-15-13 14BCC2	55-618545	320736110593701	12/01/87	134	2338
1519		55-618545	320736110593701	01/17/95	155	2317
1520	D-15-13 14CCC	55-618547	320716110593701	02/16/55	78	2409
1521		55-618547	320716110593701	02/01/56	65	2422
1522		55-618547	320716110593701	02/02/60	73	2414
1523		55-618547	320716110593701	02/01/62	84	2403
1524		55-618547	320716110593701	02/05/65	100	2387
1525		55-618547	320716110593701	11/01/67	104	2383
1526		55-618547	320716110593701	11/01/68	110	2377
1527		55-618547	320716110593701	11/01/69	114	2373
1528		55-618547	320716110593701	12/01/70	121	2366
1529		55-618547	320716110593701	11/15/76	131	2356
1530		55-618547	320716110593701	11/10/77	130	2357

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1531		55-618547	320716110593701	11/12/78	129	2358
1532		55-618547	320716110593701	11/15/79	132	2355
1533	D-15-13 14CCD	55-618546	320713110572801	03/18/55	76	2402
1534		55-618546	320713110572801	01/30/58	71	2407
1535		55-618546	320713110572801	02/02/59	79	2399
1536		55-618546	320713110572801	02/02/60	72	2406
1537		55-618546	320713110572801	02/02/61	87	2391
1538		55-618546	320713110572801	02/02/62	83	2395
1539		55-618546	320713110572801	01/30/63	92	2386
1540		55-618546	320713110572801	02/05/65	100	2378
1541	D-15-13 14CDD1	55-801510	320716110590801	12/22/81	186	2311
1542		55-801510	320716110590801	12/03/87	165	2332
1543		55-801510	320716110590801	01/19/95	162	2335
1544		55-801510	320716110590801	02/22/00	202	2295
1545	D-15-13 14CDD2	55-801178	320713110591201	12/22/81	50	2443
1546		55-801178	320713110591201	12/03/87	56	2437
1547		55-801178	320713110591201	01/19/95	42	2451
1548		55-801178	320713110591201	02/22/00	47	2446
1549	D-15-13 15AAB1		320757110595001	09/01/39	36	2432
1550			320757110595001	09/28/39	36	2432
1551			320757110595001	11/13/39	36	2432
1552			320757110595001	12/26/39	36	2432
1553			320757110595001	03/18/40	35	2433
1554			320757110595001	05/01/40	36	2432
1555			320757110595001	05/28/40	36	2432
1556			320757110595001	08/13/40	37	2431
1557			320757110595001	10/04/40	38	2430
1558			320757110595001	12/30/40	38	2430
1559			320757110595001	02/24/41	36	2432
1560			320757110595001	06/05/41	36	2432
1561			320757110595001	07/11/41	37	2431
1562			320757110595001	08/12/41	37	2431
1563			320757110595001	09/30/41	37	2431
1564			320757110595001	11/13/41	37	2431

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1565			320757110595001	12/29/41	36	2432
1566			320757110595001	03/06/42	36	2432
1567			320757110595001	08/24/42	38	2430
1568			320757110595001	12/23/42	38	2430
1569			320757110595001	04/15/43	38	2430
1570			320757110595001	11/10/43	39	2429
1571			320757110595001	12/16/43	39	2429
1572			320757110595001	01/14/44	39	2429
1573			320757110595001	07/18/44	42	2426
1574			320757110595001	02/12/45	40	2428
1575			320757110595001	07/27/45	42	2426
1576			320757110595001	10/12/45	41	2427
1577			320757110595001	12/06/45	41	2427
1578			320757110595001	03/01/46	40	2428
1579			320757110595001	05/09/46	41	2427
1580			320757110595001	06/17/46	41	2427
1581			320757110595001	07/23/46	42	2426
1582			320757110595001	08/30/46	41	2427
1583			320757110595001	10/11/46	42	2426
1584			320757110595001	12/02/46	40	2428
1585			320757110595001	12/24/46	42	2426
1586			320757110595001	02/14/47	43	2425
1587			320757110595001	03/31/47	43	2425
1588			320757110595001	04/29/47	43	2425
1589			320757110595001	07/14/47	44	2424
1590			320757110595001	08/28/47	44	2424
1591			320757110595001	09/26/47	44	2424
1592			320757110595001	10/28/47	43	2425
1593			320757110595001	01/07/48	44	2424
1594			320757110595001	05/21/48	46	2422
1595			320757110595001	07/28/48	45	2423
1596			320757110595001	08/24/48	45	2423
1597			320757110595001	09/30/48	44	2424
1598			320757110595001	10/25/48	44	2424

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1599			320757110595001	11/26/48	45	2423
1600			320757110595001	01/27/49	44	2424
1601	D-15-13 15ABC	55-625408	320751111000701	02/02/60	64	2411
1602		55-625408	320751111000701	02/02/62	76	2399
1603		55-625408	320751111000701	01/30/63	79	2396
1604		55-625408	320751111000701	01/31/64	86	2389
1605		55-625408	320751111000701	12/03/64	84	2391
1606		55-625408	320751111000701	01/15/65	84	2391
1607		55-625408	320751111000701	02/04/65	84	2391
1608		55-625408	320751111000701	11/01/67	96	2379
1609		55-625408	320751111000701	02/06/68	90	2385
1610	D-15-13 15BAB		320756111002001	07/05/72	148	2332
1611	D-15-13 15BBD		320749111002601	06/25/46	43	2432
1612	D-15-13 15BCD		320738111002901	05/05/64	93	2385
1613	D-15-13 15BDC		320738111002201	02/21/55	70	2405
1614			320738111002201	02/15/56	60	2415
1615			320738111002201	02/13/57	64	2411
1616			320738111002201	02/02/59	66	2409
1617			320738111002201	02/04/60	74	2401
1618			320738111002201	02/02/61	81	2394
1619			320738111002201	02/02/62	77	2398
1620			320738111002201	02/06/63	84	2391
1621			320738111002201	01/31/64	89	2386
1622	D-15-13 15CAC	55-620157	320726111002001	01/31/64	90	2390
1623		55-620157	320726111002001	05/01/70	129	2351
1624		55-620157	320726111002001	12/04/74	144	2336
1625		55-620157	320726111002001	12/01/75	158	2322
1626		55-620157	320726111002001	01/05/78	167	2313
1627		55-620157	320726111002001	02/02/78	164	2316
1628		55-620157	320726111002001	12/26/78	172	2308
1629		55-620157	320726111002001	03/05/79	165	2315
1630		55-620157	320726111002001	01/11/80	167	2314
1631		55-620157	320726111002001	12/22/80	174	2306
1632		55-620157	320726111002001	12/28/81	171	2309

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1633		55-620157	320726111002001	12/01/82	174	2306
1634		55-620157	320726111002001	01/09/84	158	2322
1635		55-620157	320726111002001	01/04/85	146	2334
1636		55-620157	320726111002001	01/10/86	132	2348
1637		55-620157	320726111002001	12/23/86	132	2348
1638		55-620157	320726111002001	12/23/87	134	2346
1639		55-620157	320726111002001	01/04/89	141	2339
1640		55-620157	320726111002001	01/08/91	151	2329
1641		55-620157	320726111002001	12/26/91	151	2329
1642		55-620157	320726111002001	12/16/93	156	2324
1643		55-620157	320726111002001	02/03/95	157	2323
1644		55-620157	320726111002001	12/20/96	165	2315
1645		55-620157	320726111002001	02/11/98	173	2307
1646		55-620157	320726111002001	01/21/99	179	2301
1647	D-15-13 15CCC1		320711111002801	02/01/52	52	2438
1648	D-15-13 15CCD2		320710111003301	02/01/52	42	2448
1649			320710111003301	02/12/54	65	2425
1650			320710111003301	02/11/55	62	2428
1651			320710111003301	02/15/56	53	2437
1652			320710111003301	02/13/57	59	2431
1653			320710111003301	01/30/58	60	2430
1654			320710111003301	02/02/59	62	2428
1655			320710111003301	02/04/60	62	2428
1656			320710111003301	02/02/61	70	2420
1657			320710111003301	02/02/62	70	2420
1658			320710111003301	02/05/63	76	2414
1659			320710111003301	01/31/64	81	2409
1660			320710111003301	09/01/65	86	2404
1661			320710111003301	02/06/68	86	2404
1662	D-15-13 15CDB		320719111002101	02/01/70	145	2341
1663	D-15-13 15CDC		320712111002201	09/05/39	32	2459
1664			320712111002201	09/23/39	32	2458
1665			320712111002201	11/13/39	32	2458
1666			320712111002201	12/26/39	32	2458

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1667			320712111002201	02/19/40	35	2455
1668			320712111002201	03/18/40	35	2455
1669			320712111002201	05/01/40	36	2454
1670	D-15-13 15DBB	55-625405	320732111003701	01/16/53	60	2415
1671		55-625405	320732111003701	02/09/53	62	2413
1672		55-625405	320732111003701	02/18/55	66	2409
1673		55-625405	320732111003701	02/15/56	57	2418
1674		55-625405	320732111003701	02/13/57	62	2413
1675		55-625405	320732111003701	01/30/58	67	2408
1676		55-625405	320732111003701	02/02/60	66	2409
1677		55-625405	320732111003701	02/02/62	76	2399
1678		55-625405	320732111003701	01/30/63	83	2392
1679		55-625405	320732111003701	01/31/64	91	2384
1680		55-625405	320732111003701	12/01/64	86	2389
1681		55-625405	320732111003701	02/06/68	95	2380
1682		55-625405	320732111003701	11/01/68	103	2372
1683		55-625405	320732111003701	11/01/69	113	2362
1684		55-625405	320732111003701	12/01/70	117	2358
1685		55-625405	320732111003701	12/01/75	133	2342
1686		55-625405	320732111003701	11/15/76	129	2346
1687		55-625405	320732111003701	11/10/77	129	2346
1688		55-625405	320732111003701	11/12/78	127	2348
1689		55-625405	320732111003701	11/15/79	131	2344
1690		55-625405	320732111003701	12/22/81	169	2307
1691		55-625405	320732111003701	01/07/84	157	2318
1692		55-625405	320732111003701	11/30/87	134	2341
1693		55-625405	320732111003701	01/18/95	156	2319
1694		55-625405	320732111003701	02/22/00	183	2292
1695	D-15-13 15DCB	55-618549	320720111000601	01/31/64	103	2381
1696		55-618549	320720111000601	02/20/78	157	2327
1697	D-15-13 15DCC	55-625404	320712111000601	10/28/47	48	2442
1698		55-625404	320712111000601	02/20/48	46	2444
1699		55-625404	320712111000601	02/09/49	133	2357
1700		55-625404	320712111000601	07/13/50	58	2432

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	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1701		55-625404	320712111000601	09/15/50	140	2350
1702		55-625404	320712111000601	01/21/52	52	2438
1703		55-625404	320712111000601	02/06/52	49	2441
1704		55-625404	320712111000601	01/14/53	55	2435
1705		55-625404	320712111000601	02/09/53	60	2430
1706		55-625404	320712111000601	01/04/55	65	2425
1707		55-625404	320712111000601	02/11/55	65	2425
1708		55-625404	320712111000601	01/04/56	57	2433
1709		55-625404	320712111000601	02/01/56	49	2441
1710		55-625404	320712111000601	02/13/57	63	2427
1711		55-625404	320712111000601	12/27/57	53	2437
1712		55-625404	320712111000601	01/30/58	66	2424
1713		55-625404	320712111000601	02/02/59	68	2422
1714		55-625404	320712111000601	02/03/59	59	2431
1715		55-625404	320712111000601	01/05/60	68	2422
1716		55-625404	320712111000601	02/02/60	64	2426
1717		55-625404	320712111000601	02/01/61	79	2411
1718		55-625404	320712111000601	02/02/61	83	2407
1719		55-625404	320712111000601	02/02/62	79	2411
1720		55-625404	320712111000601	02/21/62	74	2416
1721		55-625404	320712111000601	10/10/62	87	2403
1722		55-625404	320712111000601	01/30/63	87	2403
1723		55-625404	320712111000601	03/01/63	92	2398
1724		55-625404	320712111000601	01/31/64	05	2395
1725		55-625404	320712111000601	03/05/64	96	2394
1726		55-625404	320712111000601	01/14/65	93	2397
1727		55-625404	320712111000601	02/04/65	94	2306
1728		55-625404	320712111000601	01/10/66	89	2401
1729		55-625404	320712111000601	04/25/66	93	2397
1730		55-625404	320712111000601	11/01/66	91	2399
1731		55-625404	320712111000601	01/26/67	89	2402
1732		55-625404	320712111000601	03/23/67	95	2395
1733		55-625404	320712111000601	11/01/67	99	2391
1734		55-625404	320712111000601	02/01/68	100	2390

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1735		55-625404	320712111000601	11/01/69	111	2379
1736		55-625404	320712111000601	12/01/70	120	2370
1737		55-625404	320712111000601	11/15/76	129	2361
1738		55-625404	320712111000601	11/10/77	128	2362
1739		55-625404	320712111000601	11/12/78	127	2363
1740		55-625404	320712111000601	11/15/79	130	2360
1741	D-15-13 15DDC		320712110595001	04/14/31	47	2443
1742			320712110595001	05/14/31	48	2442
1743			320712110595001	06/17/31	47	2443
1744			320712110595001	07/16/31	48	2442
1745			320712110595001	08/22/31	47	2443
1746			320712110595001	09/11/31	46	2444
1747			320712110595001	10/15/31	46	2444
1748			320712110595001	12/21/31	45	2445
1749			320712110595001	01/29/32	45	2445
1750			320712110595001	02/26/32	45	2445
1751			320712110595001	03/12/32	45	2445
1752			320712110595001	04/01/32	45	2445
1753			320712110595001	05/01/32	45	2445
1754			320712110595001	06/01/32	46	2444
1755			320712110595001	08/01/32	46	2444
1756			320712110595001	09/01/32	46	2444
1757			320712110595001	10/01/32	46	2444
1758			320712110595001	11/01/32	46	2444
1759			320712110595001	12/01/32	47	2443
1760			320712110595001	01/01/33	46	2444
1761			320712110595001	02/01/33	46	2444
1762			320712110595001	03/01/33	46	2444
1763			320712110595001	04/01/33	46	2444
1764			320712110595001	06/01/33	47	2443
1765			320712110595001	07/01/33	47	2443
1766			320712110595001	01/01/34	47	2443
1767			320712110595001	04/01/34	47	2443
1768			320712110595001	05/01/34	47	2443

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1769			320712110595001	08/01/34	48	2442
1770			320712110595001	09/01/34	48	2442
1771			320712110595001	11/01/34	48	2442
1772			320712110595001	12/01/34	48	2442
1773			320712110595001	01/01/35	48	2442
1774			320712110595001	06/01/35	48	2442
1775			320712110595001	08/01/35	48	2442
1776			320712110595001	09/01/35	48	2442
1777			320712110595001	12/01/35	47	2443
1778			320712110595001	07/17/36	48	2442
1779			320712110595001	02/24/37	47	2443
1780			320712110595001	06/16/37	48	2442
1781			320712110595001	07/15/37	49	2441
1782			320712110595001	08/19/37	49	2441
1783			320712110595001	09/01/37	49	2441
1784			320712110595001	10/13/37	49	2441
1785			320712110595001	11/17/37	49	2441
1786			320712110595001	12/21/37	49	2441
1787			320712110595001	01/18/38	49	2441
1788			320712110595001	02/17/38	48	2442
1789			320712110595001	03/16/38	48	2442
1790			320712110595001	04/14/38	48	2442
1791			320712110595001	05/16/38	49	2441
1792			320712110595001	06/16/38	49	2441
1793			320712110595001	08/16/38	49	2441
1794			320712110595001	10/01/38	49	2441
1795			320712110595001	11/01/38	49	2441
1796			320712110595001	12/01/38	49	2441
1797			320712110595001	01/01/39	49	2441
1798			320712110595001	02/01/39	48	2442
1799			320712110595001	03/01/39	48	2442
1800			320712110595001	04/01/39	50	2440
1801			320712110595001	05/01/39	49	2441
1802			320712110595001	07/01/39	49	2441

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1803			320712110595001	08/01/39	49	2441
1804			320712110595001	09/05/39	48	2442
1805			320712110595001	11/13/39	48	2442
1806			320712110595001	12/26/39	48	2442
1807			320712110595001	02/19/40	48	2442
1808			320712110595001	03/18/40	48	2442
1809			320712110595001	05/01/40	48	2442
1810			320712110595001	06/01/40	49	2441
1811			320712110595001	07/01/40	49	2441
1812			320712110595001	08/31/40	49	2441
1813			320712110595001	10/04/40	49	2441
1814			320712110595001	11/04/40	49	2441
1815			320712110595001	12/30/40	48	2442
1816			320712110595001	01/01/41	49	2441
1817			320712110595001	02/24/41	48	2442
1818			320712110595001	03/25/41	48	2442
1819			320712110595001	04/28/41	48	2442
1820			320712110595001	06/16/41	49	2441
1821			320712110595001	07/11/41	49	2441
1822			320712110595001	08/14/41	49	2441
1823			320712110595001	09/30/41	49	2441
1824			320712110595001	11/13/41	49	2441
1825			320712110595001	12/29/41	48	2442
1826			320712110595001	02/26/42	49	2441
1827			320712110595001	10/20/42	50	2440
1828			320712110595001	03/31/43	50	2440
1829			320712110595001	10/26/43	51	2439
1830			320712110595001	03/21/44	50	2440
1831			320712110595001	06/27/44	52	2438
1832			320712110595001	10/13/44	51	2439
1833			320712110595001	03/10/45	51	2439
1834			320712110595001	06/19/45	53	2437
1835			320712110595001	03/07/46	52	2438
1836			320712110595001	02/09/49	117	2373

	Location	Registration No.	Well Site ID	Date Measured	Depth to Water	Water Level Elevation
1837			320712110595001	09/15/50	122	2368
1838			320712110595001	02/06/52	63	2427
1839			320712110595001	01/13/53	67	2424
1840			320712110595001	02/01/54	70	2420
1841			320712110595001	02/18/55	74	2416
1842			320712110595001	02/13/56	64	2426
1843			320712110595001	12/27/57	74	2416
1844			320712110595001	02/02/60	70	2420
1845			320712110595001	02/02/62	80	2410
1846			320712110595001	01/30/63	93	2397
1847			320712110595001	01/31/64	101	2389
1848		-	320712110595001	10/23/67	83	2407
1849			320712110595001	11/01/67	100	2390
1850			320712110595001	12/21/67	55	2435
1851			320712110595001	11/01/68	113	2377
1852			320712110595001	09/28/81		
1853	D-15-13 15DDD		320712110594401	12/01/64	91	2389
1854			320712110594401	09/28/81		
1855	D-15-16 18ADD		320735110442201	12/04/87	176	2726
1856			320735110442201	01/17/95	173	2728

APPENDIX D

Approximate Locations of Trash & Debris

LANDFILLS AND WASTE DISPOSAL SITES ALONG THE SANTA CRUZ RIVER FROM GRANT ROAD TO PIMA MINE ROAD

Prepared for

City of Tucson
Office of Environmental Management

July 1996

Pima Association of Governments

PIMA ASSOCIATION OF GOVERNMENTS

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July 1996

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EXECUTIVE SUMMARY

The purpose of this study was to determine the nature and extent of waste disposal along the Santa Cruz River in east-central Pima County. The study area encompassed the 100-year flood plain of the Santa Cruz River between Grant Road and Pima Mine Road. As part of this study, PAG staff identified several previously undocumented wildcat dumps in this area. In addition, PAG visited known landfills in, or adjacent to, the study area to briefly assess their surface conditions. Because of the scope of the project, no new research was conducted at the documented landfills.

The study consisted of the following tasks: flood plain delineation, aerial photograph and topographic map analysis, personal interviews, literature review, field reconnaissance, and report preparation. Historical and current aerial photographs were analyzed for evidence of disturbed or well-travelled land within the flood plain that could have been used for waste disposal. The topographic maps were studied to determine access routes and to locate excavated gravel pits that might have been filled in with solid waste.

Interviews were conducted to determine local knowledge about the areas of concern. PAG staff interviewed personnel from the University of Arizona Garbage Program, Pima County Solid Waste Management Department, Pima County Department of Environmental Quality, Pima County Department of Transportation, City of Tucson Office of Environmental Management (OEM), Arizona Department of Transportation-Environmental Planning Division, the U.S. Indian Health Service, and the Tohono O'odham Nation.

PAG identified 106 possible waste disposal sites through analysis of aerial photographs of the Santa Cruz River area. PAG visited 68 of these sites, but did not visit sites which were outside of the flood plain or inaccessible by road. Because the study area included tribal lands of the San Xavier District, on May 14, 1996, PAG and OEM staff received permission to conduct field work on tribal lands from the San Xavier District Council. An escort from the San Xavier District Office accompanied PAG staff for field work on tribal lands. At each of the sites, PAG staff noted whether the area was clean or showed evidence of waste disposal. If waste disposal was seen, staff recorded the type, general amount, and distribution of the waste. In most cases, a photograph showing the waste was taken at the site.

PAG staff identified six major waste disposal sites and seventeen minor waste disposal sites within the study area. No significant undocumented landfills were identified through this study. Additional sites had piles of dirt, concrete, and, to a lesser degree, green waste. A "major" waste disposal site was defined as a wildcat dump or undocumented landfill with large piles of waste that were probably dumped by pickup trucks or larger vehicles. A "minor" waste disposal site was defined as a wildcat dump or undocumented landfill which consisted mostly of scattered surface litter which would at the most be equivalent to a few pickup truck loads worth of waste. Major and minor wildcat dumps are listed in the "Conclusions" section of this report.

INTRODUCTION

Pima Association of Governments (PAG), in cooperation with the City of Tucson Office of Environmental Management (OEM), field checked active and abandoned landfills and waste disposal sites, including wildcat dumps, along a reach of the Santa Cruz River. The purpose of this study was to determine preliminary information about waste disposal site locations, land uses, and types of waste deposited at each site. For this study, PAG conducted interviews, analyzed historical aerial photographs, and visited potential waste disposal sites.

The study area encompassed waste disposal sites within, or directly adjacent to, the 100-year flood plain along the Santa Cruz River between Grant Road to the north and Pima Mine Road to the south. The study area included tribal lands which are part of the San Xavier District of the Tohono O'odham Nation. Figure 1 is a regional location map showing the approximate study area boundaries. Potential waste disposal sites were identified by analyzing aerial photographs and conducting interviews. The interviews were conducted with representatives from Pima County, the City of Tucson, the University of Arizona, the State of Arizona, and the Tohono O'odham Nation. Details are provided in the Methodology section of this report. Each site was visited in the field to determine if it was actually used for waste disposal.

PAG and OEM personnel coordinated the field reconnaissance with the San Xavier District Office prior to the scheduled site visits for the sites on San Xavier District tribal lands. Permission to access the San Xavier District tribal lands was granted on May 14, 1996, by the San Xavier Tribal Council. An escort was provided by the San Xavier District during the field reconnaissance.

Two types of waste disposal sites were identified as part of this study: landfills and wildcat dumps. Landfills were defined as sites where waste had been covered by dirt. Documented City of Tucson landfills were also described in this report; however, this report notes only changes at the sites since they had last been documented. Wildcat dumps were defined as sites where waste had been dumped on the ground surface, usually in an area that was not permitted for dumping.

Because this study did not include an investigation of property ownership, there was no reference to land owners unless the information was posted on the property or was provided to PAG by OEM staff. Even if ownership was known, there is no guarantee that the owners are aware of, or responsible for, waste disposal on their property.

This study did not include investigations such as soil-gas monitoring, groundwater sampling, or collection of soil borings, and the study was not intended as an environmental assessment of the properties investigated. Also, only limited efforts were made to gain access to private property. Interested parties could incorporate this report, as well as additional investigative studies, into a preliminary site assessment for waste disposal sites, but they should not rely on this study as a sole source for field information.

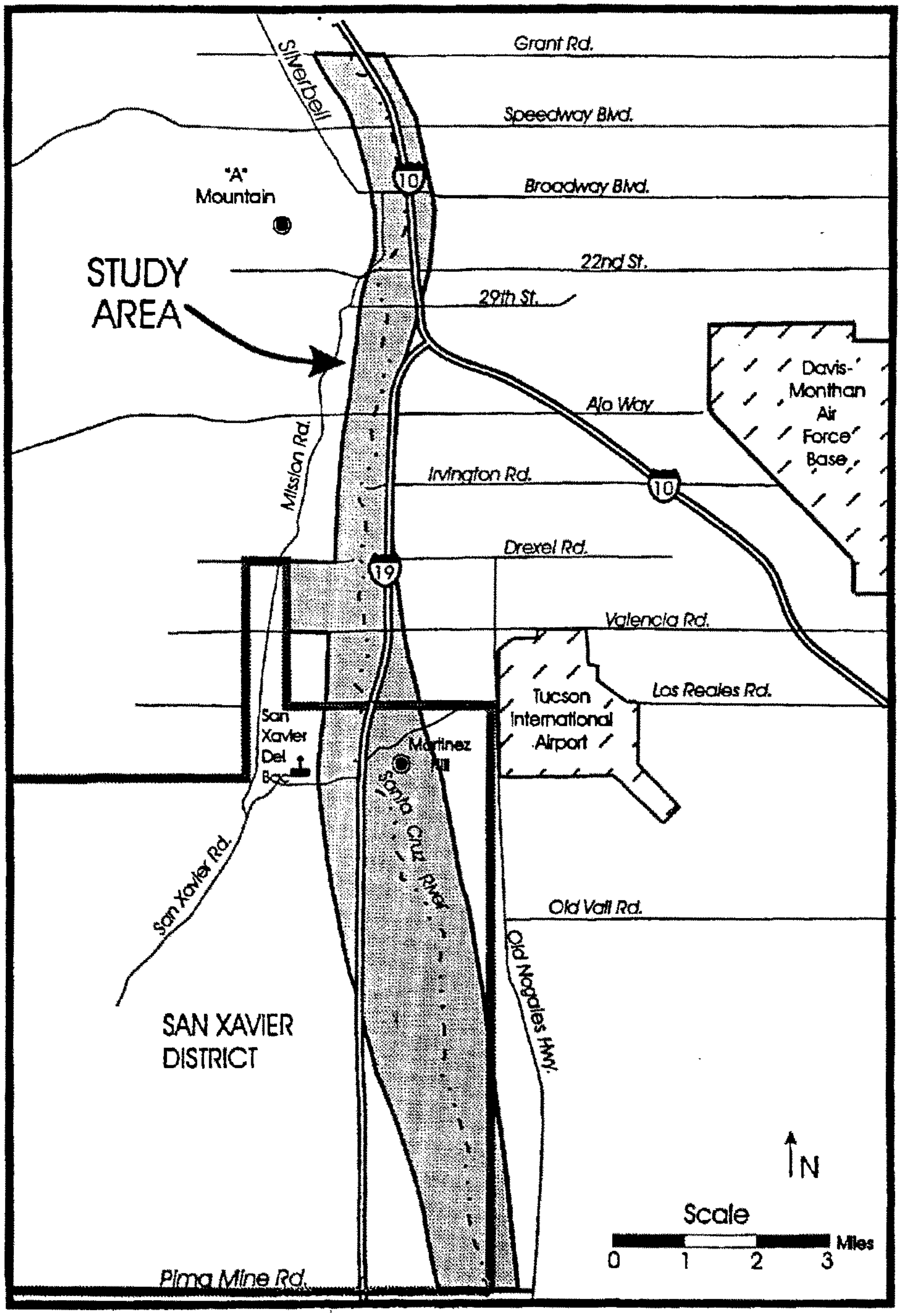


Figure 1 Study Area Location Map

METHODOLOGY

Existing maps and flood plain information were used to delineate the flood plain for this project and to create the project maps. The procedures used to create the maps are described in the "Flood Plain Delineation and Map Preparation" portion of this section.

Existing information about landfills and wildcat dumps was collected from a literature review, a review of USGS topographic maps, and personal interviews. Details of these activities are described in the "Literature Review," "Analysis of Historical Aerial Photographs," and "Personal Interviews" subsections, within the Methodology section of this report. In addition, historical aerial photographs were analyzed to identify sites that appeared to have been disturbed surface areas that might contain undocumented waste disposal. Attempts were made to visit all potential waste disposal sites and all documented landfills during the field reconnaissance portion of the project.

This report is divided into four sections. The first section, the "Introduction," describes the study area and the scope of the project. The second section, "Methodology," describes the techniques used for the flood plain delineation, literature review, analysis of topographic maps and analysis of historical aerial photographs. The third section, "Site Descriptions," includes an overview of sites with wildcat dumping or landfilling, as well as a "Field Descriptions of Sites" subsection, which presents the particular findings from field visits to each site. The fourth section, "Conclusions," summarizes PAG's examination of wildcat dumps and landfills in the study area. Appendix 1 includes the results of the aerial photograph analysis, and is intended as a guide for further photograph review.

Flood Plain Delineation and Map Preparation

The first task in this investigation was to identify the 100-year flood plain within the study area. The flood plain delineation was taken from the 1992 Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) for the area outside the San Xavier District and two reports for the District lands (John M. Tettemer & Associates, 1984 and Bureau of Indian Affairs, 1986). A few of the FIRM maps were last revised in 1983 and may be outdated. However, most of the bank protection constructed since that time has been in the areas that have been updated since 1983. The Flood Hazard Areas on the FIRM maps were divided into flood zone areas: A, AE, AO, and X. These are shown collectively as the 100-year flood plain in Figures 2 through 6 at the end of this section. The FIRM map flood zone definitions are shown on Table 1:

Table 1: FIRM Map Flood Hazard Areas

FIRM Code	Description
Zone A	Special Flood Hazard Areas inundated by 100-year flood with the base flood elevations determined
Zone AE	Special Flood Hazard Areas inundated by 100-year flood with no base flood elevations determined
Zone AO	Special Flood Hazard Areas inundated by 100-year flood with average flood depths of 1 to 3 feet
Zone X	Areas of 500-year flood, areas of 100-year flood with average depth of less than 1 foot or with drainage areas less than 1 square mile, or areas protected by levees from the 100-year flood

Due to the status of the San Xavier District tribal lands as property of a separate nation, it was necessary to seek sources other than the FIRM maps to define the flood plain on the District's land. The references used for the flood plain within the San Xavier District were a *Report on Hydrology and Flood Control for the San Xavier Planned Community* by John M. Tettemer & Associates (1984) and a *Draft Environmental Impact Statement for the San Xavier Planned Community* by the Bureau of Indian Affairs (1986). Two reports were used to confirm the flood plain delineation within the San Xavier District boundaries: *Surficial Geologic Maps of the Northeastern, Southeastern, and Southwestern Portions of the Tucson Metropolitan Area.*(Jackson, 1989) and *Surficial Geologic Maps of the Tucson Metropolitan Area* (McKittrick, 1988). This research resulted in a flood plain that was different from that shown in the PAG 1995 report entitled *Landfills and Waste Disposal Sites along the Upper Santa Cruz River* (PAG, 1995a).

The sites were numbered according to the order they were visited in the field, renumbered so the site numbers generally increased from north to south, and plotted on computer-generated basemaps (Figures 2 through 6). The basemaps were prepared by overlaying the PAG's 1996 Draft Landfill Map and the Pima County Basemap from MapInfo Professional™ (Version 4.0, 1992-1995). The section lines, portions of the Santa Cruz River and its West Branch, and some major roads were provided by PAG's Landfill Map. Highways, additional paved roads, and dirt roads were provided by the MapInfo map, the 1994 Metropolitan Tucson and Eastern Pima County Street Atlas, and the 1995 Pima County Roadway System Map. Some reaches of the Santa Cruz River, particularly in the Grant Road and Martinez Hill areas, were redrawn to reflect current channel characteristics using 1995 aerial photographs as a base reference. Flood plains were added to the maps based on the FIRM maps, the John M. Tettemer & Associates report, and the Bureau of

Indian Affairs report. These maps were combined using AutoCAD and edited using Generic CADD.

Literature Review

Existing literature was reviewed to determine where old landfills, gravel pits, and/or disturbed vacant lands were located. Documents reviewed are shown on Table 1 with the area of coverage, date, and type of information provided. These documents are not summarized in this report; instead, they were used to direct PAG's field investigations.

Table 2: Summary of literature review.

DOCUMENT AND AUTHOR	DATE	AREA OF COVERAGE	TYPE OF INFORMATION
U.S.G.S. Topographic Maps (including the following 7.5' quadrangles: Cat Mountain, San Xavier Mission, Tucson, and Tucson SW)	1957-1975	Entire study area	Road access and locations of gravel pits, borrow pits, wells, etc.
Draft Environmental Impact Statement, Santa Cruz River Park, Tucson, Arizona, Guy S. Greene & Assoc. and Don Laidlaw & Assoc.	1976	From Grant Road to Los Reales Road	Land use and bank protection along the Santa Cruz River
Upper Santa Cruz Groundwater Quality Baseline Report, Upper Santa Cruz Basin Mines Task Force	1979	The San Xavier District	Land use
Landfill Environmental Studies Program Phase I (LESP I) - Final Report, Dames & Moore	1989	From Grant Road to Ajo Way	Locations of landfills
Application of Historic Well Closure Information for Protection of Existing Wells, PAG	1992	From Speedway Boulevard to Silverlake Road and from Ajo Way to Los Reales Road	Locations of disturbed vacant land and landfills

DOCUMENT AND AUTHOR	DATE	AREA OF COVERAGE	TYPE OF INFORMATION
Environmental Assessment of 10 City - Operated Landfills, Tucson, Arizona, PAG	1993	From Grant Road to Ajo Way	Locations of landfills and characteristics of adjacent bank protection
Landfills along the Santa Cruz River in Tucson and Avra Valley, Arizona, PAG	1995	Entire study area	Locations of landfills, including those with less documentation
Landfills and Waste Disposal Sites along the Upper Santa Cruz River, PAG	1995	From Old Vail Road to Pima Mine Road East of San Xavier District boundaries	Locations of landfills and disturbed vacant land
Identified Public Landfills (Excluding State and Federal Facilities) and Permanent Transfer Stations in Eastern Pima County and Ajo - Draft Map, PAG	1996	Entire study area	Locations of landfills

Analysis of Topographic Maps

Topographic maps were collected and analyzed for the entire study area. These maps were dated 1957 to 1968 and three of them had been photorevised in 1975. Any gravel pits, wells, ponds, storage bins, borrow pits, or sewage ponds shown on the maps were noted and corroborated through photo analysis or field investigation.

Personal Interviews

Interviews with Pima County, City of Tucson, University of Arizona, State of Arizona, and Tohono O'odham Nation personnel were conducted to identify potential disposal sites in the study area. PAG staff conducted the interviews in the Spring of 1996 to collect information on the potential sites' locations, sizes, type of waste, and the presence of bank protection. The site information did not include in-depth descriptions of the landfills.

Pima County personnel had the most comprehensive information about the presence of illegal dumping along the Santa Cruz River and the condition of the bank protection. Kenrick Custer, Pima County's Wildcat Dump Officer, provided information about illegal dumping in the study area. He identified twelve wildcat dumps, nine potential problem sites, and sixteen landfill sites in the area. Susan Hess at Pima County Solid Waste Management Department was contacted about closed landfills, but she possessed no information about potential sites in the study area. Becky Pearson at Pima County Department of Transportation was contacted because she was familiar with the landfills along the river adjacent to bank protection. She mentioned the 29th Street and St. Mary's Landfills, which have bank protection along the landfill edges, but she had no additional information about them.

The University of Arizona Garbage Program staff were contacted because they had been excavating old dumps along the Santa Cruz River. Tim Jones at the University Garbage Program pointed out the location of an old dump directly south of Grant Road on the east bank of the Santa Cruz River. He also mentioned the presence of approximately ten-foot deep trenches located south of St. Mary's Road along the Santa Cruz River. Tim Jones believed that the trenches were used to dispose of incinerator ashes in the 1940's.

The Arizona Department of Transportation (ADOT) was contacted, because they encountered old landfills during construction along I-10 and I-19. Tom Sullivan at the ADOT Environmental Planning Division indicated one landfill site that was located beneath the ADOT Maintenance Division site directly south of Grant Road.

Tohono O'odham Nation personnel were contacted after permission to access tribal lands was granted by the San Xavier District Tribal Council. Carol Young, the Environmental Representative with the Tohono O'odham Nation, and Mark Jackson from the U.S. Indian Health Service were contacted. Neither of them knew of any landfilling or open dumping in the study area. However, Randy Willard at the U.S. Indian Health Service said that although he knew of no open dumps that existed in the study area, there were two dumps near Black Mountain approximately three miles west of the study area.

Analysis of Historical Aerial Photographs

PAG staff obtained aerial photographs of the entire study area from Pima County Department of Transportation Mapping and Records. Reprints of these aerial photographs, dated 1974, 1990, and 1995, were used for the analysis. Complete coverage was available for 1974 and 1990, and all but one photo was available for 1995 (T14S R13E, Secs. 3,4,9,10). The reprints included four Sections per photograph and were provided to PAG as blue lines at a scale of 1 inch=400 feet.

Aerial photographs were analyzed for evidence of potential landfilling or waste disposal. Cleared or excavated areas were circled on the photographs and these sites are described in an annotated list of photographs included in Appendix 1. This appendix also includes a description of the general land uses adjacent to suspected sites. The following types of land uses, noted on the aerial photographs, were considered to be potential indicators of landfilling or waste disposal: disturbed vacant land with road access; abandoned excavation sites (pits and ponds) with road access; and bulldozed areas. Other land uses that were noted during the aerial photograph analysis included active and abandoned agricultural lands, highways and roads, industrial complexes, commercial areas, and undisturbed vacant lots. A few of the areas noted on the photographs were not visited in the field, because they were inaccessible by road or because they were out of the 100-year flood plain. The original annotated blue lines are stored at OEM, but PAG has retained copies of the blue lines for future review.

Reconnaissance Mapping

Reconnaissance mapping was conducted throughout the study area. Efforts were concentrated on potential landfills or waste disposal sites that were targeted through the analysis of aerial photographs and topographic maps or through interviews. Each of the sites was located on the aerial photographs and was numbered in the order in which it was visited in the field. In the case of the sites within the boundaries of San Xavier District tribal lands, permission to access the tribal lands was granted after the potential sites were located. The sites were renumbered during compilation of this report so that the site numbers generally increased from north to south. These numbers are shown on the Site Location Maps and they directly correspond to the site numbers listed in the "Site Descriptions" section of the report. During a three day period in April and May of 1996, 68 sites were visited to gather the following information about each site:

- current land use on site;
- current land use adjacent to the site, if relevant;
- evidence for ongoing wildcat dumping;
- evidence for buried waste;
- evidence for ongoing storage of suspected hazardous materials;
- evidence for differential settling, which can be a common characteristic of old landfills;
- approximate location of waste, if evident;
- types of materials, if evident;
- approximate age of waste, if evident;
- evidence of cleanup; and
- access, including roads and fences.

If evidence for wildcat dumping or landfilling was observed while driving slowly past the site, PAG staff stopped and walked through the site. Access routes used by PAG staff during the field visit are listed under each site description. Additional access routes may be available. However, if "no access" is noted in the site description, PAG staff was not able to find an access route to the site. Thirteen sites of the 68 were not visited because they were inaccessible due to closed or nonexistent roads, barbed wire or wooden fences, or "No Trespassing" signs.

PAG staff took field photographs at 21 of the 68 sites visited during this study. Field photographs were taken if the waste was well exposed and clustered so that it could be shown in a photograph. A field photograph was generally not taken if the waste consisted of distributed surface litter. Photographs were included in the "Field Descriptions of Sites" section of the report if the nature of the waste disposal was accurately shown in the photograph.

Several types of containers were seen at the sites, and details are given in the "Field Descriptions of Sites" section of this report. Small containers found at the sites included cans, bottles, and buckets that held less than 5 gallons of material. Drums were defined as containers that held approximately 55 gallons of material. Most of the containers identified at the sites were made out of metal and glass, except for small motor oil bottles and one-gallon jugs, which were commonly made out of plastic.

A general description of land use and waste disposal is included in the "Site Descriptions" section, followed by a detailed description of each site. In many cases, sites that looked suspicious on the aerial photographs did not show evidence of waste disposal when visited during the field reconnaissance part of this study.

SITE DESCRIPTIONS

General Land Use

Land use varied extensively within the study area. Within the City of Tucson, industrial and commercial uses were prevalent near the Santa Cruz River, but south of Silverlake Road these land uses were concentrated near the intersection of major roads. Residential density generally decreased north to south. The I-10 and I-19 freeways were located just east of the Santa Cruz River, and they paralleled the river throughout the study area. Excavation associated with construction of the interstate frontage roads was noted from Grant Road to Speedway Boulevard at the time of the site visit. The Santa Cruz River Park was located along both banks of the river from Grant Road to Silverlake Road and then continued on both sides of the Santa Cruz River from Ajo Way to Irvington Road. Along the Santa Cruz River, north of the San Xavier District, there were several vacant lots, some of which were closed landfills, including Rio Nuevo North, Rio Nuevo South, "A" Mountain, and Ryland landfills. There were also a few wildcat dumps along the banks, but they were not extensive.

Within the San Xavier District, south of the City of Tucson, the land use was primarily agricultural, consisting of grazing lands and active and retired cropland. There were also residential areas, especially south of the San Xavier Mission along San Xavier Loop Road and Little Nogales Drive. No landfills were identified in the San Xavier District. Wildcat dumps, identified mostly along the banks of the Santa Cruz River, were not extensive.

Undocumented Landfills and Wildcat Dumps

As part of this study, PAG searched for previously undocumented landfills and wildcat dumps. No undocumented landfills were identified in the study area. A few sites had small amounts of buried trash or a slightly hummocky topography, but there was not substantial evidence to indicate the presence of a landfill. Old landfills can be difficult to identify in the field, unless there are obvious signs such as exposed waste at the land surface.

Wildcat dumping was identified at 23 of the sites surveyed for this project. The sites were divided into two size categories: 1) "major," i.e. waste disposal sites with large piles of waste that were probably dumped by pickup trucks or, in some cases, larger vehicles; and 2) "minor," i.e. sites that consisted primarily of scattered surface litter which would at the most be equivalent to a few pickup truck loads of waste. Major wildcat dumps were identified at sites 11, 34, 37, 48, 56, and 57. Trash at these sites included bottles, cans, car parts, metal, rubber tires, oil filters, construction debris, miscellaneous household trash (appliances, furniture, cloth), and empty 55-gallon metal drums. Most containers appeared to have been empty and a few of them had readable labels. Minor wildcat dumps, containing trash, were identified at seventeen other sites: 9, 12, 13, 14, 18, 19, 23, 27, 28, 33, 41, 45, 49, 52, 61, 62, and 64. In addition, many sites (3, 4, 7, 9, 10, 11, 12, 13, 14, 17, 19, 20, 23, 24, 27, 28, 29, 32, 34, 36, 37, 41, 42, 43, 44, 45, 48, 56, 57, 58, 61, and 62) contained piles of dirt, concrete debris, or green waste. In most cases, the size of the piles was comparable to a few pickup truck loads of the material.

Documented Landfills

PAG staff also visited nine documented closed landfills in, or near, the study area. The landfills located in the more developed urban area north of Silverlake Road included "El Dumpe," St. Mary's, Rio Nuevo North, Rio Nuevo South, "A" Mountain, Mission, and 29th Street landfills. The landfills located in the less urbanized area south of Silverlake Road included Cottonwood and Ryland landfills. Most of the landfills' characteristics were presented in the LESP Phase I reports by Dames & Moore (1989) and PAG (1993). PAG staff visited these landfills to document changes in surface conditions subsequent to the LESP investigations. It was beyond the scope of this project to conduct any additional research into the nature or extent of the landfills.

"El Dumpe" Landfill was located north of Speedway Boulevard, east of the Santa Cruz River and west of I-10 (Site 4 on Figure 2). Before the highway construction, the material had all been buried (Jones, 1996). This landfill was described in PAG's 1995 report. Evidence for the landfill that was noted during the field reconnaissance included previously buried landfill material that had been excavated during highway construction as well as a cross-section of material still *in situ*. After PAG's field site check, the excavated material was removed and sent to Harrison Landfill (Murray, 1996).

St. Mary's Landfill was located south of St. Mary's Road and west of Grande Avenue (Site 6 on Figure 2). This landfill was described in PAG's 1993 report and its location was shown on PAG's 1996 draft landfill map. Evidence for the landfill that was noted during the field reconnaissance included some hummocky topography either due to surface grading or to differential settling. Menlo Park had been constructed over the landfill at this site. There had been no changes to the site since PAG's last visit in the Spring of 1993.

The Rio Nuevo North Landfill was located south of St. Mary's Road and north of Congress Street along the western bank of the Santa Cruz River (Site 7 on Figure 2). This landfill was described in PAG's 1993 report and its location was shown on PAG's 1996 draft landfill map. Evidence for the landfill that was noted during the field reconnaissance included hummocky topography either due to site grading or differential settling. There appeared to have been a methane monitoring well system around the perimeter. Since PAG's last visit to the landfill, construction of a Pima Community College campus building had begun north of the landfill. The methane monitoring well system had been modified to match the parking lot grades along the northern edge of the site (Murray, 1996). The landfill site appeared to have been unchanged.

The Rio Nuevo South Landfill was located south of Congress Street and east of Mission Road on the western bank of the Santa Cruz River (Site 10 on Figure 2). This landfill was described in PAG's 1993 report and its location was shown on PAG's 1996 draft landfill map. Rio Nuevo South consisted of two smaller landfills: Nearmont, located in the northwestern part of the site, and Congress, located in the eastern part of the site. Evidence for the landfill that was noted during the field reconnaissance included hummocky topography possibly due to differential settling. Since PAG's 1993 visit to the landfill, there was less green waste along the northern border of Congress Landfill and there had been construction to the north of Congress Landfill. Also, the land surface covering Nearmont showed evidence of a recent fire.

The "A" Mountain Landfill was located on the western bank of the Santa Cruz River north of the convergence of Mission Road and the River (Site 11 on Figure 2). This landfill and its location were described in Dames & Moore's 1989 report. Its location was also shown on PAG's 1996 draft landfill map. Evidence for the landfill that was noted during the field reconnaissance included hummocky topography, possibly due to differential settling, and exposed materials on the surface. Most of the waste appeared to have been on the surface, but some of it may have been part of the landfill.

The Mission Landfill was located at the northeastern corner of Mission Road and 22nd Street (Site 16 on Figure 2). This landfill was described in PAG's 1993 report and its location was shown on PAG's 1996 draft landfill map. Evidence for the landfill that was noted during the field reconnaissance included hummocky topography either due to surface grading or to differential settling. The Santa Cruz River Park had been constructed on top of the landfill. There had been no changes to the site since PAG's last visit in the Spring of 1993.

The 29th Street Landfill was located directly north of Silverlake Road along the western bank of the Santa Cruz River (Site 21 on Figure 3). This landfill was described in PAG's 1993 report and its location was shown on PAG's 1996 draft landfill map. PAG staff was not able to visit this landfill because Pima County facilities had been built on site after landfill closure. Based on drive-by viewing of the site, there had been no changes since PAG's last visit in the Spring of 1993 (i.e., no new surface waste or differential settling).

Cottonwood Landfill was located north of Ajo Way west of the Santa Cruz River (Site 25 on Figure 3). This landfill was described in the 1989 Dames & Moore report. Its location was also shown on PAG's 1996 draft landfill map. Evidence for the landfill that was noted during the field reconnaissance included the presence of what appeared to have been a methane monitoring well system. However, no exposed waste or hummocky topography was seen. Based on aerial photographs, a manufactured-home subdivision had been constructed over the landfill site since 1990.

The Ryland Landfill was located west of the I-10/I-19 intersection along the east bank of the Santa Cruz River (Site 22 on Figure 3). This landfill was described in PAG's 1993 report and its location was shown on PAG's 1996 draft landfill map. Evidence for the landfill noted during field reconnaissance included hummocky topography probably due to differential settling and exposed materials on the landfill surface and along the eroded and unprotected river bank. There had been no changes since PAG's last visit during the Spring of 1993.

Originally, the sites were numbered in the order they were visited in the field. However, the sites were renumbered for the report, so that site numbers generally increased from north to south. These site numbers directly correspond to the numbers shown on the Site Location Maps at the beginning of the report. Field photographs were taken of each of the sites that showed significant wildcat dumping. The photographs were included in the report, only if they depicted a representative picture of the site. The detailed description and location of each site is presented in the "Field Descriptions of Sites" section. Because the study area was so large, the sites are presented on five separate maps (Figures 2 through 6) showing the area from north to south. The aerial photographs were not included in this report.

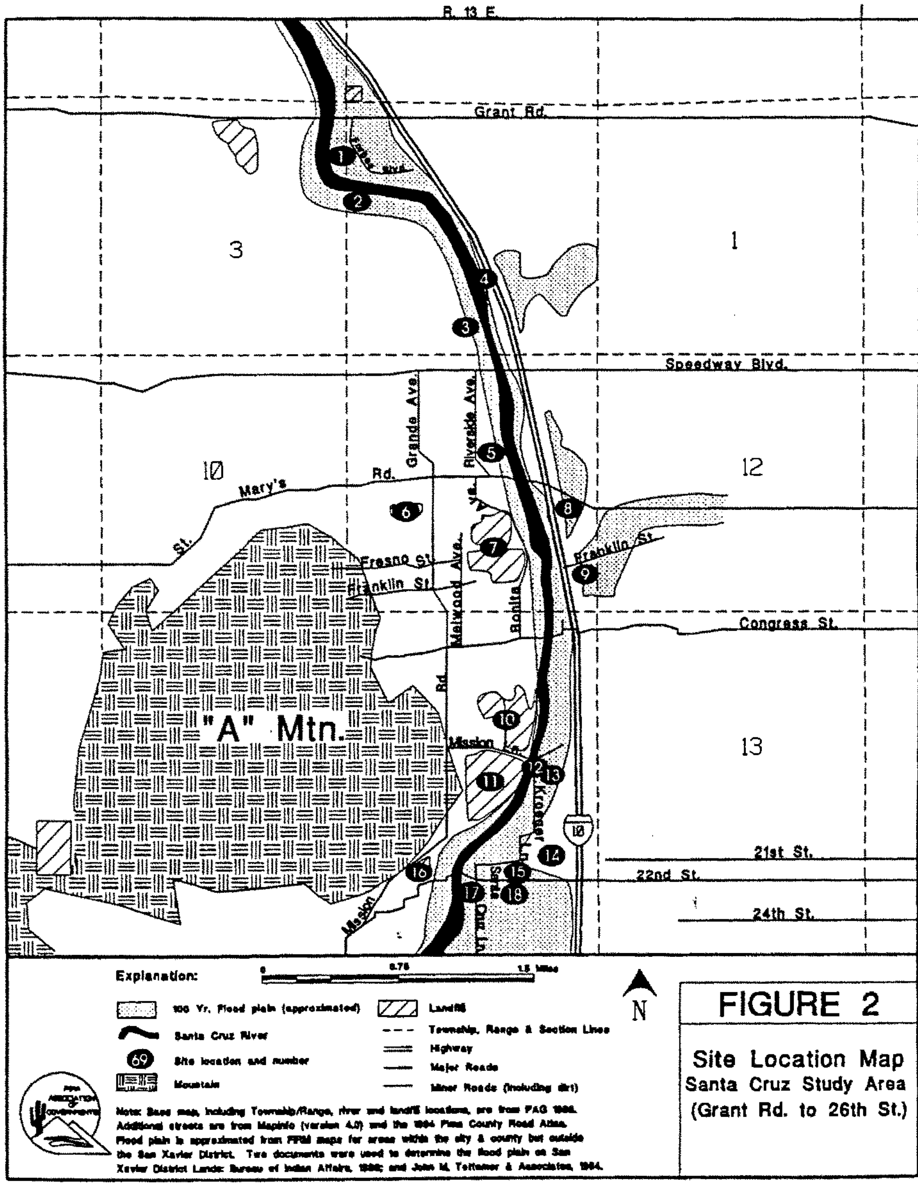


FIGURE 2

Site Location Map
Santa Cruz Study Area
(Grant Rd. to 26th St.)

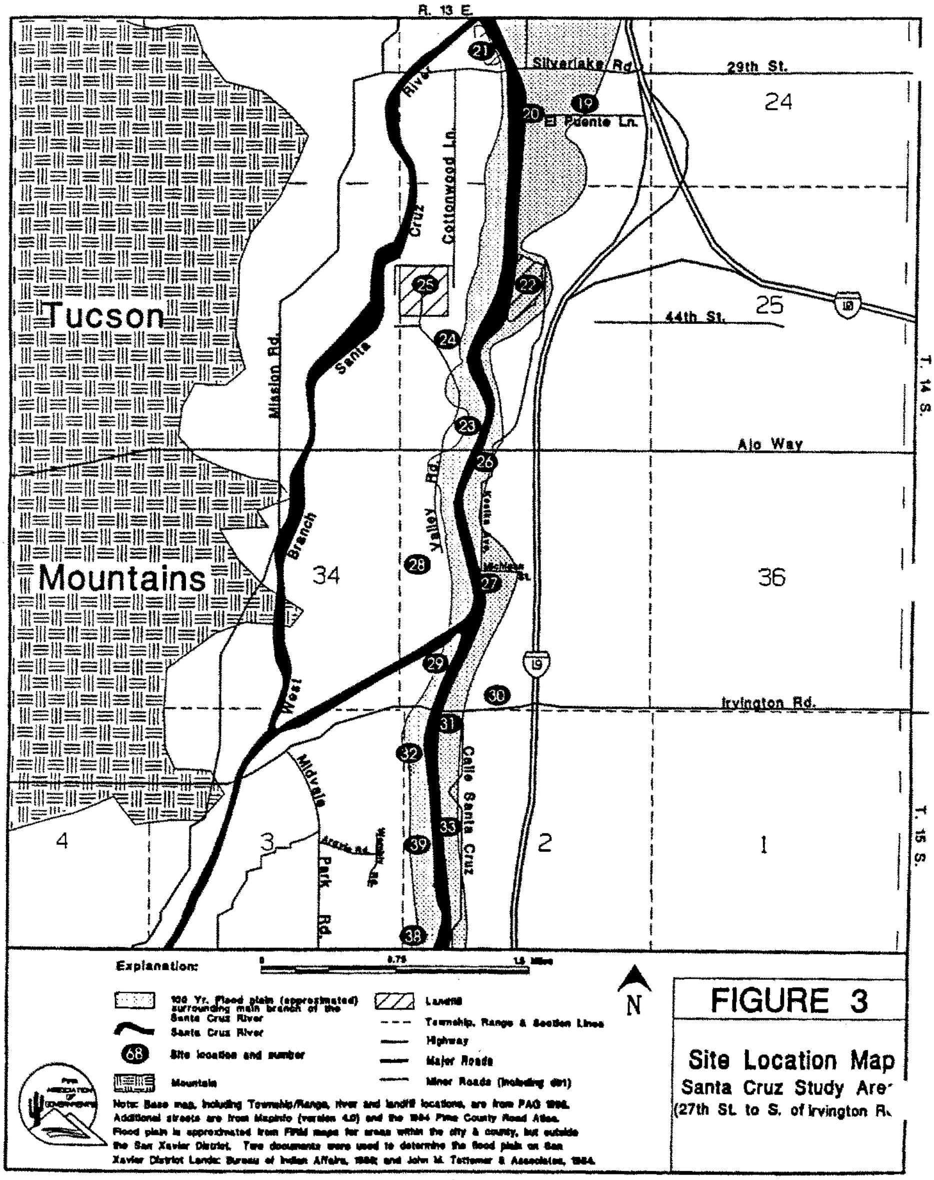


FIGURE 3

Site Location Map
Santa Cruz Study Are
(27th St. to S. of Irvington R

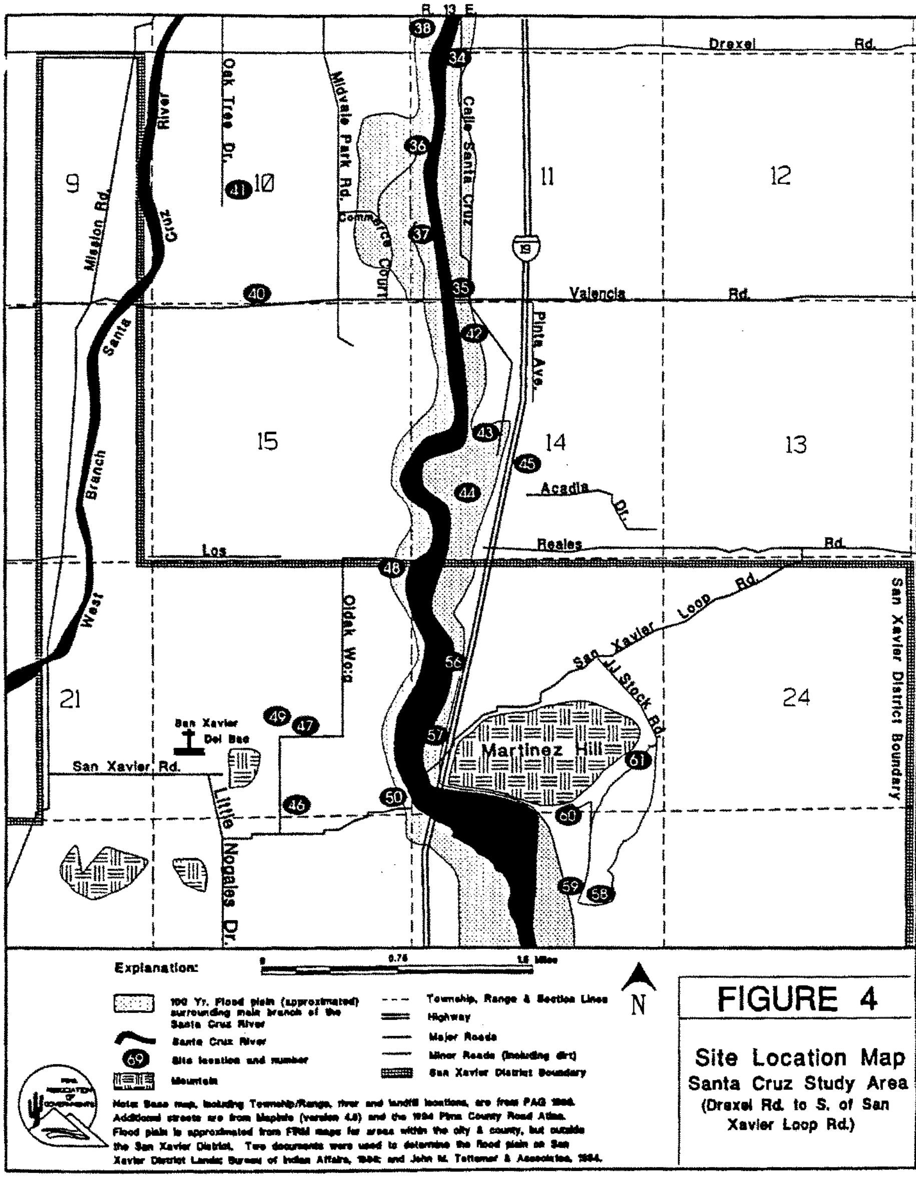


FIGURE 4

Site Location Map
Santa Cruz Study Area
(Drexel Rd. to S. of San Xavier Loop Rd.)

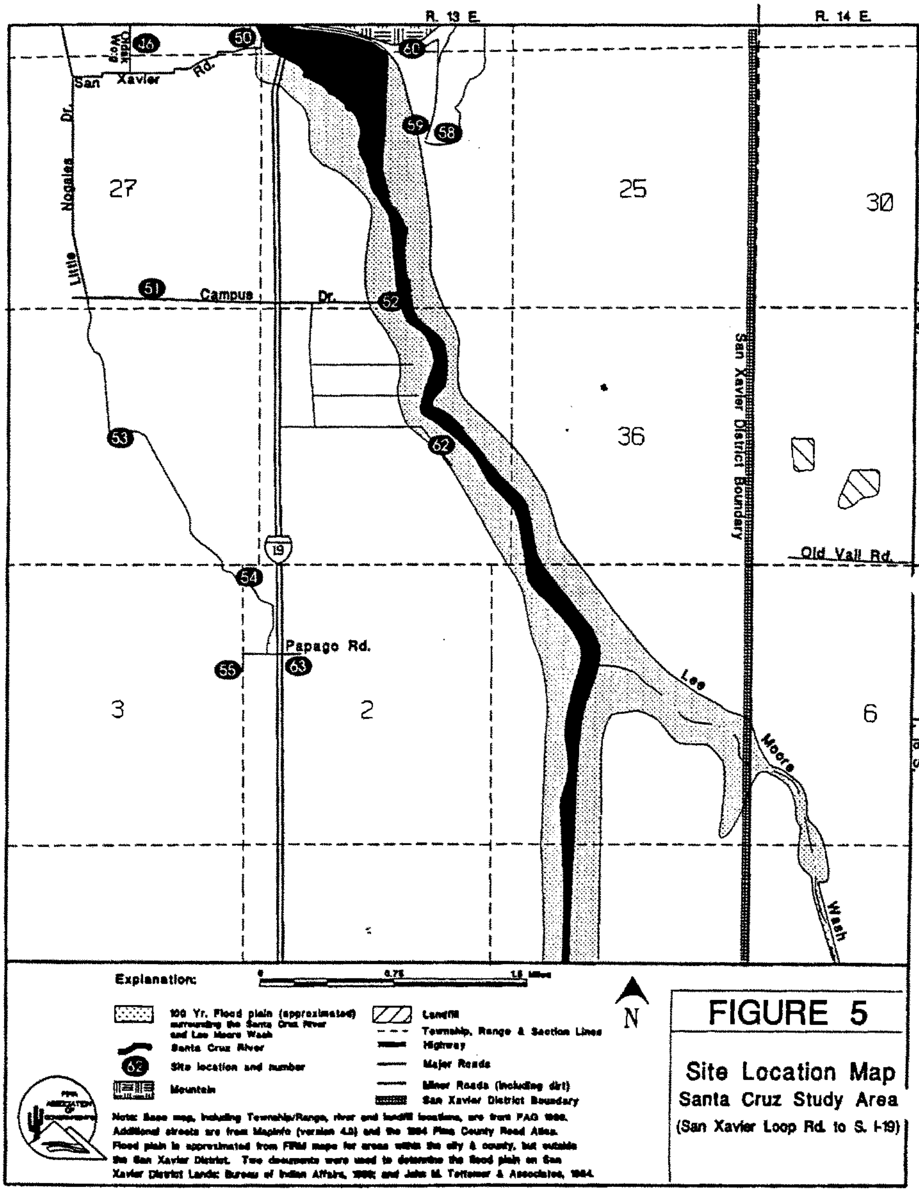


FIGURE 5

Site Location Map
Santa Cruz Study Area
(San Xavier Loop Rd. to S. I-19)

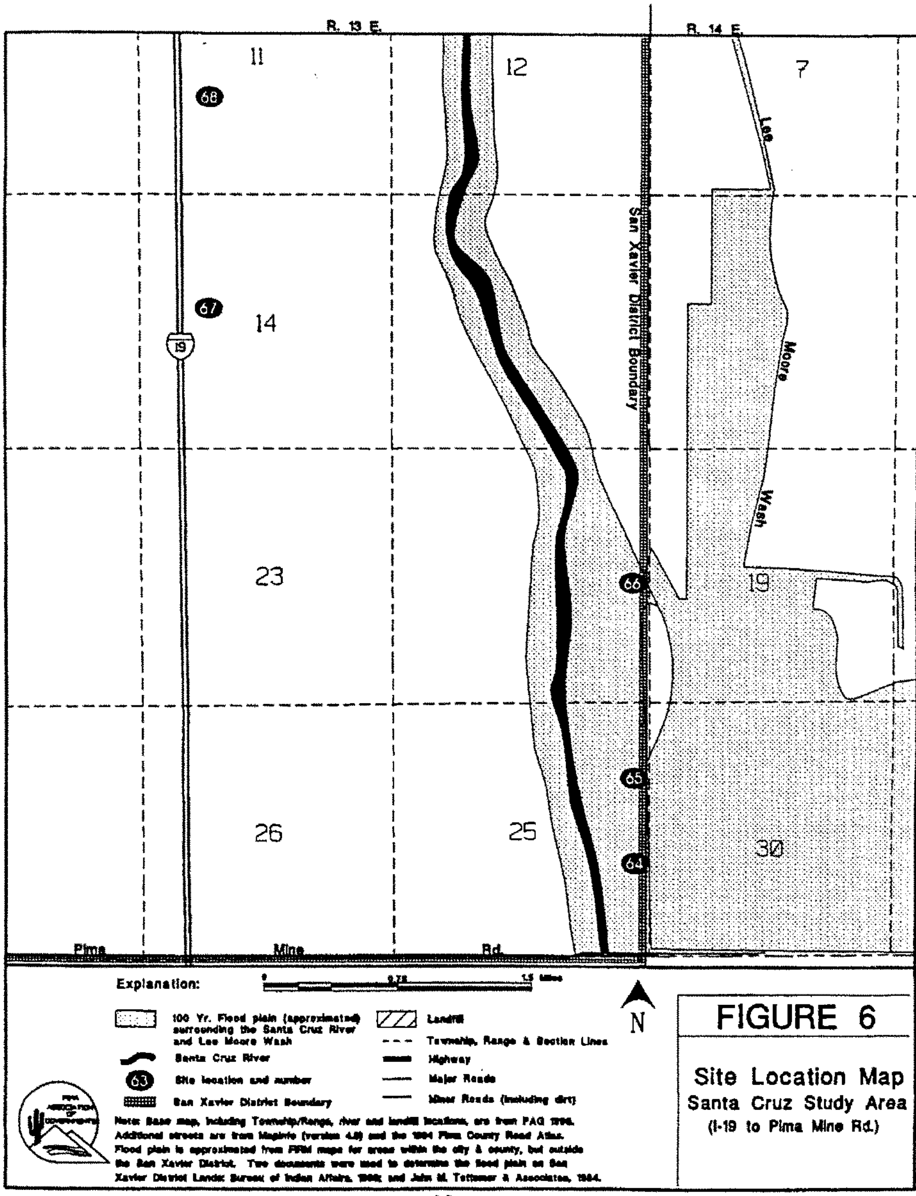


FIGURE 6

Site Location Map
Santa Cruz Study Area
(I-19 to Pima Mine Rd.)

Field Description of Sites

The following sites were visited because the interviews, literature review, or aerial photograph analysis indicated that the land had potentially been used for waste disposal. The following site descriptions are based on field observations only. If a particular facility or feature that could help to easily identify the site was noted in the field, it is listed in the description after the site number and before the location information.

Site 1
Location: T14S R13E, Section 3
Approximately 1/4 mile south of Grant Road, west of Forbes Boulevard, and directly east of Santa Cruz River
Field Description: No dumping or landfilling was evident on this site. The site consisted of a vacant lot and a section of the Santa Cruz River Park with an asphalt path, power lines, and landscaping, including palo verde and mesquite trees. Access was available from the parking lots to the east and north, but there was a short post-and-cable fence that prohibited vehicles from entering the Santa Cruz River Park. The surrounding land uses included industrial areas to the east and north and the Santa Cruz River with bank protection to the west and south. This site was visited because hummocky topography was identified in the 1974 photograph (prior to the construction of the Santa Cruz River Park), and Tom Sullivan from ADOT had indicated that an old landfill had existed in this location.

Site 2
Location: T14S R13E, Section 3
Approximately 1/3 mile south of Grant Road and directly north of Riverview Boulevard, along west bank of the Santa Cruz River
Field Description: No dumping or landfilling was evident on this site. The site consisted of a section of the Santa Cruz River Park with an asphalt path and landscaping, including palo verde and mesquite trees. Access was available from Riverview Boulevard, but there was a short post-and-cable fence that prohibited vehicles from entering. The surrounding land uses included residential areas to the west, east and south, and the Santa Cruz River with bank protection to the north and east. This site was visited because homes had existed on the site in the 1974 photograph that were not present in the 1990 photograph, and the resulting vacant lot (in the 1990 photograph) appeared to have been disturbed.

Site 3

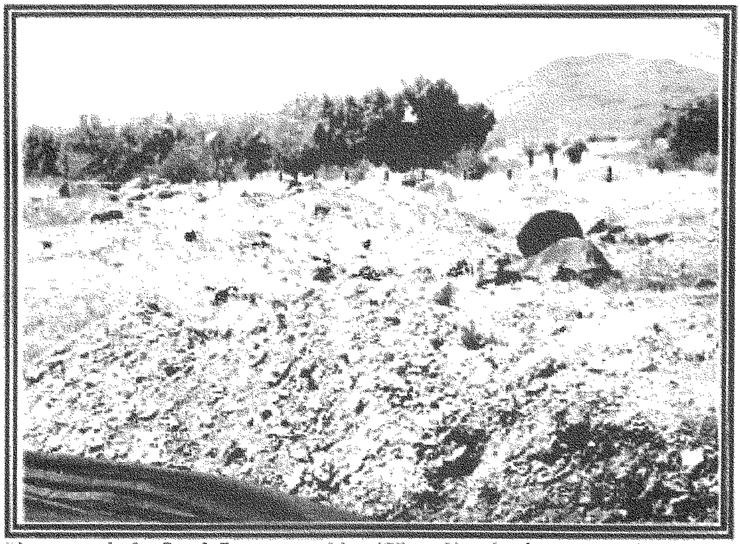
Location: T14S R13E, Section 2
Approximately 200 feet north of Speedway Boulevard, directly east of the Arizona School for the Deaf and Blind, and approximately 100 feet west of the Santa Cruz River

Field Description: No dumping or landfilling was evident on this site. The site consisted of a vacant lot of approximately 100 X 300 feet, with a few palo verde and mesquite trees. There were piles of concrete debris and bricks. Access was available from the Arizona School for the Deaf and Blind (ASDB) parking lots and access road. The surrounding land uses included the ASDB school to the west and north, Speedway Boulevard and residential areas to the south, and the Santa Cruz River to the east. This site was visited because it appeared to have been disturbed in the 1990 photograph.

Site 4
"El Dumpe"

Location: T14S R13E, Section 2
Approximately 1/10-1/2 mile north of Speedway Boulevard, directly east of the Santa Cruz River, and directly west of I-10

Field Description: This site consisted of a frontage road construction site, measuring approximately 200 feet wide by 1/2 mile long, with various types of dirt-moving machinery. Piles of dirt and an excavation site of an old landfill ("El Dumpe") were located approximately 1/3 mile north of Speedway Boulevard in an area approximately 100 feet wide by 200 feet long. Pottery shards, glass, iron and other scrap metal, 55-gallon drums, and asphalt debris were seen at the site. Photograph #1 shows the southern half of the exposed portion of the landfill. Access was possible from I-10, but restricted by the construction company for safety reasons. The surrounding land uses included I-10 to the east, the Santa Cruz River to the west, an AM/PM Mini Mart under construction to the south, and an industrial park to the north.



Photograph 1. Partially exposed landfill at Site 4, view toward the west-northwest.

Site 5
Location: T14S R13E, Section 11
Approximately 200 feet north of St. Mary's Road, directly east of Riverside Avenue, and directly west of the Santa Cruz River

Field Description: No dumping or landfilling was evident on this site. The site consisted of a section of the Santa Cruz River Park with an asphalt path and landscaping. Access was available from Riverside Avenue, but there was a short post-and-cable fence that prohibited vehicles from entering. The surrounding land uses included residential areas to the north and west, the Santa Cruz River with bank protection to the east, and commercial areas to the south. The site was visited because it appeared to have been hummocky in the 1974 photograph, prior to the Santa Cruz River Park construction.

Site 6
St. Mary's Landfill
Location: T14S R13E, Section 11
Approximately 1/3-1/4 mile south of St. Mary's Road, on northwest corner of Grande Avenue and Fresno Street

Field Description: St. Mary's Landfill was covered by a parking lot and a playing field after closure. Access was available from Grande Avenue and included a park access road to the parking lot. The surrounding land uses included single-family residential areas to the south, east and west, multi-family residential areas to the north and northeast. The site was slightly hummocky, but this may have been due to grading of the site after the landfill had been closed, rather than to differential settling. PAG staff did not see any change in the appearance of the site since the area had been visited in the Spring of 1993.

Site 7
Rio Nuevo North Landfill
Location: T14S R13E, Section 11
Approximately 1/4-1/2 mile south of St. Mary's Road, approximately 1/4 mile east of Melwood Avenue, and directly west of the Santa Cruz River
Field Description: Rio Nuevo North Landfill was located at this site. There appeared to have been methane monitoring wells located on the northern part of the site. Piles of rock, dirt, and asphalt were seen on the southern part of the site. The landfill material was not exposed. PAG staff did not see any change in the appearance of the site since the area had been visited in the Spring of 1993. Access was available from Bonita Avenue and Commerce Park Loop. The surrounding land uses included residential areas to the west and south, Dragon's View Restaurant to the northeast, and the Santa Cruz River with bank protection to the east, and multi-family residences, and educational and commercial areas to the north. A Pima Community College building was being constructed just north of the landfill's northern boundary. As of April 30, the construction company, Kern Contractors, had not excavated any trash (they had excavated 5 feet down and 12 feet around their building site). They were planning to build a parking lot on the north side of the landfill just south of the building site.

Site 8
Location: T14S R13E, Section 11
Southeast corner of I-10 and St. Mary's Road, directly northwest of Quality Hotel & Suites
Field Description: No dumping or landfilling was evident at this site. The site consisted of a vacant lot east of I-10 with mesquite trees and large prickly pear cacti. Surface litter included paper, glass, and plastic bags. Access was available from Franklin Street and the I-10 off ramp. The surrounding land uses included I-10 to the west, commercial areas to the north, and a Quality Hotel & Suites to the southeast. This site was visited because it appeared to have been hummocky in the 1990 photograph.

Site 9
Location: T14S R13E, Section 11
Directly south of Franklin Street, approximately 200 feet north of Paseo Redondo, and approximately 50 feet east of I-10
Field Description: This site consisted of a minor wildcat dump on a vacant lot with mesquite and palo verde trees, a pit, and a large mound of dirt. Surface litter consisted of

a metal rod & wire, asphalt, bricks, concrete debris, and piles of dirt. Access was available from the parking lot west of Manning House on Paseo Redondo, but otherwise the site was enclosed by a chain link fence. The surrounding land uses included commercial areas to the south and east, I-10 to the west, and a Quality Hotel & Suites to the north.

Site 10

Rio Nuevo South Landfill (includes Congress and Nearmont Landfills)

Location: T14S R13E, Section 14
Approximately 200 feet south of Congress Street, approximately 100-200 feet east of Mission Road, and directly west of the Santa Cruz River

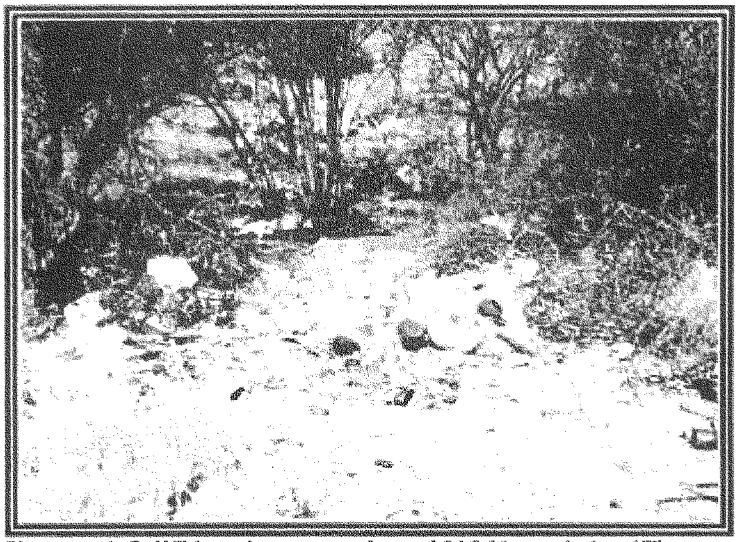
Field Description: Rio Nuevo South Landfill includes both Congress and Nearmont landfills. This site was graded with a drainage ditch running west to east along the northern edge of the site. Surface material included surface piles of dirt, concrete debris, bricks, and green waste directly north of the Congress Landfill. Surface litter included tin cans, plastic, glass, green waste and rubber tires along the western end of the site and in the drainage ditch along the northern side of the site. Access was available from Congress Street directly to the north. The surrounding land uses included a bus fueling station, residential areas, and the "A" Mountain Landfill to the south, commercial and residential areas to the north, the Santa Cruz River to the east, and residential areas to the west. Since PAG's last visit in the Spring of 1993, the surface of the Nearmont Landfill had been burned, and the drainage ditch along the northern edge of the landfill had been re-graded.

Site 11

"A" Mountain Landfill

Location: T14S R13E, Section 14
Southeast corner or Mission Road and Mission Lane, directly west of the Santa Cruz River

Field Description: "A" Mountain Landfill was located at this site and there was a major wildcat dump on the surface. PAG staff observed several wellheads (open and closed) on the site as well as two thin pipes protruding approximately 6 feet from the land surface. The surface material included partially buried rubber tires, old chairs and appliances (mostly on the northern edge of the site), and surface piles of concrete debris, rubber tires, glass, asphalt, plastic, cloth, paper, carpet, rubber, rebar, wood, tin cans, metal screening, cloth, concrete debris, and rubber throughout the site. Photograph #2 shows a 10-foot-by-10-foot area of wildcat dumping, which was representative of the concentration of surface material throughout the site. Access was available from Mission Road and Mission Lane by car; there was also a low post-and-cable fence that was part of the Santa Cruz River Park along the eastern edge of the site. The surrounding land uses included residential areas and the Rio Nuevo South Landfill to the north, "A" Mountain Park to the west, the Santa Cruz River Park to the east and south, and the Mission Landfill to the southwest. The surface was extremely hummocky and, according to a sign, there was an El Paso Gas line at 39 feet below land surface. It was difficult to discern the amount of exposed buried material because there was so much surface material on the site.



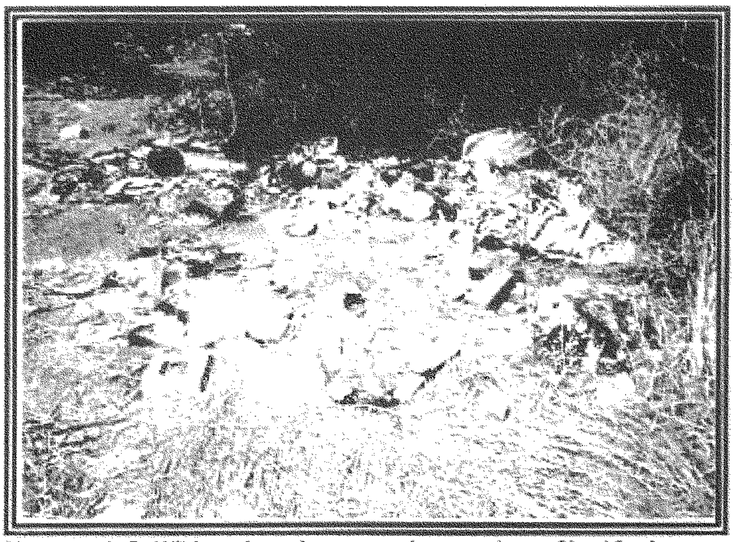
Photograph 2. Wildcat dump on surface of "A" Mountain Landfill at Site 11, view toward the southeast.

Site 12
Location: T14S R13E, Section 14
Approximately 1/2 mile south of Congress Street, directly west of Kroeger Lane, and directly east of the Santa Cruz River

Field Description: The site consisted of a minor wildcat dump on a vacant lot with sparse vegetation located on the east bank of the Santa Cruz River. The waste seen on the surface included plastic bottles, piles of concrete debris, chair frames, cans, and a few empty 55-gallon drums. Access was available from Kroeger Lane. The surrounding land uses included the Santa Cruz River with bank protection to the west, a power substation, vacant and residential areas to the east, commercial areas to the north, and residential areas to the south.

Site 13
Location: T14S R13E, Section 14
Approximately 1/2 mile south of Congress Street and directly east of Kroeger Lane

Field Description: This site consisted of a minor wildcat dump on a vacant lot with shallow drainages running approximately southeast-northwest and desert broom along with other vegetation. Waste seen on the surface included dirt piles, asphalt, rubber tires, office dividers, a few empty 55-gallon drums, one-gallon cans, carpet, concrete debris, paper, metal screening, aluminum foil, a plastic oil bottle, rusted cans, glass, plastic, cloth, brick, mattress springs, and a refrigerator. Photograph #3 shows an area of concentrated dumping in the center of the site. The waste on the rest of the site was more scattered. Access was available from Kroeger Lane. The surrounding land uses included vacant land to the west (Site 12), and residential areas to the east, south, and north.

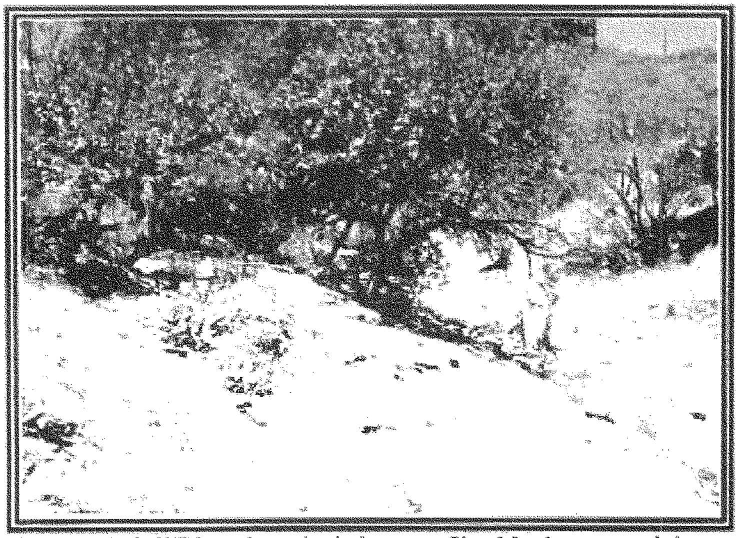


Photograph 3. Wildcat dump in center of vacant lot at Site 13, view toward the northeast.

Site 14

Location: T14S R13E, Section 14
Southeast of intersection of Kroeger Lane and 21st Street, and directly north of 22nd Street

Field Description: This site consisted of a disturbed, vacant lot with a minor wildcat dump in a well-vegetated (mesquite and other trees and shrubs) drainage running north-south on the eastern edge of the site. The waste seen on the site included dirt piles, cardboard, cloth, old chairs, paper, plastic bags and bottles, glass, asphalt, cloth, and concrete debris. The waste was concentrated in, or near, the drainage. Photograph #4 shows an area along the western bank of the drainage that represented the concentration of surface material within the drainage. There were also a large number of plastic bags and paper products that were probably blown onto the site. Access was available from Kroeger Lane. The surrounding land uses included residential areas to the west and north, commercial areas (hotels) to the east, and 22nd Street and vacant land to the south. The litter may have originated from open, poorly maintained dumpsters located east of the site. Several homeless encampments were also seen on the site.



Photograph 4. Wildcat dump in drainage at Site 14, view toward the north.

Site 15

Location: T14S R13E, Section 14
Approximately 50 feet west of Kroeger Lane, directly north of 22nd Street and directly south of 21st Street

Field Description: No dumping or landfilling was evident on this site. The site consisted of a disturbed, vacant lot with sparse vegetation just north of 22nd Street. Access was available from Kroeger Lane and 21st Street. The surrounding land uses included vacant land to the east and south, and residential areas to the north and west. This site was visited because it appeared to have been disturbed in the 1990 photograph.

Site 16

Mission Landfill

Location: T14S R13E, Section 14
Northeast corner of Starr Pass Blvd./22nd Street and Mission Road

Field Description: Mission Landfill was located at this site. After landfill closure, the site was converted to part of the Santa Cruz River Park. The landfill material was not exposed, so it was not possible to specify the types of material present. Access was available from Mission Road, but entrance to the site was possible only on foot or bicycle. The surrounding land uses included Sentinel Peak Park to the west and north, the Santa Cruz River with bank protection to the east, and county government land to the south. The site was hummocky, but this may have been due to grading of the site after the landfill was closed, rather than to differential settling. PAG staff did not see any change in the appearance of the site since the area had been visited in the Spring of 1993.

Site 17

Location: T14S R13E, Section 23
Southeast corner of 22nd Street and the Santa Cruz River

Field Description: This site consisted of a vacant lot on the east bank of the Santa Cruz River with sparse vegetation. The waste seen on the site (between 22nd Street and Santa Cruz Lane) included green waste and wood piles along the eastern edge of the Santa Cruz River directly east of 24th Street. Access was not possible because the site was surrounded by fenced private property. The surrounding land uses included residential areas to the east, the Santa Cruz River with bank protection to the west, 22nd Street and industrial areas to the north, and vacant land to the south.

Site 18

Location: T14S R13E, Section 23
Southeast corner of 22nd Street and Santa Cruz Lane

Field Description: This site consisted of a minor wildcat dump on a large, disturbed, slightly hummocky vacant lot south of 22nd Street with sparse vegetation. The surface litter included rubber tires, plastic, cloth, and paper. There was no visible evidence of buried waste. Access was available from Santa Cruz Lane and 24th Street. The surrounding land uses included residential areas to the west and south, commercial areas to the east, and vacant land and 22nd Street to the north. There was an old concrete building foundation on the southwestern corner of the site.

Site 19
Location: T14S R13E, Section 23
Approximately 1/5 mile south of Silverlake Road, 1/3 mile east of the Santa Cruz River, and directly north of El Puente Lane
Field Description: This site consisted of a minor wildcat dump on a vacant lot with mounds of dirt and palo verde and mesquite trees. The waste seen on the surface included rubber tires, piles of concrete debris, bricks, wood, and asphalt. Access was available from the parking lot and the 1/4 mile driveway at 947 W. Silverlake. The surrounding land uses included commercial areas to the west, an auto recycling plant to the north, a small drainage and vacant land to the east, and vacant land to the south.

Site 20
Location: T14S R13E, Section 23
Directly south of Silverlake Road, running along both banks of the Santa Cruz River for approximately 3/4 mile
Field Description: This site consisted of an active sand and gravel operation, Ace Sand & Gravel, encompassing both sides of the Santa Cruz River south of Silverlake Road (no bank protection along river). The material seen on the site from Cottonwood Lane, 200 feet west of the site, included piles of concrete debris and bricks. Access was not available; the property was private and surrounded by chain link fence. The surrounding land uses included dormant farmland and mobile home parks to the west; commercial areas and vacant land to the east; vacant land to the south; and industrial, vacant, and residential land to the north.

Site 21
29th Street Landfill
Location: T14S R13E, Section 23
Approximately 1/3 mile north of Silverlake Road directly south of the West Branch Confluence
Field Description: 29th Street Landfill was located at this site. However, no access was available because Pima County Parks and Redreation, Pima County's garage and storage areas, and the Pima County Sheriffs Department training area were built over the site after the landfill was closed. The landfill was not exposed and the property was surrounded by a chain link fence. The surrounding land uses included a prison and industrial land to the south, the Santa Cruz River with bank protection to the east, and the West Branch of the Santa Cruz River with partial bank protection to the west and north.

Site 22
Ryland Landfill
Location: T14S R13E, Section 26
West of I-10/I-19 intersection on east bank of Santa Cruz River
Field Description: Ryland Landfill was located at this site. The landfill material exposed along the river bank included glass, cans, paper, wood, plastic, concrete and asphalt debris, bricks, rubber tires, newspaper, and household waste. Photograph #5 shows most of the bank edge of the landfill. Rubber tires were also seen on the surface of the landfill. Access was available from Ajo Way along a dirt road. The surrounding land uses included the river with no bank protection to the west, I-19 to the east, and vacant lots to the north and south. The surface of the landfill was extremely hummocky, which was probably due to differential settling. PAG staff did not see any change in the appearance of the site since the area had been visited in the Spring of 1993.

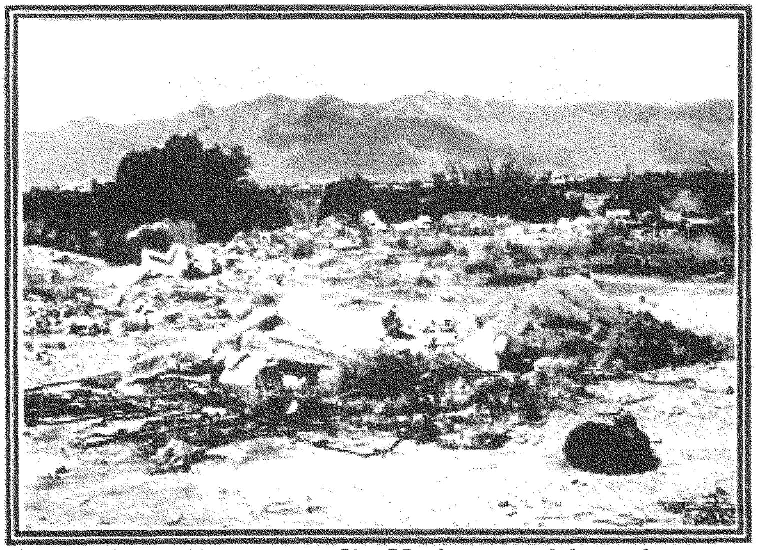
Photograph 5. Bank edge of Ryland Landfill at Site 22, view toward the southeast.

Site 23

Location: T14S R13E, Section 26

Northeast corner of Ajo Way and Cottonwood Lane on west bank of Santa Cruz River

Field Description: This site consisted of a minor wildcat dump on a vacant lot, approximately 1/4 mile long and 200 feet wide, located on the west bank of the Santa Cruz River with desert broom and grasses. The waste seen on the site included piles of concrete debris, metal, rubber tires, glass, brick, oil filters, dirt and a washing machine. Photograph #6 shows an area of concentrated dumping, in the foreground, located in the center of the site. The waste on the rest of the site was more scattered, such as the waste in the background of the photograph. Access was available from dirt paths off Cottonwood Lane. The surrounding land uses included the river with no bank protection on the east, a gravel pit to the north, and residential areas to the west and south.



Photograph 6. Wildcat dump at Site 23, view toward the north.

Site 24
Small Gravel Pit
Location: T14S R13E, Section 26
Southeast corner of Cottonwood Lane and 44th Street alignment on west bank of Santa Cruz River

Field Description: This site consisted of a gravel pit on the west bank of the Santa Cruz River. The waste seen on the site included piles of brick and concrete debris. Access was not possible because the site was fenced by a high chain link fence with interwoven wood strips. The surrounding land uses included a mobile home park to the west, residential areas to the north, the Santa Cruz River with no bank protection to the east, and a mobile home park and vacant land to the south.

Site 25
Cottonwood Landfill
Location: T14S R13E, Section 26
Northwest corner of Cottonwood Lane and 44th Street alignment on west side of Santa Cruz River

Field Description: Cottonwood Landfill was located at this site. Historical aerial photographs indicated that the site had been developed for residential use between 1990 and the present. PAG staff observed that approximately six mobile homes had been built on top of the landfill site. There appeared to have been methane monitoring wells around the perimeter of the site. The surrounding land uses included residential areas to the south, north, and east, and agricultural areas to the west. Access was possible from Cottonwood Lane. There was no evidence of recent dumping.

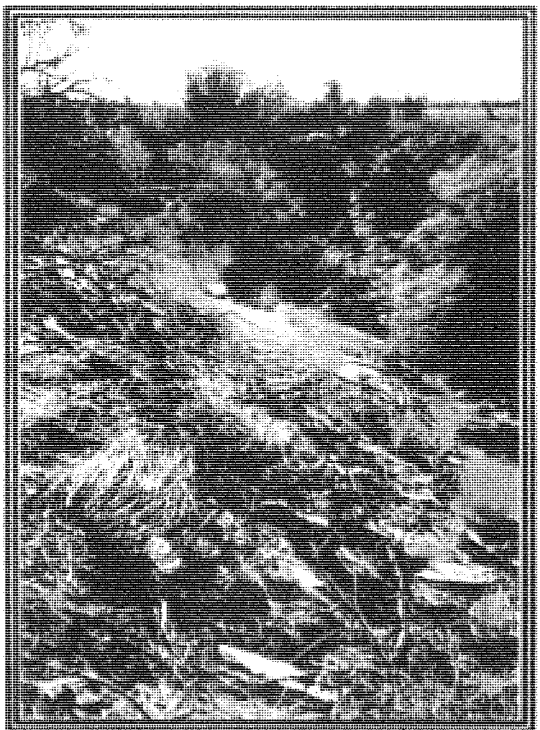
Site 26
Location: T14S R13E, Section 35
At the southwest corner of Ajo Way and Kostka Ave. on east bank of Santa Cruz River

Field Description: No dumping or landfilling was evident at this site. The site consisted of a vacant lot east of the Santa Cruz River Park. There were creosote bushes and other desert brush vegetation on site. Access was available from Kostka Avenue; however, there was no road onto the site, which was surrounded by a low post-and-cable fence. The surrounding land uses included a recreational park and residential land and there was bank protection. The surface was somewhat hummocky, but there was no evidence of buried waste. This site was visited because it appeared to have been hummocky in the 1990 photograph.

Site 27

Location: T14S R13E, Section 35
Southeast of Kostka Ave. - Michigan St. intersection on east side of Santa Cruz River and south of a Tucson Water well

Field Description: This site consisted of a minor wildcat dump in a drainage east of the Santa Cruz River. The waste seen on the site included piles of green waste, concrete debris, bricks, cans, bottles, and empty 55-gallon drums. Photograph #7 shows an area of concentrated dumping along the northern bank of the drainage. The waste on the rest of the site was more scattered. Access was available from the empty lot located south of Michigan Street on the northern side of the drainage. The surrounding land uses included vacant land, residential land, and a Tucson Water well to the north (#SS-12); residential land to the east; vacant land to the south; and recreational park to the west.



Photograph 7. Wildcat dump in drainage at Site 27, view toward the east.

Site 28

Location: T14S R13E, Section 35
Between Ajo Way and Irvington Road on west bank of Santa Cruz River and east and south of mobile home parks

Field Description: This site consisted of a minor wildcat dump on a large vacant lot with mature mesquite trees, desert broom, and grasses. The northern third of the site was investigated on foot and the following features were identified: old building foundations on the east and west sides of the area; old concrete towers (measuring approximately 25 to 30 feet high and 15 feet in diameter) on the east side; and a somewhat hummocky surface. The material identified around the old foundations on the northern third of the site included: green waste; small rusted cans; old wood; concrete debris; bottle glass; and metal screening. The southern two-thirds of the site was checked by driving roads located in a mobile home park to the west of the site. PAG staff observed that the southern two thirds of the site consisted of a large disturbed area with piles of dirt and some glittery debris (probably glass). Access was possible on foot, but not by car, because the entrance at the north end of the site was blocked by a short fence. The surrounding land uses included mobile home parks to the north and west and the Santa Cruz River Park with bank protection to the east and south. In the mobile home park to the north, there was a trash collection area for the residents that included dumpsters and piles of concrete and asphalt debris, wood, and brick. The waste around the building foundations on the site could have resulted from the demolition of the buildings.

Site 29

Location: T14S R13E, Section 35
Northwest corner of intersection of Midvale Park Road and the Santa Cruz River

Field Description: No dumping or landfilling was evident at this site. The site consisted of a disturbed vacant lot with piles of dirt and some vegetation, including desert broom and mesquite trees. There was surface litter present. Access was not possible by car. The surrounding land uses included a man-made drainage channel to the north, multi-family residential property to the west, vacant lots to the south, and the Santa Cruz River Park to the east. This site was visited because it appeared to have been disturbed in the 1990 photograph.

Site 30

Location: T14S R13E, Section 35
Northwest corner of I-19 and Midvale Park Road/Irvington Road and east of Santa Cruz River

Field Description: No dumping or landfilling was evident on this site. The site consisted of a large rectangular lot that, according to several signs posted on buildings and fencing, was used by Tucson Water for a treatment plant and storage of tanks and pipes. Access by car was available from Irvington Road to the south, but the site was fenced and was most likely closed at night. The surrounding land uses included vacant lots to the north and south, the Santa Cruz River Park with bank protection to the west, and I-19 to the east. This site was visited because it had been noted in PAG's 1992 report to be an old landfill.

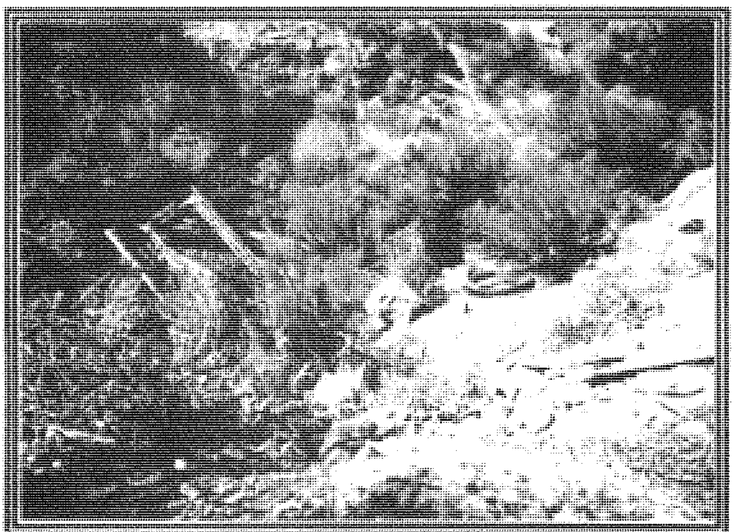
Site 31
Location: T15S R13E, Section 2
Southwest corner of Midvale Park Road and Calle Santa Cruz on east bank of Santa Cruz River
Field Description: No dumping or landfilling was evident at this site, although evidence could have been eroded away. The site was a vacant lot adjacent to the Santa Cruz River with 20-foot cliffs along the river. Access was available on foot from Calle Santa Cruz, but there was no access for vehicles due to the high curb along the road. The surrounding land uses included vacant lots on the north, east, and south sides, and the river with no bank protection on the west. This site was visited because there appeared to have been rubble along the river bank in the 1974 photograph.

Site 32
Location: T15S R13E, Section 2
South of Irvington Road on west bank of Santa Cruz River
Field Description: This site consisted of a vacant lot, measuring approximately 300 feet wide by 1/3 mile long, on the west bank of the Santa Cruz River. The waste seen on the site included concrete debris on top of the bank and wood piles near the bottom of the bank within the floodway. Access was not available by road, so it was necessary to make observations from the east bank of the Santa Cruz River. The surrounding land uses included vacant lots on the north, south, and west sides, and the river with no bank protection on the east side.

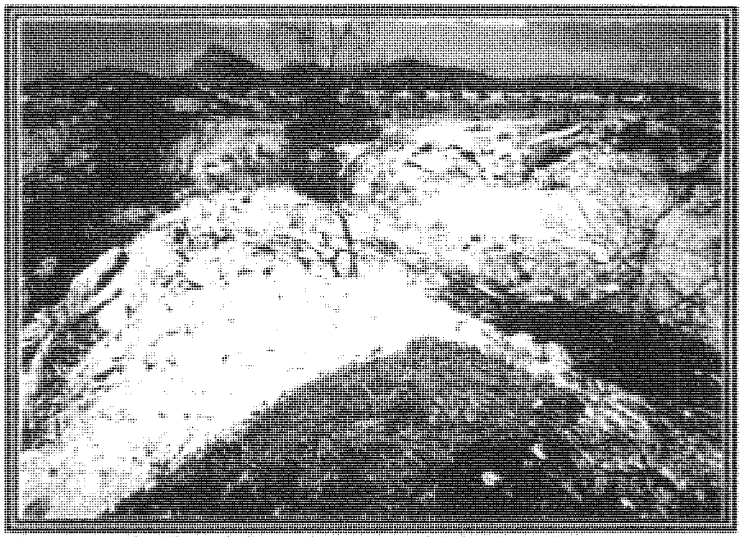
Site 33
Location: T15S R13E, Section 2
West of Calle Santa Cruz and approximately 1/2 mile north of Drexel Road, on east bank of Santa Cruz River
Field Description: This site consisted of a minor wildcat dump on a vacant lot, measuring approximately 1/4 mile long and 150 feet wide, on the east bank of the Santa Cruz River with desert broom. The waste seen on the site included 10 rubber tires, several small cans of various types and broken glass. Access was available along Calle Santa Cruz, but the high curb prevented vehicles from driving onto the site. The surrounding land uses included vacant lots to the north, west, and south, and the Santa Cruz River with no bank protection to the east.

Site 34
Drexel Road Area
Location: T15S R13E, Section 11
Southwest corner of Drexel Road and Calle Santa Cruz on east bank of Santa Cruz River

Field Description: This site consisted of a major wildcat dump along the edge of a vacant lot. It encompassed two drainages and the intervening section of river bank on the east side of the Santa Cruz River. The disposal area was located a few hundred feet west of Calle Santa Cruz and was hidden from the road by trees and bushes. The dump appeared to have been primarily on the surface, not buried. The drainage on the southern edge of the site contained piles of wood, brick, carpet, towels, tiles, metal, clothing, asphalt, rubber tires, and shoes. Brick, concrete debris, miscellaneous scrap metal, and wood piles were identified along approximately 200 feet of the river bank down to the river bed. Photograph #8 shows an area of dumping in the southern drainage that indicates the density of waste in that drainage. Photograph #9 shows the representative concentration of waste on top of the wildcat dump. The drainage north of the site was clean, except for a buried tire and concrete debris with rebar protruding from it. Access was available from Calle Santa Cruz into the vacant lot and recent tire tracks were observed in a large cleared area east of the bank. The surrounding land uses included vacant lots to the north and south, the river with no bank protection to the west, and a commercial and industrial area to the east.



Photograph 8. Drainage at southern edge of wildcat dump at Site 34, view toward the southwest.



Photograph 9. Piles of dirt and concrete debris along the western perimeter of a wildcat dump directly east of Santa Cruz River at Site 34, view toward the west-northwest.

Site 35
Location: T15S R13E, Section 11
Northwest corner of Valencia Road and Calle Santa Cruz on east bank of Santa Cruz River
Field Description: No dumping or landfilling was evident at this site. The site consisted of a disturbed vacant lot with desert broom on the east bank of the Santa Cruz River. Access was available by foot from Calle Santa Cruz, but the curb was too high for vehicles to access the site. The surrounding land uses included the Santa Cruz River with bank protection to the west, vacant lots to the north and east, and the San Xavier Rock & Materials sand and gravel operation to the south. Minor surface litter was observed.

Site 36
Location: T15S R13E, Section 10
On west bank of Santa Cruz River between Drexel Road alignment and Valencia Road
Field Description: This site consisted of a vacant lot, measuring approximately 1/2 mile long by 300 feet wide, that seemed to have been unofficially used as an off-road vehicle recreational area. The waste seen on the site included piles of dirt and concrete debris along the river bank. Access was available from Commerce Court and was well-travelled.

The surrounding land uses included the river with no bank protection and a major drainage to the east, a residential area to the west and south, and vacant lots to the north. The drainages surrounding the site were clean with no bank protection.

Site 37

Location: T15S R13E, Section 11
On west bank of Santa Cruz River north of Valencia Road and east of Commerce Court

Field Description: This site consisted of a vacant lot, measuring approximately 1/3 mile long by 250 feet wide, containing three waste disposal areas that constitute a major wildcat dump. At the southern end of the site, PAG observed a pile of carpet, wood, metal pipes, tiles, cardboard, and rubber. Farther to the north, tarps, cardboard, motor oil cans, carpet, WD40 spray cans, rubber tires, anti-freeze, and scrap metal were identified. At the northern end of the site, an old, partially-buried wildcat dump was seen beside, and within, a tributary drainage of the Santa Cruz River. The waste was identified in an area measuring approximately 200 feet-by-100 feet, and consisted of rusted cans, old shoes, glass, wood, concrete and asphalt debris, rubber tires, plastic, rubber, bedsprings, cloth, and aluminum foil. Photograph #10 shows an area with a concentrated amount of waste in the center of the site. Natural runoff processes may have contributed to the burial of the trash. Access to these sites was available from Valencia Road, via dirt trails large enough for vehicles. The surrounding land uses included a residential area, a hospital, and a minor drainage to the west, the river with bank protection to the east, and vacant lots to the north and south.

Photograph 10. Wildcat dump at Site 37, view toward the northwest.

Site 38

Location: T15S R13E, Section 3

Just north of Drexel Road alignment on west bank of Santa Cruz River

Field Description: No dumping or landfilling was evident at this site. The site consisted of a vacant lot on the west bank of the Santa Cruz River and to the north of an east-west drainage that separated it from Site 36. Access was available from Wembly Road in the residential area to the west, but it was possible to visually check the site from Site 36 to the south. The surrounding land uses included vacant lots to the north and south, the river with no bank protection to the east, and a residential area to the west. The bank on the east side of the site was eroded. This site was visited because there appeared to have been rubble and piles of material on site in the 1990 photograph.

Site 39

Location: T15S R13E, Section 2

Between Midvale Park Road and Drexel Road alignment on west bank of Santa Cruz River and east of Wembly Road

Field Description: No dumping or landfilling was evident on this site. The site consisted of a vacant lot, measuring approximately 1/5 mile long by 100 feet wide, along the west bank of the Santa Cruz River. Rip-rap along the bank was probably being used as bank protection. Access was not available by car or foot, so the site was visually checked from the other side of the river. The surrounding land uses included the river with minimal bank protection to the east, a residential development to the west, and vacant lots to the north and south.

Site 40

Location: T15S R13E, Section 10

West of Wal-Mart on northwest corner of Midvale Park Road and Valencia Road, east of Oaktree Drive, and approximately 1/2 mile west of the Santa Cruz River

Field Description: No dumping or landfilling was evident on this site. The site consisted of a disturbed, vacant lot with sparse grasses. Access was available from Valencia Road, Oaktree Drive, and the nearby parking lots. The surrounding land uses included a Wal-Mart to the west, industrial and commercial properties to the south, a vacant lot to the north, and a commercial strip mall to the east. Paper and plastic products, which were probably blown onto the site from the adjacent parking lots, were present on the site. This site was visited because it appeared to have been disturbed in the 1990 photograph.

Site 41

Location: T15S R13E, Section 10

Approximately 1/2 mile west of the Santa Cruz River, approximately 1/2 mile north of Valencia Road, and east of Oaktree Drive

Field Description: This site consisted of a minor wildcat dump on a large vacant lot (old farmland) with grasses. The waste seen on the site included dirt piles, green waste, large tree segments, concrete debris and scrap metal. Access was available from Oaktree Drive to the west. The surrounding land uses included new residential areas to the north and west, a vacant lot and commercial land to the south, and a vacant lot to the east.

Site 42

Location: T15S R13E, Section 14
Southwest corner of I-19 and Valencia Road on east bank of Santa Cruz River

Field Description: No dumping or landfilling was evident at this site. The site consisted of an old gravel pit (San Xavier Rock & Material) located on the east bank of the Santa Cruz River that was devoid of vegetation and contained some dirt piles. Access was not available because the site was fenced with chain link and barbed wire. The surrounding land uses included a vacant lot to the north, I-19 to the east, the river with bank protection to the west, and an active sand and gravel operation to the south. A minor drainage southeast of the site had some glass, cans, cardboard, and plastic bags in it. This site was visited because the pit appeared in the 1974 photograph.

Site 43

Location: T15S R13E, Section 14
Directly south of Site 17, west of I-19, east of Santa Cruz River, and halfway between Valencia Road and Los Reales Road alignment

Field Description: This site consisted of an active sand and gravel operation (San Xavier Rock & Materials) on the east bank of the Santa Cruz River. Several tailings ponds were located on site, one of which had become a marsh. The waste seen surrounding the tailings pond that had become a marsh included concrete debris and wood. Access was restricted because it was fenced private property and only sand and gravel trucks were allowed to enter. The surrounding land uses included old sand and gravel operations (with the same company) to the north and south, the river with bank protection to the west, and I-19 to the east.

Site 44

Location: T15S R13E, Section 14
Directly south of Site 18, west of I-19, east of Santa Cruz River, and north of Los Reales Road alignment

Field Description: This site consisted of an old sand and gravel operation (San Xavier Rock & Material) on the east bank of the Santa Cruz River. There could have been some piles of dirt and concrete debris, but it was not possible to access the site to verify the observations made from the highway. Access was not available because the road was fenced off and there was a "No Trespassing" sign. Vegetation growing up through cracks in the asphalt indicated that the access road had not been used extensively for some time. The surrounding land uses included an active sand and gravel operation to the north, I-19 to the east, the river with bank protection to the west, and a vacant lot to the south.

Site 45

Location: T15S R13E, Section 14
Alley south of, but coincidental with, the Pinta Avenue alignment east of I-19 between Valencia Road and Los Reales Road

Field Description: This site consisted of a vacant lot east of I-19 and west of the alley coincidental with the Pinta Avenue Alignment. The site contained a minor wildcat dump near a drainage at the northern edge. The waste seen on the site consisted of dirt, green waste, rubber tires, concrete debris and wood piles. Access to the side of the site was available from the alley that coincided with the Pinta Avenue Alignment, although there was a short barbed wire fence. The surrounding land uses included I-19 to the west, a residential area to the east and south, and a vacant lot to the north.

Site 46

Location: T15S R13E, Section 22
Approximately 200 feet north of San Xavier Loop Road and approximately 1/4 mile west of the Santa Cruz River

Field Description: No dumping or landfilling was evident at this site. The site consisted of abandoned farmland 200 feet north of San Xavier Loop Road with farm machinery and stacked hay bales. There were a few scattered glass bottles and metal cans on the surface. Access was not possible because the site was private property and it was enclosed by a barbed wire fence. The surrounding land uses included active and abandoned farmland to the west, east, and south, and residential land and abandoned farmland to the north. This site was visited because it appeared to have been disturbed in the 1990 photograph.

Site 47

Location: T15S R13E, Section 22
Approximately 1/2 mile north of San Xavier Loop Road and approximately 1/4 mile west of the Santa Cruz River

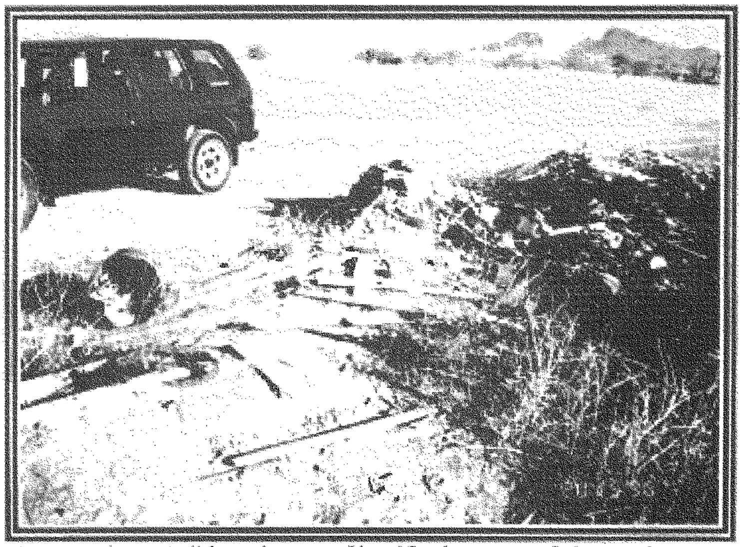
Field Description: No dumping or landfilling was evident at this site. The site consisted of a vacant lot 1/2 mile north of San Xavier Loop Road that had been farmland at one time, but now contained only sparse vegetation. Access was not possible because the site was private property and it was enclosed by barbed wire fencing. The surrounding land uses included abandoned farmland to the east, north, and south, and residential land to the west. This site was visited because it appeared to have been disturbed and appeared to have contained rubble piles in the 1990 photograph.

Site 48

Location: T15S R13E, Section 22
Approximately 1 mile north of San Xavier Loop Road and directly west of the Santa Cruz River

Field Description: This site contained a major wildcat dump within a drainage and a 300-foot section (approximate) of the river bank. Most of the drainage was essentially clean. The site was located directly west of the Santa Cruz River approximately one mile north of

San Xavier Loop Road, and had mesquite and palo verde trees and grasses. The material seen on the site included piles of asphalt, bricks, scrap metal strips, roofing materials, a paint can, rubber tires, an old car, old corrugated pipes, glass, an old water heater, old stoves, carpet, concrete debris, metal cans, wire, a 5-gallon can of roof cement, an empty 55-gallon metal drum, and wood. Photograph #11 shows an area on the eastern edge of the site containing more concentrated waste than the rest of the wildcat dump. Access was available from Oidak Wo:g. The surrounding land uses included abandoned farmland to the north, west, and south, and the Santa Cruz River with minor bank protection to the east.



Photograph 11. Wildcat dump at Site 48, view toward the southwest.

Site 49

Location: T15S R13E, Section 22
Approximately 1/2 mile north of San Xavier Loop Road and approximately 1/3 mile west of the Santa Cruz River

Field Description: The site consisted of a private car parts storage area approximately 1/2 mile north of San Xavier Loop Road and a minor wildcat dump in a drainage directly to the west. The waste seen on the site was primarily in the drainage and included piles of metal cans, glass bottles, plastic, carpet, a toilet, old appliances, a large metal water tank, and corrugated cardboard. Access was available from Oidak Wo:g. The surrounding land uses included abandoned farmland to the west, east, and north, and residential property to the south.

Site 50
Location: T15S R13E, Section 22
Northwest corner of San Xavier Loop Road and the Santa Cruz River

Field Description: No dumping or landfilling was evident at this site. The site consisted of a well-vegetated vacant lot directly west of the Santa Cruz River and directly north of San Xavier Loop Road. Access was not available because the site was enclosed by a barbed wire fence. The surrounding land uses included the Santa Cruz River with bank protection to the east, active farmland to the west and south, and abandoned farmland to the north. This site was visited because the site appeared to have been hummocky in the 1974, 1990, and 1995 photographs.

Site 51
Location: T15S R13E, Section 27
Approximately 1 mile south of San Xavier Loop Road, 1/4 mile east of Little Nogales Drive, 3/4 mile west of I-19, and directly north of Campus Drive

Field Description: No dumping or landfilling was evident at this site. The site consisted of a drainage, located directly north of Campus Drive, with grasses and mesquite trees. Access was available from Campus Drive. The surrounding land uses included abandoned farmland to the east, and residential land and natural desert to the west, north and south. This site was visited because there appeared to have been hummocky topography in the photographs caused by factors other than surface runoff eroding the site.

Site 52
Location: T15S R13E, Section 26
Approximately 1/2 mile east of I-19 and 1.5 miles south of San Xavier Loop Road on west bank of the Santa Cruz River

Field Description: The site consisted of a minor wildcat dump on a portion of the river bank east of I-19 and along the west bank of the Santa Cruz River. The waste seen at this site included glass bottles, plastic cups, 12-pack beer boxes, aluminum beer cans, wire, oil filters and cans, as well as partially buried metal cans, rubber and rubber tires. Photograph #12 shows waste in the center of the site that is more concentrated than the waste on the rest of the site. Access was available from the eastern terminus of Campus Drive. The surrounding land uses included abandoned farmland to the west, natural desert to the north and south, and the Santa Cruz River with no bank protection to the east.

Photograph 12. Wildcat dump at Site 52, view toward the southeast.

Site 53
Water Tank
Location: T15S R13E, Section 34
Approximately 1/2 mile west of I-19, 1/2 mile east of San Xavier Road, and 1/2 mile south of Campus Drive on Little Nogales Drive

Field Description: No dumping or landfilling was evident at this site. The site consisted of a clearing with a water tank in the center approximately 3/4 mile west of I-19. Access was available from Little Nogales Drive. The surrounding land uses included natural desert and grazing land. This site was visited because the clearing and the dirt roads around the water tank appeared to have been well-travelled in the 1974, 1990, and 1995 photographs, which indicated the possibility of wildcat dumping on the site.

Site 54
Location: T15S R13E, Section 34
Approximately 1/5 mile north of Papago Road and directly west of I-19 at southern terminus of Little Nogales Drive

Field Description: No dumping or landfilling was evident at this site. The site consisted of a disturbed area directly west of I-19, surrounded by less-disturbed desert. Access was available from Little Nogales Drive and there was barbed wire along the eastern edge of the site. The surrounding land uses included natural desert and grazing land to the north, west, and south, and I-19 to the east. This site was visited because the vegetation appeared to have been more disturbed than the surrounding desert in the 1974, 1990, and 1995 photographs.

Site 55
Location: T16S R13E, Section 3
Southwest corner of Papago Road and I-19
Field Description: No dumping or landfilling was evident at this site. The site consisted of slightly disturbed desert directly west of I-19 at the Papago Road extension. Access was available from Little Nogales Drive and other unnamed dirt roads. The surrounding land uses included natural desert and grazing land to the north, west, and south, and I-19 to the east. This site was visited because it appeared to have been disturbed on the 1974, 1990, and 1995 photographs.

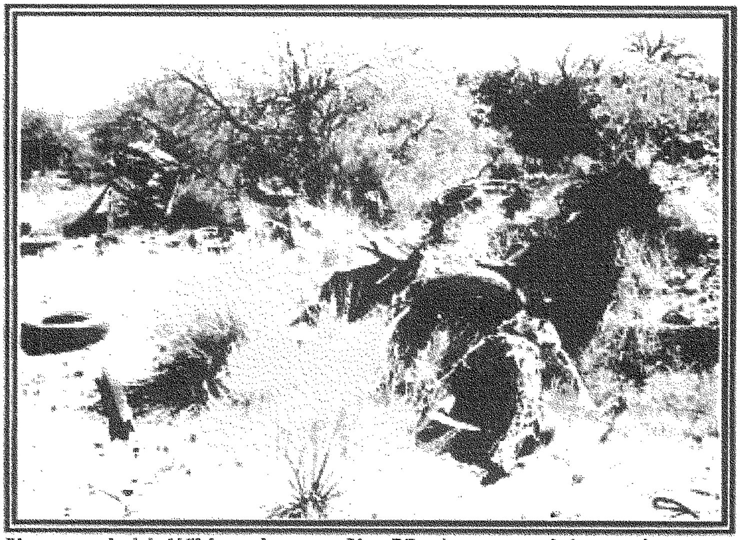
Site 56
Location: T15S R13E, Section 23
Approximately 3/4 mile north of San Xavier Loop Road, directly west of I-19 and in, or along, the east bank of the Santa Cruz River
Field Description: The site consisted of a major wildcat dump with excavated pits and piles of dirt in the floodway of the Santa Cruz River northwest of Martinez Hill. The waste seen on the site included concrete debris and metal pylons, and piles of dirt with old rubber car tires, steering wheels, and bumpers that appeared to have been dated from the 1940's. Photograph #13 shows piles of concrete debris, metal, and dirt that were representative of the rest of the site. Some of the waste had been buried, probably by natural deposition within the river channel. Access was available from two dirt roads directly west of I-19 and directly north of San Xavier Loop Road. The surrounding land uses included the Santa Cruz River to the west, north and south with riprap bank protection, and I-19 and vacant land to the east.

Photograph 13. Piles of concrete debris, dirt, and metal at Site 56, view toward the northwest.

Site 57

Location: T15S R13E, Section 23
Approximately 1/2 mile north of San Xavier Loop Road, directly west of I-19 and directly east of the Santa Cruz River

Field Description: The site consisted of a major wildcat dump on a portion of the river bank along the east side of the Santa Cruz River with mesquite and palo verde trees, desert broom, and grasses. The waste seen on the site included mainly intact and partially-buried old cars possibly dating from the 1940's; there were also piles of wire, wood, metal cans, metal springs, rubber tires, a muffler, rebar, dirt, glass, oil filters, concrete blocks, a car bench seat, and a vehicle gas tank. Photograph #14 shows piles of waste on the eastern edge of the site that were representative of the waste on the rest of the site. Access was available from two dirt roads directly west of I-19 and directly north of San Xavier Loop Road. The surrounding land uses included the Santa Cruz River with riprap bank protection to the west, north, and south, and vacant land and I-19 to the east.



Photograph 14. Wildcat dump at Site 57, view toward the northeast.

Site 58

Location: T15S R13E, Section 26
Approximately 1/2 mile east of the Santa Cruz River and 1.5 miles south of Martinez Hill

Field Description: The site consisted of a vacant lot with sparse vegetation, located 1.5 miles south of Martinez Hill. Piles of dirt were the only waste materials seen on the site. Access was available from dirt roads originating at JJ Stock Road and the San Xavier Health Clinic. The surrounding land uses included natural desert and a few scattered residences.

Site 59

Location: T15S R13E, Section 26
Approximately 200 feet east of the Santa Cruz River and 1 mile south of Martinez Hill

Field Description: No dumping or landfilling was evident at this site. The site consisted of flat, vegetated vacant land 200 feet east of the Santa Cruz River. Access was available from dirt roads originating at JJ Stock Road and the San Xavier Health Clinic. The surrounding land uses included natural desert to the south, the Santa Cruz River with no bank protection to the west, and rural residential areas to the north and east. Ponding may have occurred at this site in the past, because flat ground, desiccation cracks, and tall grasses were seen on site. This site was visited because it appeared to have been hummocky on the 1974, 1990, and 1995 photographs.

Site 60

Location: T15S R13E, Section 23
Approximately 1/4 mile east of the Santa Cruz River and directly south of Martinez Hill

Field Description: No dumping or landfilling was evident at this site. The site consisted of a small clearing directly south of Martinez Hill with a burnt prickly pear cactus in the center. Access was available from dirt roads originating at JJ Stock Road and the San Xavier Health Clinic. The surrounding land use included natural desert on all sides. This site was visited because the dirt road leading to the clearing appeared to have been well-travelled in the 1990 and 1995 photographs, which indicated the possibility of dumping on the site.

Site 61

Location: T15S R13E, Section 23
Approximately 200 feet south of JJ Stock Road and approximately 200 feet southeast of the San Xavier Health Clinic

Field Description: The site consisted of a minor wildcat dump on a vacant lot directly southeast of the San Xavier Health Clinic with palo verde and mesquite trees. The waste seen on the site included piles of concrete debris with rebar, bricks, green waste, and dirt. Access was possible from JJ Stock Road and a dirt road southeast of the Clinic. The surrounding land uses included natural desert to the south, east, and west, and the Clinic to the north and northwest.

Site 62

Location: T15S R13E, Section 35
Approximately 3/4 mile east of I-19 and 2 miles south of Martinez Hill on the west bank of the Santa Cruz River

Field Description: The site consisted of a minor wildcat dump in a cleared area, measuring approximately 1/4 mile long by 100 feet wide, that was located directly west of the Santa Cruz River and directly north of a large flood diversion berm, which measured approximately four feet high. The material seen on the site included surface piles of concrete debris, large corrugated piping, metal, wood, barbed wire, red clay piping, glass bottles, green waste, dirt, and cobbles. Access was available from dirt roads originating near the eastern end of Campus Drive. The surrounding land uses included natural desert to the north and west, a flood diversion berm to the south, and the Santa Cruz River with no bank protection to the east.

Site 63

Location: T16S R13E, Section 2
Southwest corner of Papago Road and I-19

Field Description: Access was not possible due to barricades and fencing at the eastern terminus of Papago Road. The site appeared to have contained abundant mesquite and palo verde trees with no large clearings. The surrounding land uses included I-19 to the west and natural desert to the north, east, and south.

Site 64

Location: T16S R13E, Section 25
Approximately 1/3 mile north of Pima Mine Road and directly west of the San Xavier District's eastern boundary

Field Description: The site consisted of a minor wildcat dump in a cleared area at the intersection of a dirt road and a berm approximately 1/3 mile north of Pima Mine Road. The waste seen on the site included a surface pile of glass bottles, as well as a few plastic bottles and a wooden crate. Access was available from the dirt road that runs perpendicular to Pima Mine Road just west of the eastern boundary of the San Xavier District. The surrounding land uses included District grazing lands to the north, south, and west, and private grazing lands to the east.

Site 65

Location: T16S R13E, Section 25
Approximately 1.25 miles north of Pima Mine Road and directly west of the San Xavier District's eastern boundary

Field Description: No dumping or landfilling was evident at this site. The site consisted of an approximately 200-foot wide drainage located approximately 1.25 miles north of Pima Mine Road. The site contained some ponding as well as cholla cacti, mesquite trees, and grasses. Access was available from the dirt road that runs perpendicular to Pima Mine Road just west of the eastern boundary of the San Xavier District. The surrounding land uses included District grazing lands to the north, south, and west, and private grazing lands to the east. This site was visited because the dirt road leading to the site appeared to have been well-travelled on the 1990 and 1995 photographs, indicating the possibility of dumping on the site.

Site 66

Location: T16S R13E, Section 24
Approximately 2 miles north of Pima Mine Road and directly west of the San Xavier District's eastern boundary

Field Description: No dumping or landfilling was evident at this site. The site consisted of a clearing directly south of Lee Moore Wash and approximately two miles north of Pima Mine Road with mesquite trees and heavily-grazed grasses. Access was available from the dirt road that runs perpendicular to Pima Mine Road just west of the eastern boundary of the San Xavier District. The surrounding land uses included District grazing lands to the north, south, and west, and private grazing lands and a cattle corral to the east. This site was visited because the dirt road leading to the site appeared to have been well-travelled on the 1990 and 1995 photographs, indicating the possibility of dumping on the site.

Site 67

Location: T16S R13E, Section 14

Approximately 2.5 miles north of Pima Mine Road and 200 feet east of I-19

Field Description: Access was not possible due to the topography and the fencing along I-19 to the west of the site. There were some clearings evident from I-19, but it was unclear whether they were on the site. The surrounding land uses included District grazing lands to the east, south, and north, and I-19 and grazing land to the west.

Site 68

Location: T16S R13E, Section 11

Approximately 3.5 miles north of Pima Mine Road and 200 feet east of I-19

Field Description: Access was not possible due to the topography and the fencing along I-19 to the west of the site. There were a few clearings evident from I-19, but it was unclear whether they were on the site. The surrounding land uses included District grazing lands to the east, south, and north, and I-19 and grazing land to the west.

CONCLUSIONS

The site information in this report provides an overview of waste disposal locations and materials. The project focused on identifying previously undocumented wildcat dumps and landfills within the flood plain of the Santa Cruz River. The study area extended from Grant Road to the north to Pima Mine Road to the south. Because the study area included tribal lands of the San Xavier District, PAG and OEM staff coordinated with the San Xavier District Office prior to scheduling the site visit. Permission to access the District lands was granted at the San Xavier Tribal Council meeting in May 1996.

Previously Undocumented Waste Disposal Sites

PAG staff identified 106 sites as possible waste disposal sites through analysis of aerial photographs of the Santa Cruz River area. The surfaces of the previously documented landfills, which are described in the "Previously Documented Landfills" section of this report, were included in the total number of sites. PAG staff field checked 68 of these sites, including the landfills, and noted whether they were clean or showed evidence of waste disposal. Sites were not visited if they were either outside the flood plain or were inaccessible by road.

Six (6) major waste disposal sites were identified in the study area. A "major" waste disposal site was defined as a wildcat dump or undocumented landfill with large piles of waste that were probably dumped by pickup trucks or larger vehicles. One of the major wildcat dumps (site 11) was located on the surface of "A" Mountain Landfill, just south of Mission Lane. All of the other major wildcat dumps identified in this study were located between Drexel Road and the San Xavier Loop Road. Two major sites (34 and 37) were located near the Santa Cruz River within the City of Tucson Boundaries. Three major sites (48, 56, and 57) were located within the San Xavier District near the northeastern border of tribal lands. All of these sites contained piles of dirt, concrete, or green waste in addition to the dumped trash.

Seventeen (17) minor waste disposal sites (9, 12, 13, 14, 18, 19, 23, 27, 28, 33, 41, 45, 49, 52, 61, 62, and 64) were identified in the study area. A "minor" waste disposal site was defined as a wildcat dump or undocumented landfill which consisted mostly of scattered surface litter which would at the most be equivalent to a few pickup truck loads of waste. Twelve (12) of these sites (9, 12, 13, 14, 19, 23, 27, 28, 41, 45, 61, and 62) also contained piles of dirt, concrete, or, to a lesser degree, green waste. Minor waste disposal sites were distributed throughout the study area, but were generally lacking north of St. Mary's Road and in unpopulated areas on San Xavier District lands.

Fourteen (14) sites (3, 4, 7, 10, 17, 20, 24, 29, 32, 36, 42, 43, 44, and 58) contained piles of dirt, concrete, or, to a lesser degree, green waste, but did not have any additional wildcat dumping. In some cases, these sites might be considered storage sites rather than dumping sites.

Previously Documented Landfills

Nine (9) previously documented landfills, "El Dumpe," St. Mary's, Rio Nuevo North, Rio Nuevo South, "A" Mountain, Mission, 29th Street, Cottonwood, and Ryland were located within, or adjacent to, the study area. PAG staff visited each of these sites to document changes in land surface characteristics since PAG's site visits in 1993 for another project. However, it was beyond the scope of this project to further investigate landfill characteristics. More detailed landfill descriptions are available in PAG's 1993 and Dames & Moore's 1989 reports.

Several of the landfills (St. Mary's, Mission, 29th Street, and Cottonwood) had been graded and developed after landfill closure. Because of the on-site development, it was not possible to see any evidence for landfilling during the site visit for this project. Menlo Park, complete with baseball fields, basketball courts, and parking lots, was built over the St. Mary's Landfill. Mission Landfill had been graded and the Santa Cruz River Park had been constructed over the site. Pima County facilities had been built over most of the 29th Street Landfill. Single-family homes and mobile homes had been built on the surface of the Cottonwood Landfill.

Four (4) of the landfills (Rio Nuevo North, Rio Nuevo South, "A" Mountain, and Ryland) had significant amounts of wildcat dumping on site. Ryland Landfill was notable because the hummocky surface appeared to be a result of differential settling of landfill material. In addition, landfill material was exposed along the western edge of Ryland Landfill because the cover material had been eroded by high flows in the Santa Cruz River during episodic storm events.

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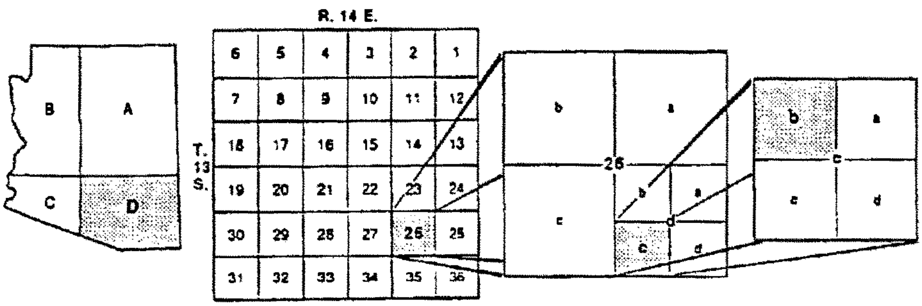
APPENDIX 1

NOTES FROM ANALYSES OF AERIAL PHOTOGRAPHS, SANTA CRUZ RIVER AREA BETWEEN GRANT ROAD AND PIMA MINE ROAD

This appendix contains notes made during the initial aerial photograph review. As part of this review, PAG identified and briefly described areas that appeared to be potential waste disposal locations. These sites included gravel pits, ponds, areas with significant off-road travel, and other unidentified disturbed areas. A general description of land use in the area was also included, if relevant.

The 1990 photo sets were reviewed as part of this project, with comparative analysis using corresponding 1974 and 1995 photo sets. The locations of areas that appeared disturbed on the photographs are provided in this Appendix. Each blue line photograph included four sections. The disturbed areas are described under the photograph on which they were identified, and under the section in which they were located. For each Township/Range, the photos are described from the north to south. Within each section, the sites are listed starting in the northeast and progressing counterclockwise to the southeast, using the Bureau of Land Management's system of land subdivision (see below). According to this system, the first letter in the site location denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters are assigned in a counterclockwise direction from the northeast quadrant to the southeast quadrant as A, B, C, and D.



(adopted from Tadayon, 1995)

Time and budget constraints prevented PAG from visiting all of the sites noted on the aerial photographs. Sites that were excluded from the field visits included those that were out of the flood plain and those that had no nearby road access and were too far from a road to reach by foot. For completeness, however, all of the sites noted during the initial photo review are presented below.

1990 Photo 8-15
T14S, R13E
Sections 1, 2, 11, 12

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residential, commercial, and industrial development

Section 2

DCA: one site east of I-10 & west of railroad tracks -- creek bed with good access from highway & side street;

CDD: one site west of river -- vacant lot with good side street access;

B, C, D: one long large site on east bank with vacant & disturbed land, and dirt roads with some nubby texture;

1974 Photo 12-15:	DCA - undisturbed creek bed & vegetation;
(same area as above)	CDD - vacant;
	B,C,D - undisturbed, except for south end;
1995 Photo 69-28:	DCA - less disturbed than 1990;
(same area as above)	CDD - vacant;
	B, C, D - partially covered by river park;

Section 11

DAA, DAC, DDB: 3 sites east of I-10 -- vacant lots with sparse vegetation north of downtown (between Congress & St. Mary's);

AB, AC: two strip sites along Santa Cruz (North and south of St. Mary's) --disturbed and vacant;

DB: one large site (Rio Nuevo North landfill) -- west of river with great access;

CD: one site (now a park) that was St. Mary's Landfill -- west of Rio Nuevo North;

1974 Photo 12-15:	DAA, DAC - same as 1990;
(same area as above)	DDB - structures present;
	AB - structures present;
	AC - hummocky texture;
	DB - most disturbed and hummocky at this time;
	CD - same as 1990;

1995 Photo 69-28: DAA, DAC - same as 1990;
(same area as above) DDB - more disturbed than 1990;
AB, AC - covered by river park;
DB - same as 1990;
CD - structures present;

1990 Photo 7-15
T14S, R13E
Sections 3, 4, 9, 10

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residential, commercial, and industrial development

<u>Section 3</u>

AA, AD: two sites (vacant lots) on either side of river south of Grant -- good access;

1974 Photo 11-15: AA, AD - structures present that were destroyed before 1990;
(same area as above)

No 1995 Photo Available

1990 Photo 8-14
T14S, R13E
Sections 13, 14, 23, 24

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residential, commercial, and industrial development

<u>Section 14</u>

AC, DB, DC: 3 sites on west bank between Broadway and Starr Pass Blvd. -- A-Mountain & Congress/Nearmont landfills and one disturbed lot (Starr Pass & Mission);

AC, DC, CD: 3 sites on east bank between Broadway and Starr Pass Blvd. (2 disturbed lot and one vacant lot);

1974 Photo 12-14: AC, DB, DC - landfilling more active than 1990;
(same area as above)
AC - vacant land;
DC - slightly disturbed land, possible old dump;
CD - a few structures present, but otherwise dirt patch;

1995 Photo 69-27 : *(same area as above)*	AC, DB, DC - partially covered by river park; AC, DC - same as 1990; CD - covered by river park;

Section 23

BDA: one site on west bank at Y of Santa Cruz and West Branch -- old landfill;

AB, BA, BD: 3 sites on east bank between Starr Pass and Silverlake -- disturbed land and vacant lots;

CA: one site encompassing river south of Silverlake -- old landfill;

1974 Photo 12-14: *(same area as above)*	BDA - more disturbed than 1990, because more active and not built over; AB - vacant lot with dirt track; BA - disturbed land; BD - disturbed with more vegetation; CA - more disturbed-looking than 1990;
1995 Photo 69-27 : (same area as above)	BDA - built over more than 1990; AB - same as 1990; BA - still disturbed but river park built over part; BD - disturbed with river park over part; CA - less disturbed-looking than 1990;

1990 Photo 8-13
T14S, R13E
Sections 25, 26, 35, 36

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residential, commercial, and industrial development

Section 26

BC, BCBC, CBA, BD, CD: 5 sites west of river and between Ajo Way and 36th Street -- one is Cottonwood Landfill and one is well;

BD, ACCC, A, CD: 4 sites east of river -- one is Ryland Landfill and one is well;

1974 Photo 12-13: (same area as above)	BC, BCBC, CBA, BD, CD - same as 1990; BD, ACCC, A, CD - same as 1990;
1995 Photo 69-26: *(same area as above)*	BC, BCBC, CBA, BD, CD - same as 1990; BD, ACCC, A, CD - same as 1990;

Section 35

CAC, CBA, CCC: 3 wells on east side of river in vacant lot;

BBA: one site south of Ajo Way -- vacant lot near structures and east of river;

CC: Possible wildcat dump near influx of West Branch -- disturbed land;

B & C: one site west of river -- disturbed land -- sparse vegetation;

CD: one site north of Irvington, west of I-19 and east of river - old landfill according to Well Protection Document; Slightly suspicious-looking;

1974 Photo 12-13: *(same area as above)*	CAC, CBA, CCC - same as 1990; BBA - same as 1990; CC - not present; B & C - farmland; CD - same as 1990;
1995 Photo 69-26: *(same area as above)*	CAC, CBA, CCC - same as 1990; BBA - same as 1990; CC - same as 1990; B & C - more vegetation than 1990, otherwise same; CD - same as 1990;

1990 Photo 8-12
T15S, R13E
Sections 1, 2, 11, 12

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mainly new residential development

Section 2

BBA, BB, BD, CB: 5 sites along river and west of Calle Santa Cruz -- disturbed land with main and dirt road accesses -- sparse vegetation, linear areas parallel with river;

1974 Photo 12-12 : *(same area as above)*	BBA, BB, BD, CB - vacant, but not disturbed;
1995 Photo 69-25 : *(same area as above)*	BBA, BB, BD, CB - same as 1990;

Section 11

BB, B, CC, CCD: 4 sites along river on both sides west of I-19 and Calle Santa Cruz -- vacant lots, good access from river and N-S roads;

CAC: one small site east of Calle Santa Cruz -- separate access road; dirt patch amidst native vegetation;

CBA: two wells on east bank of river and west of Calle Santa Cruz -- good access, dirt roads small disturbed dirt patches surrounding each;

1974 Photo 12-12: *(same area as above)*	BB, B, CC, CCD - vacant land but not as disturbed as 1990; CAC - same as 1990; CBA - same as 1990;
1995 Photo 69-25: *(same area as above)*	BB, B, CC, CCD - same as 1990; CAC - same as 1990; CBA - same as 1990;

1990 Photo 7-12
T15S, R13E
Sections 3, 4, 9, 10

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agricultural, residential and vacant lots;

Section 3
mainly vacant lots and new development;

(2 sites on margin with Section 2 - described in that section);

Section 10

(1 site on margin with Section 11 - described in that section);

A: one site along west bank of river -- disturbed land;

DBB, DCC: two disturbed areas amidst farmland (outside boundary);

1974 Photo 11-12: *(same area as above)*	A - vacant lot with some disturbed vegetation; DBB, DCC - farmland;
1995 Photo 68-25: *(same area as above)*	A - same as 1990; DBB, DCC - same as 1990;

1990 Photo 8-11
T15S, R13E
Sections 13, 14, 23, 24

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agricultural, industrial, and residential;

Section 14

CAD, CDD: two sites east of I-19 near structures; dirt patches with good access -- vacant lots;

CCB, CCD: site on either side of river north of Los Reales Road with slight hummocky texture and vegetation;

B & C: Sand & gravel operation with pits and piles and ponds -- large site in bend of river;

B: Site north of above site that is a vacant lot -- large dirt patch;

BBB: Site across river from above site and south of Valencia -- possible pits and little vegetation;

1974 Photo 12-11: *(same area as above)*	CAD, CDD - dirt and farmland; CCB, CCD - same as 1990; B & C - operation smallest at this time; B - part of above sand & gravel operation; BBB - brush and old farmland;
1995 Photo 69-24: *(same area as above)*	CAD, CDD - same as 1990; CCB, CCD - same as 1990; B & C - operation largest at this time; B - same as 1990; BBB - same as 1990;

Section 23

DC, CDD, CC, DBB: 4 sites around Martinez Hill -- small with small dirt access roads -- one along riverbank looks partially washed away;

B: one large site east of I-19 that has hummocky texture;

BD: one site east of I-19 near a structure -- looks like someone tossed stuff down a hill;

B, CB: two sites west of I-19 in or near river -- all with good access from roads and river -- partly washed away;

BA: one site near good dirt road -- disturbed vegetation;

1974 Photo 12-11: *(same area as above)*	DC, CDD, CC, DBB - not present; B - farmland; BD - undisturbed land; B, CB - largest at this time, active sand & gravel operations; BA - undisturbed land and vegetation;
1995 Photo 69-24: *(same area as above)*	DC, CDD, CC, DBB - same as 1990, except one along river bank has been partially washed away; B - same as 1990; BD - same as 1990; B, CB - more washed away between 1990 & 1995; BA - same as 1990;

1990 Photo 7-11
T15S, R13E
Sections 15, 16, 21, 22

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agricultural, industrial, and residential;

Section 15

D: large site that's a landfill or sand & gravel operation;

A: one site south of industrial complex south of Valencia -- vacant, some vegetation, slightly disturbed;

ABB: one site near industrial -- large vacant lot;

BB: Huge vacant lot south of Valencia and west of industrial -- good access;

CD: Large vacant lot with dirt track - north of Los Reales Road -- good access from south and east;

AAB: small lot south of Valencia east of industrial -- vegetation, vacant lot, great access from north and west;

1974 Photo 11-11: *(same area as above)*	D - farmland; A - somewhat disturbed; ABB - farmland; BB - same as 1990; CD - farmland with track; AAB - same as 1990;
1995 Photo 68-24: *(same area as above)*	D - same as 1990; A - some of 1990 site converted to industrial; ABB - same as 1990; BB - some of 1990 site converted to commercial and/or industrial use; CD - same as 1990; AAB - same as 1990;

Section 22

DCC: one site north of San Xavier Road -- disturbed area between two structures;

DD: one large site north of San Xavier Road and next to west bank of river -- disturbed land with little vegetation;

ADA: one hummocky site west of river and east of farmland;

CDB: one site north of San Xavier Road -- hummocky site adjacent to farmland, good access;

DBCD, DBCB: two sites near structures and northeast of San Xavier Mission -- adjacent to farmland -- one is disturbed, the other one had old cars or something on it -- good access;

B: one site south of Los Reales Road surrounded on 3 sides by farmland -- vegetated, rectangular, no visible structures;

1974 Photo 11-11: *(same area as above)*	DCC - disturbed land present; DD - more vegetation than 1990; ADA - more land present (partly washed away before 1990); CDB - farmland; DBCD - farmland; DBCB - same as 1990; B - farmland;

1995 Photo 68-24: *(same area as above)*	DCC - same as 1990; DD - less land and vegetation than 1990 (partly washed away); ADA - more of site washed away between 1990 & 1995; CDB - same as 1990; DBCD, DBCB - same as 1990; B - same as 1990;

1990 Photo 8-10
T15S, R13E
Sections 25, 26, 35, 36

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mainly undisturbed desert;

Section 25

AAAA: site near Nogales Highway -- intersection of two dirt roads -- large dirt patch;

ADB: small site with separate access road -- dirt patch with no visible structure;

1974 Photo 12-10: *(same area as above)*	AAAA - same as 1990; ADB - not present;
1995 Photo 69-23: *(same area as above)*	AAAA - same as 1990; ADB - same as 1990;

Section 26
active & dormant agriculture and undisturbed land, except for dirt access roads;

AC, DABA: two sites on east side of river that are connected by access -- large disturbed area with mounds of dirt and little vegetation -- access to east and north and to river;

BD: site on west side of river in sandbar with streaky patterns perpendicular to riverflow -- access from west near farmland;

1974 Photo 12-10: *(same area as above)*	AC, DABA - farmland; BD - access present, but land not disturbed;
1995 Photo 69-23: *(same area as above)*	AC, DABA - same as 1990; BD - same as 1990;

Section 35
undisturbed land with dirt access roads and flood diversion berm running from I-19 to the Santa Cruz River;

BA: one site near access to west side of river -- old uncultivated farmland (dirt patch);

ABB: one site near access to west side of river -- disturbed land near edge of river where access ends;

A & D: site on west of river with several access roads (large area of irregular shape) -- fairly disturbed land with some vegetation;

1974 Photo 12-10: *(same area as above)*	BA - farmland; ABB - same as 1990; A & D - sandbar, no disturbance;
1995 Photo 69-23: *(same area as above)*	BA - same as 1990; ABB - same as 1990; A & D - disturbed land present;

Section 36
undisturbed desert with small dirt access roads; nothing "suspicious" on topographic map or aerial photos;

1990 Photo 7-10
T15S, R13E
Sections 27, 28, 33, 34

Section 27
active farmland; scattered structures and dirt roads amidst natural desert;

AD: one site along I-19 near river -- disturbed land;

CAC: one site close to Little Nogales Dr. southwest of farmland -- mounds of dirt;

CD: one site close to Little Nogales Dr. southwest of farmland -- a drainage channel;

CCC: one site close to Little Nogales Dr. southwest of farmland -- an intersection with vacant lots;

1974 Photo 11-10: *(same area as above)*	AD - same as 1990; CAC - farmland; CD - drainage not disturbed; CCC - intersection not in same form at this point;
1995 Photo 68-23: *(same area as above)*	AD - same as 1990; CAC - same as 1990; CD - same as 1990; CCC - lots around intersection most disturbed at this point;

Section 34
mainly undisturbed desert with dirt roads;

BDD: water tank surrounded by disturbed land;

DA, DD: two sites along west side of I-19 -- one small with wall around it and other to the south a large disturbed area;

AB: one site south of farmland -- disturbed area;

1974 Photo 11-10: *(same area as above)*	BDD - land around water tank most disturbed at this time; DA, DD - not present; AB - disturbed land located at south end of 1990 site;
1995 Photo 68-23: *(same area as above)*	BDD - land around water tank less disturbed than 1990; DA, DD - same as 1990; AB - area of disturbance larger than 1990;

1990 Photo 8-9
T16S, R13E
Sections 1, 2, 11, 12

undisturbed desert;

Section 2

B: site near I-19 -- disturbed land with roads -- most established in 1974;

Found Gravel pit west of I-19 on topographic maps and aerials -- present since 1974 when it was most established (in Section 3, but located on fringe of this photo);

1974 Photo 12-9: *(same area as above)*	B - disturbed land most established (heavily traveled) at this time;
1995 Photo 69-22: *(same area as above)*	B - land not as disturbed as 1990;

<u>Section 11</u>

C: Borrow Pit north of one in Section 14 -- large, rectangular lot with access roads coming from west (near I-19) -- disturbed land with little vegetation;

1974 Photo 12-9: *(same area as above)*	C - borrow pit largest and most heavily used at this time (roads most pronounced);
1995 Photo 69-22: *(same area as above)*	C - borrow pit present, but not heavily used;

1990 Photo 8-8
T16S, R13E
Sections 13, 14, 23, 24

---

mostly undisturbed desert;

<u>Section 13</u>

CA: cut-in area near river and road to Borrow Pit -- present in 1974 and 1995 also;

BBB: water tank with clearing and creek/road access -- disturbed land 1974-1995;

1974 Photo 12-8: *(same area as above)*	CA - cut-in area present; BBB - land disturbed around water tank;
1995 Photo 69-21: *(same area as above)*	CA - cut-in area present, although harder to see; BBB - land still disturbed;

<u>Section 14</u>

C: Borrow pit on topographic map -- large rectangular lot with roads leading east and west;

1974 Photo 12-8: *(same area as above)*	C - borrow pit present;
1995 Photo 69-21: *(same area as above)*	C - borrow pit present;

Section 24
roads are virtually nonexistent (main one is along eastern district boundary);

D: disturbed land along north-south main road;

1974 Photo 12-8: *(same area as above)*	D - land not disturbed in 1974;
1995 Photo 69-21: *(same area as above)*	D - disturbance not as obvious as 1990, but still present;

1990 Photo 8-7
T16S, R13E
Sections 25, 26, 35, 36

---

mainly undisturbed desert;

Section 25

roads are sparse;

DA: one site SSW of diagonal road between river and reservation boundary -- dirt patch;

AD, DAD: two intersections on E1/2 may have some dumping (near boundary road - one with creek and one with dirt road);

1974 Photo 12-7: *(same area as above)*	DA - vacant lot with some vegetation; AD, DAD - same as 1990;
1995 Photo 69-20: *(same area as above)*	DA - vacant lot with no vegetation; AD, DAD - same as 1990.

APPENDIX E

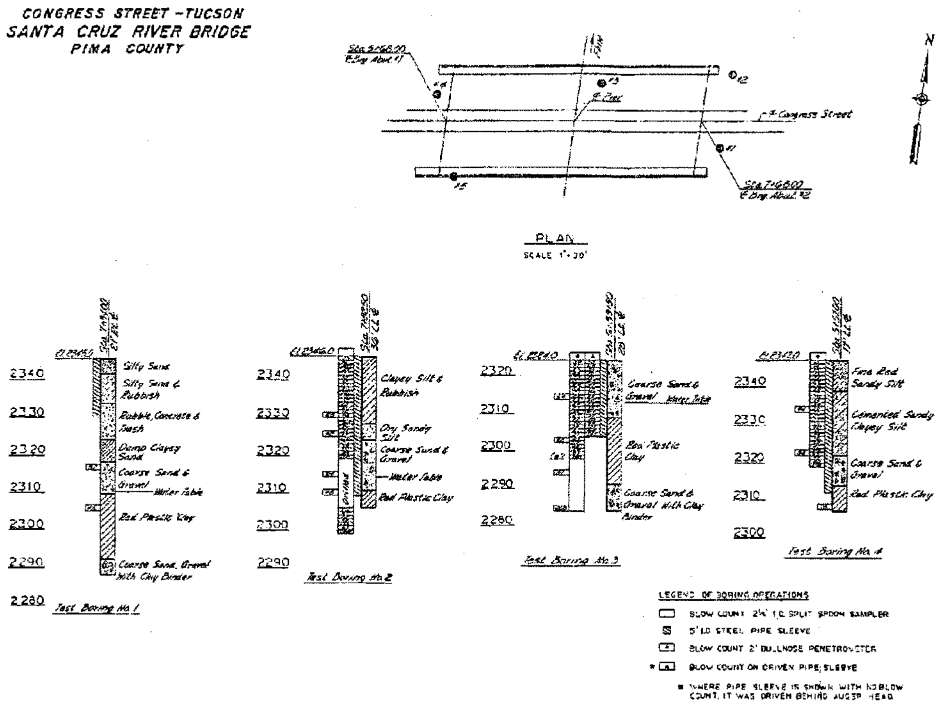
Test Pit And Test Boring Logs

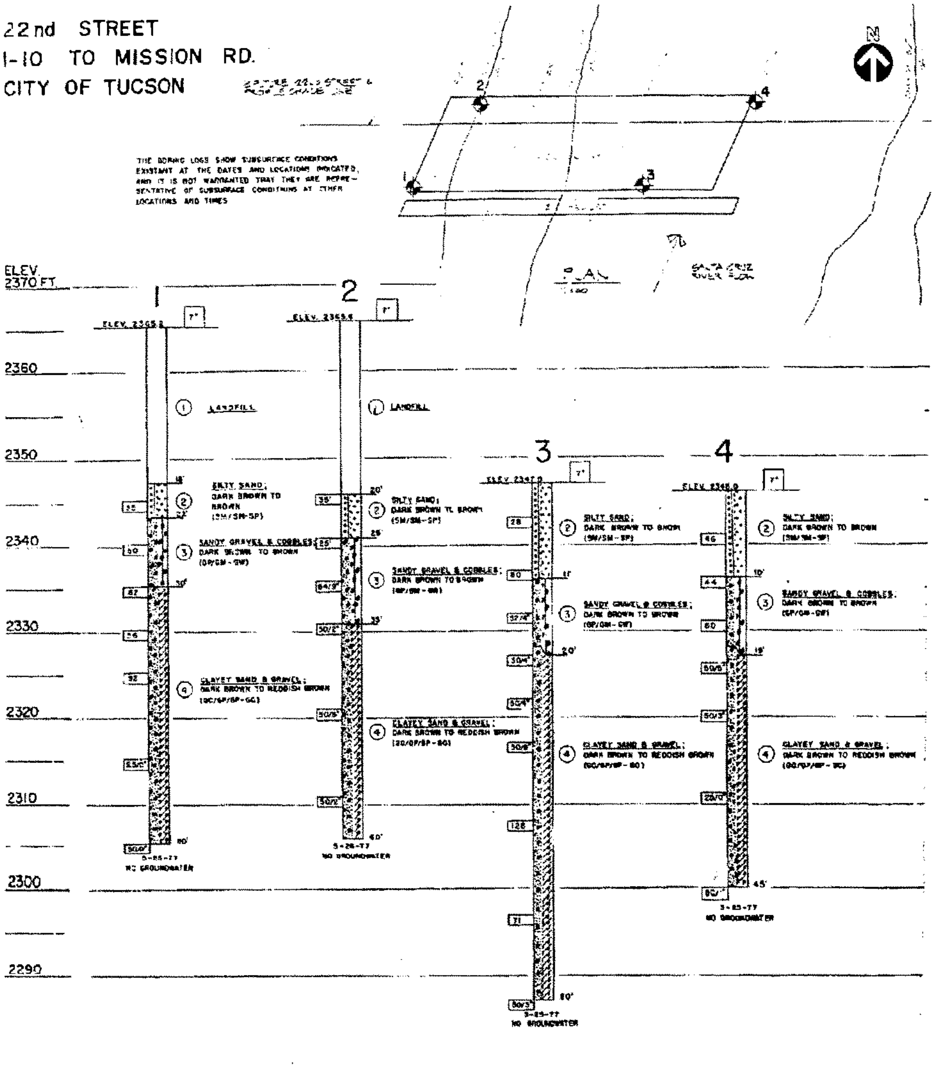
PASEO DE LAS IGLESAS - SANTA CRUZ RIVER
TUCSON, ARIZONA
PIMA COUNTY WO#: 4FPDLI

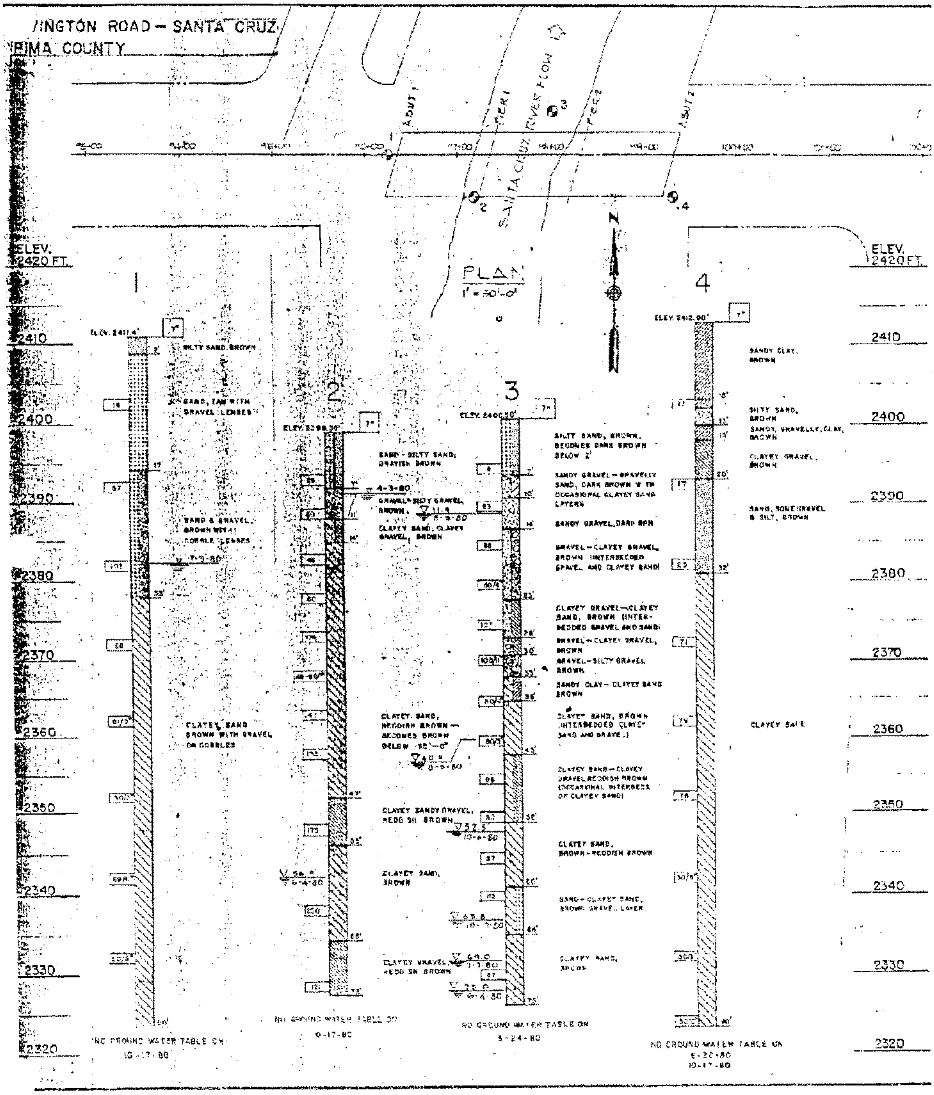
BORING LOGS FOR THE BACKHOE TEST PITS

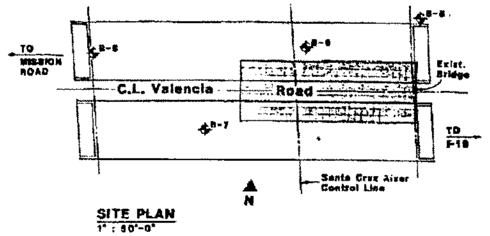
(Reference the aerial photo site plan for the test pit locations)

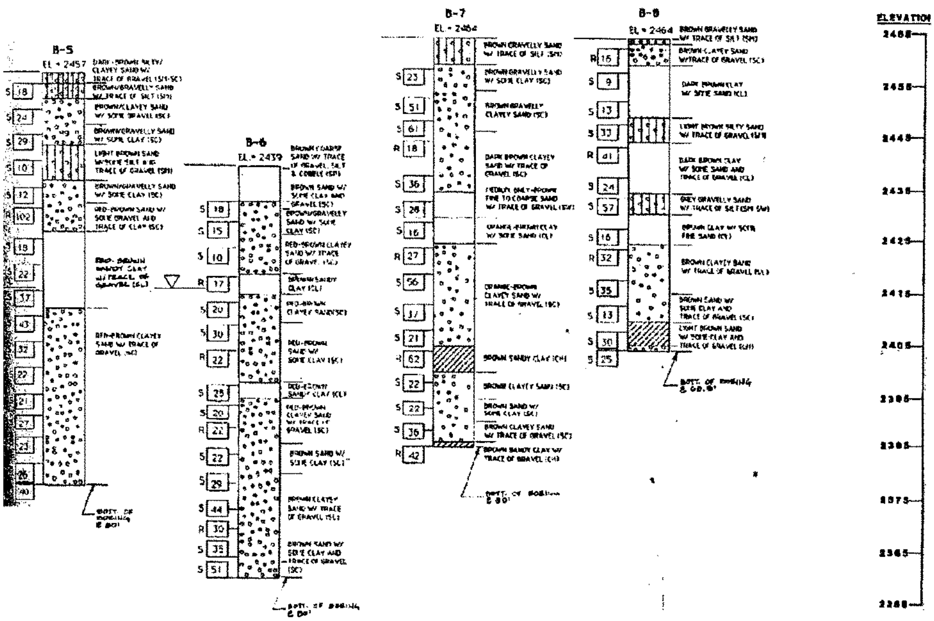
TEST BORING	DEPTH	SAMPLE SOIL CLASSIFICATION
1C	0 - 4 ft.	Silty Sand (SM) brown
2C	0 - 2 ft.	Silty Gravel (GM) brown
2E	0 - 2 ft.	Sandy Silt (ML) light brown
3C	0 - 5 ft.	Silty Sand (SM) brown
4C	0 - 2 ft.	Silty Sand (SM) brown
4E	0 - 2 ft.	Sandy Silt (ML) light brown
4W	0 - 8 ft.	Sandy Silt (ML) light brown
5C	0 - 2 ft.	Silty Sand (SM) brown
5E	0 - 2 ft.	fine Silty Sand (SM) light brown
5W	0 - 2 ft.	Sandy Silt (ML) light brown to tan
6C	0 - 2 ft.	Silty Gravel (GM) brown
6E	0 - 10 ft.	Sandy Silt (ML) light brown
7C	0 - 3 ft.	Silty Sand (SM-SP) brown
7E	0 - 10 ft.	Gravel with Sand, Silt and Clay (GM) brown
7W	0 - 5 ft.	Sandy Silt (ML) light brown
8C	0 - 4 ft.	Sandy Silt (ML) light brown to tan
8W	0 - 8 ft.	Sandy Silt (ML) light brown to tan
9C	0 - 3 ft.	Silty Sand (SM) light brown
10C	0 - 4 ft.	Silty Sand (SM) light brown
11C	0 - 2 ft.	Silty Sand (SM) light brown


CONGRESS STREET - TUCSON
SANTA CRUZ RIVER BRIDGE
PIMA COUNTY
Congress Street
PLAN
SCALE 1"=30'
N
2340
2330
2320
2310
2300
2290
2280
Silty Sand
Silty Sand & Rubbish
Rubble, Concrete & Trash
Damp Clayey Sand
Coarse Sand & Gravel
Water Table
Red Plastic Clay
Coarse Sand, Gravel With Clay Binder
Test Boring No. 1
Clayey Silt & Rubbish
Dry Sandy Silt
Coarse Sand & Gravel
Water Table
Red Plastic Clay
Test Boring No. 2
Coarse Sand & Gravel
Water Table
Red Plastic Clay
Coarse Sand & Gravel With Clay Binder
Test Boring No. 3
Fine Red Sandy Silt
Cemented Sandy Clayey Silt
Coarse Sand & Gravel
Red Plastic Clay
Test Boring No. 4
LEGEND OF BORING OPERATIONS
BLOW COUNT 2½" I.D. SPLIT SPOON SAMPLER
5" I.D. STEEL PIPE SLEEVE
BLOW COUNT 2" BULLNOSE PENETROMETER
BLOW COUNT ON DRIVEN PIPE SLEEVE
WHERE PIPE SLEEVE IS SHOWN WITH NO BLOW COUNT, IT WAS DRIVEN BEHIND AUGER HEAD


22nd STREET
I-10 TO MISSION RD.
CITY OF TUCSON
PLAN
ELEV. 2370 FT.
2360
2350
2340
2330
2320
2310
2300
2290
1
2
3
4
LANDFILL
SILTY SAND;
SANDY GRAVEL & COBBLES;
CLAYEY SAND & GRAVEL;
NO GROUNDWATER


/INGTON ROAD – SANTA CRUZ
PIMA COUNTY
RIVER FLOW
SANTA CRUZ
PLAN
ELEV. 2420 FT.
1
2
3
4
ELEV. 2420 FT.
2410
2400
2390
2380
2370
2360
2350
2340
2330
2320
N


TO MISSION ROAD
C.L. Valencia Road
Exist. Bridge
Santa Cruz River Control Line
N
SITE PLAN


B-5
B-6
B-7
B-8
ELEVATION

MAP 1

Site Plan

MAP 2

Depth to Groundwater (Tucson Water)

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX G

PHASE I SITE ASSESSMENT

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

US Army Corps of Engineers
Los Angeles District

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PHASE I SITE ASSESSMENT

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

PHASE I ENVIRONMENTAL SITE ASSESSMENT FOR THE PASEO DE LAS IGLESIAS PROJECT, PIMA COUNTY, ARIZONA

Submitted to:

U.S. ARMY CORPS OF ENGINEERS

Planning Division

Attn: Mr. Sam Arrowood
3636 No. Central, Ste 740
Phoenix, AZ 85012

Submitted By:
Tetra Tech, Inc.
Infrastructure Southwest Group
33 N. Stone, Suite 1500
Tucson, AZ 85701

In Association With:

SWCA, Inc. Environmental Consultants
343 South Scott Avenue
Tucson, Arizona 85701

In Partial Fulfillment of
Contract No. DACW09-98-D-0007
Task Order No. 0020

September 24, 2002

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APPENDICES

EXECUTIVE SUMMARY

The Paseo de las Iglesias site is located in Pima County, Arizona, within the urbanized area of South Tucson. The site consists of approximately 9 square miles along the east and west sides of the Santa Cruz River, an ephemeral stream that occasionally flows in response to storm events. The majority of the study area consists of residential properties. Various commercial and light industrial facilities are, for the most part, concentrated along the study area perimeter and on the eight major east-west thoroughfares that cross the study area.

SWCA reviewed seventy-two aerial photographs made from 1935, 1959, and 1963 through 2001. The aerial photograph review did not reveal evidence of RECs. The most recent (1954, photo-revised 1992, text revised 1995) USGS topographic map of the site did not reveal evidence of any recognized environmental conditions (RECs). Several interviews were attempted, but because of the vast amount of documented material in the form of reports available, interviewees provided very little information and suggested that extensive file reviews were necessary to adequately summarize environmental issues related to properties within and near the subject site.

As part of the Phase I ESA, applicable federal and state environmental regulatory databases were reviewed. The database search identified thirty-three sites or facilities within the study area that have been registered, investigated, or otherwise documented by various environmental regulatory, emergency response, or enforcement agencies. During the site reconnaissance, SWCA observed numerous private and municipal facilities that store or use petroleum products or hazardous materials within the study area. Contaminant migration from some of these sites or facilities may have occurred, or has the potential to occur in the future.

SWCA personnel observed debris scattered throughout most of the length of the river corridor. Based on the wide distribution of the disposal sites and the contents of the debris piles (papers, boxes, food and beverage containers, scrap wood and metal, household trash, furniture, appliances), it does not appear that the river bottom has been the site of prolonged commercial or industrial waste disposal activities. Some of the discarded items, such as small paint or fuel containers, suggest the possibility that small amounts of hazardous materials may have been discarded in these areas, although the actual contents of the containers now, or at the time of disposal is not known. The Site Reconnaissance did not reveal evidence of any RECs.

Research identified the presence of several inactive landfills concentrated along the Santa Cruz River. These landfills have the potential to affect groundwater, surface water and soil quality, depending on landfill contents and potential mobility of contaminants. Due to voids, decomposition of materials, and lack of compaction during filling, the landfills can pose engineering and structural risks with respect to structures built on or near the landfills. Chemical exposure hazards could be created during excavation of landfill materials for building or utility construction. Construction or excavation on or near landfills should be prohibited until potential hazards are fully characterized and mitigated.

The subject property could be affected by migration of contaminants from the landfills or from facilities observed nearby and/or identified in the environmental regulatory databases. In most instances, only catastrophic releases would result in impacts to the subject site from off-site facilities. As a matter of housekeeping and to preclude the miscellaneous trash and debris in the river bottom from contributing to surface or groundwater contamination, or detracting from the aesthetics of the river bottom, this trash/debris should be removed.

1.0 INTRODUCTION

This report, prepared by SWCA, Inc. (SWCA), presents the results of its Phase I Environmental Site Assessment (ESA) within the Paseo de las Iglesias study area, a seven-mile reach of the Santa Cruz River adjacent to the City of Tucson. This section of the river flows northward between Los Reales Road and Congress Street in Tucson, Pima County, Arizona. The study focuses on a corridor including the incised banks and the river bottom, extending east to Interstate Highways 10 and 19, and west to Mission Road, an area totaling approximately 9 square miles (Figure 1). SWCA completed the ESA for Tetra Tech, Inc. in partial completion of a Baseline Conditions Report to evaluate the redevelopment potential of the Santa Cruz River corridor.

The Phase I ESA followed the standards described in the American Society for Testing and Materials (ASTM) Standard E 1527-2000, Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process. Deletions or deviations from ASTM Standard E 1527-2000 are documented in this report. The objective of the Phase I ESA was to assess, to the extent practical, the existence of recognized environmental conditions (RECs). RECs are defined in the ASTM standard as "the presence or likely presence of hazardous materials or petroleum products under conditions that indicate and existing release, a past release, or material threat of a release of any hazardous substances or petroleum products into structures on the property, or into the ground, groundwater, or surface water of the property." The term is not intended to include *de minimus* conditions that generally do not present risks of harm to public health or the environment and that generally would not be the subject of enforcement actions if brought to the attention of appropriate regulating agencies.

The Phase I ESA did not include a sample collection for the presence of asbestos-containing materials (ACM), radon and all other radioactive substances, lead-based paint, non-hazardous wastes and materials, or biological or medical wastes. The assessment also did not include interviews with local residents or occupants of the many business and government facilities within the study area.

2.0 SCOPE OF WORK

To achieve the objective referenced above, SWCA completed the following tasks:

- Reviewed topographic maps and historical aerial photographs made from 1935 to 2001;
- Surveyed relevant documents in order to assess the site's physiography, including a review of the local hydrogeology and geology below the site and surrounding area;
- Reviewed available federal and state regulatory databases;
- Visually surveyed the properties within the study area; and
- Interviewed Pima Association of Governments, Water Quality Staff; City of Tucson Solid Waste Department, Catalina Sanchez; and City of Tucson Environmental Management Division, Ray Murray.
- Conducted file reviews for 13 sites located within the Project area.

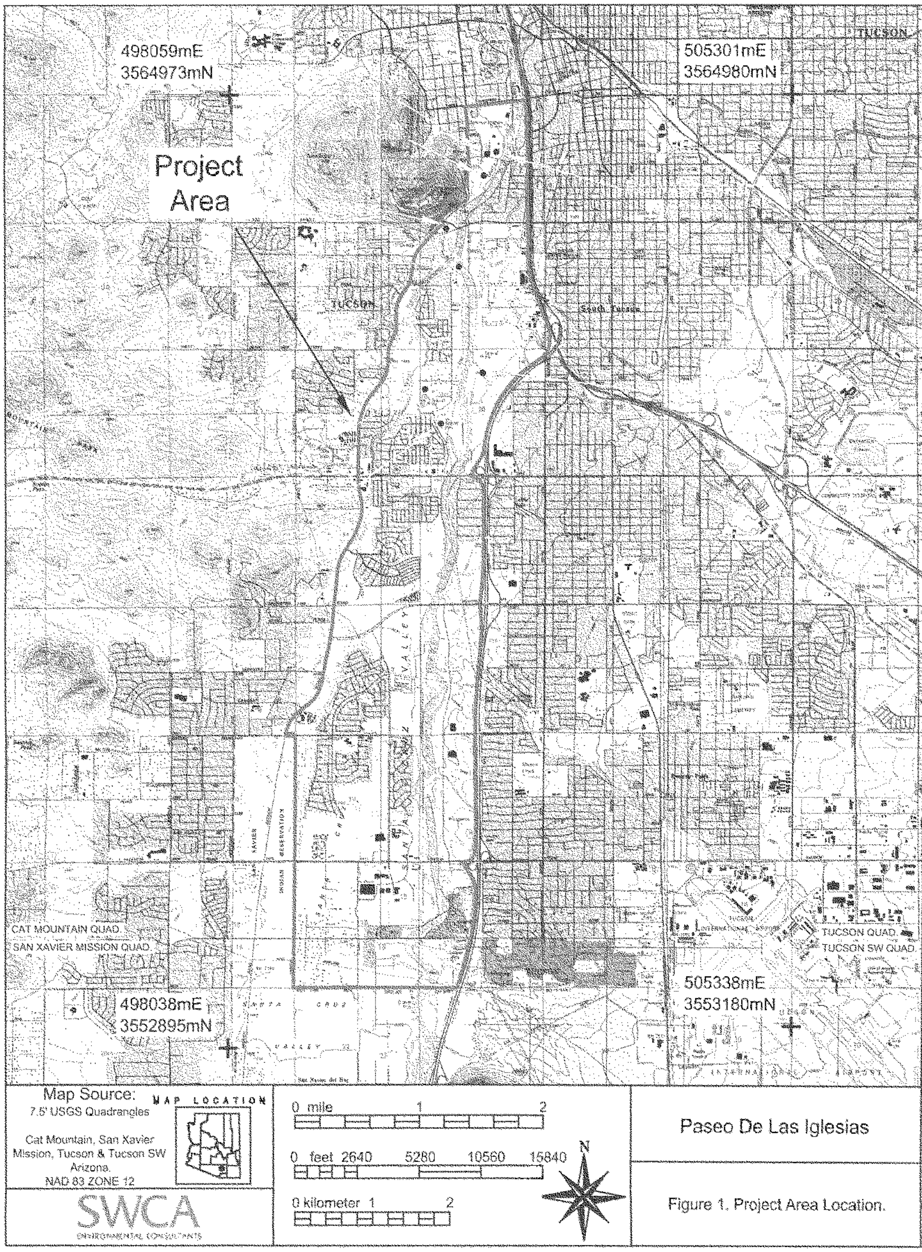


Figure 1. Project Area Location.

Some standard historical sources were not used in preparation of the Phase I ESA report. Sanborn fire insurance maps are not available for the site. The subject site is not known to have been assigned a specific street address because the project area includes multiple parcels; therefore city directories were not searched. SWCA was not provided with a copy of a chain of title report for the site, nor was one required within the scope of this ESA.

3.0 SITE DESCRIPTION

3.1 SITE LOCATION

The site is located in Pima County, Arizona, within the urbanized area of South Tucson. The study area focuses on a seven-mile segment of the Santa Cruz River, bounded on the north by Congress Street, on the west by Mission Road, on the South by Los Reales Road, and on the east by Interstate Highways 10 and 19.

3.2 SITE DESCRIPTION

The site consists of a roughly trapezoidal area of approximately 9 square miles including each side of the river and the river bottom. At its northern end the site is at its narrowest, approximately one half mile wide from east to west, reaching a maximum width of about two miles at the southern end. The river flows northward and is generally paralleled on the east by Interstate Highway 19 from the southern end of the site to 36th Street, and by Interstate Highway 10 from 36th Street north to Congress Street. From Los Reales Road, Mission Road generally parallels the Santa Cruz River and extends along a roughly north-northeasterly path to Congress Street to form the western border of the site. Portions of the project area have been developed in various ways. The southernmost portion (approximately one mile from south to north), on both sides of the river is currently used for sand and gravel excavation and storage. Other portions of the site have been developed into residential, commercial, and industrial areas. Much of the area outside the riverbanks consists of vacant desert. There are also six inactive landfills within the project area. These six landfills are discussed in Sections 4.4 and 8 of this report.

3.3 SITE UTILITIES

Tucson Electric Power lines pass through and serve the project area, and include a substation with numerous transformers located at the intersection of West Clark Street and South Freeway on the east side of the River. The condition of the transformers could not be determined due to enclosure within a locked fence and gate. Wastewater management services are divided among the Pima County Wastewater Management department, individual septic system, and sewage systems maintained by homeowners associations. Tucson Water serves the area, but it is unknown if all homes and buildings acquire their potable water from this department. Visible evidence of other utility providers was not apparent at the project site, although natural gas pipeline markers were observed along mission road. There is a concrete irrigation ditch along the top edge of the bank on the west side of the Santa Cruz in the northernmost reach of the project area south of Congress Street. There are signs along this ditch warning of the non-potable nature of the water. According to reports by local officials, the irrigation ditch is not active or functional, but serves as part of an educational display related to the role of irrigation in the area.

3.4 SITE VICINITY

The project area is a seven-mile long corridor following the Santa Cruz River located in a developed area of South Tucson, Pima County, Arizona. Properties surrounding the site include vacant desert, residential, commercial, and industrial properties. Various residential streets, arterial and collector roads, and Interstate Highways run through or adjacent to the site.

The headwaters of the Santa Cruz River are in the San Rafael Valley in southeastern Arizona. The river channel courses south and, after a 35-mile loop through Mexico, reenters Arizona about six miles east of Nogales. The river continues northward to Tucson, then north-northwest to its confluence with the Gila River about 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the U.S.-Mexico border before entering the study area. The River channel through the project area is approximately 30 feet wide in the low flow channel and approximately 250 feet bank-to-bank width with incised banks approximately 15 to 20 feet high. Flow in the River channel is rare, typically occurring locally in response to heavy rains and resultant runoff.

Five bridges cross the River within the project area. Various natural and man-made drainage channels enter the river within and near the site boundaries. Tucson International Airport is approximately 1.5 miles east of the southern portion of the project area, south of Valencia Road.

4.0 PHYSICAL SETTING ANALYSIS

The following sections have been taken from the Appendix F (LMT Engineering, Inc., 2002) of the Paseo de las Iglesias Environmental Restoration Study.

4.1 TOPOGRAPHY

The study area is located near the central portion of the Tucson basin, a broad, 1,000 square mile valley located in the Santa Cruz drainage basin. The topography of this basin is typical of the Basin and Range Physiographic Province. Northwestward trending, step, rugged fault block mountains border the broad, gently northwestward sloping alluvium-filled valley. The basin is approximately 50 miles long and 20 miles wide in the southern and central parts, narrowing to 4 miles wide at the northwest outlet. The basin is bounded on the north and east by the Tortolita, Santa Catalina, Tanque Verde, Rincon, Empire and Santa Rita Mountains; and on the west by the Tucson, Black, and Sierrita Mountains. The mountains on the west side of the basin range from 3,000 to 6,000 feet above mean sea level (msl), and those on the north and east side have elevations generally ranging from 6,000 to 8,000 feet msl, with peaks rising to elevations of 9,400 feet msl.

The metropolitan City of Tucson resides at the approximate center of this basin at an elevation of approximately 2,400 feet msl. The Santa Cruz River channel extends north from Mexico into the south-central portion of this basin and exits north of the basin where it eventually terminates into the Gila River. Flow occurs in the channel during most of the year south of the Tucson Basin. The flow during dry times of the year is a result of discharges from the Nogales, Arizona, and Nogales, Sonora, Mexico, sewage treatment plants. During dry times of the year, such flow does not normally extend further north than Green Valley, Arizona, which is located approximately 15 to 20 miles south of the study area.

Along the extent of this study area, sixteen tributaries flow into the main Santa Cruz River (including the South Channel), as well as the historic and diverted West Branch(es) of the Santa Cruz, Tucson Diversion Channel, and many others. The main channel, west branch(es), and the tributaries are ephemeral and generally only flow in direct response to rainfall and/or snow melt in the region and nearby mountains.

4.2 GEOLOGY

The complex geological history of Arizona has resulted in the formation of three geologic physiographic provinces. The three provinces consist of the Colorado Plateau (in the northern area of the state), the Basin and Range Province (encompassing southern and western Arizona), and the Central Highlands or Transitional Zone (encompassing the central part of the state). The Santa Cruz River Watershed lies within the Sonoran Desert of the Basin and Range Physiographic Province. The north to northwest trending alluvial basin is characterized by a semi-arid to arid broad valley.

The Santa Cruz River Basin is paralleled by steep mountain ranges composed of igneous, metamorphic, and sedimentary rocks of Precambrian (over 600 million years old) to Tertiary (63 to 2 million years old) age. The mountains lie upon a Precambrian igneous and metamorphic basement complex that is composed predominantly of granite and diorite, schist and gneiss, and volcanics.

The present relief of the Santa Cruz River Basin is a direct result of a period of regional uplifting due to block faulting that took place during the late Tertiary (63 to 2 million years ago) or early Quaternary (2 million years ago to present). Concurrent with the uplifting of the regional mountains, large amounts of alluvium from the surrounding mountains have been deposited within the basin (at the center of the Santa Cruz River basin, bedrock is currently buried by more than 11,000 feet of alluvial sediments). The Tucson basin, a structural depression, is filled primarily with unconsolidated to indurated Tertiary and Quaternary age sedimentary deposits, with lesser amounts of intercalated evaporates and volcanic rocks.

The alluvial sediments deposited within the basin have been divided into four geologic units that are, in descending order of depth (younger to older): surficial or recent alluvial deposits, the Fort Lowell Formation, the Tinaja Beds, and the Pantano Formation. The extent of these layers in the study area is shown in Table 1. The surficial deposits occupy the streambed channels and are generally less than 100 feet thick. The coarse surficial deposits allow the infiltration of surface water to recharge the underlying units. The Fort Lowell Formation underlies the recent alluvial deposits and consists of unconsolidated to moderately consolidated sands and silts 300 to 400 feet thick throughout most of the basin.

4.2.1 Regional Geology

Beds lie under the Fort Lowell Formation and are composed of sandstones and conglomerates with a total thickness of up to 5,000 feet at the center of the basin. The Pantano Formation, which underlies the Tinaja Beds, ranges up to 6,400 feet in thickness near Davidson Canyon, which is located about 20 miles southeast of Tucson along 1-10. This formation consists of consolidated sandstones, conglomerates, and mudstones. In addition to these sediments, as a result of intermittent periods of volcanism, there are areas of extrusive igneous rocks interbedded within the valley alluvium layers. Below the alluvial units and beds of volcanic rock, there is an impermeable basement complex, which extends to the surrounding mountainsides.

Table 1 – Stratigraphic Sediment Layers (from Well Logs)*	
At Marana	
Fort Lowell Formation and Recent Alluvium	73 m-thick (240 ft) layer
Upper Tinaja Beds	73 m-thick (240 ft) layer
Volcanic Bedrock	Top at - 146 m (-480 ft)
Near Grant Road Crossing	
Fort Lowell Formation and Recent Alluvium	24 m-thick (80 ft) layer
Upper Tinaja Beds	73 m-thick (240 ft) layer
Middle Tinaja	49 m-thick (160 ft) layer
Volcanic Bedrock	Top at - 146 m (-480 ft)
½ Mile South of I-19/I10 interchange	
Fort Lowell Formation and Recent Alluvium	46 m-thick (150 ft) layer
Upper Tinaja Beds	46 m-thick (150 ft) layer
Volcanic Bedrock	Top at - 91 m (-300 ft)
1.5 Miles South of San Xavier Mission	
Fort Lowell Formation and Recent Alluvium	49 m-thick (160 ft) layer
Upper Tinaja Beds	37 m-thick (120 ft) layer
Lower Tinaja Beds	24 m, minimum (80 ft)
1.5 Miles North of Sahuarita/I-19 Interchange	
Fort Lowell Formation and Recent Alluvium	52 m-thick (170 ft) layer
Upper Tinaja Beds	43 m-thick (140 ft) layer
Lower Tinaja Beds	195 m, minimum (640 ft)
1 Mile North of Green Valley	
Fort Lowell Formation and Recent Alluvium	73-thick (240ft) layer
Upper Tinaja Beds	37m-thick (120 ft) layer
Lower Tinaja Beds	180 m, minimum (600 ft)

Poorly developed drainage systems gave rise to numerous pluvial lakes during the middle Tertiary, which accounted for rapid sediment filling of the basins. During the Pleistocene (2 million to 10,000 years ago) drainage was established westward by the Gila River and its tributaries (including the Santa Cruz River). During high erosion and deposition periods, the Santa Cruz River basin floor developed numerous bajadas (smooth slopes originating at the base of the mountains) which extended outward into the Santa Cruz River channel. In more recent geologic time, during the Quaternary Period (present to 2 million years ago), climatic changes and regional uplift accelerated erosion, resulting in the upper bajada slopes being deeply dissected by lateral washes, causing development of terraces along the main drainage systems including the Santa Cruz River Basin.

The Santa Cruz River main channel through Tucson flows on the far west side of the Basin over the relatively thin, peripheral parts of the basin fill sediments. Typical sections, derived from well logs identify specific stratigraphic sediment layers underlying the Santa Cruz River.

4.2.2 Local Geology

The alluvial deposits in the study area consist mainly of recent stream channel and floodplain deposits. These alluvial basin sediments are generally gravel and gravelly sand. Locally, the sediments in the study area are sand to sandy silt of fluvial origin. Lithified sediments do not crop out along the Santa Cruz River and generally they should not be present within excavation depths of the channel for structure installation, though such formations do approach the riverbed elevation in the vicinity of 22nd Street. The nearest rock exposures, classified as the Pantano Formation, occur in the foothills of the Santa Catalina Mountains to the north and east of the study. Rocks of this formation consist of highly faulted and tilted beds of conglomerate, sandstone and mudstone, interbedded in places with volcanic flows and tuffs and locally containing landslide debris and lenses of megabreccia (Anderson 1987a). Other subsurface information is presented in the Subsurface Investigations section of this report.

The surficial soil deposits as classified by the National Resource Conservation Service (previously Soil Conservation Service) are a Grabe-Anthony-Gila association consisting of level and nearly level to gently sloping soils that are dominantly loam to gravelly sandy loam, on flood plains and alluvial fans in the main channel of the river and Cave-Rillito-Mohave association consisting of nearly level to gently rolling soils that are dominantly gravelly loam and gravelly sandy loam, on low dissected terraces in portions of the banks away from the main channel (U. S. Dept of Agriculture, Soil Conservation Service, U of A Agricultural Experiment Station, Soil Survey of Tucson-Avra Valley Area, Arizona, April 1972).

A study by Jackson classified the soils in the channel as part of the T2 terrace, one of five terraces that exist in the Tucson Basin. The T2 terrace is defined as historically abandoned stream terraces occurring on the Santa Cruz River and Pantano Wash. Forms wide floodplain inset into stream valley. Soils are weakly developed (Torrifluvents). Topographically the T2 terrace is higher than T1 but several meters below T3. Gravelly sand dominates the sediments. Banks are unstable; recent incision and lateral erosion has left banks standing at an angle greater than the angle of repose, often vertical. Middle to late Holocene in age (Jackson, 1989).

<u>FAULTING</u>

The Tucson basin was formed during the Basin and Range disturbance of middle Miocene time (23 to 5 million years ago). A tectonic event was responsible for producing the deep basins and high ranges characteristic of present-day Basin and Range physiography. This extreme relief resulted from movement along deep-seated, highangle normal faults. Anderson's (1987a) structural interpretation of the Tucson basin infers two major north to northwest-trending basin-bounding faults: the Santa Cruz fault and a segmented subparallel fault system on the north and east edges of the basin and a secondary, oblique, and generally northeast-trending fault system. The large-scale, low-angle structural feature that extends along a sinuous trace on the south and west flanks of the Santa Catalina and Rincon Mountains, respectively, is referred to as the Catalina detachment fault (Dickenson 1988). This feature represents a stage in the development of the Santa Catalina-Rincon Mountain metamorphic core complex during the mid-Tertiary Orogeny, which preceded the Basin and Range disturbance.

The concealed basin faults and the detachment fault are not considered to be active or capable faults and are not underlying this study area. The Basin and Range province in southwestern Arizona has been considered tectonically inactive since the waning of the Basin and Range disturbance during the early Pliocene (Anderson1987a), due in part to the low levels of historical seismicity and the extensive pedimentation of mountain blocks (Pearthree et al. 1983). Quaternary faults are rare in southwestern Arizona and none have been identified in the Tucson metropolitan area (Menges and Pearthree 1983; Scarborough et al. 1986). The nearest concentration of Quaternary faults occurs along the western edge of the Santa Rita Mountains in southeastern Arizona, approximately 20 miles southeast of the study area. Pearthree (1986) estimated that the most recent movement along the Santa Rita fault occurred during the late Pleistocene. The Quaternary faulting observed in southeastern Arizona may represent minor reactivation of older Basin and Range structures or may be related to the Rio Grande Rift system of New Mexico (Pearthree et al. 1983).

SEISMICITY

The Tucson metropolitan area straddles the boundary between Zone 1 and Zone 2A of the Seismic Zone Map of the Contiguous States (Uniform Building Code, 1994 and USACE ER 1110-2-1806, dated 31 July 1995) and thus is located in a region of low to moderate seismic potential. Seismic activity has occurred throughout Arizona but southeastern Arizona (part of Zones 2A and 2B) is one of three regions where more frequent activity and earthquake epicenters with intensities greater than VI on the Modified Mercalli Scale and magnitudes greater than 4.0 have been concentrated (DuBois and Smith, et al. 1982). Estimates of average regional recurrence intervals between surface-rupturing earthquakes over the last 20,000 years for this portion of the state range from 3000 to 4000 years (Pearthree 1986). The report by Pearthree also contains a map of earthquake epicenters in the vicinity of Tucson.

The largest historical earthquake known to have affected the study area was the1887 Sonora, Mexico, event with a maximum epicentral intensity of XII and an estimated magnitude of 7.2. An isoseismic map of the earthquake area in DuBois and Smith (1982) indicates an intensity of VII was experienced in the Tucson area. This event, although 130 miles southeast of the study area, resulted in rock falls and landslides in the Santa Catalina Mountains and caused widespread damage in Arizona as far north as Phoenix. A seismicity map of the State of Arizona compiled by Stover et al. (1986) indicates that the largest known historical earthquakes within 100 miles of the study area occurred near Nogales, Arizona, in 1916; in western Pima County in 1961; and near Globe, Arizona, in 1969. The 1916 event, approximately 60 miles south of Tucson, had a maximum epicentral intensity of VI. The 1961 event, about 90 miles west-northwest of Tucson, had a magnitude of 4.7, while the 1969 event, approximately 85 miles northeast of Tucson, had a magnitude of 4.4. Only three earthquakes have been reported within a 25-miles radius of the study area. Two of these events, with maximum epicentral intensities of IV, occurred in 1888, approximately 3 miles southwest of Tucson. The third, a magnitude 4.4 event, occurred in 1965 about 25 miles west of Tucson.

Using Schnabel and Seed's (1973) attenuation curves for horizontal acceleration in rock (USACE, South Pacific Division, 1979), the previously mentioned earthquakes would have produced maximum bedrock accelerations of less than 0.1g at the study site. By contrast, a maximum credible earthquake of magnitude 6.7 to 7.2 generated by movement on the 12 to 36-mile long Santa Rita fault would produce a maximum bedrock acceleration of approximately 0.2g at the study site. The Uniform Building Code and International Building Code both recommend accelerations of 0.2g for the Tucson metropolitan area.

4.3 HYDROGEOLOGY

The main groundwater in the Tucson basin occurs in the sedimentary rocks and alluvium that form a single aquifer. The aquifer consists of the Pantano Formation, the Tinaja Beds, and the Fort Lowell Formation (from bottom to top) (Anderson 1987b). The Pantano Formation yields small to moderate amounts of water to wells while the Tinaja beds yield small to large amounts of water to wells, frequently in excess of 1000 gal/min (Anderson 1987b). The water table for this main aquifer is within 350 ft of the ground surface throughout most of the basin. Due to localized and/or perched water tables, the depth to groundwater ranges from less than 20 feet to about 170 ft below the ground surface along the Santa Cruz and Rillito Rivers (Babcock et al. 1988; City of Tucson 1996). Groundwater is generally under unconfined conditions. However, it may occur locally under confined or perched conditions. Groundwater movement is typically in a west-northwest direction, away from the basin margins toward the narrow northwest outlet (Osterkamp 1974). A groundwater contour map prepared by Tucson Water is attached to this report. This map shows the depth to groundwater throughout the Tucson Basin and in this study area.

We obtained information from the Arizona Department of Water Resources (ADWR) regarding depth of groundwater in wells in this study area. This information is included in Appendix C of this report. The key to the locations of the wells is also included in this Appendix. The wells with current water level readings are denoted with letters "A" through "K" on the right side of the well data sheets. These well locations are noted as ADWR Well Locations A through K on the aerial photo of the study region included with this report. The current well information included in this report indicates that depths to groundwater in the wells generally ranged from about 100 to 200 feet below ground surface in areas close to the Santa Cruz channel. Groundwater data were also obtained from soil borings made for bridges along the Santa Cruz River. Reports for the bridges at Congress, 22nd St., Irvington, and Valencia were reviewed. Information in these reports indicates groundwater (perched) was encountered at depths ranging from about 5 to 35 feet at Congress, Irvington, and Valencia. No groundwater was encountered in the test boring for the 22nd St. Bridge where the borings were advanced to depths of 45 to 60 feet. Due to the perched and/or localized nature of the groundwater along the Santa Cruz channel, these groundwater conditions are expected to vary in relation to flows in the River, well pumping, subsurface stratification, and other factors.

Long-term groundwater withdrawal has resulted in a general decline in water levels in the Tucson area since the 1900's. This groundwater decline can be noted in the ADWR data for the depth to groundwater for the wells in this vicinity.

Large-scale pumping of groundwater in the Tucson basin began about 1900 and increased dramatically in the 1940's. Most of the groundwater pumped in 1940 was used for irrigation. Later, groundwater pumpage was approximately equally divided among irrigation, municipal, and industrial uses (Anderson et al. 1982). The centers of greatest water-level decline are along the Santa Cruz River near Sahuarita and in the City of Tucson. Declines exceeding 100 ft have occurred in Tucson and portions of the study area, while to the south along the river, the maximum decline has been about 150 ft (Schumann and Genualdi 1986). This difference has resulted in the formation of two distinct cones of depression in the groundwater table.

Infiltration of storm runoff in the stream channels during the rainy seasons is the major source of recharge to the groundwater basin (Davidson 1973). Seepage of runoff along the mountain fronts constitutes the second largest source of recharge. This natural system recharges about 100,000 acre-ft/yr; however, there is currently a demand for 300,000 to 400,000 acre-ft annually. The resulting deficit is causing the water table to decline at an approximate average annual rate of 2.7 ft (PCDOT 1986).

Several studies have been performed to evaluate the rate of recharge for both the Santa Cruz and Rillito Rivers (Wilson 1979; Katz 1987; Wilson and Newman 1987; Cluff et al. 1987). These studies attempted to evaluate the recharge rate using primarily empirical methods. The study by Katz indicated that the infiltration rates for all the studies ranged from 286 to 551 acre-feet/day for the Santa Cruz River and from 272 to 1,262 acre-feet/day for the Rillito. The studies by Cluff, et al., and Wilson and Newman, evaluate the effects of channel stabilization on infiltration and ground water recharge. These reports are available at the Pima County Flood Control in-house library.

4.3.1 Subsidence, Fissuring and Collapsing Soils

Groundwater depletion in the Tucson basin has caused the aquifer system to compact. This compaction, in turn, has resulted in large areas of land subsidence, a problem that exists in other parts of the Basin and Range province of southern Arizona. The U.S. Geological Survey (USGS) is currently using seven vertical extensometer installations (VEIs) to measure and monitor aquifer compaction and water-level changes in the Tucson Basin. The VEIs are located in areas where the potential for land subsidence is believed to be large. Measurements made by the USGS from 1980 to the end of 1987 indicate that approximately 0.01 to 0.1 ft of compaction has occurred in the aquifer-system deposits underlying the basin during this period (Babcock et al. 1988). The amount of land subsidence resulting from aquifer compaction would be equal to the amount of compaction in all the compressible deposits of the aquifer. Since the water 12 wells used in the USGS study do not fully penetrate the aquifer, measured aquifer compaction would be less than or equal to the amount of land subsidence (Anderson et al. 1982). Thus, the greatest amount of land subsidence that has occurred in the Tucson basin between 1980 and 1987 is approximately 0.1 ft. This would equate to a subsidence rate of about 0.01 ft/yr. The closest VEI to the study area is located at well D-13-14 31cac, about 2-1/4 miles south of the Rillito River at First Avenue and about 2- 1/2 miles northeast of the north end of this study area. A total of about 0.04 ft of aquifer compaction was measured at this installation. From 1982, this amount would correspond to a minimum subsidence rate of less than 0.01 ft/yr. An aquifer compaction study near the town of Eloy, Arizona, in the lower Santa Cruz basin, revealed that compaction and expansion of the aquifer materials corresponds to seasonal trends in water-level fluctuations, while measured land subsidence corresponds to net annual water-level declines (Schumann et al. 1986).

Land subsidence was also identified and measured by National Geodetic Survey releveling in the Tucson basin in 1980 (Anderson 1987b; Winikka 1984). Results indicated that from 1951-54 to 1979-80, land subsidence ranged from less than 0.1 ft to almost 0.5 ft; the largest amount occurred southeast of Tucson in an area south of Davis-Monthan Air Force Base, approximately 7 to 10 miles east of the Santa Cruz River channel. Subsidence generally was small in relation to water-level decline in the basin during this period. Long-term data indicate a ratio of subsidence to water-level decline of generally less than 0.003 foot per foot (Anderson 1987b).

The area of greatest potential land subsidence in the Tucson basin is from the Davis-Monthan Air Force Base area to south of Sahuarita, where water-level declines have been large (Anderson 1987b). Anderson (1987b) indicates that by the year 2030, approximately 3 to 10-plus feet of potential subsidence may result from a 200 to 400 foot decline in 1940 water levels in this region.

Earth fissures, produced in alluvial deposits by differential land subsidence, have not yet been reported in the Tucson basin but have been mapped near seven groundwater areas in southern Arizona where maximum water-level declines have equaled or exceeded 200 ft (Schumann et al. 1986). The greatest concentration of fissures is found about 30 miles north of Tucson in the lower Santa Cruz basin, which has experienced the most severe groundwater depletion. The closest earth-fissure sites to the study area are in the Avra Valley, approximately 20 miles west of Tucson.

Earth fissures, which generally occur on the periphery of subsidence areas, may eventually develop in the Tucson basin if the magnitude of groundwater depletion approaches that found in the areas noted above that presently contain fissures. Anderson (1987b) delineated zones of potential severe localized differential land subsidence in the Tucson basin and noted that geohydrologic similarities with the Eloy-Picacho area in the lower Santa Cruz basin strongly indicate that earth fissures may occur in the Tucson basin by the year 2030, or perhaps sooner, assuming further ground water overdraft in the Tucson basin. The area from south of the Tucson International Airport to southeast of Sahuarita, which parallels a 15-mile segment of the Santa Cruz fault, was identified as the area most likely to be seriously affected by fissuring. However, a recent U.S. Geological Survey assessment of potential surface subsidence in response to overdraft in the Tucson area (Tucson Water et al. 1998) indicates that the Santa Cruz Mainstem in the Tucson Vicinity has potential to subside "less than two feet (0.6 m) to the north of the Interstate 19/I-10 interchange (the lowest number assigned in the potential ranking scheme) and no potential to subside south of that interchange." Those subsidence potential numbers represent a significant decrease in estimated subsidence potential from earlier U.S. Geological Survey work. The decrease is related to local control of groundwater pumping instituted in the interim between the two U.S. Geological Survey studies (Anderson 1987).

The ADWR well data indicate water-level declines exceeding 100 ft in the wells in the vicinity of this study. Therefore, this vicinity and the Tucson metropolitan area in general will likely to continue to be affected by subsidence as long as groundwater overdraft continues. Efforts are being made to reduce groundwater overdraft through water conservation and groundwater replacement. Specifically, the goal of the Tucson Active Management Area is to achieve a long-term balance of groundwater withdrawal with natural and artificial recharge by the year 2025 (USACE, 1986).

Collapsible soils are common in the southwestern desert environments where the natural evaporation greatly exceeds the precipitation. Collapsible soil deposits are formed when the alluvially deposited soils dry and form chemical bonds between the soil particles. These chemical bonds "tack weld" the soil particles together and give the soil a high dry strength. However, when these soils become wet, the chemical bonds weaken or dissolve and the soil structure reaches a point when it cannot withstand the applied overburden stress and the soil structure collapses. Structures supported on collapsing soils that undergo this collapsing phenomenon can undergo significant settlements and damage. Collapsing soils are typically composed of sands, silts and clays of low plasticity. These soils types and soils with collapsing potentials are known to exist within this vicinity. Usually, such collapsing soils occur at a distance of up to 1 mile from the main channel of a river where silts and clays are deposited by channel overflows. Specific studies should be undertaken once the type of remedial measures have been determined to evaluate the existence of collapsing soils.

4.3.2 Subsurface Investigations

The subsurface investigation for this study consisted of excavating shallow pits in the banks and bed of the rivers using a standard, wheel-mounted backhoe. These pits were excavated to maximum depths of about 10 feet below existing grade to obtain samples of the bed and bank materials to perform laboratory classification tests. The laboratory tests were performed to determine the gradation of the soil samples. Locations of the samples are noted on the site plan included with the maps in the jacket at the end of this report. Results of laboratory tests on these samples are presented in Appendix B of this report.

In addition to the sampling performed for this study, information from geotechnical engineering studies for several of the bridges along the Santa Cruz channel was reviewed - specifically the bridges at Congress, 22nd St., Irvington, and Valencia. Based on the information available in these reports and the authors' personal experience on other projects in this vicinity, the subsurface materials below the channels generally consist of sands and gravels, with some cobble layers. These soils generally become more granular and denser with increasing depth. However, some interbedded layers of silt and clay were also encountered in the borings for the Congress Bridge. These silt and clay layers existed at various depths in the borings, generally between about 15 and 50 feet. The perched water encountered in these borings appears to sit on top of the silt/clay layers. The subsurface soils are generally not cemented, although there is a heavily cemented layer approximately 25 feet below the riverbed at the site of the 22nd Street Bridge.

5.0 SITE HISTORY

The history of the site and adjacent properties was reviewed in accordance with the applicable ASTM standards. Previous environmental reports specific to the entire study area, property ownership data, Sanborn fire insurance maps, and city directories were not reviewed during preparation of this report because no such records could be identified or made available. SWCA learned that certain state and county agencies might have records related to environmental investigations of some of the landfills in the study area. However, acquiring and reviewing such documents was outside the scope of this ESA because the agencies were not able to state what, if any, documents exist, nor were they able to identify the locations of the documents or provide copies for review within a reasonable time. Historical aerial photographs covering the period 1935 (the earliest available) through 2001 (the most recent) were reviewed, as well as the USGS topographic map of the area made in 1943, 1948 and 1954 (photo revised 1992, text revised 1995). Interviews with site contacts consisted of telephone discussions with representatives from various agencies of Pima County and the City of Tucson. A summary of the information obtained from these sources follows.

5.1 AERIAL PHOTOGRAPHS

SWCA reviewed aerial photographs in the archives of Landiscor Aerial Information in Phoenix, Arizona, which had photographic coverage of the site from 1963 to 2001.

The March 31, 2001 aerial photograph shows the site similar to that observed during the site reconnaissance (detailed later in this report). The gravel pit and piles are visible, as are most of the structures observed during the site visit. Some structures or equipment are visible near the gravel pit; however, the scale of the photograph does not permit positive identification of the items. The area surrounding the site is similar to that observed during the site visit, with residential structures, the community college, the Interstate Highways, and the buildings of the few commercial and industrial areas located along each side of the study area. A copy of the May 5, 1998 aerial photograph, which shows the site essentially as it appeared at the time of SWCA's site reconnaissance, is included as Appendix A.

SWCA reviewed seventy-two additional aerial photographs made from 1935, 1959, and 1963 through 2001. Due to the length of the site corridor, each photograph date included at least three aerial photographs to cover the project area. The earliest photographs showed that the entire western side of the project area (west of the river) was being used for agricultural purposes. A small orchard or grove is apparent in the 1963 photographs, eventually being taken over by residential development, as seen on later photographs. The eastern banks of the river were agricultural and scrub desert. Tucson was being developed and there were housing developments approximately 1 to 1½ miles east of the project area at that time.

The gravel pit located east of the Santa Cruz River and in the southern portion of the project area first appears in the 1966 aerial photograph. The photographs show a steady progression from agricultural and desertscape to mostly residential developments with a small amount of industry or commercial use, although details of land use are not apparent.

The landfill areas were observed during the photograph review, and while surface disturbances were evident in some areas, specific activities could not be ascertained.

The aerial photograph review did not reveal evidence of RECs.

5.2 TOPOGRAPHIC MAPS

The most recent (1954, photo-revised 1992, text revised 1995) USGS topographic map of the site shows the site within an urbanized section of South Tucson. The maps show some indication of small commercial industrial areas and gravel pits in and near the site, in essentially the same locations as observed during the site reconnaissance. Most of the developed areas within the project boundaries were shown as residential, with the commercial or industrial buildings located along the study area boundaries or on the arterial roads crossing from east to west. The land is primarily flat with a gradual downward slope to the northwest. The topographic map did not reveal evidence of any REC's.

5.3 INTERVIEWS

Several interviews were attempted, but because of the vast amount of documented material in the form of reports available, interviewees contacted by telephone provided very little information and suggested that extensive file reviews were necessary to adequately summarize environmental issues related to properties within and near the subject site. In most cases, interviewees indicated that they were not aware of specific contents and locations of relevant documents, if they exist. The following is an account of personnel interviewed and the information that they provided.

- *Pima Association of Governments (PAG)*
  - Mr. Greg Hess (Hess, July 9, 2002), Water Quality Manager with PAG, provided direction to substantial PAG reports and documentation their office has regarding "wildcat" dumpsites and cleanups, well surveys, land use, and water quality surveys. Mr. Hess indicated that copies of the PAG reports and documentation were on file with the City of Tucson. A file review was conducted at the City of Tucson, Office of Environmental Management on July 15, 2002, and is discussed in Section 8.0 of this report.

- *City of Tucson Solid Waste Department*
  - Ms. Catalinea Sanchez (Sanchez, July 10, 2002), Environmental Scientist with the City of Tucson Solid Waste Department, indicated that landfills located in the Project area were not well documented during the time they were utilized (1953 through 1970), but that available

information may be of some use for determining the hazardous waste content of the landfills when dealing with issues such as collapsing landfill walls.

A file review was conducted at the City of Tucson Solid Waste Department on July 15, 2002, and is discussed in Section 8.0 of this report.

- *City of Tucson, Office of Environmental Management*
  - Mr. Murray (Murray, July 10, 2002), indicated the City of Tucson, Office of Environmental Management maintained files on most landfills located in the Project area. A file review was conducted at the City of Tucson, Office of Environmental Management on July 15, 2002, and is discussed in Section 8.0 of this report.

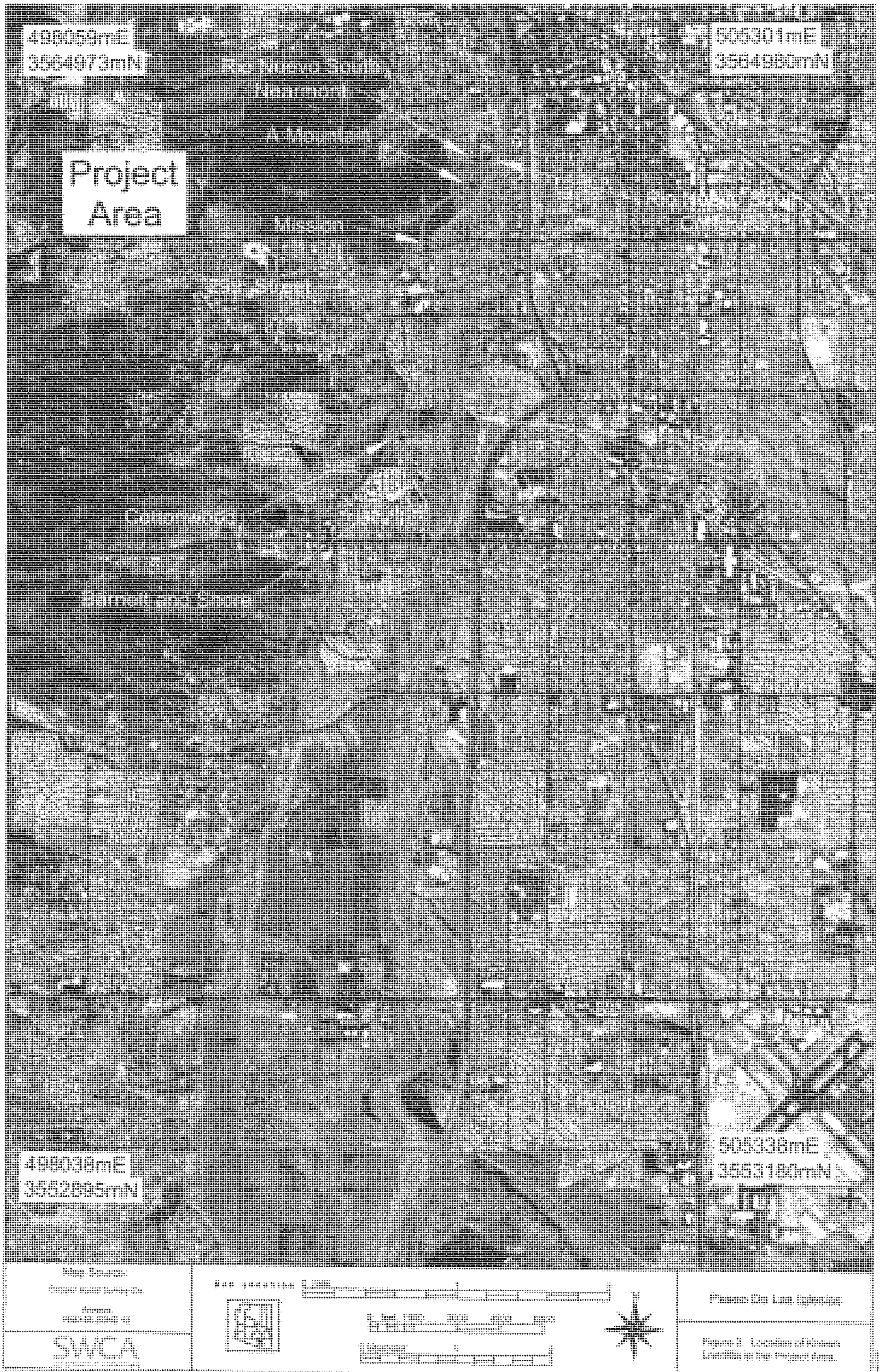
5.4 PREVIOUS REPORTS

Reconnaissance Study by Collins/Piña, Inc., Summer 1999
Information from a Reconnaissance Study by Collins/Piña, Inc in the summer of 1999 provided information regarding the location of the six landfills within the designated project area. Several closed landfill sites currently owned and managed by the City of Tucson are located along the Santa Cruz River (Figure 2). These landfills were closed prior to federal, state or local regulations for closure specifications and monitoring of landfill gases. They include:

1. Rio Nuevo South (also known as Congress landfill, located south of Congress Street along the west bank of the Santa Cruz River; approximately 40 acres; operated 1953-60)
2. Nearmont (located south of Congress Street, northeast of Rio Nuevo landfill, approximately 10 acres; operated 1960-67)
3. "A" Mountain (located between Mission Lane and 22nd Street; approximately 36 acres; operated 1953-1962)
4. Mission (located north of 22nd Street/Starr Pass Boulevard, west of the Santa Cruz River; approximately 30 acres; operated 1963-1970)
5. 29th Street (located north of Silverlake Road along the west bank of the Santa Cruz River; approximately 50 acres; operated 1963-1967)
6. Ryland (located between 36th and 44th Streets along the east bank of the Santa Cruz; approximately 50 acres; operated 1960-1965)

No information was contained in this report regarding who managed the landfill sites during operation, landfill contents, type of landfill (commercial, industrial, municipal, residential), or any groundwater sampling programs at or near the landfills.

Landfills and Waste Disposal Sites Along the Santa Cruz River from Grant Road to Pima Mine Road by the Pima Association of Governments for the City of Tucson, Office of Environmental Management, July 1996.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SWCA

his report identifies 61 sites along a reach of the Santa Cruz River that includes the entire Paseo de las Iglesias project area. The sites identified include wildcat dumpsites, areas of erosion or other concern, and landfills. The report identifies all of the landfills that are located within the project area and provides details regarding the surface content of the landfill as well as features of the landfill such as re-graded areas. This report also identifies and provides information regarding the private landfill area owned and operated by Barnett and Shore (Figure 2). The contents are reportedly piles of brick and concrete debris.

6.0 REGULATORY REVIEW

As part of the Phase I ESA, applicable federal and state environmental regulatory databases were reviewed. The review checked facility listings available through agency databases to determine whether the site or any adjacent facilities have been subject to environmental actions or review. The databases were obtained through Environmental Data Resources, Inc. (EDR) of Southport, Connecticut. The EDR database searches follow current ASTM standards and represent the most recent site-specific data available at the time that the information was requested. Appendix C provides a description of the types of facilities that may be listed in each database.

Under the ASTM standard, various databases are searched within specific distances of the target property. The search distances usually range from 1/8 to 1 mile, however, for this assessment, the search for each database was done as an area survey including the area bounded by Congress Street, Mission Road, Los Reales Road, and Interstate Highways 10 and 19. To ensure complete coverage of the study area, the database search was expanded 1/8 of a mile outside the perimeter roads described. SWCA reviewed database information for the 16 regulated facilities identified in the 1/8-mile "buffer" area and determined that 15 of them are not RECs with respect to the study area, and do not warrant further consideration or discussion within the context of this ESA. The Tucson International Airport Area (TIAA), located adjacent to the southwest corner of the study area is a potential REC with respect to the study area. The listed facilities or sites within the study area and the buffer zone are shown on Figure 3. Table 2 itemizes the listed facilities in the study area and indicates the databases in which the entries were found.

6.1 EDR FINDINGS

Forty-four facilities or sites within the study area were identified in the database reports. Numerous listed facilities appeared on more than one database. For example, facilities at the Pima County Mission Road Complex were identified in five different regulatory databases, and many of the gasoline stations appear on both the underground storage tank (UST) and leaking underground storage tank (LUST) databases.

SWCA observed that the database report does not include some of the gasoline stations in the study area. Virtually all active gasoline stations are UST facilities and are required to be registered. It is possible that the stations have been constructed since the last UST database update, or that the Arizona Department of Environmental Quality has incorrect address information for these facilities, which would result in their

TABLE 2. SITES AND FACILITIES IDENTIFIED IN REGULATORY DATABASES

THAT ARE LOCATED IN THE STUDY AREA

Paseo de las Iglesias Phase I ESA

EDR Map ID No.	Facility or Site Name	Site or Facility Address	Databases in which Sites were Identified: CERC-NFRAP	RCRIS-LQG	RCRIS-SQG	ERNS	State Haz Waste	State Landfill	LUST	UST	FINDS	PADS	AZ Spills	WWFAC	Dry Wells	Comments
3	Rio Nuevo Project	700 Congress St.					X									File Review Conducted
4&6	Boatner's Station/E-Z #060179	292 South Freeway				X			X	X						File Review Conducted
5	Circle K #171	1002 W. Congress St.							X	X						No Further Action
9	Citizen Auto Stage Co.	351 S. Brickyard Lane							X	X						No Further Action
10	Chevron USA Inc. Tucson Asph.	601 W. Simpson St.			X											No incidents
11	Ralph's Transfer, Inc.	747 S. Freeway							X	X						False Alarm
13	Recycle America	945 S. Freeway								X						No incidents
14	Unocal #4897	1210 S. Freeway							X	X						No Further Action
14	Circle K #1838	1145 S. Freeway							X	X						No Further Action
14	Guadalupe Lespron	1114 S. Farmington								X						No incidents
14	Western Emulsions	1015 S. Freeway			X						X					No Further Action
16	Pima County D.O.T.	1313 S. Mission Rd.		X					X	X	X					No Further Action
16	Pima County Automotive Service	1301 S. Mission Rd.			X				X	X	X		X			No Further Action
18	Kushmaul Machine & Engineering	2210 South Freeway							X	X						No Further Action
19	Pima County Parks & Rec.	1204 W. Silverlake Rd.				X								X		File Review Conducted
19	Tucson Electric Power Co.	1177 W. Silverlake Rd.				X							X			File Review Conducted
20	Pima County Correctional Facility	1270 W. Silverlake Rd.								X						No files available
22	Barnett & Deyoe Contractors	701 W. Silverlake Rd.			X					X	X	X		X		Not within Project vicinity
23	E-Z Serve/Quik Mart #100909	1890 S. Mission Rd.								X						No incidents
24	American Scrap metal Recycling	2140 S. Freeway					X									No incidents
25	H and K Barrels	2122 S. 12th Ave.			X						X					Not within Project Vicinity
28	Diamond Shamrock #1623	2616 S. Mission Rd.														No incidents
28	Circle K #1931	2590 S. Mission Rd.								X						No incidents
29	Cottonwood	3000 S. Cottonwood Lane						X						X		File Review Conducted
33	Mesa Ridge - Mfr'd. Home Commun	1402 W. Ajo Way													X	No incidents
34	Giant #925	1202 W. Ajo Way								X						No incidents
36	T.A.R.P. - Tucson Airport Remed. Pr	1100 W. Irvington Rd.		X							X					Not within Project vicinity
38	The Home Depot #0467	1155 W. Irvington Rd.									X					No files available
39	Circle K #1606	5680 S. Mission Rd.								X						No incidents
40	Pima Community College	5901 S. Calle Santa Cruz	X		X		X				X				X	File Review Conducted
40	EFTC Southwest Operations	1150 W. Drexel Rd.	X		X		X				X		X			File Review Conducted
44	The Woods I and II Apartments	1907 W. Valencia Rd.													X	No incidents
45	Walgreens Store 3837	1550 W. Valencia Rd.			X						X					No incidents
46	American Airline	1645 W. Valencia Rd.				X							X			File Review Conducted
47	Holmes Tuttle Ford, Inc.	1431 W. Valencia Rd.									X					No incidents
48	The Larson Company	6701 S. Midvale Park Rd.			X	X					X				X	No incidents
49	Weiser Lock Co.	6700 S. Weiser Lock Dr.		X							X		X			File Review Conducted
nmappe	29th St. Landfill	Silverlake & Santa Cruz						X								File Review Conducted
nmappe	Ryland	W. End 40th St. at Santa Cruz River						X								File Review Conducted
nmappe	A Mountain	Mission Rd. at Base of "A" Mountain						X								File Review Conducted
nmappe	Nearmont	Nearmont St. and Melwood						X								File Review Conducted
nmappe	Linda Landfill	N. of Alameda and E. of Santa Cruz						X								Not within Project vicinity
nmappe	Ajo Chevron	1285 W. Ajo Way								X						No files available
nmappe	Your Cleaners	1645 W. Valencia, Ste. 101			X						X					No files available

See Complete EDR report (Appendix C) for description of databases and abbreviations.

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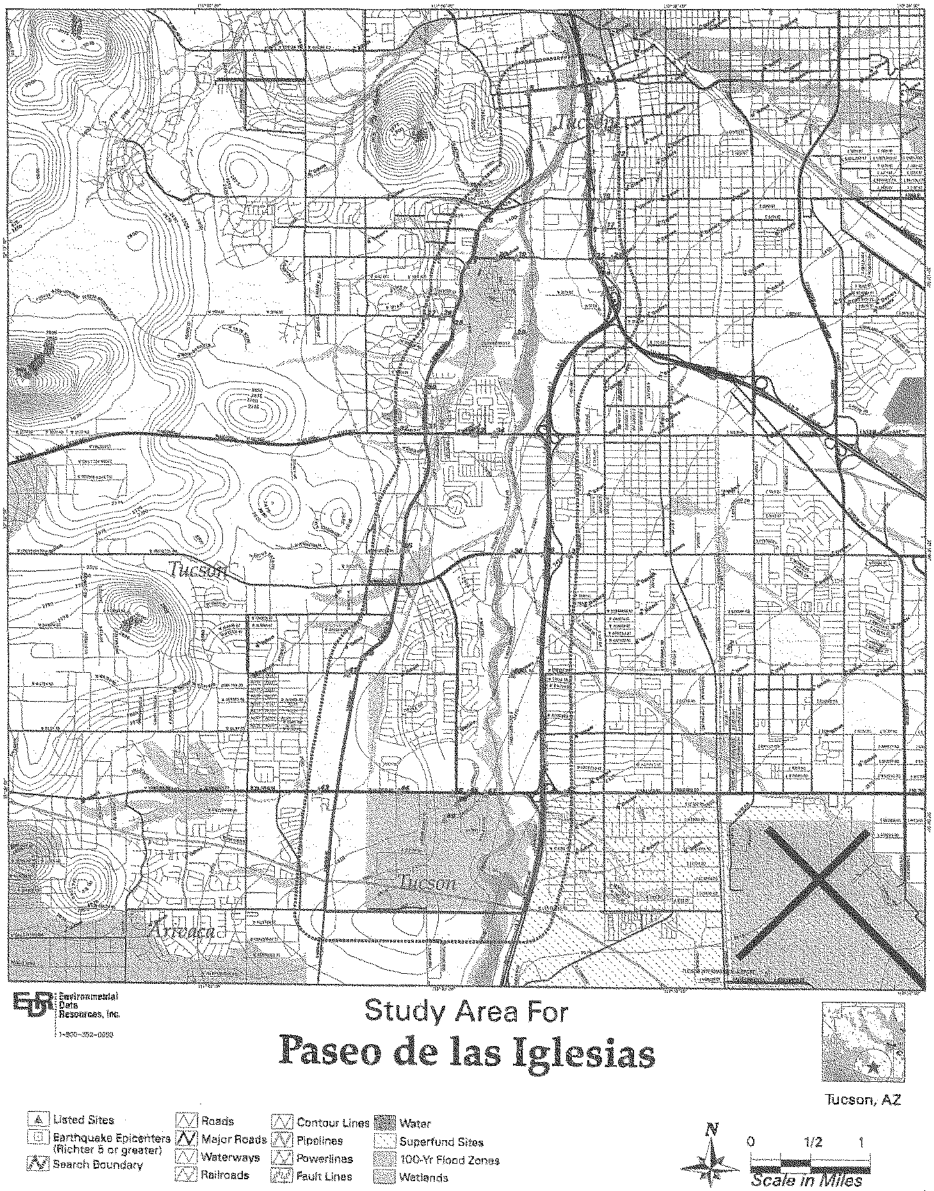
Tucson
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Environmental Data Resources, Inc.
Study Area For
Paseo de las Iglesias
Tucson, AZ
Listed Sites
Earthquake Epicenters (Richter 5 or greater)
Search Boundary
Roads
Major Roads
Waterways
Railroads
Contour Lines
Pipelines
Powerlines
Fault Lines
Water
Superfund Sites
100-Yr Flood Zones
Wetlands
N
0
1/2
1
Scale in Miles

absence from the UST list. If the gasoline stations are compliant with current regulations regarding UST leak detection and overfill protection, SWCA does not believe they warrant consideration as RECs. However, any past releases from these facilities, if any occurred, could be considered RECs.

Automobile repair and salvage operations, fire stations, household appliance repair and salvage sites were observed in the study area. Such businesses or industries may involve the use or storage of petroleum products or hazardous materials, or the generation of hazardous waste. Several such facilities noted within the study area did not appear on the EDR database report as registered UST sites or hazardous waste facilities.

The following locations or facilities identified in the database report are those that SWCA has selected as potential RECs within the study area.

1. *Tucson International Airport Area*

   This site is identified on the AZ WQARF, CONSENT, ROD, CERCLIS, and NPL databases. This site is adjacent to, but not within the study area boundaries, but may have an effect on the project site through contaminant migration in groundwater.

   TIAA Superfund Site covers approximately 24 square miles. The airport itself is located on the south side of the City of Tucson, Arizona approximately 1.5 miles from the project site at its closest point. The site is bounded by Interstate Highway 19 to the west, Hughes Access Road to the east and south, and Los Reales Road and Valencia Road to the north.

   In May 1981, organic chemicals commonly used as solvents by electronic and aerospace industries were found in several City of Tucson drinking water wells in southwest Tucson. Later that year, the City of Tucson closed the contaminated wells to ensure that water served to the public would meet drinking water standards. TIAA was placed on the NPL in 1983. The EPA is the lead regulatory agency at this site with ADEQ performing regulatory support and technical oversight. The TIAA CERCLA Site contains seven major project areas including Air Force Plant 44 (AFP44), Tucson Airport Remediation Project (TARP), the Airport Property, the Arizona Air National Guard (AANG) 162^{nd} Facility, Burr-Brown Corporation, the former West-Cap Property, and West Plume-B. Groundwater investigations have defined a groundwater contamination plume (main plume) in the regional aquifer. The main plume, consisting mainly of trichloroethylene (TCE), with smaller amounts of dichloroethylene (DCE), chloroform, and chromium, extends from AFP44 north past Irvington Road 15 miles south of downtown Tucson and is along the west boundary of the airport.

   EPA constructed a groundwater extraction system for the former West-Cap property. This system delivers contaminated groundwater from the West-Cap property to the Burr-Brown treatment plant. A Consent Decree (CD) to address cleanup of soils and shallow groundwater beneath the Airport Property and to provide continued funding for operation and maintenance of the TARP system has recently been finalized. This CD provides for the cleanup of a highly contaminated portion of the

Airport Property near the Three Hangers Area. The CD calls for four separate remedies for the Three Hangers Area: 1) a soil vapor extraction (SVE) system will be built to remove TCE from the soils; 2) a pump-and-treat groundwater remediation system to contain, and if possible, remediate TCE contamination in the shallow groundwater zone; 3) excavation and off-site disposal of PCB and metals contaminated soils and sediments; 4) capping and monitoring of an abandoned landfill. Part of the shallow groundwater zone is included in an area of "technical impracticability," meaning that there is no known technology that can provide complete remediation. However, this area will be hydraulically contained and closely monitored to ensure that contamination does not spread, and when new technologies are available, they will be evaluated.

A file review of the Tucson International Airport (EDR Map No. 0) was conducted at the City of Tucson El Pueblo Library on August 20, 2002: The results of the file review is summarized in Section 8.0 of this report.

2. *Gasoline Stations and Other UST or LUST Sites*

Various gasoline stations operated by Circle K, Mobil, Chevron, Exxon, Diamond Shamrock, Texaco, Giant, Conoco and other retailers are located in the study area. The Pima County Mission Road Complex and various other automotive service facilities in the study area are also identified as UST or LUST sites. Releases from gasoline station LUSTs do not typically affect areas of soil that extend far beyond the station's property boundaries; however, petroleum hydrocarbons have the potential to affect other sites by migrating considerable distances through groundwater. The database report indicates that there are nine LUST sites located within the Project area. Of the nine, eight have received No Further Action letters.

On August 6, 2002, a file review for the one remaining LUST site (Boatner's Station, EDR Map Nos. 4 & 6) was at the ADEQ to evaluate the nature and extent of soil or groundwater contamination and potential effects on the Paseo de las Iglesias project. The results of the file reviews are summarized in Section 8.0 of this report.

3. *Rio Nuevo South Landfill*

This property is located at 700 Congress Street in Tucson, Arizona, and is listed on the CERC-NFRAP and SHWS databases. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require federal Superfund action or NPL consideration. There is no additional information regarding the specific reason this site was placed on the CERCLIS list. The SHWS (ZipAcids List) consists of more than 750 locations subject to investigation under the State Water Quality Assurance Revolving Fund (WQARF) and Federal CERCLA programs. The list is no longer updated by the state.

On July 18' 2002, file reviews were conducted for the Rio Nuevo South Landfill at the City of Tucson Solid Waste Department and the City of Tucson Office of Environmental Quality. The results of the file reviews are summarized in Section 8.0 of this report.

4. *Tucson Electric Power Company*

This property is located at 1177 West Silverlake Road Tucson, Arizona, and is listed on the ERNS and AZ Spills databases. There is no information regarding the ERNS entry and it is unclear whether the ERNS notification is related to the AZ Spills report. On December 29, 1987 a PCB spill occurred. No further information is available in the regulatory report regarding this incident, perhaps because the spill or spills were minor and were cleaned up relatively quickly, as is typically the case when such incidents are reported to regulatory authorities.

On August 6, 2002, a file review of the Tucson Electric Power Company facility (EDR Map No. 19) was conducted at the ADEQ to evaluate if past releases at the facility pose a concern for the Project area. The results of the file reviews are summarized in Section 8.0 of this report.

5. *Cottonwood Landfill*

This property is located at 3000 S. Cottonwood Lane, Tucson, Arizona, and is listed on the SWF/LF and WWFAC databases. This property is a known closed solid waste facility. Based on the presumed groundwater and surface water flow it could be a source of contamination within the study area. This property also has a listing as a wastewater treatment facility.

On July 18, 2002, file reviews were conducted for the Cottonwood Landfill at the City of Tucson Solid Waste Department and the City of Tucson Office of Environmental Quality. The results of the file reviews are summarized in Section 8.0 of this report.

6. *EFTC Southwest Operations*

This property is located at 1150 W. Drexel Road, Tucson, Arizona. This address is listed three separate times under Lambda Electronics Power Supply and what are apparently its subsidiaries at the same address. It is currently occupied by Honeywell. This property is listed on the CERC-NFRAP, FINDS, RCRIS-LQG, AZ Spills, and SHWS databases. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund action or NPL consideration. There is no additional information regarding the specific reason this site was placed on the CERCLIS list.

The Resource Conservation and Recovery Information list (RCRIS-LQG) database indicates the site was owned by LAMBDA Electronics, Inc. The facility was classified as a Large Quantity Generator of hazardous waste. The RCRIS includes selective information on sites that generate, transport, store, treat, and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). There have been six violated regulations reported at this site. There are no details available regarding those violations or enforcement actions. Compliance to the regulations was achieved in all six cases. The most recent date of compliance is April 1994.

According to the FINDS database, other Pertinent Environmental Activity identified at the site includes, in addition to the RCRIS, a listing on the Toxic Chemical Release Inventory system (TRIS) database. TRIS identifies facilities that release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313. No further details are available in the EDR report regarding these listings.

A release of sulfuric acid was reported on October 8, 1986 and is listed on the AZ Spills list. No further information is available regarding this release or cleanup activities. The final listing for this site is on the SHWS database.

On August 6, 2002, a file review of the EFTC Southwest Operations facility (EDR Map No. 40) was conducted at the ADEQ to evaluate if the facility poses a concern for the Project area. The results of the file reviews are summarized in Section 8.0 of this report.

7. *National Semiconductor Corp.*
This property is located at 5901 South Calle Santa Cruz in Tucson, Arizona. The site is listed on the SHWS database. No further details are available in the EDR report regarding this listing.

On August 6, 2002, a file review of the National Semiconductor Corporation facility (EDR Map No. 40) was conducted at the ADEQ to evaluate if the facility poses a concern for the Project area. The results of the file reviews are summarized in Section 8.0 of this report.

8. *Pima Community College D V*
This site also has an address of 5901 S. Calle Santa Cruz, Tucson, Arizona, and is listed on the CERC-NFRAP, RCRIS-SQG, DRY WELLS, and FINDS databases. In reference to the CERC-NFRAP listing, there was a Discovery and a Preliminary Assessment conducted. There was no further remedial action planned for this site. There is no further information available regarding this database listing.

The RCRIS database listing classifies this facility as being a Conditionally Exempt Small Quantity (hazardous waste) Generator. Violations were reported on August 29, 1990. Pima Community College achieved compliance with regulations on June 14, 1991.

According to the FINDS database, this site was listed as a RCRIS and TRIS site. No further information is available in the EDR report regarding these listings.

No files for this facility were available at the ADEQ. However, the facility shares the same address as the National Semiconductor facility discussed above, and it is most likely that these two facilities are in actuality one facility that is listed under two separate business names.

6.2 EDR UNMAPPED SITES

EDR listed several "unmapped" facilities for which the databases reported incomplete or unknown address information. Based on the partial address information and SWCA's local knowledge and observations of the site area, most of the unmapped sites have been eliminated as potential RECs because they are beyond the perimeter of the study area.

The following "unmapped" sites are listed as Solid Waste Facility/Landfill Sites (SWF/LF) and one as a State Hazardous Waste Site (SHWS). SWF/LF records typically contain and inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

1. Ryland – This site is a closed landfill located at the west end of 40th street at the Santa Cruz River. This site is located within the project area. No additional information is available in the EDR report regarding this site.

2. "A" Mountain – This site is a landfill located on Mission Road at the base of "A" Mountain. This landfill is located within the project area. No additional information is available in the EDR report regarding this site.

3. Nearmont – This site is a landfill located at Nearmont Street and Melwood. This landfill is located within the project area. No additional information is available in the EDR report regarding this site.

4. 29th Street Landfill – This site is located at Silverlake Road at "Santa Cruz" (whether this is the River, a street, or some other feature is not indicated) and is on the State Landfill list. No further information is available in the EDR report regarding this site.

Given the uncertainty of details in the report regarding contaminants, these sites may have potential to affect the project site through contaminants migration.

On July 18, 2002, file reviews were conducted for the above-listed landfills at the City of Tucson Solid Waste Department and the City of Tucson Office of Environmental Quality. The results of the file reviews are summarized in Section 8.0 of this report.

7.0 SITE RECONNAISSANCE

SWCA personnel visited the site on August 28, 2001 and February 13, 2002 to visually inspect the site and surrounding properties for evidence of RECs. Photographs made during the site visits are included in Appendix C. The information reported in this section has been broken out by "reaches" of the Santa Cruz River as it is crossed by major streets from south to north.

The study area includes vacant desert, commercial, light industrial and residential areas. Several closed landfills are located along the Santa Cruz River. Landfill surfaces vary from flat to slightly rolling terrain, most of which has acquired a vegetative cover similar to that of the surrounding vacant land. Items that appeared to consist of construction debris (concrete and asphalt rubble, bent pipes) were visible in some of the upper portions of the riverbanks where it appeared that soil cover had eroded. This debris may be exposed landfill contents or material placed for bank stabilization.

Throughout the entire seven-mile stretch of the Santa Cruz River bottom, there is substantial debris and rubbish, much of which appears to have been the result of numerous, isolated, "wildcat" dumping events carried out over many years. Based on the wide distribution of the disposal sites and the contents of the debris piles (papers, boxes, food and beverage containers, scrap wood and metal, household trash, furniture, appliances), it does not appear that the river bottom has been the site of prolonged commercial or industrial waste disposal. Some of the discarded items, such as small paint or fuel containers, suggest the possibility that small amounts of hazardous materials may have been discarded in these areas, although the actual contents of the containers now, or at the time of disposal is not known.

7.1 REACH #1 - LOS REALES TO VALENCIA

This section of the project area is being mined as part of a sand and gravel operation (Appendix E, Photo #1). Several open gravel pits exist in this reach of the corridor. A road has been created through the riverbed to reach both sides of the river for mining purposes. The main mining operations area is closed to the public. Large hauling and dump trucks are the primary type of vehicle throughout this area. There were no visible areas of soil staining in the areas that could be accessed. The area west of the mining operation and east of Mission Road consists of agricultural lands and residential development. Several automotive repair facilities, the former Larson Company site, and the Weiser Lock Company facility are located within this sector. The Larson and Weiser facilities are identified on several regulatory databases, as shown in the EDR report in Appendix C.

7.2 REACH #2 - VALENCIA ROAD TO DREXEL ROAD

This reach of the Santa Cruz has deeply cut and eroded banks that have not been stabilized. Calle Santa Cruz runs north-south from Drexel Road to Irvington Road within the project boundaries. Pima Community College is also located east of the river on the east side of Calle Santa Cruz. Residential development within the project boundary extends from the west side of the river to Mission Road. (See Appendix D, Photo # 4 for view north from Valencia Road bridge.)

Two automotive service facilities, a fire station, a gasoline station, and Pima Community College are located in this sector. The fire station and automotive repair facilities are not listed in the EDR report. The gasoline station, which is a Chevron facility located at the northwest corner of Valencia and Midvale Park Roads, is likely a UST site, but does not appear on the UST database. Pima Community College appears in the EDR report as a hazardous waste generator.

7.3 REACH #3 – DREXEL ROAD TO IRVINGTON ROAD

Reach #3 of the Santa Cruz also has deeply cut and eroded banks. There is residential development along the entire reach of the west bank of the river and within the project boundaries. The east bank of the river is primarily Sonoran Desertscrub. Three gasoline stations are located in this sector, and are listed in the EDR report. A Honeywell facility where electronic circuits are produced is located at the northeast corner of Drexel Road and Calle Santa Cruz. The address of the Honeywell facility corresponds to the location of Lambda Electronics and EFTC Southwest Operations. The EDR report indicates that a sulfuric acid spill and hazardous waste violations occurred at this facility in the 1980s.

7.4 REACH #4 – IRVINGTON ROAD TO AJO WAY

This reach of the river includes parts of the Santa Cruz Park on both sides of the river. There is substantial residential development up to the riverbanks on both sides of the river in the northern portion of this reach. Residential development dominates the area west of the river and south of Ajo Way. There is also a gas station (Chevron) in the extreme northwest corner of this reach on the south side of Ajo Way and along the riverbank. The Chevron facility did not appear on EDR's database report.

7.5 REACH #5 - AJO WAY TO 36TH STREET

Ryland landfill is located along the east bank of this reach of the river. Landfill material is exposed in the east bank where erosion has occurred. There is residential development along the western project boundary. A portion of Interstate Highway 19 is within the project boundaries on the east side of the river, as well as portions of the Ajo Way Interchange. There is a Conoco gas station on the north side of Ajo Way on the west bank of the Santa Cruz. The Conoco facility did not appear on EDR's database report. An unpaved roadway leads north from Ajo Way into the river bottom. Piles of rubble have been dumped along the riverbank (Appendix D, Photo # 2). Various piles of debris and trash were also observed along the river bottom in this reach (Appendix D, Photo #3).

7.6 REACH #6 - 36TH STREET TO 22ND STREET (STARR PASS BOULEVARD.)

Within this reach of the river there is one landfill, the 29th Street landfill, located on the west side of the river. Additionally, there is a complex of buildings located between Mission Road and the west bank of the Santa Cruz. These buildings house Pima County divisions such as the transportation and flood control offices, the motor fleet/maintenance area, sign and painting shops, wastewater engineering offices, graphics and records archives, and prison facilities. Undisturbed desertscrub occupies land immediately east of the river. Further east is an area of mixed-use commercial and residential properties, including several automobile salvage and repair shops, none of which are listed in the EDR report.

7.7 REACH #7 – 22ND STREET (STARR PASS BOULEVARD) TO CONGRESS STREET

There are four closed landfills in this reach of the project area. They are Rio Nuevo South, Nearmont, "A" Mountain, and Mission. All of these landfills are along the west bank of the Santa Cruz River. Please see the Site History section of this report for further information on these landfills. Immediately south-southwest of the Nearmont landfill is an experimental project site within a fenced area (Appendix E, Photo #6). The City of Tucson's Office of Environmental Management is conducting this project under the direction of the City of Tucson's City Manager's Office. The intent is to investigate one method of expediting the decomposition of the landfill contents and determining if this method is viable in the desert southwest. The experimental method involves the addition of oxygen and water to the landfill to create an aerobic environment from an anaerobic one. Methane monitoring wells were noticed on and near the Nearmont landfill.

East of this experimental project site and west of the river are two maintenance stations, one for buses, and the other for tractor trailers (Appendix D, Photo #9). Neither maintenance facility is listed in the EDR report.

A concrete irrigation ditch is located along the top of the west bank of the Santa Cruz in this reach. There are signs along this ditch warning of the non-potable nature of the water. The water that normally flows through that ditch is effluent used for landscaping and golf course irrigation (Appendix D, Photo # 9). There are at least four groundwater monitor wells located at the north end of the Nearmont landfill in this reach (Appendix D, Photo #7).

There is a small block building enclosed by a fence but no signs were present to indicate the purpose or ownership of the building. Additionally, there is a transformer located near Congress Street in this reach that is the property of Tucson Electric Power Company. No leakage was apparent in the area around the transformer. There are two hotels along the east side of the Santa Cruz River, along the Interstate Highway 10 frontage road. A Circle K gasoline station with, according to the EDR report, a closed LUST and two active USTs is located at the corner of Congress Street and Mission Road.

8.0 FILE REVIEWS

Table 2 provides a summary of 38 facilities mapped by EDR that are located in the project area. Of those 38 sites, file reviews were conducted for nine of the facilities, two of which are landfills. In addition, file reviews were also conducted for five landfills located in the project area but were not mapped by EDR.

8.1 ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

In most instances, only catastrophic releases would result in impacts to the project area from off-site CERCLA, SHW, ERNS, and LUST facilities. However, sites have the potential to slowly release contaminants that, in the long term, could impact soil, groundwater, or surface water quality at the project area.

File reviews were conducted for the following sites: The Tucson International Airport (EDR Map No. 0), Boatner's Station (EDR Map No. 4 & 6), Tucson Electric Power Company (EDR Map No. 19), Pima Community College (EDR Map No. 40), EFTC Southwest Operations (EDR Map No. 40), American Airlines (EDR Map No. 46), and The Weiser Lock Company (EDR Map No.49).

8.1.1 Tucson International Airport

Files were reviewed for TIAA Superfund Site (EDR Map No. 0) at the ADEQ office in Phoenix, Arizona, and at the City of Tucson (COT) El Pueblo Library that is located in Tucson, Arizona. The COT El Pueblo Library is the repository site for all documents generated for the TIAA Superfund Site.

The TIAA Superfund Site is located on the south side of the City of Tucson, Arizona approximately 1.5 miles from the project area at its closest point. The site is bounded by Interstate Highway 19 to the west, Hughes Access Road to the east and south, and Los Reales Road and Valencia Road to the north.

In May 1981, organic chemicals commonly used as solvents by electronic and aerospace industries were found in several City of Tucson drinking water wells in southwest Tucson. Later that year, the City of Tucson closed the contaminated wells to ensure that water served to the public would meet drinking water standards. TIAA was placed on the National Priorities List (NPL) in 1983. The EPA is the lead regulatory agency at this site with ADEQ performing regulatory support and technical oversight. The TIAA CERCLA site contains seven major project areas including Air Force Plant 44 (AFP44), TARP, the Airport Property, the Arizona Air National Guard (AANG) 162nd Facility, Burr-Brown Corporation, the former West-Cap Property, and West Plume-B. Groundwater investigations have defined a groundwater contamination plume (main plume) in the regional aquifer. The main plume, consisting mainly of trichloroethylene (TCE), with smaller amounts of dichloroethylene (DCE), chloroform, and chromium, extends from AFP44 north past Irvington Road, 15 miles south of downtown Tucson, and is along the west boundary of the airport.

In 1997, EPA constructed a groundwater extraction system for the former West-Cap property (March 23, 2002). This system delivers contaminated groundwater from the West-Cap property to the Burr-Brown treatment plant. A Consent Decree (CD) to address cleanup of soils and shallow groundwater beneath the Airport Property and to provide continued funding for operation and maintenance of the TARP system was finalized in 1999. This CD provides for the cleanup of a highly contaminated portion of the Airport Property near the Three Hangers Area. The CD calls for four separate remedies for the Three Hangers Area: 1) a soil vapor extraction (SVE) system will be built to remove TCE from the soils; 2) a pump-and-treat groundwater remediation system to contain, and if possible, remediate TCE contamination in the shallow groundwater zone; 3) excavation and off-site disposal of PCB and metals contaminated soils and sediments; 4) capping and monitoring of an abandoned landfill.

EPA and ADEQ are currently reviewing the Draft SVE Remedy Technical Memorandum submitted by Conestoga Rovers and Associates (TIA, June 27, 2002) for an SVE system to be installed to remove TCE from the soils.

EPA is currently pumping contaminated groundwater from a groundwater extraction system installed at the Burr-Brown Corporation facility located approximately 4 miles east of the project area. The groundwater extraction system consists of a cluster of three extraction wells (identified as WC-3U, WC-3U2, and WC-3L), a transfer pipeline, and a treatment facility (CH2MHill, July 1999).

No files were available that discussed the progress of the PCB- and metals-impacted soil and sediment cleanup activities, nor the capping and monitoring of the abandoned landfill. However, since these areas of concern are located approximately 3 to 4 miles east of the Santa Cruz River, they are not likely to have any impact on the project area.

8.1.2 Boatner's Station

The Boatner's Station/E-Z Facility #100935 (EDR Map Nos. 4 & 6) is located at 292 South Freeway, which is located near the northeast boundary of the project area. The EDR report indicates that in October 1989, a known or probable effect on groundwater was reported at the facility due to a release from a LUST. The EDR reports also indicates an undefined or unknown source of soil contamination was reported at the facility in April 1999.

The file review indicates that two 10,000-gallon unleaded gasoline USTs were removed from the site in October 1996. Soil beneath the USTs had been impacted with petroleum hydrocarbons at levels in excess of the ADEQ Soil Remediation Levels. Previous investigations indicate that a perched aquifer located approximately 35 feet below the ground surface at the facility was impacted by petroleum hydrocarbons as early as 1991 (Terranext, January 1996).

A Site Characterization Assessment conducted at the site in late 1996 (SECOR, February 1996) indicates that the direction of groundwater flow in the shallow aquifer is to the north. Groundwater analytical results from several groundwater monitoring wells located on the Boatner's property indicate that dissolved benzene in excess of the ADEQ Soil Remediation Levels had been detected in two wells located near the eastern property boundary. The Boatner's facility was purchased by ADOT as part of I-10 right-of-way. ADOT removed the USTs and pump islands in June 1996. The former Boatner's facility most likely will not have any impact on the project area since the USTs have been removed, and the shallow aquifer impacted with residual benzene flows north, away from the project area.

8.1.3 Tucson Electric Power Company

The Tucson Electric Power Company (EDR Map No. 19) is located at 1177 West Silverlake Road Tucson, Arizona, and is listed on the ERNS and AZ Spills databases. The file review indicated that on

December 29, 1987, approximately 2 to 3 gallons of oil leaked from an electric transformer. A small area of soil was impacted, and the soil was subsequently excavated and disposed at a licensed landfill, thereby alleviating any environmental threat to the project area.

8.1.4 Pima Community College

Pima Community College (EDR Map No. 40) is located at 5901 South Calle Santa Cruz, Tucson, Arizona and is listed on the CERC-NFRAP, RCRIS-SQG, DRY WELLS, and FINDS databases. In reference to the CERC-NFRAP listing, there was a Discovery and a Preliminary Assessment conducted.

The RCRIS database listing classifies this facility as being a Conditionally Exempt Small Quantity (hazardous waste) Generator. Violations were reported on August 29, 1990. Pima Community College achieved compliance with regulations on June 14, 1991.

The file review indicates that this address is listed as the National Semiconductor Corporation facility. ADEQ inspected the facility on August 29, 1990 and issued several violations associated with housekeeping protocols. All wastes generated from the facility were containerized and disposed offsite. The ADEQ inspection report indicates that the facility planned to cease operations by the end of 1991. The facility most likely does not pose an environmental threat to the project area.

8.1.5 EFTC Southwest Operations

The EFTC Southwest Operations facility (EDR Map No. 40) is located at 1150 W. Drexel Road, Tucson, Arizona. In the EDR report, the address is listed three separate times under Lambda Electronics Power Supply and what are apparently its subsidiaries at the same address. The site is currently occupied by Honeywell. This property is listed on the CERC-NFRAP, FINDS, RCRIS-LQG, AZ Spills, and SHWS databases. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund action or NPL consideration. There is no additional information regarding the specific reason this site was placed on the CERCLIS list.

The Resource Conservation and Recovery Information list (RCRIS-LQG) database indicates the site was owned by LAMBDA Electronics, Inc. The facility was classified as a Large Quantity Generator of hazardous waste. The RCRIS includes selective information on sites that generate, transport, store, treat, and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA).

The file review indicates that the Lamba Electronics facility manufactured and assembled various electronic components. ADEQ conducted an inspection of the facility on April 11, 1986 (Hazardous Waste Inspection AZD097113856) and 16 violations were reported. The violations included the failure of Lamba to submit manifests to ADEQ, to train employees, to label drums, and to keep hazardous waste in a closed waste container. All of the violations were related to general housekeeping protocols.

On October 8, 1986, approximately 50 gallons of 10% dilute sulfuric acid was released at the facility. The acid flowed into a storm drain and into an area of landscaping on the property where it impacted approximately 350 square feet. The impacted soil was excavated and disposed offsite, thereby alleviating any potential impact to the project area.

8.1.6 American Airlines

The American Airlines facility (EDR Map No. 46) is located at 1645 West Valencia, Tucson, Arizona. The EDR report indicates that a release of an unknown substance, possible fuel, was reported at the facility on February 2, 1999. The file review indicates that a resident near the airport called ADEQ to report that an aircraft was releasing excess fuel because it was "flying circles around the city polluting the atmosphere." It is not likely that this incident poses an environmental concern for the project area.

8.1.7 Weiser Lock Company

The Weiser Lock Company (EDR Map No. 49) is located at 6700 South Weiser Lock Drive, Tucson, Arizona. The EDR report indicates that a release of a cyanide-based solution was reported at facility on February 24, 1994. The file review indicates that approximately 25 gallons of electroplating solution consisting of 15 pounds of sodium cyanide was released inside the facility on February 24, 1994. The solution was contained in a secondary containment underneath the primary holding tank. The solution was pumped out and collected in drums and disposed offsite. It is not likely that this incident poses an environmental concern for the project area.

8.2 LANDFILLS

On-site landfills have the potential to affect local groundwater, surface water and soil quality, depending on landfill contents and potential mobility of contaminants. On July 18, 2002, City of Tucson Environmental Management Division and the City of Tucson Solid Waste Department files were reviewed for the following landfills: Rio Nuevo South [which includes Nearmont, Congress, and "A" Mountain Landfills] (EDR Map No. 3), Mission (No EDR Map No.), 29th Street (No EDR Map No.), Ryland (EDR Map No. 29), and Cottonwood (EDR Map No. 29).

8.2.1 Rio Nuevo South

The Rio Nuevo South Landfill (EDR Map No. 3) includes the Nearmont, former Congress, and "A" Mountain Landfills (Hydro Geo Chem., Inc. 2000). The Nearmont and former Congress landfills are located along the west bank of the Santa Cruz River, east of Melwood Avenue and Brickyard Lane, and north of Mission Lane. Their northern boundary is located approximately halfway between Congress and Mission Lane. The "A" Mountain landfill is located to the south of Mission Lane.

Records indicate that the Nearmont Landfill was used for solid waste disposal between 1960 and 1967. Based on available soil boring data, the base of the landfill ranges from 15 to 40 feet below the land surface (bls). The Nearmont Landfill encompasses approximately 6 acres, and the estimated volume of refuse is 264,000 cubic yards (yd^3). The Nearmont Landfill contains construction debris, which includes bricks and other inorganic and organic debris, as well as municipal solid waste [MSW] (Dames and Moore, 1989).

The former Congress Landfill was used for MSW disposal beginning in the early 1900's, but aerial photographs indicate that most refuse was added between 1953 and 1960. The area of the former Congress Landfill is approximately 12 acres. It ranges in depth between 10 to 35 feet, and probably averages more than 20 feet deep (FOX, 1984; ETL, 1981). The refuse in the former Congress Landfill consists of both MSW and construction debris, and its volume is estimated at 384,000 yd^3.

Records indicate that the "A" Mountain Landfill was used for solid waste disposal between 1953 and 1962. Depths of refuse at the "A" Mountain Landfill range from approximately 15 to 50 feet bls over a total area of approximately 36 acres, and the volume of refuse is estimated at 2,000,000 yd^3. "A" Mountain Landfill received primarily residential refuse typical of most municipal waste landfills.

No contaminants have been detected in water samples collected from groundwater beneath Rio Nuevo South Landfill at concentrations above the Arizona Aquifer Water Quality Standards. A soil gas survey conducted by Hydro Geo Chem, Inc. in 2000 indicated that only trace concentrations of volatile organic compounds (VOCs) are present in the shallow refuse (Sverdrup, 1987). Recent soil gas monitoring indicates that the landfill gas in wells at the Nearmont and "A" Mountain Landfill contains as much as 45% methane. (Hydro Geo Chem, Inc., 2000).

The area containing the three closed municipal landfills is scheduled for development by COT. The COT is managing the Landfill Stabilization Project (LSP) to reduce methane production, monitoring requirements, and maintenance costs at the Rio Nuevo Landfill. Hydro Geo Chem, Inc. is currently conducting pilot tests at the landfill to determine if enhanced in-situ aerobic degradation is a feasible method for stabilizing the refuse in the Rio Nuevo Landfill (Petrus, 2002).

Groundwater beneath and downgradient of the landfill has not been impacted by contaminants, and the landfill is currently being monitored for methane, and is targeted for enhanced in-situ aerobic degradation.

8.2.2 Mission

The Mission Landfill (No EDR Map No.) is located between Mission Road on the west and the Santa Cruz River on the east. The northern boundary is located where the Santa Cruz River and Mission Road nearly converge. The southern boundary is probably a few hundred feet south of the access Road from 22nd Street to Mission Road.

Records indicate that the Mission Landfill was used for solid waste disposal during the mid to late 1960's. There are no records in City of Tucson files showing dates of operations. According to Wilson and Sebenik (1977), Mission Landfill was active from approximately 1966 through 1968. However, aerial photographs indicate that the landfill operation may have started as early as 1963 in the western part of the site. Landfill operations may have extended into the early 1970's because the landfill was listed as active as recently as 1973 (Marum and Marum, 1973). Before the landfill operation, the eastern part of the site was used as junk yard. Much of this area has been removed by the Santa Cruz River, which presently runs well to the west of its location in the 1970's. The approximate depth of the landfill was estimated as 40 feet by Wilson and Sebenik (1977). However, aerial photographs do not show any excavated area, and the only naturally low-lying area was a shallow creek bed in the western part of the site. According to PAG (1992), the Mission site was a small depressed area approximately 10 feet deep or less.

Mission Landfill served as a repository for City Class II Trash and Debris, which primarily consisted of green waste and construction debris. In 1992, Pima Association of Government (PAG) staff observed bricks, concrete, and rebar protruding from disturbed areas under construction for the Santa Cruz Park. During construction of the bank protection, mixed waste, including newspapers, was found at the site (PAG, 1993). Local construction workers recall deposits of newspapers, concrete, and green waste, but no household waste in the landfill (PAG, 1993). Wilson and Sebenik (1977), recorded that the COT deposited 40 to 50 tons of trash per day into the landfill for a total of 32,872 tons throughout the life of the landfill.

An undated PAG site profile of the Mission Landfill review at the COT indicates that in 1996 and 1997, Heath Consultants installed a test hole to a depth of three feet around the landfill perimeter and within the landfill and that no methane was detected. Waste material was not encountered in any of the test holes.

The Mission Landfill has been incorporated into the Santa Cruz River Park by Pima County. Much of the area is landscaped, and drainage has been installed in the northern and eastern parts of the site.

8.2.3 29th Street

The 29th Street Landfill (No EDR Map No.) is located west of the Santa Cruz River, east of Cottonwood Lane, and north of 29th Street/Silverlake Road. The northern boundary is at the confluence of the East and West forks of the Santa Cruz River.

The 29th Street Landfill was used for solid waste disposal in the early 1960's. There are no records in COT files showing the dates of operation for the landfill. According to Wilson and Sebenik (1977), the landfill was in operation for less than a year, starting in 1965. However, historical aerial photographs show that that the landfill was already active by 1963 and was closed and graded by 1967. The approximate depth of the landfill is listed as 50 feet by Wilson and Sebenik (1977).

The 29th Street Landfill served as a repository for City Class II trash, green waste, and construction debris. PAG staff observed rubber tires, concrete, and bricks protruding from disturbed areas under construction for the Santa Cruz River Park. Also, sanitary landfill waste was intersected during construction of bank protection along the Santa Cruz River (PAG, 1993). Wilson and Sebenik (1977) indicate that COT deposited 150 tons of trash per day for a total of 41,090 tons throughout the lifetime of the landfill.

There are no records or evidence that the 29th Street Landfill was either lined or capped with an impermeable material. The engineering firm Cella Barr Associates, Inc. confirmed that no liner or cap material was found during construction of the bank protection along the river.

Methane gas monitoring was conducted at the landfill after the site was inundated by flood waters in 1983. A monitoring and venting system was installed at the southern end, where the waste deposits were most extensive (PAG, 1993). Although methane gas was detected, the monitoring was not continued and no records of the monitoring results were on file at COT.

Data obtained from Pima County Solid Waste Management (SWM) indicate that shallow soil gas studies conducted at the former 29th Street Landfill in March 1995 indicate that the site is producing landfill gas and several different trace VOCs may be present in the methane (Pima County SWM, 1995). Most of the landfill gas trace organics appeared to be concentrated within the central portion of the site with very limited levels at perimeter monitoring points. This suggests that gas being produced is most likely venting and rapidly dissipating vertically through the ground surface and that limited subsurface lateral migration of gas is occurring.

8.2.4 Ryland

The Ryland Landfill (No EDR Map No.) is located east of the Santa Cruz River, west of I-19, south of Julian Wash (also known as Tucson Diversion Channel), and north of 44th Street.

Ryland Landfill was used for solid waste disposal during the mid-1960's. There are no records in COT files showing the dates of operation for the landfill. According to Wilson and Sevenik (1977), Ryland Landfill was used for solid waste disposal from approximately 1960 to 1965. Historical aerial photographs show that the landfill was active in 1963, but that it was closed by 1967. The approximate depth of the landfill was estimated at 50 feet by Wilson and Sevenik (1977).

Ryland Landfill primarily served as a repository for COT Class I and II trash. According to Wilson and Sevenik (1977), COT deposited only green waste and construction debris into the landfill. However, by 1993, erosion along the bank of the Santa Cruz River had exposed the contents of the landfill for approximately 600 feet along a north-south transect near the center of the landfill area. Field investigations by PAG showed the presence of tires, wood, and assorted trash such as shoes, glass, metal bed frames, bottles, plastics, and newspapers. Tires were by far the most abundant component visible at the site (PAG, 1993). Wilson and Sevenik (1977) also reported that the COT deposited 200 tons of trash per day into the landfill for a total of 365,250 tons throughout the lifetime of the landfill.

There are no records or evidence that the landfill was either lined or capped with an impermeable material. The cross-section provided by erosion along the Santa Cruz River in 1993 showed no evidence for either a liner or a cap. Further, the fact that tires are surfacing all over the landfill suggests that cap material was installed, or was very thin.

A letter written to the ADEQ by the COT Department of Solid Waste Management on February 27, 2001 indicates that the COT was preparing to excavate, regrade, maintain, repair, and hydroseed the landfill. The project was designed to provide additional cover and to reshape the landfill areas to provide positive storm water drainage and eliminate surface water ponding. The letter indicates that any exposed trash encountered during the project would be recovered on site with two feet of cover soil. The ultimate purpose of the project is to prevent any increase in leachate that could result in added moisture, and to reduce the potential for methane gas by decreasing the moisture allowed to penetrate the closed landfill.

8.2.5 Cottonwood

The Cottonwood Landfill (EDR Map No. 29) is located between west 36th Street and Ajo Way and Mission Road and the Santa Cruz River.

The Cottonwood Landfill was used as a sanitary landfill and was permitted to accept trash. Operations at the landfill began in 1973 and ceased in 1985. Landfill operations consisted of placing trash in an open pit. The estimated total area of the landfill is 18 acres, and the total depth is unknown. The loading rate when the landfill was active was 150 tons per day (Dames & Moore, 1989).

Dames & Moore (1989) reports that the landfill appears to be capped and the cap is in good condition with minimal evidence of erosion. Historical aerial photographs indicate that the landfill was developed for residential use (primarily mobile homes) between 1990 and the present.

In early 1996, Environmental Engineering Consultants, Inc. (EEC) installed five methane extraction wells through the refuse at the landfill. The refuse consisted of green waste and construction debris (EEC, 1996). Methane was measured in the five extraction wells at concentrations ranging from 1.1 % to 23.5%.

On January 19, 1996, the COT collected groundwater samples from two wells located in close proximity to the former Cottonwood Landfill. The wells were installed by a sand and gravel company in operation near the landfill, and the wells provide drinking water to five residences on the landfill. Except for coliform and nitrate, laboratory test results from the two groundwater samples indicate that there are indications that the groundwater in the vicinity of the landfill has been impacted by materials that may have been disposed in the landfill (COT, 1996). Coliform is typically associated with bacteria in the well or distribution system, and nitrate is typically associated with agricultural activities.

9.0 CONCLUSIONS AND RECOMMENDATIONS

SWCA has completed a Phase I ESA of the property described in this document in conformance with the scope and limitations of ASTM Standard E 1527. Information obtained during completion of this Phase I ESA indicates that the site was used primarily for agriculture through the 1960's at which time development began to encroach upon the riverbanks primarily in the form of residential areas. The site has a history of seven landfills. There is some commercial development within the project boundaries such as gas stations, government operations (county offices and motor fleet maintenance), as well as bus and truck maintenance. Additionally, there is substantial gravel pit activity at the south end of the project area. Based primarily on the site visit, interviews, and records review described in this report, SWCA recommends further investigation of the site with respect to potential RECs.

1. As a matter of housekeeping and to preclude the miscellaneous trash and debris in the river bottom from contributing to surface or groundwater contamination, or detracting from the aesthetics of the river bottom, this trash/debris should be removed. The materials should be visually screened for potentially hazardous materials, and if warranted, tested for possible chemical hazards.

2. Due to voids, decomposition of materials, and lack of compaction during filling, the landfills can pose engineering and structural risks with respect to structures built on or near the landfills. Chemical exposure hazards could be created during excavation of landfill materials for possible building or utility construction. Construction or excavation on or near landfills should be prohibited until potential hazards are fully characterized and mitigated. Consideration should be given to the application of Voluntary Environmental Mitigation Use Restrictions (VEMUR's) for all landfill areas if they are to remain in their present condition without further investigation.

10.0 LIMITATIONS

SWCA warrants that competent professionals prepared this report in conformance with ethical business practices and industry standards. A chain of title search was not required within the scope of this project and therefore not included in this assessment. Because the site involves hundreds of individual properties and has no specific street address, city streets directories and fire or emergency response records that track incidents by street address could not be investigated in this assessment.

SWCA has accepted as true and accurate the information provided by site contacts, regulatory database services, and other sources cited in this report. SWCA is not liable for any inaccuracies, errors, or omissions resulting from reliance upon those sources. A chain-of-title search was not included in the scope of work and was therefore, not completed for this assessment.

Credentials of the individuals involved in preparing this report are included in Appendix F. The information contained in this report relates only to the referenced property and should not be extrapolated or construed to apply to any other site or property whatsoever. The description of the site as provided herein is as it existed as of the date of the site reconnaissance. The contents of this report are valid as of the date shown on the report. The information presented in this report is intended for the exclusive use of the TetraTech, Inc. and its current affiliates, subsidiaries, underwriters, and lenders. Reliance of any other parties on the information presented herein is the sole responsibility of said parties.

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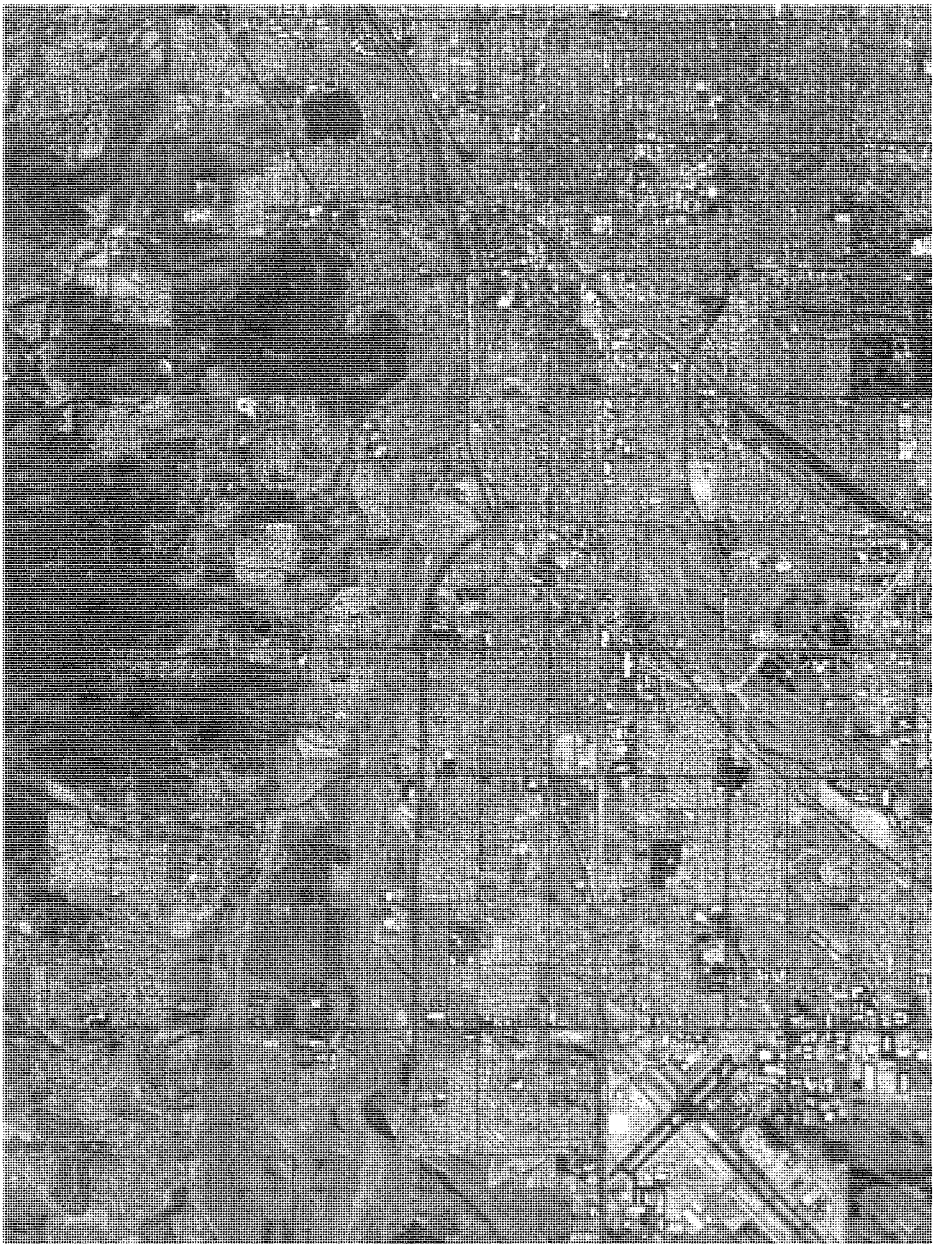
APPENDIX A AERIAL PHOTOGRAPH, MAY 5, 1998



APPENDIX B DESCRIPTIONS OF REGULATORY DATABASES

List and Descriptions of Regulatory Databases

NPL: National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by EPA's Environmental Photographic Interpretation Center (EPIC).

CERCLIS: Comprehensive Environmental Response, Compensation, and Liability Information System. CERCLIS contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLIS contains sites that are either proposed to or on the National Priorities List (NPL) and sites that are in the screening and assessment phase for possible inclusion on the NPL.

CERCLIS-NFRAP: CERCLIS No Further Remedial Action Planned. As of February 1995, CERCLIS sites designated "No Further Remedial Action Planned" (NFRAP) have been removed from CERCLIS. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund action or NPL consideration. EPA has removed approximately 25,000 NFRAP sites to lift the unintended barriers to the redevelopment of these properties and has archived them as historical records so EPA does not needlessly repeat the investigations in the future. This policy change is part of the EPA's Brownfields Redevelopment Program to help cities, states, private investors and affected citizens to promote economic redevelopment of unproductive urban sites.

RCRIS: Resource Conservation and Recovery Information System. RCRIS includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA).

ERNS: Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

CONSENT: Superfund (CERCLA) Consent Decrees. Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by the United States District Courts after settlement by parties to litigation matters.

ROD: Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

FINDS: Facility Index System/Facility Identification Initiative Program Summary Report. FINDS contains both facility information and "pointers" to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Date System).

SHWS: ZipAeids List. The ACIDS list consists of more than 750 locations subject to investigation under the State Water Quality Assurance Revolving Fund (WQARF) and Federal CERCLA programs. The list is no longer updated by the state.

SWF/LF: Directory of Solid Waste Facilities. Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

LUST: Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tanks incidents. Not all states maintain these records, and the information stored varies by state.

UST: Underground Storage Tank Listing. Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

WQARF: Water Quality Assurance Revolving Fund Sites. Sites that may have an actual or potential impact upon the waters of the state, caused by hazardous substances. The WQARF program provides matching funds to political subdivisions and other state agencies for cleanup activities.

SPILLS: Hazardous Materials Logbook. ADEQ Emergency Response Unit. The ADEQ Emergency Response Unit documents chemical spills and incidents that are referred to the Unit. The logbook information for 1984-1986 consists of handwritten entries of the date, incident number, name, city (zip codes not included), county, chemical and quality.

WWFAC: Waste Water Treatment Facilities. Statewide list of waste water treatment facilities.

DRYWELLS: Drywell Registration. A drywell is a bored, drilled, or driven shaft or hole whose depth is greater than its width and is designed and constructed specifically for the disposal of storm water.

TRIS: Toxic Chemical Release Inventory System. Toxic Release Inventory System. TRIS identifies facilities that release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

APPENDIX C REGULATORY DATABASE REPORT

Environmental
Data
Resources, Inc.

The EDR Area Study Report

Study Area
Paseo de las Iglesias
Tucson, AZ 85746

February 11, 2002

Inquiry number 733153.1s

The Source
For Environmental
Risk Management
Data

3530 Post Road
Southport, Connecticut 06490

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802
Internet: www.edrnet.com

EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc. (EDR).

TARGET PROPERTY INFORMATION

ADDRESS

PASEO DE LAS IGLESIAS
TUCSON, AZ 85746

DATABASES WITH NO MAPPED SITES

No mapped sites were found in EDR's search of available ("reasonably ascertainable ") government records within the requested search area for the following databases:

FEDERAL ASTM STANDARD

Proposed NPL............... Proposed National Priority List Sites
CORRACTS................. Corrective Action Report
RCRIS-TSD................. Resource Conservation and Recovery Information System

STATE ASTM STANDARD

SPL......................... Superfund Program List
AZ WQARF................. Water Quality Assurance Revolving Fund Sites

FEDERAL ASTM SUPPLEMENTAL

Delisted NPL............... National Priority List Deletions
HMIRS..................... Hazardous Materials Information Reporting System
MLTS...................... Material Licensing Tracking System
MINES..................... Mines Master Index File
NPL Liens................. Federal Superfund Liens
RAATS..................... RCRA Administrative Action Tracking System

STATE OR LOCAL ASTM SUPPLEMENTAL

AST........................ List of Aboveground Storage Tanks
AZ DOD.................... Department of Defense Sites
Aquifer.................... Waste Water Treatment Facilities
AZ AIRS................... Arizona Airs Database

EDR PROPRIETARY HISTORICAL DATABASES

Coal Gas.................. Former Manufactured Gas (Coal Gas) Sites

SURROUNDING SITES: SEARCH RESULTS

Surrounding sites were identified.

EXECUTIVE SUMMARY

Page numbers and map identification numbers refer to the EDR Radius Map report where detailed data on individual sites can be reviewed.

Sites listed in ***bold italics*** are in multiple databases.

Unmappable (orphan) sites are not considered in the foregoing analysis.

FEDERAL ASTM STANDARD

NPL: Also known as Superfund, the National Priority List database is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund program. The source of this database is the U.S. EPA.

A review of the NPL list, as provided by EDR, and dated 10/22/2001 has revealed that there is 1 NPL site within the searched area.

Site	Address	Map ID	Page
TUCSON INTERNATIONAL AIRPORT A	***NOGALES HWY***	***0***	***3***

CERCLIS: The Comprehensive Environmental Response, Compensation and Liability Information System contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).
CERCLIS contains sites which are either proposed to or on the National Priorities List (NPL) and sites which are in the screening and assessment phase for possible inclusion on the NPL.

A review of the CERCLIS list, as provided by EDR, and dated 11/21/2001 has revealed that there is 1 CERCLIS site within the searched area.

Site	Address	Map ID	Page
TUCSON INTERNATIONAL AIRPORT A	***NOGALES HWY***	***0***	***3***

CERCLIS-NFRAP: As of February 1995, CERCLIS sites designated "No Further Remedial Action Planned" (NFRAP) have been removed from CERCLIS. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund Action or NPL consideration. EPA has removed approximately 25,000 NFRAP sites to lift the unintended barriers to the redevelopment of these properties and has archived them as historical records so EPA does not needlessly repeat the investigations in the future. This policy change is part of the EPA's Brownfields Redevelopment Program to help cities, states, private investors and affected citizens to promote economic redevelopment of unproductive urban sites.

A review of the CERC-NFRAP list, as provided by EDR, and dated 11/21/2001 has revealed that there are 3 CERC-NFRAP sites within the searched area.

Site	Address	Map ID	Page
PIONEER PAINTS AND VARNISH CO	***438 W CONGRESS ST***	***1***	***8***
PIMA COMMUNITY COLLEGE D V	***5901 S CALLE SANTA CRUZ***	***40***	***46***
E F T C SOUTHWEST OPERATIONS	***1150 W DREXEL RD NE COR***	***40***	***47***

EXECUTIVE SUMMARY

RCRIS: The Resource Conservation and Recovery Act database includes selected information on sites that generate, store, treat, or dispose of hazardous waste as defined by the Act. The source of this database is the U.S. EPA.

A review of the RCRIS-LQG list, as provided by EDR, and dated 06/21/2000 has revealed that there are 4 RCRIS-LQG sites within the searched area.

Site	Address	Map ID	Page
PIMA COUNTY DEPT OF TRANSPORTA	*1313 S MISSION RD*	*16*	*26*
TARP TUCSON AIRPORT REMED PROJ	*1100 W IRVINGTON RD*	*36*	*43*
E F T C SOUTHWEST OPERATIONS	*1150 W DREXEL RD NE COR*	*40*	*47*
WEISER LOCK CO	*6700 S WEISER LOCK DR*	*49*	*55*

RCRIS: The Resource Conservation and Recovery Act database includes selected information on sites that generate, store, treat, or dispose of hazardous waste as defined by the Act. The source of this database is the U.S. EPA.

A review of the RCRIS-SQG list, as provided by EDR, and dated 06/21/2000 has revealed that there are 15 RCRIS-SQG sites within the searched area.

Site	Address	Map ID	Page
PIONEER PAINTS AND VARNISH CO	*438 W CONGRESS ST*	*1*	*8*
CHEVRON U S A INC TUCSON ASPHA	*601 W SIMPSON ST*	*10*	*16*
RALPHS TRANSFER INC	*747 S FWY*	*11*	*17*
WATER DEPARTMENT	501 W 18TH ST BLDG 1	12	17
TUCSON WATER CITY OF TUCSON	510 W 18TH ST BLDG 10	12	17
TUCSON CITY OF WATER DEPARTMEN	*510 W 18TH ST*	*12*	*19*
WESTERN EMULSIONS INC	*1015 SOUTH FREEWAY*	*14*	*22*
EXXON CO USA 73904	*655 W 22ND ST AND I 10*	*15*	*24*
PIMA COUNTY AUTOMOTIVE SERVICE	*1301 S MISSION RD*	*16*	*27*
PIMA COUNTY MISSION RD COMPLEX	*1301-1313 S MISSION RD*	*16*	*30*
BARNETT ABD DEYOE CONTRACTORS	*701 W SILVERLAKE RD*	*22*	*35*
H AND K BARRELS	*2122 S 12TH AVE*	*25*	*36*
PIMA COMMUNITY COLLEGE D V	*5901 S CALLE SANTA CRUZ*	*40*	*46*
WALGREENS STORE 3837	*1550 W VALENCIA*	*45*	*52*
LARSON COMPANY THE	*6701 S MIDVALE PARK RD*	*48*	*53*

ERNS: The Emergency Response Notification System records and stores information on reported releases of oil and hazardous substances. The source of this database is the U.S. EPA.

A review of the ERNS list, as provided by EDR, and dated 08/08/2000 has revealed that there are 10 ERNS sites within the searched area.

Site	Address	Map ID	Page
292 SOUTH FREEWAY	292 SOUTH FREEWAY	4	13
501 W 18TH STREET	501 W 18TH STREET	12	17
1204 W SILVERLAKE RD	1204 W SILVERLAKE RD	19	33
1177 W. SILVERLAKE	1177 W. SILVERLAKE	19	33
1775 WEST CALLE ACATULCO	1775 WEST CALLE ACATULC	30	39
1645 W. VALENCIA	1645 W. VALENCIA	46	53
6701 SOUTH MIDVILLE PARK ROAD	6701 SOUTH MIDVILLE PAR	48	55
6701 SOUTH MIDVILLE PARK ROAD	6701 SOUTH MIDVILLE PAR	48	55

EXECUTIVE SUMMARY

Site	Address	Map ID	Page
6660 SOUTH BROADMOOR	6660 SOUTH BROADMOOR	49	57
6660 SOUTH BROADMOOR	6660 SOUTH BROADMOOR	49	57

STATE ASTM STANDARD

SHWS: The State Hazardous Waste Sites records are the states' equivalent to CERCLIS. These sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup using state funds (state equivalent of Superfund) are identified along with sites where cleanup will be paid for by potentially responsible parties. The data come from the Department of Environmental Quality's ZipAcids database.

A review of the SHWS list, as provided by EDR, has revealed that there are 5 SHWS sites within the searched area.

Site	Address	Map ID	Page
PIONEER PAINT & VARNISH COMPAN	*438 W CONGRESS*	*1*	*10*
RIO NUEVO PROJECT	700 CONGRESS ST.	3	13
AMERICAN SCRAP METAL RECYCLING	2140 S. FREEWAY	24	36
NATIONAL SEMICONDUCTOR CORP.	5901 S. CALLE SANTA CRU	40	46
LAMBDA ELECT. DIV VEECO INST C	1150 W DREXEL RD	40	49

SWF/LF: The Solid Waste Facilities/Landfill Sites records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. The data come from the Department of Environmental Quality's Municipal Solid Waste Landfills.../Closed Solid Waste Landfills...database.

A review of the SWF/LF list, as provided by EDR, has revealed that there is 1 SWF/LF site within the searched area.

Site	Address	Map ID	Page
COTTONWOOD	*3000 S. COTTONWOOD LN.*	*29*	*39*

LUST: The Leaking Underground Storage Tank Incident Reports contain an inventory of reported leaking underground storage tank incidents. The data come from the Department of Environmental Quality's LUST File Listing by Zip Code.

A review of the LUST list, as provided by EDR, and dated 11/08/2001 has revealed that there are 24 LUST sites within the searched area.

Site	Address	Map ID	Page
PIONEER PAINT & VARNISH COMPAN	*438 W CONGRESS*	*1*	*10*
CIRCLE K # 8838	*2 N FREEWAY*	*2*	*11*
TEXACO SERVICE	*480 W CONGRESS*	*2*	*12*
CIRCLE K # 171	*1002 W CONGRESS*	*5*	*13*
BOATNER'S STATION/E-Z #060179	*292 S FREEWAY*	*6*	*13*
CITIZEN AUTO STAGE CO	*351 S BRICKYARD LN*	*9*	*15*
RALPH'S TRANSFER INC	*747 S FREEWAY*	*11*	*16*
WEST 18TH ST FUEL ISLAND	*510 W 18TH ST*	*12*	*18*

EXECUTIVE SUMMARY

Site	Address	Map ID	Page
ASPHALT PRODUCTS TRANSPORT CO	*635 W 18TH ST*	*12*	*19*
UNOCAL # 4897	*1210 S FREEWAY*	*14*	*20*
CIRCLE K # 1838	*1145 S FREEWAY*	*14*	*21*
CRICLE K #5579	*655 W 22ND*	*15*	*23*
EXPRESS-IT	*601 W 22ND ST*	*15*	*25*
PIMA COUNTY DEPT OF TRANSPORTA	*1313 S MISSION RD*	*16*	*26*
PIMA COUNTY AUTOMOTIVE SERVICE	*1301 S MISSION RD*	*16*	*27*
ATKO BUILDING MATERIALS INC	*600 W 25TH ST*	*17*	*31*
KUSHMAUL MACHINE & ENGINEERING	*2210 S FREEWAY*	*18*	*32*
E-Z SERVE/QUIK MART #100909	*1890 S MISSION RD*	*23*	*35*
CIRCLE K # 678	*1777 W 36TH ST*	*27*	*37*
VAN'S EXXON	*3761 S MISSION RD*	*31*	*39*
BORDER PATROL HEADQUARTERS	*1970 W AJO WAY*	*32*	*40*
US BORDER PATROL TUCSON	*2010 W AJO WAY/1970 W A*	*32*	*41*
CIRCLE K # 998	*4820 S MISSION RD*	*35*	*42*
CIRCLE K # 654	*2526 W VALENCIA*	*43*	*51*

UST: The Underground Storage Tank database contains registered USTs. USTs are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA). The data come from the Department of Environmental Quality's Arizona UST-DMS Facility and Tank Data Listing by City database.

A review of the UST list, as provided by EDR, and dated 11/07/2001 has revealed that there are 38 UST sites within the searched area.

Site	Address	Map ID	Page
PIONEER PAINT & VARNISH COMPAN	*438 W CONGRESS*	*1*	*10*
CIRCLE K # 8838	*2 N FREEWAY*	*2*	*11*
TEXACO SERVICE	*480 W CONGRESS*	*2*	*12*
CIRCLE K # 171	*1002 W CONGRESS*	*5*	*13*
BOATNER'S STATION/E-Z #060179	*292 S FREEWAY*	*6*	*13*
FLINT OIL CO INC	500 W SIMPSON	8	14
CITIZEN AUTO STAGE CO	*351 S BRICKYARD LN*	*9*	*15*
RALPH'S TRANSFER INC	*747 S FREEWAY*	*11*	*16*
WEST 18TH ST FUEL ISLAND	*510 W 18TH ST*	*12*	*18*
ASPHALT PRODUCTS TRANSPORT CO	*635 W 18TH ST*	*12*	*19*
GELCO	949 S FREEWAY	13	20
RECYLE AMERICA	945 S FREEWAY	13	20
UNOCAL # 4897	*1210 S FREEWAY*	*14*	*20*
CIRCLE K # 1838	*1145 S FREEWAY*	*14*	*21*
GUADALUPE LESPRON	1114 S FARMINGTON	14	22
CRICLE K #5579	*655 W 22ND*	*15*	*23*
EXPRESS-IT	*601 W 22ND ST*	*15*	*25*
PIMA COUNTY DEPT OF TRANSPORTA	*1313 S MISSION RD*	*16*	*26*
PIMA COUNTY AUTOMOTIVE SERVICE	*1301 S MISSION RD*	*16*	*27*
ATKO BUILDING MATERIALS INC	*600 W 25TH ST*	*17*	*31*
KUSHMAUL MACHINE & ENGINEERING	*2210 S FREEWAY*	*18*	*32*
PIMA COUNTY CORRECTIONAL FAC	1270 W SILVERLAKE	20	33
CARL GREMMLER	527 W 29TH ST	21	34
BARNETT & DEZOL CONT INC	701 W SILVER LAKE RD	22	34
E-Z SERVE/QUIK MART #100909	*1890 S MISSION RD*	*23*	*35*
CIRCLE K # 678	*1777 W 36TH ST*	*27*	*37*
DIAMOND SHAMROCK # 1623	2616 S MISSION RD	28	38
CIRCLE K # 1931	2590 S MISSION RD	28	38

EXECUTIVE SUMMARY

Site	Address	Map ID	Page
VAN'S EXXON	***3761 S MISSION RD***	***31***	***39***
BORDER PATROL HEADQUARTERS	***1970 W AJO WAY***	***32***	***40***
US BORDER PATROL TUCSON	***2010 W AJO WAY/1970 W A***	***32***	***41***
GIANT #925	1202 W AJO	34	42
CIRCLE K # 998	***4820 S MISSION RD***	***35***	***42***
CIRCLE K # 1606	5680 S MISSION RD	39	45
DIAMOND SHAMROCK # 1613	2160 W DREXEL RD	41	49
SAN XAVIER ROCK & MATERIALS	1011 W VALENCIA DRIVE	42	50
CIRCLE K # 654	***2526 W VALENCIA***	***43***	***51***
CIRCLE K # 5540	1555 W VALENCIA RD	45	52

FEDERAL ASTM SUPPLEMENTAL

CONSENT: Major Legal settlements that establish responsibility and standards for cleanup at NPL (superfund) sites. Released periodically by U.S. District Courts after settlement by parties to litigation matters.

A review of the CONSENT list, as provided by EDR, has revealed that there is 1 CONSENT site within the searched area.

Site	Address	Map ID	Page
TUCSON INTERNATIONAL AIRPORT A	***NOGALES HWY***	***0***	***3***

RODS: Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid the cleanup.

A review of the ROD list, as provided by EDR, has revealed that there is 1 ROD site within the searched area.

Site	Address	Map ID	Page
TUCSON INTERNATIONAL AIRPORT A	***NOGALES HWY***	***0***	***3***

FINDS: The Facility Index System contains both facility information and "pointers" to other sources of information that contain more detail. These include: RCRIS; Permit Compliance System (PCS); Aerometric Information Retrieval System (AIRS); FATES (FIFRA [Federal Insecticide Fungicide Rodenticide Act] and TSCA Enforcement System, FTTS [FIFRA/TSCA Tracking System]; CERCLIS; DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes); Federal Underground Injection Control (FURS); Federal Reporting Data System (FRDS); Surface Impoundments (SIA); TSCA Chemicals in Commerce Information System (CICS); PADS; RCRA-J (medical waste transporters/disposers); TRIS; and TSCA. The source of this database is the U.S. EPA/NTIS.

A review of the FINDS list, as provided by EDR, and dated 10/29/2001 has revealed that there are 26 FINDS sites within the searched area.

Site	Address	Map ID	Page
TUCSON INTERNATIONAL AIRPORT A	***NOGALES HWY***	***0***	***3***

EXECUTIVE SUMMARY

Site	Address	Map ID	Page
PIONEER PAINTS AND VARNISH CO	***438 W CONGRESS ST***	***1***	***8***
ARIZONA DEPT OF TRANSP	611 W MESA	7	14
CHEVRON U S A INC TUCSON ASPHA	***601 W SIMPSON ST***	***10***	***16***
RALPHS TRANSFER INC	***747 S FWY***	***11***	***17***
TUCSON CITY OF WATER DEPARTMEN	***510 W 18TH ST***	***12***	***19***
WESTERN EMULSIONS INC	***1015 SOUTH FREEWAY***	***14***	***22***
EXXON CO USA 73904	***655 W 22ND ST AND I 10***	***15***	***24***
PIMA COUNTY DEPT OF TRANSPORTA	***1313 S MISSION RD***	***16***	***26***
PIMA COUNTY AUTOMOTIVE SERVICE	***1301 S MISSION RD***	***16***	***27***
PIMA COUNTY MISSION RD CMPLX	1301-1313 S. MISSION RD	16	30
PIMA COUNTY MISSION RD COMPLEX	***1301-1313 S MISSION RD***	***16***	***30***
BARNETT ABD DEYOE CONTRACTORS	***701 W SILVERLAKE RD***	***22***	***35***
H AND K BARRELS	***2122 S 12TH AVE***	***25***	***36***
MISSION VERDE APT	***1702 W 36TH ST APT 1174***	***26***	***37***
TARP TUCSON AIRPORT REMED PROJ	***1100 W IRVINGTON RD***	***36***	***43***
FRYS FOOD STORES 119	902 W IRVINGTON RD	37	45
HOME DEPOT THE 0467	1155 W IRVINGTON RD	38	45
PIMA COMMUNITY COLLEGE D V	***5901 S CALLE SANTA CRUZ***	***40***	***46***
E F T C SOUTHWEST OPERATIONS	***1150 W DREXEL RD NE COR***	***40***	***47***
SAN XAVIER ROCK & MATERIAL	1000 W VALENCIA RD	42	51
WALGREENS STORE 3837	1550 W VALENCIA	45	52
WALGREENS STORE 3837	***1550 W VALENCIA***	***45***	***52***
HOLMES TUTTLE FORD INC	1431 W VALENCIA	47	53
LARSON COMPANY THE	***6701 S MIDVALE PARK RD***	***48***	***53***
WEISER LOCK CO	***6700 S WEISER LOCK DR***	***49***	***55***

PADS: The PCB Activity Database identifies generators, transporters, commercial storers and/or brokers and disposers of PCBs who are required to notify the United States Environmental Protection Agency of such activities. The source of this database is the U.S. EPA.

A review of the PADS list, as provided by EDR, and dated 09/30/2001 has revealed that there is 1 PADS site within the searched area.

Site	Address	Map ID	Page
BARNETT ABD DEYOE CONTRACTORS	***701 W SILVERLAKE RD***	***22***	***35***

TRIS: The Toxic Chemical Release Inventory System identifies facilities that release toxic chemicals to the air, water, and land in reportable quantities under SARA Title III, Section 313. The source of this database is the U.S. EPA.

A review of the TRIS list, as provided by EDR, and dated 12/31/1999 has revealed that there is 1 TRIS site within the searched area.

Site	Address	Map ID	Page
WEISER LOCK CO	***6700 S WEISER LOCK DR***	***49***	***55***

EXECUTIVE SUMMARY

TSCA: The Toxic Substances Control Act identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site. The United States Environmental Protection Agency has no current plan to update and/or re-issue this database.

A review of the TSCA list, as provided by EDR, and dated 12/31/1998 has revealed that there is 1 TSCA site within the searched area.

Site	Address	Map ID	Page
CHEVRON	600 W SIMPSON ST	10	16

FTTS: FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act) over the previous five years. To maintain currency, EDR contacts the Agency on a quarterly basis.

A review of the FTTS list, as provided by EDR, and dated 10/25/2001 has revealed that there are 2 FTTS sites within the searched area.

Site	Address	Map ID	Page
MISSION VERDE APT	***1702 W 36TH ST APT 1174***	***26***	***37***
ROSELLA ROBERTS MISSION VERDE	1702 W 36TH ST APT 1174	26	37

STATE OR LOCAL ASTM SUPPLEMENTAL

SPILLS: The ADEQ Emergency Response unit documents chemical spills and incidents that are referred to the Unit. The logbook information for 1984-1986 consists of handwritten entries of the date, incident number and name of facility if known. Current logbooks are computerized and can be sorted by date, incident number, name, city (zip codes are not included), county, chemical and quantity. The sources is the Department of Environmental Quality's Hazardous Material Logbook.

A review of the AZ Spills list, as provided by EDR, has revealed that there are 6 AZ Spills sites within the searched area.

Site	Address	Map ID	Page
PIMA COUNTY HEALTH	1301 SO. MISSION	16	31
TUCSON ELECTRIC POWER CO.	1177 W SILVERLAKE	19	33
LAMBDA ELECTRONICS POWER SPLY	1150 W. DREXEL RD.	40	49
AMERICAN AIRLINE	1645 W. VALENCIA	46	53
WEISER LOCK CO	***6700 S WEISER LOCK DR***	***49***	***55***
WEISER LOCK	6660 SO. BROADMOOR	49	57

WWFAC: Statewide list of waste water treatment facilities.

A review of the WWFAC list, as provided by EDR, and dated 12/12/2000 has revealed that there are 4 WWFAC sites within the searched area.

Site	Address	Map ID	Page
PIONEER PAINTS AND VARNISH CO	***438 W CONGRESS ST***	***1***	***8***

EXECUTIVE SUMMARY

Site	Address	Map ID	Page
PIMA COUNTY PARKS & REC - GILB	1204 W. SILVERLAKE RD.	19	33
BARNETT ABD DEYOE CONTRACTORS	***701 W SILVERLAKE RD***	***22***	***35***
COTTONWOOD	***3000 S. COTTONWOOD LN.***	***29***	***39***

Drywells: Drywell is a bored, drilled, or driven shaft or hole whose depth is greater than its width and is designed and constructed specifically for the disposal of storm water. The source is Arizona's Department of Environmental Quality.

A review of the Dry Wells list, as provided by EDR, has revealed that there are 4 Dry Wells sites within the searched area.

Site	Address	Map ID	Page
MESA RIDGE-A MANUFACTURED HOME	1402 W. AJO WAY	33	41
PCC-DESERT VISTA CAMPUS EXPANS	5901 SOUTH CALLE SANTA	40	46
THE WOODS I AND II APARTMENTS	1970 W. VALENCIA RD.	44	52
THE LARSON COMPANY	6701 SOUTH MIDVALE PARK	48	55

EXECUTIVE SUMMARY

Please refer to the end of the findings report for unmapped orphan sites due to poor or inadequate address information.

MAP FINDINGS SUMMARY

	Database	Total Plotted
FEDERAL ASTM STANDARD		
	NPL	1
	Proposed NPL	0
	CERCLIS	1
	CERC-NFRAP	3
	CORRACTS	0
	RCRIS-TSD	0
	RCRIS Lg. Quan. Gen.	4
	RCRIS Sm. Quan. Gen.	15
	ERNS	10
STATE ASTM STANDARD		
	SPL	0
	State Haz. Waste	5
	State Landfill	1
	LUST	24
	UST	38
	AZ WQARF	0
FEDERAL ASTM SUPPLEMENTAL		
	CONSENT	1
	ROD	1
	Delisted NPL	0
	FINDS	26
	HMIRS	0
	MLTS	0
	MINES	0
	NPL Liens	0
	PADS	1
	RAATS	0
	TRIS	1
	TSCA	1
	FTTS	2
STATE OR LOCAL ASTM SUPPLEMENTAL		
	AST	0
	AZ Spills	6
	AZ DOD	0
	WWFAC	4
	Aquifer	0
	Dry Wells	4
	AZ AIRS	0
EDR PROPRIETARY HISTORICAL DATABASES		
	Coal Gas	0

MAP FINDINGS SUMMARY

Database	Total Plotted

* Sites may be listed in more than one database

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

Coal Gas Site Search: No site was found in a search of Real Property Scan's ENVIROHAZ database.

NPL Region	**TUCSON INTERNATIONAL AIRPORT AREA** **NOGALES HWY** **TUCSON, AZ 85734**	**CERCLIS** **FINDS** **NPL** **CONSENT** **ROD**	**1000384969** **AZD980737530**

CERCLIS Classification Data:

Site Incident Category:	Not reported	Federal Facility:	Not a Federal Facility
Non NPL Status:	Not reported		
Ownership Status:	Mixed Ownership	NPL Status:	Currently on the Final NPL
Contact:	Eugenia Chow	Contact Tel:	(415) 744-2258
Contact Title:	Not reported		
Contact:	D. ZUROSKI	Contact Tel:	(415) 744-2285
Contact Title:	Not reported		

Site Description: The Tucson International Airport Area (TIAA) Superfund site covers approximately five square miles and is located on the south side of the City of Tucson, Arizona. The site is bounded by Highway 89 to the west, Hughes Access Road to the east and so uth, and Los Reales Road and Valencia Road to the north. TIAA consists of industrial properties, however, residential and commercial properties are located in the immediate vicinity of the site. There are three separate properties within the TIAA S uperfund site: the Airport Property, the Burr-Brown Property, and the Former West-Cap Property. Currently, the airport property consists of an active airport and associated industrial activities; the first industrial operations at the airport proper ty began in 1940. These land uses are expected to remain the same in the future. Waste-related activities began in the area following the opening of the Consolidated Aircraft refitting facility in 1942 and included surface discharge of waste liquid s containing organic compounds into soil, disposal ponds and unlined landfills. The remaining two properties, Burr-Brown and West-Cap, are adjacent to the airport. The Burr-Brown Corporation has been in the area since 1965 and is a major manufactur er of microelectric components. The former West-Cap operated from 1963 until 1989, when they went out of business. Current activities at the property include storage and warehousing of finely machined components, and the buildings are leased to var ious tenants. Operations at both sites are expected to continue into the future. In May 1981, organic chemicals commonly used as solvents by electronic and aerospace industries were found in several City of Tucson drinking water wells in southwest Tucson. Later that year, the City of Tucson closed the contaminated wells to ensure that water served to the public would meet drinking water standards. Further investigations revealed a large groundwater plume containing trichloroethylene (TC
E) and other volatile organic compounds (VOCs) and chromium migrating in a northerly to northwesterly direction away from the airport property. This plume is called the main plume. Two smaller areas of groundwater contamination were found to the e ast of the main plume. In 1982, the Environmental Protection Agency (EPA) listed the TIAA Superfund site on the National Priorities List (NPL). Operable Unit 1 (OU1): In 1988, EPA issued a Record of Decision (ROD) that established cleanup require ments for the regional groundwater aquifer. The Air Force had begun operation of its remedial groundwater system for the southern portion of the site. The OU1 response action presented the groundwater remedy for the northern

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

TUCSON INTERNATIONAL AIRPORT AREA (Continued) 1000384969

portion of the site. T ogether, the two remedies constitute the overall remedial strategy for groundwater. OU2: In 1991, liquid contaminants and sludge were removed from an underground sump. In 1997, PCB-contaminated soil was removed from a small portion of the Airport Property and from nearby residential properties. A ROD was completed in September 1997 that addressed the remaining soil contamination on the Airport Property, Burr-Brown Property, and the former West-Cap Property. OU3: Air Force Plant (AFP) 44 i s located within the TIAA Superfund site, 15 miles south of downtown Tucson and is bounded on the east by the Tucson International Airport property. AFP 44 was first constructed in 1951 for the purpose of manufacturing Falcon air-to-air missiles. O ver the years, industrial facilities have been constructed to support several other missile systems. At present, industrial facilities occupy a total building area in excess of two million square feet. Groundwater at AFP 44 was addressed in a 1986 Remedial Action Plan. A Feasibility Study (FS), which evaluated potential remedial alternatives for contaminated soils within the AFP 44 plant, completed in January 1995. Cleanup of five sites to remove continuing sources of groundw
ater contamination or to address potential risks to human health and the environment is specifically addressed in the FS: Site 1 (Ranch Site), Site 2 (FACO Landfill), Site 3 (Inactive Drainage Channel Disposal Pits), Site 4 (Former Unlined Surface I mpoundments) including portions of the area which were originally sampled during investigation at Site 6 (Drainage Ditch and Channels), and Site 5 (Former Sludge Drying Beds). A no further action ROD has been issued for four other sites including: S ite 7 (North FACO Fire Training Area), Site 8 (South FACO Fire Training Area and Magnesium Burn Area), Site 9 (Explosive Detonation Pit), and Site 15 (Potential Trench Site). Site 14 (Shallow Groundwater Zone) will be addressed in a separate ROD. A ROD was issued in September 1998 addressing Sites 4, 5, and 6 soils only. The Air Force is currently performing non-time critical removal actions for Sites 1 through 6, and Site 14. These removal actions are being performed concurrently with the R OD process, and are consistent with the final remedies selected in the ROD.

CERCLIS Assessment History:

Assessment:	DISCOVERY	Completed:	12/01/1979
Assessment:	PRELIMINARY ASSESSMENT	Completed:	02/01/1980
Assessment:	HRS PACKAGE	Completed:	12/01/1982
Assessment:	SITE INSPECTION	Completed:	12/01/1982
Assessment:	SITE INSPECTION	Completed:	12/01/1982
Assessment:	PROPOSAL TO NPL	Completed:	12/30/1982
Assessment:	REMEDIAL ACTION MASTER PLAN	Completed:	04/01/1983
Assessment:	FINAL LISTING ON NPL	Completed:	09/08/1983
Assessment:	NPL RP SEARCH	Completed:	11/15/1985
Assessment:	COMBINED RI/FS	Completed:	08/22/1988
Assessment:	RECORD OF DECISION	Completed:	08/22/1988
Assessment:	TECHNICAL ASSISTANCE	Completed:	08/22/1988
Assessment:	IAG NEGOTIATIONS	Completed:	10/17/1988
Assessment:	RD/RA NEGOTIATIONS	Completed:	01/24/1989
Assessment:	UNILATERAL ADMIN ORDER	Completed:	01/24/1989
Assessment:	RD/RA NEGOTIATIONS	Completed:	07/13/1989
Assessment:	CONSENT DECREE	Completed:	03/16/1990
Assessment:	REMOVAL ASSESSMENT	Completed:	09/06/1990
Assessment:	UNILATERAL ADMIN ORDER	Completed:	12/11/1990

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site	Database(s)	EDR ID Number EPA ID Number

TUCSON INTERNATIONAL AIRPORT AREA (Continued) **1000384969**

Assessment:	REMOVAL ASSESSMENT	Completed:	02/26/1991
Assessment:	PREPARATION OF COST DOCM PKGE	Completed:	04/05/1991
Assessment:	PRP REMOVAL	Completed:	05/09/1991
Assessment:	PRP RD	Completed:	06/05/1991
Assessment:	CONSENT DECREE	Completed:	06/07/1991
Assessment:	PRP RD	Completed:	09/12/1991
Assessment:	COMMUNITY INVOLVEMENT	Completed:	01/30/1992
Assessment:	PREPARATION OF COST DOCM PKGE	Completed:	02/20/1992
Assessment:	UNILATERAL ADMIN ORDER	Completed:	07/09/1992
Assessment:	PRP RA	Completed:	11/09/1992
Assessment:	ADMIN/VOLUNTARY COST RECOVERY	Completed:	06/11/1993
Assessment:	PREPARATION OF COST DOCM PKGE	Completed:	10/27/1993
Assessment:	IAG NEGOTIATIONS	Completed:	10/31/1994
Assessment:	PRP RA	Completed:	11/07/1995
Assessment:	PREPARATION OF COST DOCM PKGE	Completed:	03/20/1996
Assessment:	FF RD	Completed:	04/01/1996
Assessment:	UNILATERAL ADMIN ORDER	Completed:	10/04/1996
Assessment:	RECORD OF DECISION	Completed:	11/20/1996
Assessment:	PRP REMOVAL	Completed:	02/27/1997
Assessment:	Explanation Of Significant Differences	Completed:	02/27/1997
Assessment:	FF RD	Completed:	05/12/1997
Assessment:	FF REMOVAL	Completed:	07/25/1997
Assessment:	FF REMOVAL	Completed:	08/15/1997
Assessment:	ADMINISTRATIVE RECORDS	Completed:	09/30/1997
Assessment:	PRP RI/FS	Completed:	09/30/1997
Assessment:	FF REMOVAL	Completed:	09/30/1997
Assessment:	FF REMOVAL	Completed:	09/30/1997
Assessment:	RECORD OF DECISION	Completed:	09/30/1997
Assessment:	RECORD OF DECISION	Completed:	09/30/1997
Assessment:	RECORD OF DECISION	Completed:	09/30/1997
Assessment:	FF RA	Completed:	09/30/1997
Assessment:	FF RA	Completed:	09/30/1997
Assessment:	FF RI/FS	Completed:	09/30/1997
Assessment:	FF REMOVAL	Completed:	09/30/1997
Assessment:	COMBINED RI/FS	Completed:	09/30/1997
Assessment:	TECHNICAL ASSISTANCE GRANT	Completed:	12/23/1997
Assessment:	ADMINISTRATIVE RECORDS	Completed:	02/05/1998
Assessment:	FF REMOVAL	Completed:	03/31/1998
Assessment:	FF RA	Completed:	04/13/1998
Assessment:	RECORD OF DECISION	Completed:	09/29/1998
Assessment:	RD/RA NEGOTIATIONS	Completed:	03/31/1999
Assessment:	REMOVAL	Completed:	04/06/1999
Assessment:	Lodged By DOJ	Completed:	06/17/1999
Assessment:	CONSENT DECREE	Completed:	02/17/2000
Assessment:	FF REMOVAL	Completed:	03/14/2001

CERCLIS Site Status:
Stabilized
CERCLIS Alias Name(s):
HUGHES AIRCRAFT CO
USAF PLANT 44
TUCSON AIRPORT AREA
T A A
TUCSON INTERNATIONAL AIRPORT AREA

NPL:

EPA ID:	AZD980737530
Region:	09
Federal:	General

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

TUCSON INTERNATIONAL AIRPORT AREA (Continued) **1000384969**

Final Date: 09/08/1983

NPL Contaminant:

NPL Status:	Final
Substance Id:	C321
Case Num:	Not reported
Substance :	TRICHLOROETHANE, NOS
Pathway :	NOT INDICATED
GW Scoring :	Not reported
SW Scoring :	Not reported
Air Scoring:	Not reported
Soil Scoring:	Not reported
DC Scoring:	Not reported
FE Scoring:	Not reported

NPL Status:	Final
Substance Id:	P106
Case Num:	143-33-9
Substance :	SODIUM CYANIDE
Pathway :	NOT INDICATED
GW Scoring :	Not reported
SW Scoring :	Not reported
Air Scoring:	Not reported
Soil Scoring:	Not reported
DC Scoring:	Not reported
FE Scoring:	Not reported

NPL Status:	Final
Substance Id:	U032
Case Num:	13765-19-0
Substance :	CALCIUM CHROMATE
Pathway :	NOT INDICATED
GW Scoring :	Not reported
SW Scoring :	Not reported
Air Scoring:	Not reported
Soil Scoring:	Not reported
DC Scoring:	Not reported
FE Scoring:	Not reported

NPL Status:	Final
Substance Id:	U080
Case Num:	75-09-2
Substance :	METHYLENE CHLORIDE
Pathway :	NOT INDICATED
GW Scoring :	Not reported
SW Scoring :	Not reported
Air Scoring:	Not reported
Soil Scoring:	Not reported
DC Scoring:	Not reported
FE Scoring:	Not reported

NPL Status:	Final
Substance Id:	A020
Case Num:	7440-47-3
Substance :	CHROMIUM AND COMPOUNDS, NOS (CR)
Pathway :	GW
GW Scoring :	Observed Release & Toxicity
SW Scoring :	Not reported
Air Scoring:	Not reported
Soil Scoring:	Not reported

TUCSON INTERNATIONAL AIRPORT AREA (Continued) **1000384969**

DC Scoring: Not reported
FE Scoring: Not reported

NPL Status: Final
Substance Id: A030
Case Num: 540-59-0
Substance : DICHLOROETHENE, NOS
Pathway : GW
GW Scoring : Observed Release
SW Scoring : Not reported
Air Scoring: Not reported
Soil Scoring: Not reported
DC Scoring: Not reported
FE Scoring: Not reported

NPL Status: Final
Substance Id: C395
Case Num: Not reported
Substance : BETA-ACETOXYTRIBUTYLTRICARBOXYLIC ACID
Pathway : GW
GW Scoring : Observed Release
SW Scoring : Not reported
Air Scoring: Not reported
Soil Scoring: Not reported
DC Scoring: Not reported
FE Scoring: Not reported

NPL Status: Final
Substance Id: U228
Case Num: 79-01-6
Substance : TRICHLOROETHYLENE (TCE), 1,1,2-
Pathway : GW
GW Scoring : Observed Release
SW Scoring : Not reported
Air Scoring: Not reported
Soil Scoring: Not reported
DC Scoring: Not reported
FE Scoring: Not reported

NPL Site:
CERCLIS Id: AZD980737530
Site City: Tucson
Site State: AZ
NPL Status: Final
Status Date: 09/08/83
Federal Site: Not reported
HRS Score: 57.80
GW Score: 100.00
SW Score: 0.00
Air Score: 0.00
Soil Score: 0.00
DC Score: 0.00
FE Score: 0.00

NPL Char:
NPL Status: Final
Category Description: DEPTH TO AQUIFER
Category Value: 1

NPL Status: Final

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site	Database(s)	EDR ID Number EPA ID Number

TUCSON INTERNATIONAL AIRPORT AREA (Continued) **1000384969**

Category Description: DISTANCE TO THE NEAREST POPULATION
Category Value: 10

NPL Status: Final
Category Description: OBSERVED RELEASE-Ground Water
Category Value: Not reported

NPL Status: Final
Category Description: OTHER GROUND WATER USE-Industrial Process Cooling
Category Value: Not reported

NPL Status: Final
Category Description: PERMIT-NPDES
Category Value: Not reported

NPL Status: Final
Category Description: PERMIT-RCRA
Category Value: Not reported

NPL Status: Final
Category Description: PHYSICAL STATE-Liquid
Category Value: Not reported

NPL Status: Final
Category Description: SITE ACTIVITY WASTE SOURCE-Industry Military
Category Value: Not reported

NPL Status: Final
Category Description: SITE ACTIVITY WASTE SOURCE-Industry Military Ordnance Produc
Category Value: Not reported

NPL Status: Final
Category Description: SITE ACTIVITY WASTE SOURCE-Industry Military Testing & Maint
Category Value: Not reported

NPL Status: Final
Category Description: SITE ACTIVITY WASTE SOURCE-Manufacturing
Category Value: Not reported

NPL Status: Final
Category Description: SITE ACTIVITY WASTE SOURCE-Manufacturing Fabricated Metals
Category Value: Not reported

NPL Status: Final
Category Description: SURFACE WATER ADJACENT TO SITE-River
Category Value: Not reported

ROD:
Full-text of USEPA Record of Decision(s) is available from EDR.

CONSENT:
Full-text of a consent decree on this site issued by a United States District Court is available from EDR.

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Comperhensive Environmental Response, Compensation and Liability Information System (CERCLIS)

Map ID	Site	Database(s)	EDR ID Number / EPA ID Number
1	**PIONEER PAINTS AND VARNISH CO** **438 W CONGRESS ST** **TUCSON, AZ 85701**	**RCRIS-SQG** **FINDS** **WWFAC** **CERC-NFRAP**	**1000312417** **AZD008397796**

PIONEER PAINTS AND VARNISH CO (Continued) **1000312417**

CERCLIS-NFRAP Classification Data:

Site Incident Category: Not reported | Federal Facility: Not a Federal Facility
Non NPL Code: NFRAP
Ownership Status: Unknown | NPL Status: Not on the NPL

CERCLIS-NFRAP Assessment History:

Assessment:	DISCOVERY	Completed:	12/01/1979
Assessment:	PRELIMINARY ASSESSMENT	Completed:	06/01/1983
Assessment:	SITE INSPECTION	Completed:	06/01/1983

RCRIS:

Owner: CITY OF TUCSON
(602) 791-4014

Contact: DANIEL UTHE
(602) 791-4014

Record Date: 05/17/1994
Classification: Small Quantity Generator
Used Oil Recyc: No

Violation Status: Violations exist

Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	02/13/1987
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	06/17/1987
Actual Date Achieved Compliance:	06/24/1987
Enforcement Action:	Written Informal
Enforcement Action Date:	05/07/1987
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported
Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	08/29/1986
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	11/30/1986
Actual Date Achieved Compliance:	08/11/1989
Enforcement Action:	Written Informal
Enforcement Action Date:	08/29/1986
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported
Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	03/29/1986
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	08/25/1986
Actual Date Achieved Compliance:	08/11/1989
Enforcement Action:	Written Informal
Enforcement Action Date:	07/18/1986
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site		Database(s)	EDR ID Number EPA ID Number

PIONEER PAINTS AND VARNISH CO (Continued) **1000312417**

There are 3 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	06/24/1987
Compliance Schedule Evaluation (CSE)	Generator-All Requirements	08/11/1989
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	08/11/1989

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)
Toxic Chemical Release Inventory System (TRIS)

AZ WWFAC:
Owner Address: 201 N. Stone
Tucson, A Z8572

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1 **PIONEER PAINT & VARNISH COMPANY** SHWS U001626713
438 W CONGRESS LUST N/A
TUCSON, AZ 85701 UST

SHWS:
EPA ID: AZD008397796
Program: PA/SI
Facility Id: 253
Site Code: 100377
Discovery Date: 03/77/10
Source: Not reported
Operable Unit: 0
QWARF Area: Not reported
Lat/Long: Not reported
Lat/Long Method: 80
Comments: Not reported

LUST:
Facility ID: 0-003930
Lust Number: 0912.01
Leak Priority: GROUNDWATER DEINFED, REMEDIATION PENDING
Notification: 10/02/1989
Date Closed: Not reported

UST:
Facility ID: 0-003930 Tank ID: 1
Owner: PIONEER PAINT & VARNISH COMPANYOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 11/08/89
Date Closed: / /
In Use: False

Facility ID: 0-003930 Tank ID: 2
Owner: PIONEER PAINT & VARNISH COMPANYOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 11/08/89
Date Closed: / /
In Use: False

Facility ID: 0-003930 Tank ID: 3

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

PIONEER PAINT & VARNISH COMPANY (Continued) **U001626713**

Owner:	PIONEER PAINT & VARNISH COMPANY	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	11/08/89		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-003930	Tank ID:	4
Owner:	PIONEER PAINT & VARNISH COMPANY	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	11/08/89		
Date Closed:	/ /		
In Use:	False		

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2 **CIRCLE K # 8838** — **LUST** **U003049855**
2 N FREEWAY — **UST** **N/A**
TUCSON, AZ 85705

LUST:

Facility ID:	0-003213
Lust Number:	0175.01
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	05/07/1986
Date Closed:	01/21/1988

UST:

Facility ID:	0-003213	Tank ID:	1
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-003213	Tank ID:	2
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-003213	Tank ID:	3
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-003213	Tank ID:	4
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	07/07/86		
Date Closed:	/ /		
In Use:	False		

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site		Database(s)	EDR ID Number EPA ID Number
2	**TEXACO SERVICE** **480 W CONGRESS** **TUCSON, AZ 85705**	**LUST** **UST**	**U001627254** **N/A**

LUST:

Facility ID:	0-004955
Lust Number:	4593.01
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	11/05/1996
Date Closed:	07/11/1997

Facility ID:	0-004955
Lust Number:	4593.02
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	11/05/1996
Date Closed:	07/11/1997

Facility ID:	0-004955
Lust Number:	4593.03
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	11/05/1996
Date Closed:	07/11/1997

Facility ID:	0-004955
Lust Number:	4593.04
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	11/05/1996
Date Closed:	07/11/1997

UST:

Facility ID:	0-004955	Tank ID:	1
Owner:	AZ DEPT OF TRANSPORTATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	09/23/96		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-004955	Tank ID:	2
Owner:	AZ DEPT OF TRANSPORTATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	09/23/96		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-004955	Tank ID:	3
Owner:	AZ DEPT OF TRANSPORTATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	09/23/96		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-004955	Tank ID:	4
Owner:	AZ DEPT OF TRANSPORTATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	09/23/96		
Date Closed:	/ /		

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number
	TEXACO SERVICE (Continued)		**U001627254**

In Use: False

3	**RIO NUEVO PROJECT** **700 CONGRESS ST.** **TUCSON, AZ 85714**	**SHWS**	**1000725235** **N/A**

SHWS:
EPA ID: AZD983467986
Program: PA/SI
Facility Id: 1067
Site Code: Not reported
Discovery Date: Not reported
Source: Not reported
Operable Unit: 0
QWARF Area: Not reported
Lat/Long: Not reported
Lat/Long Method: 99
Comments: Not reported

4	**292 SOUTH FREEWAY** **292 SOUTH FREEWAY** **TUCSON, AZ**	**ERNS**	**91207297** **N/A**

5	**CIRCLE K # 171** **1002 W CONGRESS** **TUCSON, AZ 85705**	**LUST** **UST**	**U003153587** **N/A**

LUST:
Facility ID: 0-001188
Lust Number: 1656.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 02/06/1991
Date Closed: 12/29/1995

UST:

Facility ID:	0-001188	Tank ID:	1
Owner:	CIRCLE K CORPORATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/98		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-001188	Tank ID:	2
Owner:	CIRCLE K CORPORATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/98		
Date Closed:	/ /		
In Use:	False		

6	**BOATNER'S STATION/E-Z #060179** **292 S FREEWAY** **TUCSON, AZ 85745**	**LUST** **UST**	**U003049731** **N/A**

LUST:
Facility ID: 0-002071

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number
EPA ID Number

BOATNER'S STATION/E-Z #060179 (Continued) U003049731

Lust Number: 0924.01
Leak Priority: KNOWN OR PROBABLE AFFECT ON GW
Notification: 10/03/1989
Date Closed: Not reported

Facility ID: 0-002071
Lust Number: 0924.02
Leak Priority: UNDEFINED OR UNKNOWN SOIL CONTAMINATION
Notification: 04/07/1999
Date Closed: Not reported

Facility ID: 0-002071
Lust Number: 0924.03
Leak Priority: UNDEFINED OR UNKNOWN SOIL CONTAMINATION
Notification: 04/07/1999
Date Closed: Not reported

UST:
Facility ID: 0-002071 Tank ID: 1
Owner: RESTRUCTURE PETROLEUM MARKETIOOwner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-002071 Tank ID: 2
Owner: RESTRUCTURE PETROLEUM MARKETIOOwner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

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7 **ARIZONA DEPT OF TRANSP** FINDS 1004438251
611 W MESA AZ0001895069
TUCSON, AZ 85701

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Enforcement Docket System (DOCKET)

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8 **FLINT OIL CO INC** UST U003049746
500 W SIMPSON N/A
TUCSON, AZ 85701

UST:
Facility ID: 0-002157 Tank ID: 1
Owner: FLINT OIL CO INC Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 08/04/99
Date Closed: / /
In Use: False

Facility ID: 0-002157 Tank ID: 2
Owner: FLINT OIL CO INC Owner ID: Not reported
Owner Contact: Not reported
In Use: False

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

FLINT OIL CO INC (Continued) **U003049746**

Date Removed: 08/04/99
Date Closed: / /
In Use: False

Facility ID: 0-002157 Tank ID: 3
Owner: FLINT OIL CO INC Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 08/04/99
Date Closed: / /
In Use: False

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9 **CITIZEN AUTO STAGE CO** **LUST** **U003049637**
351 S BRICKYARD LN **UST** **N/A**
TUCSON, AZ 85745

LUST:
Facility ID: 0-001538
Lust Number: 4985.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 12/01/1998
Date Closed: 07/26/2000

UST:
Facility ID: 0-001538 Tank ID: 1
Owner: CITIZEN AUTO STAGE COMPANY Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/22/93
Date Closed: / /
In Use: False

Facility ID: 0-001538 Tank ID: 2
Owner: CITIZEN AUTO STAGE COMPANY Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/22/93
Date Closed: / /
In Use: False

Facility ID: 0-001538 Tank ID: 3
Owner: CITIZEN AUTO STAGE COMPANY Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 11/03/98
Date Closed: / /
In Use: False

Facility ID: 0-001538 Tank ID: 4
Owner: CITIZEN AUTO STAGE COMPANY Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/22/93
Date Closed: / /
In Use: False

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

10 **CHEVRON U S A INC TUCSON ASPHALT PLT**
601 W SIMPSON ST
TUCSON, AZ 85701
RCRIS-SQG, FINDS — **1000434308** — **AZT000615302**

RCRIS:
Owner: CHEVRON USA INC / SOUTHERN PACIFIC CO
(415) 555-1212

Contact: CHUCK CULP
(520) 623-0511

Record Date: 01/01/1996
Classification: Small Quantity Generator
Used Oil Recyc: No

Violation Status: No violations found

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

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10 **CHEVRON**
600 W SIMPSON ST
TUCSON, AZ 85701
TSCA — **1000994950** — **N/A**

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11 **RALPH'S TRANSFER INC**
747 S FREEWAY
TUCSON, AZ 85745
LUST, UST — **U001626765** — **N/A**

LUST:
Facility ID: 0-004036
Lust Number: 3145.01
Leak Priority: CLOSED SUSPECTED RELEASE CASE (FALSE ALARM)
Notification: 05/27/1993
Date Closed: 08/02/1994

Facility ID: 0-004036
Lust Number: 3145.02
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 12/19/1996
Date Closed: 02/14/2000

UST:

Facility ID:	0-004036	Tank ID:	1
Owner:	RALPH'S TRANSFER INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	11/21/96		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-004036	Tank ID:	2
Owner:	RALPH'S TRANSFER INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	11/21/96		
Date Closed:	/ /		
In Use:	False		

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number
11	**RALPHS TRANSFER INC** **747 S FWY** **TUCSON, AZ 85705**	**RCRIS-SQG** **FINDS**	**1000347371** **AZD068396654**

RCRIS:

Owner: FRED STANG PRESIDENT 602 6226461
(415) 555-1212

Contact: SANDRA SODAWASSER
(520) 622-6461

Record Date: 12/01/1980
Classification: Hazardous Waste Transporter
Used Oil Recyc: No

Violation Status: No violations found

FINDS:

Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

12	**501 W 18TH STREET** **501 W 18TH STREET** **TUCSON, AZ 85701**	**ERNS**	**2000660989** **N/A**

12	**WATER DEPARTMENT** **501 W 18TH ST BLDG 1** **TUCSON, AZ 85701**	**RCRIS-SQG**	**1000904676** **AZ0000297150**

RCRIS:

Owner: CITY OF TUCSON
(602) 791-4728

Contact: RICHARD BAEZA
(602) 791-4112

Record Date: 09/17/1997
Classification: Conditionally Exempt Small Quantity Generator, Hazardous Waste Transporter
Used Oil Recyc: No

Violation Status: No violations found

12	**TUCSON WATER CITY OF TUCSON** **510 W 18TH ST BLDG 10** **TUCSON, AZ 85701**	**RCRIS-SQG**	**1001231210** **AZR000031021**

RCRIS:

Owner: TRI CLOVER INC
(602) 555-1212

Contact: MIKE JONES
(520) 791-4014

Record Date: 12/09/1997
Classification: Not reported

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number
	TUCSON WATER CITY OF TUCSON (Continued)		**1001231210**

Used Oil Recyc: No

Violation Status: No violations found

12	**WEST 18TH ST FUEL ISLAND** **510 W 18TH ST** **TUCSON, AZ 85701**	**LUST** **UST**	**U001626521** **N/A**

LUST:

Facility ID:	0-003544
Lust Number:	0370.01
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	05/03/1987
Date Closed:	11/30/1990

Facility ID:	0-003544
Lust Number:	0370.02
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	01/06/1999
Date Closed:	04/30/1999

UST:

Facility ID:	0-003544	Tank ID:	1
Owner:	CITY OF TUCSON FLEET SERVICES	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	10/15/98		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-003544	Tank ID:	2
Owner:	CITY OF TUCSON FLEET SERVICES	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/01/87		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-003544	Tank ID:	3
Owner:	CITY OF TUCSON FLEET SERVICES	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/01/87		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-003544	Tank ID:	4
Owner:	CITY OF TUCSON FLEET SERVICES	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/01/87		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-003544	Tank ID:	5
Owner:	CITY OF TUCSON FLEET SERVICES	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/01/87		

WEST 18TH ST FUEL ISLAND (Continued) **U001626521**

Date Closed: / /
In Use: False

Facility ID: 0-003544 Tank ID: 6
Owner: CITY OF TUCSON FLEET SERVICES Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/01/87
Date Closed: / /
In Use: False

---

12 **TUCSON CITY OF WATER DEPARTMENT** **RCRIS-SQG 1000904674**
510 W 18TH ST **FINDS AZ0000297135**
TUCSON, AZ 85701

RCRIS:
Owner: CITY OF TUCSON
(602) 791-4728

Contact: TONY COTA
(602) 791-4113

Record Date: 09/17/1997
Classification: Conditionally Exempt Small Quantity Generator, Hazardous Waste Transporter
Used Oil Recyc: No

Violation Status: No violations found

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Permit Compliance System (PCS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

---

12 **ASPHALT PRODUCTS TRANSPORT CO** **LUST U001624949**
635 W 18TH ST **UST N/A**
TUCSON, AZ 85701

LUST:
Facility ID: 0-000483
Lust Number: 0515.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 08/19/1988
Date Closed: 07/22/1998

UST:
Facility ID: 0-000483 Tank ID: 1
Owner: ASPHALT PRODUCTS TRANSPORT COOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/19/88
Date Closed: / /
In Use: False

Facility ID: 0-000483 Tank ID: 2
Owner: ASPHALT PRODUCTS TRANSPORT COOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 08/11/88
Date Closed: / /

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

ASPHALT PRODUCTS TRANSPORT CO (Continued) **U001624949**

In Use: False

---

13 **GELCO** **UST** **U001627136**
949 S FREEWAY **N/A**
TUCSON, AZ 85745

UST:

Facility ID:	0-004729	Tank ID:	1
Owner:	STAN-AN DEVELOPMENT	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	01/26/89		
Date Closed:	/ /		
In Use:	False		

---

13 **RECYLE AMERICA** **UST** **U003049649**
945 S FREEWAY **N/A**
TUCSON, AZ 85745

UST:

Facility ID:	0-001632	Tank ID:	1
Owner:	WASTE MANAGEMENT & TUCSON INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	08/16/95		
Date Closed:	04/29/96		
In Use:	False		

Facility ID:	0-001632	Tank ID:	2
Owner:	WASTE MANAGEMENT & TUCSON INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	08/16/95		
Date Closed:	/ /		
In Use:	False		

---

14 **UNOCAL # 4897** **LUST** **U001157544**
1210 S FREEWAY **UST** **N/A**
TUCSON, AZ 85713

LUST:

Facility ID:	0-005290
Lust Number:	4657.01
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	02/14/1997
Date Closed:	07/21/1998

Facility ID:	0-005290
Lust Number:	4657.02
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	02/14/1997
Date Closed:	07/21/1998

Facility ID:	0-005290
Lust Number:	4657.03
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	02/14/1997
Date Closed:	07/21/1998

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

UNOCAL # 4897 (Continued) **U001157544**

Facility ID: 0-005290
Lust Number: 4657.04
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 02/14/1997
Date Closed: 07/21/1998

UST:

Facility ID:	0-005290	Tank ID:	1
Owner:	UNOCAL CORPORATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/12/97		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-005290	Tank ID:	2
Owner:	UNOCAL CORPORATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/12/97		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-005290	Tank ID:	3
Owner:	UNOCAL CORPORATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/12/97		
Date Closed:	/ /		
In Use:	False		

---

14 **CIRCLE K # 1838** **LUST** **U001002156**
1145 S FREEWAY **UST** **N/A**
TUCSON, AZ 85745

LUST:

Facility ID: 0-001494
Lust Number: 4695.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/09/1997
Date Closed: 11/22/2000

Facility ID: 0-001494
Lust Number: 4695.02
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/09/1997
Date Closed: 11/22/2000

Facility ID: 0-001494
Lust Number: 4695.03
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/09/1997
Date Closed: 11/22/2000

Facility ID: 0-001494
Lust Number: 4695.04
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/09/1997

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

CIRCLE K # 1838 (Continued) U001002156

Date Closed: 11/22/2000

Facility ID: 0-001494
Lust Number: 4695.05
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/09/1997
Date Closed: 11/22/2000

Facility ID: 0-001494
Lust Number: 4695.06
Leak Priority: KNOWN OR PROBABLE AFFECT ON GW
Notification: 05/21/1997
Date Closed: Not reported

UST:
Facility ID: 0-001494 Tank ID: 1
Owner: TOSCO MARKETING CO Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 05/09/97
Date Closed: / /
In Use: False

Facility ID: 0-001494 Tank ID: 2
Owner: TOSCO MARKETING CO Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 05/09/97
Date Closed: / /
In Use: False

Facility ID: 0-001494 Tank ID: 3
Owner: TOSCO MARKETING CO Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 05/09/97
Date Closed: / /
In Use: False

---

14 **GUADALUPE LESPRON** UST U003050884
1114 S FARMINGTON N/A
TUCSON, AZ 85745

UST:
Facility ID: 0-008266 Tank ID: 1
Owner: GUADALUPE LESPRON Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 06/24/94
Date Closed: / /
In Use: False

---

14 **WESTERN EMULSIONS INC** RCRIS-SQG 1000402904
1015 SOUTH FREEWAY FINDS AZD982045148
TUCSON, AZ 85745

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

WESTERN EMULSIONS INC (Continued) **1000402904**

RCRIS:
Owner: NON NOTIFIER
(415) 555-1212

Contact: Not reported

Record Date: Not reported
Classification: Not reported
Used Oil Recyc: No

Violation Status: Violations exist

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 07/29/1987
Priority of Violation: Low
Schedule Date to Achieve Compliance: 12/29/1987
Actual Date Achieved Compliance: 05/19/1988

Enforcement Action: Written Informal
Enforcement Action Date: 11/17/1987
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

There are 1 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	05/19/1988

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

15 **CRICLE K #5579** **LUST U003153703**
655 W 22ND **UST N/A**
TUCSON, AZ 85713

LUST:
Facility ID: 0-002010
Lust Number: 0416.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 03/09/1988
Date Closed: 02/02/1998

Facility ID: 0-002010
Lust Number: 0416.02
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 06/05/1991
Date Closed: 02/02/1998

UST:
Facility ID: 0-002010 Tank ID: 1
Owner: TOSCO MARKETING CO Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 05/29/91
Date Closed: / /
In Use: False

Facility ID: 0-002010 Tank ID: 2

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

CRICLE K #5579 (Continued) **U003153703**

Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	05/29/91		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-002010	Tank ID:	3
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	05/29/91		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-002010	Tank ID:	4
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	05/29/91		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-002010	Tank ID:	5
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-002010	Tank ID:	6
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-002010	Tank ID:	7
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

15 **EXXON CO USA 73904** **RCRIS-SQG** **1000589390**
655 W 22ND ST AND I 10 **FINDS** **AZD983471020**
TUCSON, AZ 85713

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site		Database(s)	EDR ID Number EPA ID Number

EXXON CO USA 73904 (Continued) **1000589390**

RCRIS:
Contact: ALDA POOL
(713) 656-7709

Record Date: 09/30/1994
Classification: Conditionally Exempt Small Quantity Generator
Used Oil Recyc: No

Violation Status: No violations found

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

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15 **EXPRESS-IT** **LUST** **U003050795**
601 W 22ND ST **UST** **N/A**
TUCSON, AZ 85713

LUST:
Facility ID: 0-007780
Lust Number: 3259.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 12/03/1993
Date Closed: 07/13/1998

Facility ID: 0-007780
Lust Number: 3259.02
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 03/25/1996
Date Closed: 07/13/1998

UST:

Facility ID:	0-007780	Tank ID:	1
Owner:	CARL SANDBERG	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	09/23/93		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-007780	Tank ID:	2
Owner:	CARL SANDBERG	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	09/23/93		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-007780	Tank ID:	3
Owner:	CARL SANDBERG	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/25/94		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-007780	Tank ID:	4
Owner:	CARL SANDBERG	Owner ID:	Not reported

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

EXPRESS-IT (Continued) U003050795

Owner Contact: Not reported
In Use: False
Date Removed: 10/25/78
Date Closed: / /
In Use: False

16 **PIMA COUNTY DEPT OF TRANSPORTATION**
1313 S MISSION RD
TUCSON, AZ 85713

FINDS **1000142124**
LUST **AZD981161334**
RCRIS-LQG
UST

RCRIS:
Owner: PIMA COUNTY GOVERNMENT
(415) 555-1212

Contact: BECKY SAYRE PEARSON
(602) 740-6449

Record Date: 02/17/1995
Classification: Large Quantity Generator
Used Oil Recyc: No

Violation Status: No violations found

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

LUST:
Facility ID: 0-006566
Lust Number: 2065.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 11/13/1991
Date Closed: 02/13/1995

Facility ID: 0-006566
Lust Number: 2065.02 3425.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 03/16/1994
Date Closed: 05/11/1995

UST:
Facility ID: 0-006566 Tank ID: 1
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 10/24/91
Date Closed: / /
In Use: False

Facility ID: 0-006566 Tank ID: 2
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site		Database(s)	EDR ID Number EPA ID Number
16	**PIMA COUNTY AUTOMOTIVE SERVICE** **1301 S MISSION RD** **TUCSON, AZ 85713**	**RCRIS-SQG** **FINDS** **LUST** **UST**	**1000142126** **AZD982006579**

RCRIS:

Owner: PIMA COUNTY
(415) 555-1212

Contact: BECKY SAYRE PEARSON
(602) 740-6410

Record Date: 02/17/1995
Classification: Small Quantity Generator
Used Oil Recyc: No

Violation Status: No violations found

FINDS:

Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

LUST:

Facility ID: 0-006557
Lust Number: 0744.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/25/1989
Date Closed: 08/07/1996

Facility ID: 0-006557
Lust Number: 0744.02
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/25/1989
Date Closed: 08/07/1996

Facility ID: 0-006557
Lust Number: 0744.03 1979.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 09/13/1991
Date Closed: 01/26/1994

Facility ID: 0-006557
Lust Number: 0744.04 2030.01
Leak Priority: CLOSED SOIL LVL MEETS TIER3
Notification: 10/31/1991
Date Closed: 05/07/1998

Facility ID: 0-006557
Lust Number: 0744.05 2030.01
Leak Priority: CLOSED SOIL LVL MEETS TIER3
Notification: 10/31/1991
Date Closed: 05/07/1998

Facility ID: 0-006557
Lust Number: 0744.06
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 06/17/1999
Date Closed: 12/15/1999

Facility ID: 0-006557

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

PIMA COUNTY AUTOMOTIVE SERVICE (Continued) **1000142126**

Lust Number: 0744.07
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 06/17/1999
Date Closed: 12/15/1999

Facility ID: 0-006557
Lust Number: 1979.01 0744.03
Leak Priority: LUST CASE COMBINED - CLOSED OUT
Notification: 09/13/1991
Date Closed: 03/13/1996

Facility ID: 0-006557
Lust Number: 2030.01 0744.04
Leak Priority: LUST CASE COMBINED - CLOSED OUT
Notification: 10/31/1991
Date Closed: 03/13/1996

Facility ID: 0-006557
Lust Number: 3425.01 2065.02
Leak Priority: LUST CASE COMBINED - CLOSED OUT
Notification: 03/16/1994
Date Closed: 03/13/1996

UST:

Facility ID: 0-006557 Tank ID: 1
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 11/21/91
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 2
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-006557 Tank ID: 3
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 10/30/91
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 4
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 09/11/91
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 5
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported

Map ID Direction Distance Distance (ft.)Site	Database(s)	EDR ID Number EPA ID Number

PIMA COUNTY AUTOMOTIVE SERVICE (Continued) 1000142126

Owner Contact: Not reported
In Use: False
Date Removed: 04/01/89
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 6
Owner: PIMA COUNTY AUTOMOTIVE SERVICES Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 04/01/89
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 7
Owner: PIMA COUNTY AUTOMOTIVE SERVICES Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 04/01/89
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 8
Owner: PIMA COUNTY AUTOMOTIVE SERVICES Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 04/01/89
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 9
Owner: PIMA COUNTY AUTOMOTIVE SERVICES Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 04/01/89
Date Closed: / /
In Use: False

Facility ID: 0-006557 Tank ID: 10
Owner: PIMA COUNTY AUTOMOTIVE SERVICES Owner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-006557 Tank ID: 11
Owner: PIMA COUNTY AUTOMOTIVE SERVICES Owner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-006557 Tank ID: 12
Owner: PIMA COUNTY AUTOMOTIVE SERVICES Owner ID: Not reported
Owner Contact: Not reported

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

PIMA COUNTY AUTOMOTIVE SERVICE (Continued) **1000142126**

In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-006557 Tank ID: 13
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-006557 Tank ID: 14
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-006557 Tank ID: 15
Owner: PIMA COUNTY AUTOMOTIVE SERVICESOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 10/01/91
Date Closed: / /
In Use: False

---

16 **PIMA COUNTY MISSION RD CMPLX** **FINDS** **1004439009**
1301-1313 S. MISSION RD. **AZD983481912**
TUCSON, AZ 85713

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Toxic Chemical Release Inventory System (TRIS)

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16 **PIMA COUNTY MISSION RD COMPLEX** **RCRIS-SQG** **1000818046**
1301-1313 S MISSION RD **FINDS** **AZD983481656**
TUCSON, AZ 85713

RCRIS:
Owner: PIMA COUNTY A BODY POLITIC
(520) 740-8661

Contact: Not reported

Record Date: 04/07/2000
Classification: Conditionally Exempt Small Quantity Generator

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

PIMA COUNTY MISSION RD COMPLEX (Continued) **1000818046**

Used Oil Recyc: No

Violation Status: Violations exist

Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	10/03/1996
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	01/03/1997
Actual Date Achieved Compliance:	12/06/1996

There are 1 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	12/06/1996

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Biennial Reporting System (BRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

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16 **PIMA COUNTY HEALTH** — **AZ Spills** — **S104560906** / **N/A**
1301 SO. MISSION
TUCSON, AZ

Az Spills:

Facility ID:	87-196	Incident Date:	09/03/87
Response Date:	Not reported	Report / Assist:	Not reported
Type:	Release	No of Samples:	Dr
Referred to:	Not reported		
Chemicals:	Malathion		
Property Mngmt:	County		
Fund Amount:	Co/Unk		
Quantity:	Not reported		

---

17 **ATKO BUILDING MATERIALS INC** — **LUST** / **UST** — **U001627809** / **N/A**
600 W 25TH ST
TUCSON, AZ 85713

LUST:

Facility ID:	0-006056
Lust Number:	0420.01
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	03/22/1988
Date Closed:	12/22/1992

UST:

Facility ID:	0-006056	Tank ID:	1
Owner:	ATKO BUILDING MATERIALS INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	03/22/88		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-006056	Tank ID:	2
Owner:	ATKO BUILDING MATERIALS INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

ATKO BUILDING MATERIALS INC (Continued) **U001627809**

Date Removed: 03/22/88
Date Closed: / /
In Use: False

Facility ID: 0-006056 Tank ID: 3
Owner: ATKO BUILDING MATERIALS INC Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 03/22/88
Date Closed: / /
In Use: False

Facility ID: 0-006056 Tank ID: 4
Owner: ATKO BUILDING MATERIALS INC Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 03/22/88
Date Closed: / /
In Use: False

---

18 **KUSHMAUL MACHINE & ENGINEERING** **LUST U001626196**
2210 S FREEWAY **UST N/A**
TUCSON, AZ 85713

LUST:
Facility ID: 0-002903
Lust Number: 0773.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 06/15/1989
Date Closed: 03/15/1991

UST:
Facility ID: 0-002903 Tank ID: 1
Owner: KUSHMAUL MACHINE & ENGINEERINGOwner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-002903 Tank ID: 2
Owner: KUSHMAUL MACHINE & ENGINEERINGOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 06/01/89
Date Closed: / /
In Use: False

Facility ID: 0-002903 Tank ID: 3
Owner: KUSHMAUL MACHINE & ENGINEERINGOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: / /
Date Closed: / /
In Use: False

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number
19	**PIMA COUNTY PARKS & REC - GILBERT RAY** **1204 W. SILVERLAKE RD.** **TUCSON, AZ 85713**	**WWFAC**	**S104826932** **N/A**

AZ WWFAC:
Owner Address: 1204 W. Silverlake Rd.
Tucson, A Z8571

19	**1204 W SILVERLAKE RD** **1204 W SILVERLAKE RD** **TUCSON, AZ 85713**	**ERNS**	**99617233** **N/A**

19	**TUCSON ELECTRIC POWER CO.** **1177 W SILVERLAKE** **TUCSON, AZ**	**AZ Spills**	**S100888112** **N/A**

Az Spills:

Facility ID:	87-265	Incident Date:	12/29/87
Response Date:	Not reported	Report / Assist:	Not reported
Type:	Release	No of Samples:	Tr
Referred to:	Not reported		
Chemicals:	PCB		
Property Mngmt:	Private		
Fund Amount:	Pvt/Unk		
Quantity:	Not reported		

19	**1177 W. SILVERLAKE** **1177 W. SILVERLAKE** **TUCSON, AZ**	**ERNS**	**8719558** **N/A**

20	**PIMA COUNTY CORRECTIONAL FAC** **1270 W SILVERLAKE** **TUCSON, AZ 85713**	**UST**	**U001157523** **N/A**

UST:

Facility ID:	0-006559	Tank ID:	1
Owner:	PIMA COUNTY FACILITIES MANAGEME	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	05/04/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-006559	Tank ID:	2
Owner:	PIMA COUNTY FACILITIES MANAGEME	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	04/19/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-006559	Tank ID:	3
Owner:	PIMA COUNTY FACILITIES MANAGEME	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

PIMA COUNTY CORRECTIONAL FAC (Continued) U001157523

Facility ID:	0-006559	Tank ID:	4
Owner:	PIMA COUNTY FACILITIES MANAGEME	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

21 **CARL GREMMLER** UST U003051995
527 W 29TH ST N/A
SOUTH TUCSON, AZ 85713

UST:

Facility ID:	0-006277	Tank ID:	1
Owner:	CARL GREMMLER	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/23/90		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-006277	Tank ID:	2
Owner:	CARL GREMMLER	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/23/90		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-006277	Tank ID:	3
Owner:	CARL GREMMLER	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/23/90		
Date Closed:	/ /		
In Use:	False		

22 **BARNETT & DEZOL CONT INC** UST U001625030
701 W SILVER LAKE RD N/A
TUCSON, AZ 85713

UST:

Facility ID:	0-000639	Tank ID:	1
Owner:	BARNETT & DEYOE	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/14/89		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-000639	Tank ID:	2
Owner:	BARNETT & DEYOE	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	12/14/89		
Date Closed:	/ /		
In Use:	False		

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number
	BARNETT & DEZOL CONT INC (Continued)		**U001625030**

Facility ID: 0-000639 Tank ID: 3
Owner: BARNETT & DEYOE Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/14/89
Date Closed: / /
In Use: False

22	**BARNETT ABD DEYOE CONTRACTORS** **701 W SILVERLAKE RD** **TUCSON, AZ 85713**	**PADS** **RCRIS-SQG** **FINDS** **WWFAC**	**1000455279** **AZD982428542**

RCRIS:
Owner: BARNETT & DEVOE CONT
(415) 555-1212
Contact: MAX E BARNETT II
(520) 733-1740
Record Date: 08/01/1990
Classification: Hazardous Waste Transporter
Used Oil Recyc: No
Violation Status: No violations found

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
PCB Handler Activity Data System (PADS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

AZ WWFAC:
Owner Address: 701 W. Silverlake Road
Tucson, A Z8571

23	**E-Z SERVE/QUIK MART #100909** **1890 S MISSION RD** **TUCSON, AZ 85713**	**LUST** **UST**	**U003153708** **N/A**

LUST:
Facility ID: 0-002044
Lust Number: 2522.01
Leak Priority: KNOWN OR PROBABLE AFFECT ON GW
Notification: 10/19/1992
Date Closed: Not reported

UST:
Facility ID: 0-002044 Tank ID: 1
Owner: RESTRUCTURE PETROLEUM MARKETIOGner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 09/15/92
Date Closed: / /
In Use: False

Facility ID: 0-002044 Tank ID: 2
Owner: RESTRUCTURE PETROLEUM MARKETIOGner ID: Not reported
Owner Contact: Not reported

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

E-Z SERVE/QUIK MART #100909 (Continued) **U003153708**

In Use: False
Date Removed: 09/15/92
Date Closed: / /
In Use: False

Facility ID: 0-002044 Tank ID: 3
Owner: RESTRUCTURE PETROLEUM MARKETINGOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 09/15/92
Date Closed: / /
In Use: False

---

24 **AMERICAN SCRAP METAL RECYCLING** **SHWS** **1000486427**
2140 S. FREEWAY **N/A**
TUCSON, AZ 85713

SHWS:
EPA ID: AZD983474784
Program: PA/SI
Facility Id: 960
Site Code: Not reported
Discovery Date: Not reported
Source: Not reported
Operable Unit: 0
QWARF Area: Not reported
Lat/Long: Not reported
Lat/Long Method: 99
Comments: Not reported

---

25 **H AND K BARRELS** **RCRIS-SQG** **1000121177**
2122 S 12TH AVE **FINDS** **AZD982045130**
TUCSON, AZ 85713

RCRIS:
Owner: NON NOTIFIER
(415) 555-1212

Contact: Not reported

Record Date: Not reported
Classification: Not reported
Used Oil Recyc: No

Violation Status: Violations exist

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 08/29/1987
Priority of Violation: Low
Schedule Date to Achieve Compliance: 11/09/1987
Actual Date Achieved Compliance: 03/25/1988

Enforcement Action: Written Informal
Enforcement Action Date: 09/30/1987
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

H AND K BARRELS (Continued) **1000121177**

There are 1 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	03/25/1988

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

---

26 **MISSION VERDE APT** FINDS **1004437970**
1702 W 36TH ST APT 1174 FTTS **AZ0000226936**
TUCSON, AZ 85713

FTTS Insp:

Region:	09
Inspected Date:	06/23/92
Insp Number:	06/23/92
Violation occurred:	No
Inspector:	TDELAMORE
Investigation Type:	Use General Non-Agriculture
Facility Function:	Other Parties
Investig Reason:	For Cause, Private Citizen/Press Complaint
Legislation Code:	FIFRA

FINDS:
Other Pertinent Environmental Activity Identified at Site:
National Compliance Database (NCDB)

---

26 **ROSELLA ROBERTS MISSION VERDE APTS** FTTS **1004645753**
1702 W 36TH ST APT 1174 **N/A**
TUCSON, AZ 85713

FTTS Insp:

Region:	09
Inspected Date:	06/23/92
Insp Number:	06/23/92
Violation occurred:	No
Inspector:	T. DELAMOR
Investigation Type:	Use General Non-Agriculture
Facility Function:	Other Parties
Investig Reason:	For Cause, Private Citizen/Press Complaint
Legislation Code:	FIFRA

---

27 **CIRCLE K # 678** LUST **U003091199**
1777 W 36TH ST UST **N/A**
TUCSON, AZ 85713

LUST:

Facility ID:	0-001285
Lust Number:	0390.01
Leak Priority:	CLOSED SOIL LVL MEETS TIER1
Notification:	01/20/1988
Date Closed:	02/15/1995

UST:
Facility ID: 0-001285 Tank ID: 1

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

CIRCLE K # 678 (Continued) U003091199

Owner:	CIRCLE K [REJECTED LEASE SITE]	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	11/23/87		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-001285	Tank ID:	2
Owner:	CIRCLE K [REJECTED LEASE SITE]	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	11/23/87		
Date Closed:	/ /		
In Use:	False		
Facility ID:	0-001285	Tank ID:	3
Owner:	CIRCLE K [REJECTED LEASE SITE]	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	11/23/87		
Date Closed:	/ /		
In Use:	False		

---

28 **DIAMOND SHAMROCK # 1623** UST U003153965
2616 S MISSION RD N/A
TUCSON, AZ 85713

UST:

Facility ID:	0-008998	Tank ID:	1
Owner:	DIAMOND SHAMROCK ARIZONA, INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-008998	Tank ID:	2
Owner:	DIAMOND SHAMROCK ARIZONA, INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

---

28 **CIRCLE K # 1931** UST U001625475
2590 S MISSION RD N/A
TUCSON, AZ 85713

UST:

Facility ID:	0-001507	Tank ID:	1
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-001507	Tank ID:	2

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site		Database(s)	EDR ID Number EPA ID Number
	CIRCLE K # 1931 (Continued)		**U001625475**

Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

Facility ID:	0-001507	Tank ID:	3
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

29	**COTTONWOOD** **3000 S. COTTONWOOD LN.** **COTTONWOOD, AZ**	**SWF/LF** **WWFAC**	**S103277471** **N/A**

AZ WWFAC:

Owner Address: P.O. Box 57
Cottonwood, A Z8632

30	**1775 WEST CALLE ACATULCO** **1775 WEST CALLE ACATULCO** **TUSCON, AZ**	**ERNS**	**8861235** **N/A**

31	**VAN'S EXXON** **3761 S MISSION RD** **TUCSON, AZ 85713**	**LUST** **UST**	**U003051496** **N/A**

LUST:

Facility ID:	0-000109
Lust Number:	0979.01
Leak Priority:	KNOWN OR PROBABLE AFFECT ON GW
Notification:	11/17/1989
Date Closed:	Not reported

UST:

Facility ID:	0-000109	Tank ID:	1
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-000109	Tank ID:	2
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-000109	Tank ID:	3
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

VAN'S EXXON (Continued) **U003051496**

In Use: False
Date Removed: 02/26/90
Date Closed: / /
In Use: False

Facility ID:	0-000109	Tank ID:	4
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-000109	Tank ID:	5
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-000109	Tank ID:	6
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-000109	Tank ID:	7
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/90		
Date Closed:	/ /		
In Use:	False		

Facility ID:	0-000109	Tank ID:	8
Owner:	AJO MISSION SERVICE STATION	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	02/26/90		
Date Closed:	/ /		
In Use:	False		

---

32 **BORDER PATROL HEADQUARTERS** **LUST U003049755**
1970 W AJO WAY **UST N/A**
TUCSON, AZ 85713

LUST:

Facility ID: 0-002243
Lust Number: 2717.01 2717.03
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 03/12/1993
Date Closed: 12/14/1994

Facility ID: 0-002243
Lust Number: 2717.02
Leak Priority: CLOSED SOIL LVL MEETS TIER1

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

BORDER PATROL HEADQUARTERS (Continued) U003049755

Notification: 05/02/1995
Date Closed: 07/17/1998

Facility ID: 0-002243
Lust Number: 2717.03 2717.01
Leak Priority: LUST CASE COMBINED - CLOSED OUT
Notification: 05/02/1995
Date Closed: 07/16/1998

UST:

Facility ID: 0-002243 Tank ID: 1
Owner: GENERAL SERVICES ADMINISTRATIONOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/09/94
Date Closed: / /
In Use: False

Facility ID: 0-002243 Tank ID: 2
Owner: GENERAL SERVICES ADMINISTRATIONOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/09/94
Date Closed: / /
In Use: False

Facility ID: 0-002243 Tank ID: 3
Owner: GENERAL SERVICES ADMINISTRATIONOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 12/09/94
Date Closed: / /
In Use: False

---

32 **US BORDER PATROL TUCSON** **LUST** **U001624812**
2010 W AJO WAY/1970 W AJO WAY **UST** **N/A**
TUCSON, AZ 85713

LUST:

Facility ID: 0-000214
Lust Number: 4085.01
Leak Priority: CLOSED SOIL LVL MEETS TIER1
Notification: 05/10/1995
Date Closed: 01/19/2000

UST:

Facility ID: 0-000214 Tank ID: 1
Owner: ADOA/AZ DEPT OF PUBLIC SAFETY Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 03/08/95
Date Closed: / /
In Use: False

---

33 **MESA RIDGE-A MANUFACTURED HOME COMMUNITY** **Dry Wells** **S103895241**
1402 W. AJO WAY **N/A**
TUCSON, AZ 85713

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number
	MESA RIDGE-A MANUFACTURED HOME COMMUNITY (Continued)		**S103895241**

DRY WELLS:
Number of Wells: 1
Beginning Registration Number: 17905

34	**GIANT #925** **1202 W AJO** **TUCSON, AZ 85713**	**UST**	**U001002549** **N/A**

UST:

Facility ID:	0-002783	Tank ID:	1
Owner:	GIANT INDUSTRIES ARIZONA/ZEIGLER	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

Facility ID:	0-002783	Tank ID:	2
Owner:	GIANT INDUSTRIES ARIZONA/ZEIGLER	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

Facility ID:	0-002783	Tank ID:	3
Owner:	GIANT INDUSTRIES ARIZONA/ZEIGLER	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

Facility ID:	0-002783	Tank ID:	4
Owner:	GIANT INDUSTRIES ARIZONA/ZEIGLER	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

35	**CIRCLE K # 998** **4820 S MISSION RD** **TUCSON, AZ 85746**	**LUST** **UST**	**U003153670** **N/A**

LUST:

Facility ID:	0-001350
Lust Number:	2476.01
Leak Priority:	CLOSED SOIL LVL MEETS TIER3
Notification:	09/17/1992
Date Closed:	08/27/1996

UST:

Facility ID:	0-001350	Tank ID:	1
Owner:	RICHARD CLARKE	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	09/15/92		

CIRCLE K # 998 (Continued) **U003153670**

Date Closed: / /
In Use: False

Facility ID: 0-001350 Tank ID: 2
Owner: RICHARD CLARKE Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 09/15/92
Date Closed: / /
In Use: False

Facility ID: 0-001350 Tank ID: 3
Owner: RICHARD CLARKE Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 09/15/92
Date Closed: / /
In Use: False

---

36 **TARP TUCSON AIRPORT REMED PROJ** **FINDS 1000984788**
1100 W IRVINGTON RD **RCRIS-LQG AZR000000349**
TUCSON, AZ 85714

RCRIS:
Owner: TUCSON CITY OF WATER DEPT
(520) 791-2666

Contact: MICHAEL RING
(520) 791-5256

Record Date: 03/20/1995
Classification: Large Quantity Generator
BIENNIAL REPORTS:
Last Biennial Reporting Year: 1999

Waste	Quantity (Lbs)	Waste	Quantity (Lbs)
D002	25.00	F001	8352.00

Used Oil Recyc: No

Violation Status: Violations exist

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 11/18/1999
Priority of Violation: Low
Schedule Date to Achieve Compliance: 06/24/2000
Actual Date Achieved Compliance: Not reported

Enforcement Action: Written Informal
Enforcement Action Date: 02/23/2000
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 11/18/1999
Priority of Violation: Low
Schedule Date to Achieve Compliance: 06/24/2000
Actual Date Achieved Compliance: Not reported

Enforcement Action: Written Informal
Enforcement Action Date: 02/23/2000

Map ID Direction Distance Distance (ft.)Site	Database(s)	EDR ID Number EPA ID Number

TARP TUCSON AIRPORT REMED PROJ (Continued) **1000984788**

Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 11/18/1999
Priority of Violation: Low
Schedule Date to Achieve Compliance: 06/24/2000
Actual Date Achieved Compliance: Not reported

Enforcement Action: Written Informal
Enforcement Action Date: 02/23/2000
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 11/18/1999
Priority of Violation: Low
Schedule Date to Achieve Compliance: 06/24/2000
Actual Date Achieved Compliance: Not reported

Enforcement Action: Written Informal
Enforcement Action Date: 02/23/2000
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 11/18/1999
Priority of Violation: Low
Schedule Date to Achieve Compliance: 06/24/2000
Actual Date Achieved Compliance: Not reported

Enforcement Action: Written Informal
Enforcement Action Date: 02/23/2000
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 11/18/1999
Priority of Violation: Low
Schedule Date to Achieve Compliance: 06/24/2000
Actual Date Achieved Compliance: Not reported

Enforcement Action: Written Informal
Enforcement Action Date: 02/23/2000
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

There are 6 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Other Evaluation	Generator-All Requirements	
	Generator-All Requirements	
	Generator-All Requirements	
	Generator-All Requirements	
	Generator-All Requirements	
	Generator-All Requirements	

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

TARP TUCSON AIRPORT REMED PROJ (Continued) 1000984788

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Biennial Reporting System (BRS)
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

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37 **FRYS FOOD STORES 119** **FINDS** **1004176029**
902 W IRVINGTON RD **000009004680**
TUCSON, AZ 85714

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

---

38 **HOME DEPOT THE 0467** **FINDS** **1004181161**
1155 W IRVINGTON RD **000009072410**
TUCSON, AZ 85746

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

---

39 **CIRCLE K # 1606** **UST** **U001625445**
5680 S MISSION RD **N/A**
TUCSON, AZ 85746

UST:

Facility ID:	0-001447	Tank ID:	1
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

Facility ID:	0-001447	Tank ID:	2
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

Facility ID:	0-001447	Tank ID:	3
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number
40	**PCC-DESERT VISTA CAMPUS EXPANSION 5901 SOUTH CALLE SANTA CRUZ TUCSON, AZ 85709**	**Dry Wells**	**S104531030 N/A**

DRY WELLS:
Number of Wells: 2
Beginning Registration Number: 19231

40	**NATIONAL SEMICONDUCTOR CORP. 5901 S. CALLE SANTA CRUZ TUCSON, AZ 85706**	**SHWS**	**S101570986 N/A**

SHWS:
EPA ID: AZD098044795
Program: PA/SI
Facility Id: 1040
Site Code: Not reported
Discovery Date: Not reported
Source: Not reported
Operable Unit: 0
QWARF Area: Not reported
Lat/Long: Not reported
Lat/Long Method: 20
Comments: Not reported

40	**PIMA COMMUNITY COLLEGE D V 5901 S CALLE SANTA CRUZ TUCSON, AZ 85709**	**RCRIS-SQG FINDS CERC-NFRAP**	**1000260449 AZD098044795**

CERCLIS-NFRAP Classification Data:
Site Incident Category: Not reported
Non NPL Code: NFRAP
Ownership Status: Private
Federal Facility: Not a Federal Facility
NPL Status: Not on the NPL

CERCLIS-NFRAP Assessment History:
Assessment: DISCOVERY — Completed: 02/11/1992
Assessment: PRELIMINARY ASSESSMENT — Completed: 06/29/1992

RCRIS:
Owner: PIMA COMMUNITY COLLEGE D V
(520) 206-2765

Contact: ERIK GILBERT
(520) 206-2765

Record Date: 08/07/1992
Classification: Conditionally Exempt Small Quantity Generator
Used Oil Recyc: No

Violation Status: Violations exist

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 08/29/1990
Priority of Violation: Low
Schedule Date to Achieve Compliance: 07/03/1991
Actual Date Achieved Compliance: 06/14/1991

Enforcement Action: Written Informal
Enforcement Action Date: 04/08/1991
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

PIMA COMMUNITY COLLEGE D V (Continued) **1000260449**

There are 1 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	06/14/1991

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)
Toxic Chemical Release Inventory System (TRIS)

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40 **E F T C SOUTHWEST OPERATIONS** **FINDS** **1000162107**
1150 W DREXEL RD NE CORNER BLD **RCRIS-LQG** **AZD097113856**
TUCSON, AZ 85706 **CERC-NFRAP**

CERCLIS-NFRAP Classification Data:
Site Incident Category: Not reported — Federal Facility: Not a Federal Facility
Non NPL Code: NFRAP
Ownership Status: Unknown — NPL Status: Not on the NPL
CERCLIS-NFRAP Assessment History:

Assessment:	DISCOVERY	Completed:	08/01/1980
Assessment:	PRELIMINARY ASSESSMENT	Completed:	12/01/1982
Assessment:	SITE INSPECTION	Completed:	12/01/1982

RCRIS:
Owner: LAMBDA ELECTRONICS INC
(516) 694-4200

Contact: KATHRYN BROWN
(520) 806-7021

Record Date: 04/23/1998
Classification: Large Quantity Generator
BIENNIAL REPORTS:
Last Biennial Reporting Year: 1999

Waste	Quantity (Lbs)	Waste	Quantity (Lbs)
D001	4898.00	D002	39.00
D007	862.00	D008	862.00
D035	4204.00	F005	4204.00

Used Oil Recyc: Yes

Violation Status: Violations exist

Regulation Violated: Not reported
Area of Violation: Generator-Land Ban Requirements
Date Violation Determined: 10/28/1993
Priority of Violation: Low
Schedule Date to Achieve Compliance: Not reported
Actual Date Achieved Compliance: 02/11/1994

Enforcement Action: Written Informal
Enforcement Action Date: 12/16/1993
Proposed Monetary Penalty: Not reported
Final Monetary Penalty: Not reported

Regulation Violated: Not reported
Area of Violation: Generator-All Requirements
Date Violation Determined: 10/28/1993
Priority of Violation: Low
Schedule Date to Achieve Compliance: Not reported

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

E F T C SOUTHWEST OPERATIONS (Continued) **1000162107**

Actual Date Achieved Compliance:	02/11/1994
Enforcement Action:	Written Informal
Enforcement Action Date:	12/16/1993
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported
Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	10/28/1993
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	Not reported
Actual Date Achieved Compliance:	12/15/1993
Enforcement Action:	Written Informal
Enforcement Action Date:	12/16/1993
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported
Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	12/01/1993
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	03/01/1994
Actual Date Achieved Compliance:	04/26/1994
Enforcement Action:	Written Informal
Enforcement Action Date:	03/14/1994
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported
Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	04/11/1986
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	07/10/1986
Actual Date Achieved Compliance:	09/04/1986
Enforcement Action:	Written Informal
Enforcement Action Date:	06/03/1986
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported
Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	04/11/1986
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	07/10/1986
Actual Date Achieved Compliance:	09/04/1986
Enforcement Action:	Written Informal
Enforcement Action Date:	06/03/1986
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

E F T C SOUTHWEST OPERATIONS (Continued) **1000162107**

There are 6 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	04/26/1994
Compliance Evaluation Inspection (CEI)	Generator-Land Ban Requirements	02/11/1994
	Generator-All Requirements	02/11/1994
	Generator-All Requirements	12/15/1993
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	09/04/1986
	Generator-All Requirements	09/04/1986

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)
Toxic Chemical Release Inventory System (TRIS)

---

40 **LAMBDA ELECTRONICS POWER SPLY** **AZ Spills** **S104561195**
1150 W. DREXEL RD. **N/A**
TUCSON, AZ

Az Spills:

Facility ID:	86-153	Incident Date:	10/08/86
Response Date:	Not reported	Report / Assist:	Not reported
Type:	Release	No of Samples:	Dr
Referred to:	Not reported		
Chemicals:	Sulfuric Acid (10%)		
Property Mngmt:	Private		
Fund Amount:	Pvt/Unk		
Quantity:	Not reported		

---

40 **LAMBDA ELECT. DIV VEECO INST CORP** **SHWS** **1001200821**
1150 W DREXEL RD **N/A**
TUCSON, AZ 85706

SHWS:

EPA ID:	AZD097113856
Program:	PA/SI
Facility Id:	182
Site Code:	Not reported
Discovery Date:	Not reported
Source:	Not reported
Operable Unit:	0
QWARF Area:	Not reported
Lat/Long:	Not reported
Lat/Long Method:	20
Comments:	Not reported

---

41 **DIAMOND SHAMROCK # 1613** **UST** **U003154001**
2160 W DREXEL RD **N/A**
TUCSON, AZ 85746

UST:

Facility ID:	0-009039	Tank ID:	1
Owner:	DIAMOND SHAMROCK ARIZONA, INC	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		

DIAMOND SHAMROCK # 1613 (Continued) **U003154001**

Date Removed: / /
Date Closed: / /
In Use: True

Facility ID: 0-009039 Tank ID: 2
Owner: DIAMOND SHAMROCK ARIZONA, INC Owner ID: Not reported
Owner Contact: Not reported
In Use: True
Date Removed: / /
Date Closed: / /
In Use: True

---

42 **SAN XAVIER ROCK & MATERIALS** **UST** **U000017447**
1011 W VALENCIA DRIVE **N/A**
TUCSON, AZ 85706

UST:
Facility ID: 0-000051 Tank ID: 1
Owner: SOUTHWEST LAND & DEVELOPMENT COOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

Facility ID: 0-000051 Tank ID: 2
Owner: SOUTHWEST LAND & DEVELOPMENT COOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

Facility ID: 0-000051 Tank ID: 3
Owner: SOUTHWEST LAND & DEVELOPMENT COOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

Facility ID: 0-000051 Tank ID: 4
Owner: SOUTHWEST LAND & DEVELOPMENT COOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

Facility ID: 0-000051 Tank ID: 5
Owner: SOUTHWEST LAND & DEVELOPMENT COOwner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

Facility ID: 0-000051 Tank ID: 6
Owner: SOUTHWEST LAND & DEVELOPMENT COOwner ID: Not reported

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

SAN XAVIER ROCK & MATERIALS (Continued) **U000017447**

Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

Facility ID: 0-000051 Tank ID: 7
Owner: SOUTHWEST LAND & DEVELOPMENT CO Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

Facility ID: 0-000051 Tank ID: 8
Owner: SOUTHWEST LAND & DEVELOPMENT CO Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 07/17/87
Date Closed: / /
In Use: False

---

42 **SAN XAVIER ROCK & MATERIAL** **FINDS** **1004438586**
1000 W VALENCIA RD **AZD980357727**
TUCSON, AZ 85702

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

---

43 **CIRCLE K # 654** **LUST** **U003153633**
2526 W VALENCIA **UST** **N/A**
TUCSON, AZ 85706

LUST:
Facility ID: 0-001276
Lust Number: 2138.01
Leak Priority: CLOSED SOIL/GW LVL MEETS TIER1
Notification: 12/27/1991
Date Closed: 09/12/1995

UST:
Facility ID: 0-001276 Tank ID: 1
Owner: CIRCLE K [REJECTED LEASE SITE] Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 08/11/92
Date Closed: / /
In Use: False

Facility ID: 0-001276 Tank ID: 2
Owner: CIRCLE K [REJECTED LEASE SITE] Owner ID: Not reported
Owner Contact: Not reported
In Use: False
Date Removed: 08/11/92
Date Closed: / /
In Use: False

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

CIRCLE K # 654 (Continued) **U003153633**

Facility ID:	0-001276	Tank ID:	3
Owner:	CIRCLE K [REJECTED LEASE SITE]	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	False		
Date Removed:	08/11/92		
Date Closed:	/ /		
In Use:	False		

---

44 **THE WOODS I AND II APARTMENTS** **Dry Wells** **S103493225**
1970 W. VALENCIA RD. **N/A**
TUCSON, AZ 85746

DRY WELLS:
Number of Wells: 8
Beginning Registration Number: 15780

---

45 **CIRCLE K # 5540** **UST** **U003515262**
1555 W VALENCIA RD **N/A**
TUCSON, AZ 85746

UST:

Facility ID:	0-009222	Tank ID:	1
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		
Facility ID:	0-009222	Tank ID:	2
Owner:	TOSCO MARKETING CO	Owner ID:	Not reported
Owner Contact:	Not reported		
In Use:	True		
Date Removed:	/ /		
Date Closed:	/ /		
In Use:	True		

---

45 **WALGREENS STORE 3837** **FINDS** **1004181118**
1550 W VALENCIA **000009071970**
TUCSON, AZ 85746

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45 **WALGREENS STORE 3837** **RCRIS-SQG** **1001815265**
1550 W VALENCIA **FINDS** **AZR000003962**
TUCSON, AZ 85746

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

WALGREENS STORE 3837 (Continued) **1001815265**

RCRIS:
Owner: WALGREEN CO
(847) 940-2500
Contact: KENNETH MCKEVENY
(919) 484-3647
Record Date: 09/17/1997
Classification: Conditionally Exempt Small Quantity Generator
Used Oil Recyc: No
Violation Status: No violations found

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

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46 **1645 W. VALENCIA** **ERNS** **99608735**
1645 W. VALENCIA **N/A**
TUCSON, AZ 85746

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46 **AMERICAN AIRLINE** **AZ Spills** **S104561208**
1645 W. VALENCIA **N/A**
TUCSON, AZ

Az Spills:

Facility ID:	99-048-C	Incident Date:	02/02/99
Response Date:	Not reported	Report / Assist:	Not reported
Type:	Release	No of Samples:	Ai
Referred to:	PCDEQ		
Chemicals:	Unknown (Poss. Fuel)		
Property Mngmt:	Private		
Fund Amount:	Not reported		
Quantity:	Not reported		

---

47 **HOLMES TUTTLE FORD INC** **FINDS** **1004181301**
1431 W VALENCIA **000009073832**
TUCSON, AZ 85746

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)

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48 **LARSON COMPANY THE** **RCRIS-SQG** **1000325577**
6701 S MIDVALE PARK RD **FINDS** **AZD098036569**
TUCSON, AZ 85746 **CA HAZNET**

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

LARSON COMPANY THE (Continued) **1000325577**

RCRIS:
Owner: LARSON COMPANY
(602) 294-3900

Contact: RICHARD KUNZ
(602) 294-3900

Record Date: 12/06/1993
Classification: Small Quantity Generator
Used Oil Recyc: No

Violation Status: No violations found

FINDS:
Other Pertinent Environmental Activity Identified at Site:
AIRS Facility System (AIRS/AFS)
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)
Toxic Chemical Release Inventory System (TRIS)

HAZNET:
Gepaid: AZD098036569
Tepaid: CAD000088252
Gen County: 99
Tsd County: Los Angeles
Tons: .4586
Category: Unspecified solvent mixture Waste
Disposal Method: Transfer Station
Contact: THE LARSON COMPANY
Telephone: (602) 294-3900
Mailing Address: 6701 S MIDVALE PARK RD
TUCSON, AZ 85746 - 8065
County 99

Gepaid: AZD098036569
Tepaid: CAD000088252
Gen County: 99
Tsd County: Los Angeles
Tons: .0825
Category: Other inorganic solid waste
Disposal Method: Transfer Station
Contact: THE LARSON COMPANY
Telephone: (602) 294-3900
Mailing Address: 6701 S MIDVALE PARK RD
TUCSON, AZ 85746 - 8065
County 99

Gepaid: AZD098036569
Tepaid: CAD000088252
Gen County: 99
Tsd County: Los Angeles
Tons: .2085
Category: Unspecified organic liquid mixture
Disposal Method: Transfer Station
Contact: THE LARSON COMPANY
Telephone: (602) 294-3900
Mailing Address: 6701 S MIDVALE PARK RD
TUCSON, AZ 85746 - 8065
County 99

MAP FINDINGS

Map ID Direction Distance Distance (ft.)	Site	Database(s)	EDR ID Number EPA ID Number

LARSON COMPANY THE (Continued) **1000325577**

Gepaid: AZD098036569
Tepaid: CAT080022148
Gen County: 99
Tsd County: San Bernardino
Tons: .2293
Category: Unspecified solvent mixture Waste
Disposal Method: Transfer Station
Contact: THE LARSON COMPANY
Telephone: (602) 294-3900
Mailing Address: 6701 S MIDVALE PARK RD
TUCSON, AZ 85746 - 8065
County 99

Gepaid: AZD098036569
Tepaid: CAT080022148
Gen County: 99
Tsd County: San Bernardino
Tons: 5.7337
Category: Organic monomer waste (includes unreacted resins)
Disposal Method: Transfer Station
Contact: THE LARSON COMPANY
Telephone: (602) 294-3900
Mailing Address: 6701 S MIDVALE PARK RD
TUCSON, AZ 85746 - 8065
County 99

The CA HAZNET database contains 9 additional records for this site.
Please contact your EDR Account Executive for more information.

48	**THE LARSON COMPANY** **6701 SOUTH MIDVALE PARK ROAD** **TUCSON, AZ 85746**	**Dry Wells**	**S103493194** **N/A**

DRY WELLS:
Number of Wells: 1
Beginning Registration Number: 15254

48	**6701 SOUTH MIDVILLE PARK ROAD** **6701 SOUTH MIDVILLE PARK ROAD** **TUCSON, AZ 85746**	**ERNS**	**94368235** **N/A**

48	**6701 SOUTH MIDVILLE PARK ROAD** **6701 SOUTH MIDVILLE PARK ROAD** **TUCSON, AZ 85746**	**ERNS**	**94463366** **N/A**

49	**WEISER LOCK CO** **6700 S WEISER LOCK DR** **TUCSON, AZ 85746**	**FINDS** **AZ Spills** **RCRIS-LQG** **TRIS**	**1000380289** **85746WSRLC66**

MAP FINDINGS

Map ID Direction Distance Distance (ft.)Site	Database(s)	EDR ID Number EPA ID Number

WEISER LOCK CO (Continued) **1000380289**

RCRIS:

Owner: MASCO BUILDING PRODUCTS CORP
(602) 741-6200

Contact: GLYNIS COULTER
(602) 741-6366

Record Date: 02/27/1995
Classification: Large Quantity Generator

BIENNIAL REPORTS:
Last Biennial Reporting Year: 1999

Waste	Quantity (Lbs)	Waste	Quantity (Lbs)
D001	222.00	D002	2162.00
D003	296383569.00	D005	181.00
D006	118.00	D007	296411450.00
D008	5146.00	D009	2.00
D018	1708.00	D027	118.00
D039	1826.00	D040	1826.00
F003	178.00	F006	296410185.00
F007	39377.00	F008	39377.00

Used Oil Recyc: No

Violation Status: Violations exist

Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	01/29/1998
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	03/05/1999
Actual Date Achieved Compliance:	04/21/1999
Enforcement Action:	Written Informal
Enforcement Action Date:	03/18/1998
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported

Regulation Violated:	Not reported
Area of Violation:	Generator-All Requirements
Date Violation Determined:	01/29/1998
Priority of Violation:	Low
Schedule Date to Achieve Compliance:	03/05/1999
Actual Date Achieved Compliance:	04/21/1999
Enforcement Action:	Written Informal
Enforcement Action Date:	03/18/1998
Proposed Monetary Penalty:	Not reported
Final Monetary Penalty:	Not reported

There are 2 violation record(s) reported at this site:

Evaluation	Area of Violation	Date of Compliance
Compliance Evaluation Inspection (CEI)	Generator-All Requirements	04/21/1999
	Generator-All Requirements	04/21/1999

MAP FINDINGS

Map ID
Direction
Distance
Distance (ft.)Site | Database(s) | EDR ID Number / EPA ID Number

WEISER LOCK CO (Continued) **1000380289**

FINDS:
Other Pertinent Environmental Activity Identified at Site:
Biennial Reporting System (BRS)
Facility Registry System (FRS)
Resource Conservation and Recovery Act Information system (RCRAINFO)
Toxic Chemical Release Inventory System (TRIS)

Az Spills:

Facility ID:	95-065-C	Incident Date:	12/11/95
Response Date:	Not reported	Report / Assist:	Not reported
Type:	Release	No of Samples:	Ta
Referred to:	Not reported		
Chemicals:	Electroplating Solution		
Property Mngmt:	Private		
Fund Amount:	Pvt/Unk		
Quantity:	Not reported		

Facility ID:	98-021-C	Incident Date:	09/06/97
Response Date:	Not reported	Report / Assist:	Not reported
Type:	Release	No of Samples:	AS
Referred to:	Not reported		
Chemicals:	Rack Stripper Solution		
Property Mngmt:	Private		
Fund Amount:	Pvt/Unk		
Quantity:	Not reported		

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49 **6660 SOUTH BROADMOOR** **ERNS** **92293653**
6660 SOUTH BROADMOOR **N/A**
TUCSON, AZ 85746

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49 **WEISER LOCK** **AZ Spills** **S101092828**
6660 SO. BROADMOOR **N/A**
TUCSON, AZ 85746

Az Spills:

Facility ID:	94-008-C	Incident Date:	02/24/94
Response Date:	Not reported	Report / Assist:	Not reported
Type:	Release	No of Samples:	Ta
Referred to:	HWIU		
Chemicals:	Cyanide based solution		
Property Mngmt:	Private		
Fund Amount:	Pvt/Unk		
Quantity:	Not reported		

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49 **6660 SOUTH BROADMOOR** **ERNS** **93305437**
6660 SOUTH BROADMOOR **N/A**
TUCSON, AZ 85746

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)	Facility ID
PIMA COUNTY	S103895151	29TH ST. LANDFILL	29TH ST. (AKA SILVERLAKE RD.) AND SANTA CRUZ		SWF/LF	
PIMA COUNTY	S103895016	AJO	2000 N. AJO WELL RD. 1.5 MILES NORTH OF AJO		SWF/LF	
PIMA COUNTY	S103277346	CACTUS	ALLEN RD. BETWEEN TUCSON BLVD. AND CACTUS RD.		SWF/LF, WWFAC	
PIMA COUNTY	S103895018	ARIZONA PORTLAND CEMENT INERT	11115 N. CASA GRANDE HIGHWAY		SWF/LF	
PIMA COUNTY	S103895022	RYAN FIELD	6455 S. CONTINENTAL RD		SWF/LF	
PIMA COUNTY	S103895206	VINCENT MULLINS	NORTHEAST CORNER OF SPEEDWAY		SWF/LF	
PIMA COUNTY	S103895173	TUMAMOC	DIRECTLY WEST OF TUMAMOC HILL ON 22ND ST.		SWF/LF	
PIMA COUNTY	S103895169	RYLAND	WEST END OF 40TH ST. AND SANTA CRUZ RIVER		SWF/LF	
PIMA COUNTY	S103895174	WALNUT	NORTH END OF ALVEMON AND RILLITO WASH		SWF/LF	
PIMA COUNTY	S103895155	COLUMBUS #1	NORTH END OF COLUMBUS DR. ON EAST END		SWF/LF	
PIMA COUNTY	S103895156	COLUMBUS #2	NORTH END OF COLUMBUS DR. ON EAST END		SWF/LF	
PIMA COUNTY	S103895023	SAHARITA	16605 S. LACANADA DR.		SWF/LF	
PIMA COUNTY	S103895170	SAHUARO MONUMENT	1 MILE SOUTHEAST OF VISTORS CENTER		SWF/LF	
PIMA COUNTY	S103895160	LA CANADA	1 MILE SOUTH OF HELMET PEAK RD.		SWF/LF	
PIMA COUNTY	S103895019	INA	1 MILE WEST OF I-10 ON INA RD.		SWF/LF	
PIMA COUNTY	S103895176	WILMOT RD.	1 MILE SOUTH OF I-10 ON WILMONT RD.		SWF/LF	
PIMA COUNTY	S103895168	RYAN FIELD	12 MILES WEST OF TUCSON ON AZ 86 NORTH OF 86		SWF/LF	
PIMA COUNTY	S100293374	SAHURITA	.5 MILES W OF I-19 ON SAHURITA. S .		SWF/LF	
PIMA COUNTY	S103278122	PIMA COUNTY	.25 MILES WEST OF FREEWAY NORTH OF GRA RD.		SWF/LF, AZ Spills, WWFAC	92-075-B
PIMA COUNTY	S103278773	WHY	.5 MILES NORTH OF WHY ON AZ 85		SWF/LF	
PIMA COUNTY	S103895027	WHY RURAL	1/2 MILES NORTH STATE HIGHWAY 85		SWF/LF	
PIMA COUNTY	S100293371	CATALINA	.8 MILES N ON MILEPOST 84 ON WEST S		SWF/LF	
PIMA COUNTY	S100293372	IMA ROAD	.5 MILES W. OF I-10 E. OF INA RD. O		SWF/LF	
PIMA COUNTY	S100293373	LOS REALES	.5 MILES S OF I-10 ON CRAYCROFT RD.		SWF/LF	
PIMA COUNTY	S103895158	HARRISON RD. #2	.5 MILES NORTH OF IRVINGTON RD. ON HARRISON EAST		SWF/LF	
PIMA COUNTY	S103895152	A MOUNTAIN	MISSION RD. AT BASE OF "A" MOUNTAIN		SWF/LF	
PIMA COUNTY	S103895164	NEARMONT	NEARMONT ST. AND MELWOOD		SWF/LF	
PIMA COUNTY	S103895165	OLD NOGALES	EAST OF I-19 ON HUGHES ACCESS RD.		SWF/LF	
PIMA COUNTY	S103895153	BROADWAY #1	SOUTH OF BROADWAY RD. BETWEEN KOLB A		SWF/LF	
PIMA COUNTY	S103895154	BROADWAY #2	NORTH OF BROADWAY RD. BETWEEN KOLB A		SWF/LF	
PIMA COUNTY	S103895157	CORTARO ROAD	SOUTH OF THE CORTARO ROAD BRIDGE ON E SIDE		SWF/LF	
PIMA COUNTY	S103895162	LINDA LANDFILL	NORTH OF ALAMEDA AND EAST OF SANTA CR		SWF/LF	
PIMA COUNTY	S103895166	ORGAN PIPE MONUMENT	ORGAN PIPE MONUMENT, 1 MILE SOUTH OF VISTORS CENTE		SWF/LF	

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)	Facility ID
PIMA COUNTY	S102286938	SASABE	PRESUMIDO PEAK QUADRANT .5 MILES NORT OF US-MEXIC		SWF/LF	
PIMA COUNTY	S101570019	WQ-FAGAN LAKE	T17S R16E SEC 34 SE 1/4		SHWS	
PIMA COUNTY	S103895161	LA CHOLLA #1	EAST SIDE OF LA CHOLLA RD. SOUTH OF RILLITO RIVER		SWF/LF	
PIMA COUNTY	S103895167	PIMA COUNTY - LA CHOLLA #2	WEST SIDE OF LA CHOLLA RD. SOUTH RILLITC RIVER		SWF/LF	
PIMA COUNTY	S103895171	SILVERBELL (OLD)	SILVERBELL PEAK COVERED BY MINE TAILING PAG		SWF/LF	
PIMA COUNTY	S103895026	TANGERINE	10220 W. TANGERINE RD.		SWF/LF	
PIMA COUNTY	S103895172	ST. MARY'S	THE SOUTHWEST CORNER OF ST. MARY'S RD AND		SWF/LF	
PIMA COUNTY	S103086638	RESOURCE RECOVERY TRUST - SPEEDWAY	TUCSON ARIZONA		SWF/LF	
TUCSON	S103392069	WQ-ALUMINUM DROSS	(MAIL) PIMA COUNTY DEQ, 150 W. CONGRESS	85701	SHWS	
TUCSON	S103809868	U.OF A. EXPERIMENTAL FARMS	I-10 / MIRACLE MILE ROAD	85745	SHWS	
TUCSON	S104827042	TUCSON/AJO DETENTION BASIN	AJO WAY / COUNTRY CLUB RD	85714	WWFAC	
TUCSON	1001404347	DESERT XRAY SALES AND ECO RECYCLING	1311 E AJO WAY STE 109	85713	RCRIS-SQG, FINDS	
TUCSON	S104564826	SFPP L P	3841 E AJO WAY	85713	HAZNET	AZT050010131
TUCSON	U003799501	AJO CHEVRON	1285 W AJO WAY	85713	UST	0-009628
TUCSON	U003153967	AVIATION PARKWAY	AVIATION/EUCLID	85713	UST	0-009001
TUCSON	1000589610	ARIZONA LITHOGRAPHERS	351 N COMMERCE PARK LP	85745	RCRIS-SQG, FINDS	
TUCSON	1000171783	PRECIOUS METALS OF ARIZONA	2470 N JACK RABBIT DR	85745	RCRIS-SQG, FINDS	
TUCSON	1001195212	THOMAS AND BETTS CORP AUGAT WIRING SYSTE	777 E MACARTHUR CIRCLE STE12	85714	RCRIS-SQG, FINDS	
TUCSON	1001212569	ALFA LAVAL FLOW	777 E MACARTHUR CIRCLE STE 18	85714	RCRIS-SQG, FINDS	
TUCSON	S103392088	WQ-MIRACLE MILE	MIRACLE MILE RD / I-10	85745	SHWS	
TUCSON	1000261657	ENVIRONMENTAL WASTE ENTPR RECYCLE	7400 OLD NOGALES HWY	85706	FINDS, RCRIS-LQG	
TUCSON	S101570982	GATES LEARJET CORP.	7777 S OLD NOGALES HWY	85706	SHWS	AZD020703310
TUCSON	92256451	SABINO CANYON RECREATION AREA	SABINO CANYON RECREATION AREA		ERNS	
TUCSON	S103932028	WQ-SANTA CRUZ RIVER PROJECT	SANTA CRUZ RIVER / SPEEDWAY.	85745	SHWS	
TUCSON	S103932023	29TH STEEL USARTC, US ARMY RESERVE	1750 E. SILVERLAKE RD. (NEAR INTERSECTION 29TH)	85713	SHWS	
TUCSON	S104740982	PIMA COUNTY WWMD - AVRA VALLEY	10000 WEST SNYDER HILL RD		Aquifer, WWFAC	P100642
TUCSON	S103278558	TUCSON, CITY OF	T13S,R14E,S30		AZ Spills, WWFAC	00-044-C
TUCSON	S104889596	SAFETY-KLEEN CORP	4161 E TENNESSE	85714	SHWS	AZD980892897
TUCSON	1001492776	A A S COMPLETE CONTROLS	850 E TETON RD STE 8	85706	FINDS, RCRIS-LQG	
TUCSON	1000984337	COUNTY COLLECTION SYSTEM	TOWNSHIP 14 S. RANGE 14 E SEC.29 SE1/4	85713	CERCLIS, FINDS	
TUCSON	S101571005	COUNTY COLLECTION SYSTEM	TOWNSHIP 14 S.,RANGE 14 EAST,SEC.29 SE1/4	85713	SHWS	AZ0001038595
TUCSON	S103392077	ARIZONA AIR NATIONAL GUARD- TUCSON	TUCSON INTL ARPT	85706	SHWS	AZ9573124055
TUCSON	1000472606	AZ D P S FLEET MANAGEMENT	6401 S VALENCIA BLVD	85706	RCRIS-SQG, FINDS	
TUCSON	1000978049	YOUR CLEANERS	1645 W VALENCIA STE 101	85746	RCRIS-SQG, FINDS	
TUCSON	1000725147	TERMINAL STATIONS INC	WILMOT RD / I16 JCT	85706	SHWS, WWFAC	AZD980496814

EPA Waste Codes Addendum

Code	Description
D001	IGNITABLE HAZARDOUS WASTES ARE THOSE WASTES WHICH HAVE A FLASHPOINT OF LESS THAN 140 DEGREES FAHRENHEIT AS DETERMINED BY A PENSKY-MARTENS CLOSED CUP FLASH POINT TESTER. ANOTHER METHOD OF DETERMINING THE FLASH POINT OF A WASTE IS TO REVIEW THE MATERIAL SAFETY DATA SHEET, WHICH CAN BE OBTAINED FROM THE MANUFACTURER OR DISTRIBUTOR OF THE MATERIAL. LACQUER THINNER IS AN EXAMPLE OF A COMMONLY USED SOLVENT WHICH WOULD BE CONSIDERED AS IGNITABLE HAZARDOUS WASTE.
D002	A WASTE WHICH HAS A PH OF LESS THAN 2 OR GREATER THAN 12.5 IS CONSIDERED TO BE A CORROSIVE HAZARDOUS WASTE. SODIUM HYDROXIDE, A CAUSTIC SOLUTION WITH A HIGH PH, IS OFTEN USED BY INDUSTRIES TO CLEAN OR DEGREASE PARTS. HYDROCHLORIC ACID, A SOLUTION WITH A LOW PH, IS USED BY MANY INDUSTRIES TO CLEAN METAL PARTS PRIOR TO PAINTING. WHEN THESE CAUSTIC OR ACID SOLUTIONS BECOME CONTAMINATED AND MUST BE DISPOSED, THE WASTE WOULD BE A CORROSIVE HAZARDOUS WASTE.
D003	A MATERIAL IS CONSIDERED TO BE A REACTIVE HAZARDOUS WASTE IF IT IS NORMALLY UNSTABLE, REACTS VIOLENTLY WITH WATER, GENERATES TOXIC GASES WHEN EXPOSED TO WATER OR CORROSIVE MATERIALS, OR IF IT IS CAPABLE OF DETONATION OR EXPLOSION WHEN EXPOSED TO HEAT OR A FLAME. ONE EXAMPLE OF SUCH WASTE WOULD BY WASTE GUNPOWDER.
D005	BARIUM
D006	CADMIUM
D007	CHROMIUM
D008	LEAD
D009	MERCURY
D018	BENZENE
D027	1,4-DICHLOROBENZENE
D035	METHYL ETHYL KETONE
D039	TETRACHLOROETHYLENE
D040	TRICHLOROETHYLENE
F001	THE FOLLOWING SPENT HALOGENATED SOLVENTS USED IN DEGREASING: TETRACHLOROETHYLENE, TRICHLOROETHYLENE, METHYLENE CHLORIDE, 1,1,1-TRICHLOROETHANE, CARBON TETRACHLORIDE, AND CHLORINATED FLUOROCARBONS; ALL SPENT SOLVENT MIXTURES/BLENDS USED IN DEGREASING CONTAINING, BEFORE USE, A TOTAL OF TEN PERCENT OR MORE (BY VOLUME) OF ONE OR MORE OF THE ABOVE HALOGENATED SOLVENTS OR THOSE SOLVENTS LISTED IN F002, F004, AND F005, AND STILL BOTTOMS FROM THE RECOVERY OF THESE SPENT SOLVENTS AND SPENT SOLVENT MIXTURES.
F003	THE FOLLOWING SPENT NON-HALOGENATED SOLVENTS: XYLENE, ACETONE, ETHYL

EPA Waste Codes Addendum

Code	Description
	ACETATE, ETHYL BENZENE, ETHYL ETHER, METHYL ISOBUTYL KETONE, N-BUTYL ALCOHOL, CYCLOHEXANONE, AND METHANOL; ALL SPENT SOLVENT MIXTURES/BLENDS CONTAINING, BEFORE USE, ONLY THE ABOVE SPENT NON-HALOGENATED SOLVENTS; AND ALL SPENT SOLVENT MIXTURES/BLENDS CONTAINING, BEFORE USE, ONE OR MORE OF THE ABOVE NON-HALOGENATED SOLVENTS, AND, A TOTAL OF TEN PERCENT OR MORE (BY VOLUME) OF ONE OR MORE OF THOSE SOLVENTS LISTED IN F001, F002, F004, AND F005, AND STILL BOTTOMS FROM THE RECOVERY OF THESE SPENT SOLVENTS AND SPENT SOLVENT MIXTURES.
F005	THE FOLLOWING SPENT NON-HALOGENATED SOLVENTS: TOLUENE, METHYL ETHYL KETONE, CARBON DISULFIDE, ISOBUTANOL, PYRIDINE, BENZENE, 2-ETHOXYETHANOL, AND 2-NITROPROPANE; ALL SPENT SOLVENT MIXTURES/BLENDS CONTAINING, BEFORE USE, A TOTAL OF TEN PERCENT OR MORE (BY VOLUME) OF ONE OR MORE OF THE ABOVE NON-HALOGENATED SOLVENTS OR THOSE SOLVENTS LISTED IN F001, F002, OR F004; AND STILL BOTTOMS FROM THE RECOVERY OF THESE SPENT SOLVENTS AND SPENT SOLVENT MIXTURES.
F006	WASTEWATER TREATMENT SLUDGES FROM ELECTROPLATING OPERATIONS EXCEPT FROM THE FOLLOWING PROCESSES: (1) SULFURIC ACID ANODIZING OF ALUMINUM; (2) TIN PLATING ON CARBON STEEL; (3) ZINC PLATING (SEGREGATED BASIS) ON CARBON STEEL; (4) ALUMINUM OR ZINC-ALUMINUM PLATING ON CARBON STEEL; (5) CLEANING/STRIPPING ASSOCIATED WITH TIN, ZINC AND ALUMINUM PLATING ON CARBON STEEL; AND (6) CHEMICAL ETCHING AND MILLING OF ALUMINUM.
F007	SPENT CYANIDE PLATING BATH SOLUTIONS FROM ELECTROPLATING OPERATIONS
F008	PLATING BATH RESIDUES FROM THE BOTTOM OF PLATING BATHS FROM ELECTROPLATING OPERATIONS WHERE CYANIDES ARE USED IN THE PROCESS.

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Elapsed ASTM days: Provides confirmation that this EDR report meets or exceeds the 90-day updating requirement of the ASTM standard.

FEDERAL ASTM STANDARD RECORDS

NPL: National Priority List
Source: EPA
Telephone: N/A
National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by EPA's Environmental Photographic Interpretation Center (EPIC) and regional EPA offices.

Date of Government Version: 10/22/01
Date Made Active at EDR: 12/11/01
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 11/05/01
Elapsed ASTM days: 36
Date of Last EDR Contact: 02/04/02

NPL Site Boundaries

Sources:

EPA's Environmental Photographic Interpretation Center (EPIC)
Telephone: 202-564-7333

EPA Region 1
Telephone 617-918-1143

EPA Region 3
Telephone 215-814-5418

EPA Region 4
Telephone 404-562-8033

EPA Region 6
Telephone: 214-655-6659

EPA Region 8
Telephone: 303-312-6774

Proposed NPL: Proposed National Priority List Sites
Source: EPA
Telephone: N/A

Date of Government Version: 10/22/01
Date Made Active at EDR: 12/11/01
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 11/05/01
Elapsed ASTM days: 36
Date of Last EDR Contact: 02/04/02

CERCLIS: Comprehensive Environmental Response, Compensation, and Liability Information System
Source: EPA
Telephone: 703-413-0223
CERCLIS contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLIS contains sites which are either proposed to or on the National Priorities List (NPL) and sites which are in the screening and assessment phase for possible inclusion on the NPL.

Date of Government Version: 11/21/01
Date Made Active at EDR: 02/04/02
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 12/26/01
Elapsed ASTM days: 40
Date of Last EDR Contact: 12/26/01

CERCLIS-NFRAP: CERCLIS No Further Remedial Action Planned
Source: EPA
Telephone: 703-413-0223
As of February 1995, CERCLIS sites designated "No Further Remedial Action Planned" (NFRAP) have been removed from CERCLIS. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund action or NPL consideration. EPA has removed approximately 25,000 NFRAP sites to lift the unintended barriers to the redevelopment of these properties and has archived them as historical records so EPA does not needlessly repeat the investigations in the future. This policy change is part of the EPA's Brownfields Redevelopment Program to help cities, states, private investors and affected citizens to promote economic redevelopment of unproductive urban sites.

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

Date of Government Version: 11/21/01
Date Made Active at EDR: 02/04/02
Database Release Frequency: Quarterly

Date of Data Arrival at EDR: 12/26/01
Elapsed ASTM days: 40
Date of Last EDR Contact: 12/16/01

CORRACTS: Corrective Action Report
Source: EPA
Telephone: 800-424-9346
CORRACTS identifies hazardous waste handlers with RCRA corrective action activity.

Date of Government Version: 11/14/01
Date Made Active at EDR: 01/14/02
Database Release Frequency: Semi-Annually

Date of Data Arrival at EDR: 11/14/01
Elapsed ASTM days: 61
Date of Last EDR Contact: 11/14/01

RCRIS: Resource Conservation and Recovery Information System
Source: EPA/NTIS
Telephone: 800-424-9346
Resource Conservation and Recovery Information System. RCRIS includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA).

Date of Government Version: 06/21/00
Date Made Active at EDR: 07/31/00
Database Release Frequency: Varies

Date of Data Arrival at EDR: 07/10/00
Elapsed ASTM days: 21
Date of Last EDR Contact: 01/14/02

ERNS: Emergency Response Notification System
Source: EPA/NTIS
Telephone: 202-260-2342
Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 08/08/00
Date Made Active at EDR: 09/06/00
Database Release Frequency: Varies

Date of Data Arrival at EDR: 08/11/00
Elapsed ASTM days: 26
Date of Last EDR Contact: 02/01/02

FEDERAL ASTM SUPPLEMENTAL RECORDS

BRS: Biennial Reporting System
Source: EPA/NTIS
Telephone: 800-424-9346
The Biennial Reporting System is a national system administered by the EPA that collects data on the generation and management of hazardous waste. BRS captures detailed data from two groups: Large Quantity Generators (LQG) and Treatment, Storage, and Disposal Facilities.

Date of Government Version: 12/31/99
Database Release Frequency: Biennially

Date of Last EDR Contact: 12/17/01
Date of Next Scheduled EDR Contact: 03/18/02

CONSENT: Superfund (CERCLA) Consent Decrees
Source: EPA Regional Offices
Telephone: Varies
Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: N/A
Database Release Frequency: Varies

Date of Last EDR Contact: N/A
Date of Next Scheduled EDR Contact: N/A

ROD: Records Of Decision
Source: NTIS
Telephone: 703-416-0223
Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

Date of Government Version: 09/30/00
Database Release Frequency: Annually
Date of Last EDR Contact: 01/07/02
Date of Next Scheduled EDR Contact: 04/08/02

DELISTED NPL: National Priority List Deletions
Source: EPA
Telephone: N/A
The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

Date of Government Version: 11/13/01
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 02/04/02
Date of Next Scheduled EDR Contact: 05/06/02

FINDS: Facility Index System/Facility Identification Initiative Program Summary Report
Source: EPA
Telephone: N/A
Facility Index System. FINDS contains both facility information and 'pointers' to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Data System).

Date of Government Version: 10/29/01
Database Release Frequency: Quarterly
Date of Last EDR Contact: 01/07/02
Date of Next Scheduled EDR Contact: 04/08/02

HMIRS: Hazardous Materials Information Reporting System
Source: U.S. Department of Transportation
Telephone: 202-366-4526
Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 05/31/01
Database Release Frequency: Annually
Date of Last EDR Contact: 01/21/02
Date of Next Scheduled EDR Contact: 04/22/02

MLTS: Material Licensing Tracking System
Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 10/25/01
Database Release Frequency: Quarterly
Date of Last EDR Contact: 01/07/02
Date of Next Scheduled EDR Contact: 04/08/02

MINES: Mines Master Index File
Source: Department of Labor, Mine Safety and Health Administration
Telephone: 303-231-5959

Date of Government Version: 12/14/01
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 01/02/02
Date of Next Scheduled EDR Contact: 04/01/02

NPL LIENS: Federal Superfund Liens
Source: EPA
Telephone: 205-564-4267
Federal Superfund Liens. Under the authority granted the USEPA by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner receives notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

Date of Government Version: 10/15/91 | Date of Last EDR Contact: 11/19/01
Database Release Frequency: No Update Planned | Date of Next Scheduled EDR Contact: 02/18/02

PADS: PCB Activity Database System
Source: EPA
Telephone: 202-260-3936
PCB Activity Database. PADS identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 09/30/01 | Date of Last EDR Contact: 11/13/01
Database Release Frequency: Annually | Date of Next Scheduled EDR Contact: 02/12/02

RAATS: RCRA Administrative Action Tracking System
Source: EPA
Telephone: 202-564-4104
RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA. For administration actions after September 30, 1995, data entry in the RAATS database was discontinued. EPA will retain a copy of the database for historical records. It was necessary to terminate RAATS because a decrease in agency resources made it impossible to continue to update the information contained in the database.

Date of Government Version: 04/17/95 | Date of Last EDR Contact: 12/11/01
Database Release Frequency: No Update Planned | Date of Next Scheduled EDR Contact: 03/11/02

TRIS: Toxic Chemical Release Inventory System
Source: EPA
Telephone: 202-260-1531
Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/99 | Date of Last EDR Contact: 12/26/01
Database Release Frequency: Annually | Date of Next Scheduled EDR Contact: 03/25/02

TSCA: Toxic Substances Control Act
Source: EPA
Telephone: 202-260-5521
Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

Date of Government Version: 12/31/98 | Date of Last EDR Contact: 01/22/02
Database Release Frequency: Every 4 Years | Date of Next Scheduled EDR Contact: 04/22/02

FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
Source: EPA/Office of Prevention, Pesticides and Toxic Substances
Telephone: 202-564-2501
FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act). To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 10/25/01 | Date of Last EDR Contact: 12/26/01
Database Release Frequency: Quarterly | Date of Next Scheduled EDR Contact: 03/25/02

FTTS INSP: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
Source: EPA
Telephone: 202-564-2501

Date of Government Version: 10/25/01 | Date of Last EDR Contact: 12/26/01
Database Release Frequency: Quarterly | Date of Next Scheduled EDR Contact: 03/25/02

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

STATE OF ARIZONA ASTM STANDARD RECORDS

SPL: Superfund Program List
Source: Dept. of Environmental Quality
Telephone: 602-207-4360
The list is representative of the sites and potential sites within the jurisdiction of the Superfund Program Section. It is comprised of the following elements: 1) Water Quality Assurance Revolving Fund Registry Sites; 2) Potential WQARF Registry sites; 3) NPL sites; and 4) Department of Defense sites requiring SPS oversight.

Date of Government Version: 10/23/00
Date Made Active at EDR: 01/03/01
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 12/04/00
Elapsed ASTM days: 30
Date of Last EDR Contact: 12/04/01

SHWS: ZipAcids List
Source: Department of Environmental Quality
Telephone: 602-207-2202
The ACIDS list consists of more than 750 locations subject to investigation under the State Water Quality Assurance Revolving Fund (WQARF) and Federal CERCLA programs. The list is no longer updated by the state.

Date of Government Version: 01/03/00
Date Made Active at EDR: 05/16/00
Database Release Frequency: No Update Planned
Date of Data Arrival at EDR: 04/11/00
Elapsed ASTM days: 35
Date of Last EDR Contact: 01/21/02

SWF/LF: Directory of Solid Waste Facilities
Source: Department of Environmental Quality
Telephone: 602-207-4132
Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 11/01/00
Date Made Active at EDR: 02/01/01
Database Release Frequency: Annually
Date of Data Arrival at EDR: 01/02/01
Elapsed ASTM days: 30
Date of Last EDR Contact: 01/04/02

LUST: Leaking Underground Storage Tank Listing
Source: Department of Environmental Quality
Telephone: 602-207-4345
Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 11/08/01
Date Made Active at EDR: 11/27/01
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 11/13/01
Elapsed ASTM days: 14
Date of Last EDR Contact: 11/07/01

UST: Underground Storage Tank Listing
Source: Department of Environmental Quality
Telephone: 602-207-4345
Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 11/07/01
Date Made Active at EDR: 12/10/01
Database Release Frequency: Annually
Date of Data Arrival at EDR: 11/08/01
Elapsed ASTM days: 32
Date of Last EDR Contact: 01/14/02

WQARF: Water Quality Assurance Revolving Fund Sites
Source: Department of Environmental Quality
Telephone: 602-207-2202
Sites which may have an actual or potential impact upon the waters of the state, cause by hazardous substances. The WQARF program provides matching funds to political subdivisions and other state agencies for clean-up activities.

APPENDIX D SITE PHOTOGRAPHS

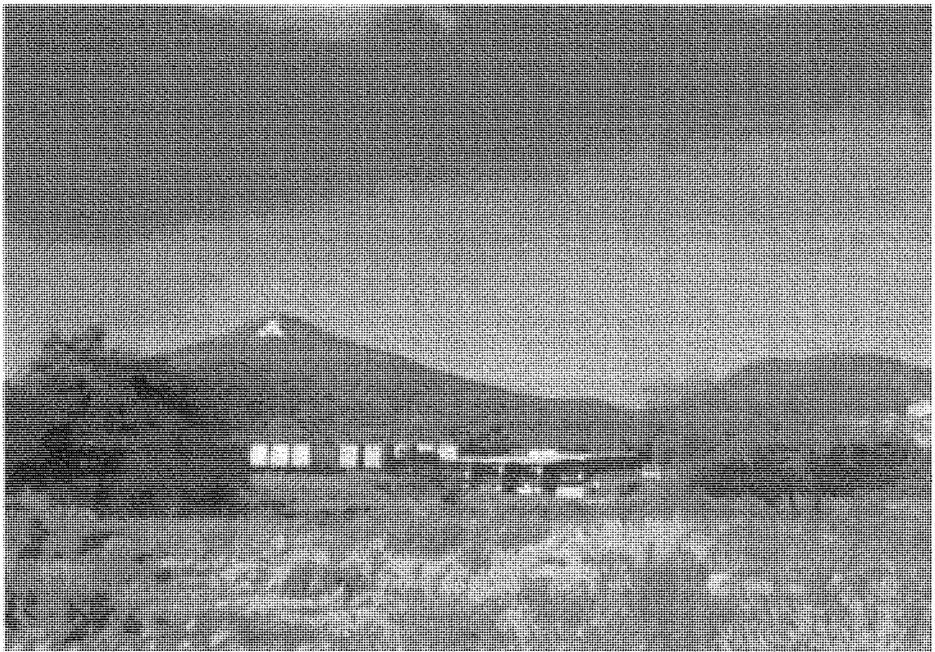
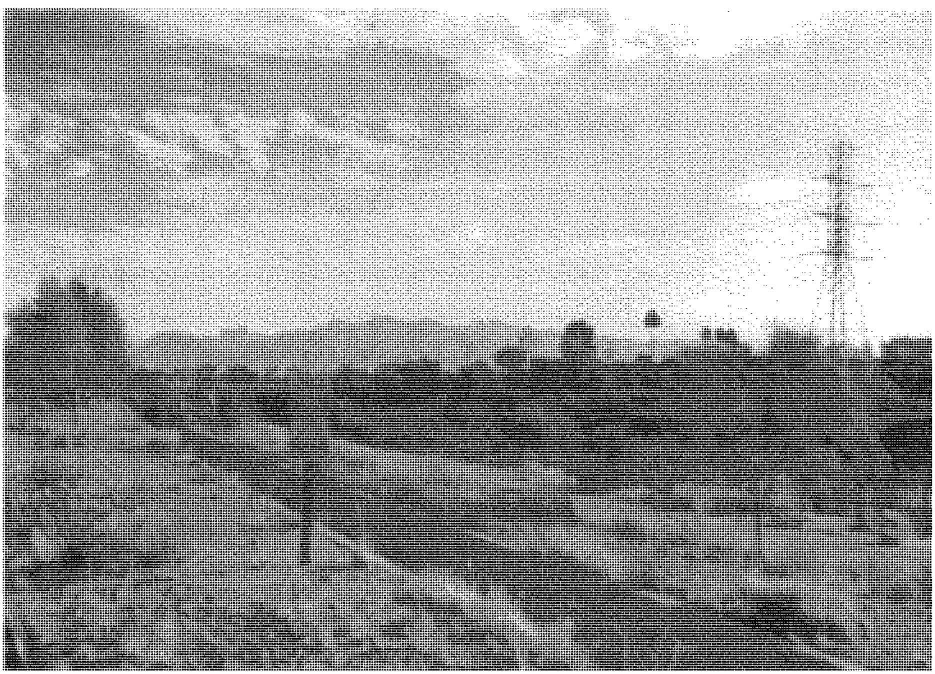


Photo 8: Bus and tractor trailer maintenance operation ½-mi. south of Congress St., ¼-mi. west of Santa Cruz

Photo 9: Irrigation ditch on top of riverbank, non-potable water for landscape irrigation; looking north towards Congress St. bridge



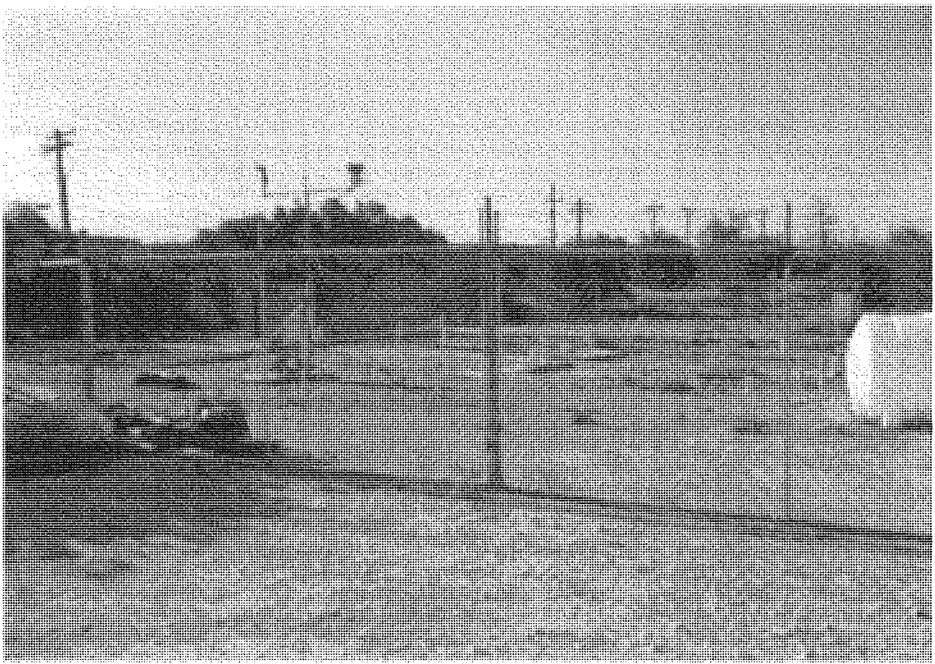


Photo 6: City of Tucson Environmental Management Division , Nearmont Environmental Management Project at the Nearmont Landfill

Photo 7: Water Monitoring wells near the Nearmont Landfill, south of Congress St., west of the Santa Cruz River

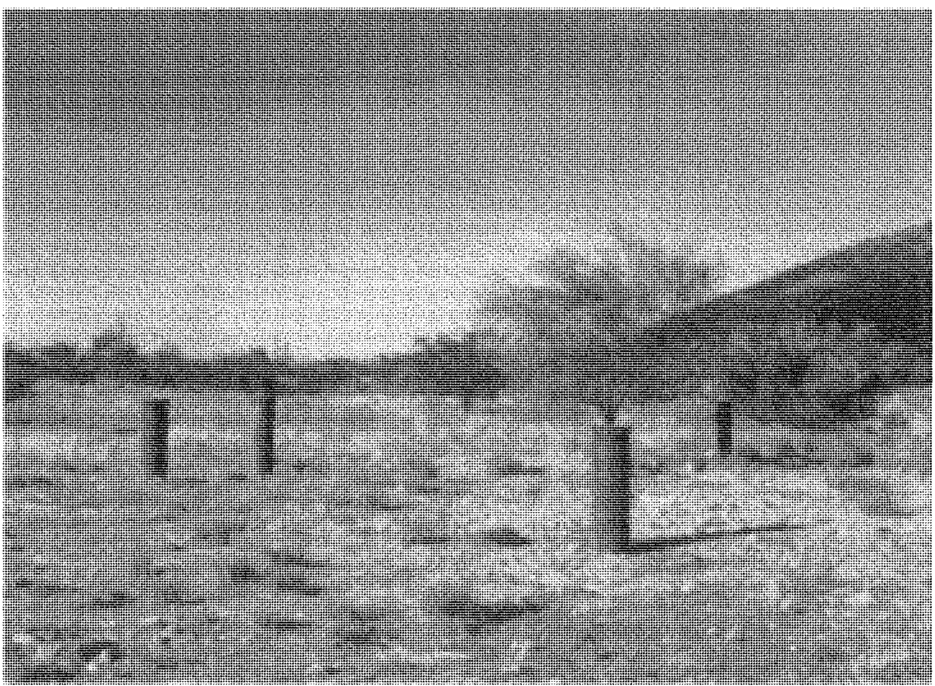
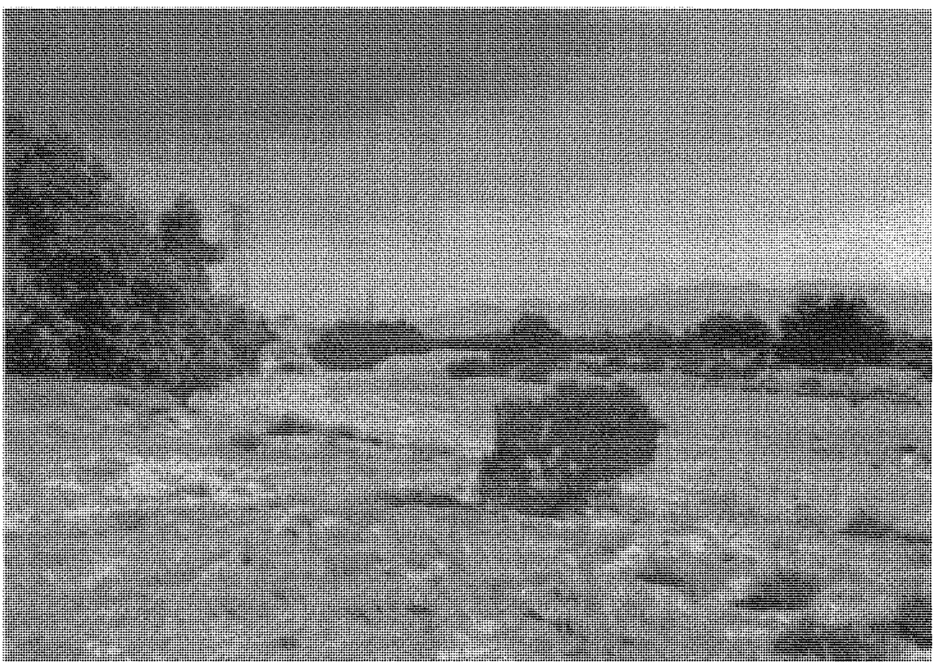


Photo 4: Santa Cruz River bottom looking north in project area from the Valencia Road Bridge

Photo 5:River bottom looking north, north of Ajo Way Bridge



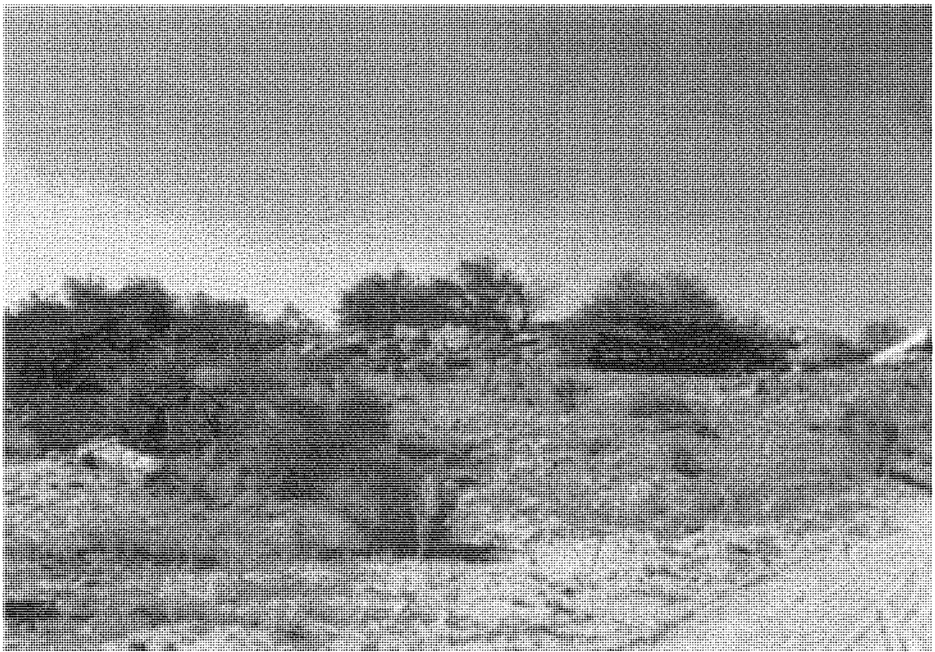


Photo 2: Rubble on west bank of Santa Cruz, looking southwest, north of Ajo Way Bridge

Photo 3: Debris in riverbottom, north of Ajo Way Bridge

Photo 1: Gravel pit operation, north of Los Reales

APPENDIX E PREPARER CREDENTIALS

KENNETH L. HOUSER
Division Director - Phoenix Natural Resources

EDUCATION

M.A., Geology, University of Missouri, Columbia
B.A., Geology and Anthropology, Catawba College

EXPERTISE

Specializing is project management and client and business development
Technical expertise in the areas of natural resource management, geology, and hydro-geology,
Technical review and quality control of various types of environmental projects

SELECTED PROJECTS

Luke Air Force Base Barry M. Goldwater Gunnery Range EIS
Biological Evaluation - For large residential development, Goodyear Arizona
Bureau of Indian Affairs - Environmental Assessment for reclamation facility, St. George Utah
Maricopa County Flood Control Area Drainage Master Plan, Phoenix Arizona
City of Phoenix - Aviation Department Goodyear Airport Soil and Groundwater Remediation Project
Surface and sub-surface abandoned mine land reclamation project, Rock Springs, Wyoming

Mr. Houser joined SWCA's Phoenix office in 1999 as Natural Resources Division Director. Mr. Houser has managed and/or supervised over 75 projects and as many as 20 people per project during his time at SWCA. His responsibilities have included management of junior, mid-level, and senior staff working in the disciplines of natural and cultural resources, engineering, earth sciences (predominately geology and hydrology), and geographical information systems (GIS).

Mr. Houser has served as a project manager on numerous environmental projects such as: DoD, BLM , and BOR EA and EIS projects, and various water supply and utility projects with the primary responsibilities of overseeing site investigations, regulatory compliance, and permitting. He has also served a project manager for several local City and County Government projects. Some duties while in this position included managing several natural and cultural resource projects, conducting Phase I and Phase II environmental site assessments and regulatory compliance audits, and conducting hydrogeologic analysis of aquifers (using computer models to investigate groundwater flow).

Mr. Houser also served as a project manager and field supervisor for various abandoned mine lands, mine hazard, and mine-subsidence control projects. He gained experience with federal and state mining-related regulations and obtained a working knowledge of compliance and contract procedures related to these regulations and their impact on clients. Also, he operated as a field supervision manager of drilling, coring, and logging operations and developed skills in geological interpretation of lithologic material, rock mechanics analyses, and groundwater sampling. He also has geotechnical materials testing experience that includes soils compaction testing, field and laboratory concrete testing, and laboratory testing of soils.

TIMOTHY J. ZEBULSKE
Project Manager/Environmental Scientist

EDUCATION
- *B.S. Aquatic Environments, Allegheny College*

EXPERTISE
- *NEPA Planner*
- *Clean Water Act permitting*
- *FERC Environmental Inspector*
- *Phase I ESA analysis*
- *Endangered Species Surveys*

SELECTED PROJECTS
- *Chief Environmental Inspector for FERC Project 2039.*
- *EA and EIS Research and document production of several BLM and BIA projects*
- *Wrote 50 EAs and processed oil/gas drilling permits for BLM, Pinedale Wyoming, in accordance with Resource Management Plans and EIS documents*
- *Phase I ESAs for various residential and commercial sites in Arizona, including properties ranging from individual buildings to 10-square mile sites*
- *Chief Environmental Inspector for natural gas line installation regulated by FERC*
- *Roston Communities Sec. 404 individual permit for 1,060-acre site*
- *Compliance inspections for oil/gas facilities in western Wyoming*
- *Hancock Communities Section 404 Permi 2,000-acre site*
- *El Paso Energy Sec. 404 permit for 750-mile long fiber optic line*
- *Various biological evaluations for residential development sites in Arizona*
- *Luke Air Force Base Groundwater sampling program*

As project manager for the Natural Resources Division Mr. Zebulske is responsible for various Section 404, Clean Water Act and NEPA projects, as well as Phase I Environmental Site Assessments. During the past 16 years, Mr. Zebulske has acquired experience in various functions of environmental science and consulting. The majority of his work has involved site assessments, including field investigations, contamination assessments, environmental compliance audits, report and permit writing, and project management within a variety of environmental regulatory programs for clients who were developing, buying, selling, or decontaminating properties. Projects included permitting and compliance for linear utility installations across Cochise, Pima, Pinal, and Maricopa Counties, and Section 404 Permits for transportation and residential development in Pinal County. Mr. Zebulske is currently serving as the Chief Environmental Inspector for FERC project 2039, an ongoing pipeline installation/abandonment project in Phoenix.

Previous to working with SWCA Mr. Zebulske was a staff scientist with ARCADIS Geraghty & Miller, Inc. He was responsible for groundwater and surface water sampling projects at numerous CERCLA and RCRA facilities and dozens of industrial sites. Other previous positions included air, soil and water sampling at a hazardous waste landfill, fieldwork for the USEPA's National Surface Water Survey, and fisheries monitoring at a coal-fired generating station.

KRISTA A. DEARING
Geologist/ NEPA Planner

EDUCATION

- *B.S., Geology, University of Cincinnati, OH*
- *M.S., Geology, University of Cincinnati, OH. In progress.*

EXPERTISE

- *ASTM Phase I/Phase II ESA's*
- *RCRA Compliance*
- *NEPA Compliance*
- *Clean Water Act Compliance*
- *Groundwater/Soil Remedial Alternatives Feasibility Studies*

SELECTED PROJECTS

- *Piper Aircraft, Vero Beach, FL: Supplemental Investigation as part of ROD to delineate nature/extent of chlorinated solvents in groundwater. Prepared focused FS.*
- *CINERY, Cincinnati, OH: Hydrogeologic investigation and designed groundwater monitoring plan for an existing flue gas desulfurization sludge fly ash disposal landfill.*
- *Community Transportations Solutions, Inc., Louisville ,KY: Comprehensive Southern Indiana HazMat Baseline Study as part of a NEPA DEIS.*
- *Honeywell Contract Employee, Phoenix, AZ: Corporate Remediation Management Division.*
- *Parson Transportation/ADOT, Phoenix, AZ: Environmental Coordinator for the design build of U.S. 60.*
    - *Aquila Energy, Houston, TX: Preparation of FERC Filing for a proposed natural gas storage facility located near Kingman, AZ.*

As a NEPA Planner/Geologist for the Natural Resources Division, Ms. Dearing is responsible for various Section 404, Clean Water Act and NEPA projects, as well as Phase I Environmental Site Assessments. Ms. Dearing is currently preparing several Resource Reports as part of a FERC Section 7 Application for a proposed natural gas storage facility located near Kingman, AZ.

Ms. Dearing was the Project Manager and Principle Investigator of a comprehensive Hazardous Material Baseline Study as part of a NEPA DEIS for the Ohio River Bridges Project located in Louisville, KY. The Project entailed a three-year effort by INDOT and KYTC to develop a comprehensive EIS of eight transportation alternatives to connect Southern Indiana and Louisville. Worked with state agencies to develop standards for the HazMat Baseline Studies for Kentucky and Indiana, and assisted client in preparation of DEIS.

Ms. Dearing served as Environmental Coordinator during the redesign/build of a 12-mile section of Superstition Highway (U.S. 60) to ensure that construction activities along the project corridor were in compliance with the State and Federal regulations.

During the past 8 years as an Environmental Consultant with Dames & Moore and Parsons Engineering Science, Ms. Dearing has acquired extensive experience providing geology/hydrogeologic services for multi-disciplinary projects in both the private and public sectors. Ms. Dearing has conducted numerous RCRA, CERCLIS, and UST remedial investigations for clients located in Ohio, Kentucky, Illinois, Pennsylvania, Indiana, Michigan, South Carolina, Colorado, Florida, and Arizona.

In addition to performing remedial investigations, Ms. Dearing has also managed numerous ASTM Phase I/Phase II investigations for clients who were developing, buying, or selling industrial, commercial, residential, or undeveloped property.

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX H

ECONOMICS

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

TABLE OF CONTENTS

INTRODUCTION

Objective:

The following presents an economic evaluation associated with flood damage reduction along the Paseo de las Iglesias segment of the Santa Cruz (Los Reales Road to Congress Street), the Old West Branch (Irvington Road to 22nd Street), the New West Branch segment of the Santa Cruz River (Valencia Road to Irvington Road), and the Los Reales Area (Los Reales Road to Valencia Road). Also, erosion, environmental restoration, and recreation opportunities will be evaluated only along the Paseo de las Iglesias.

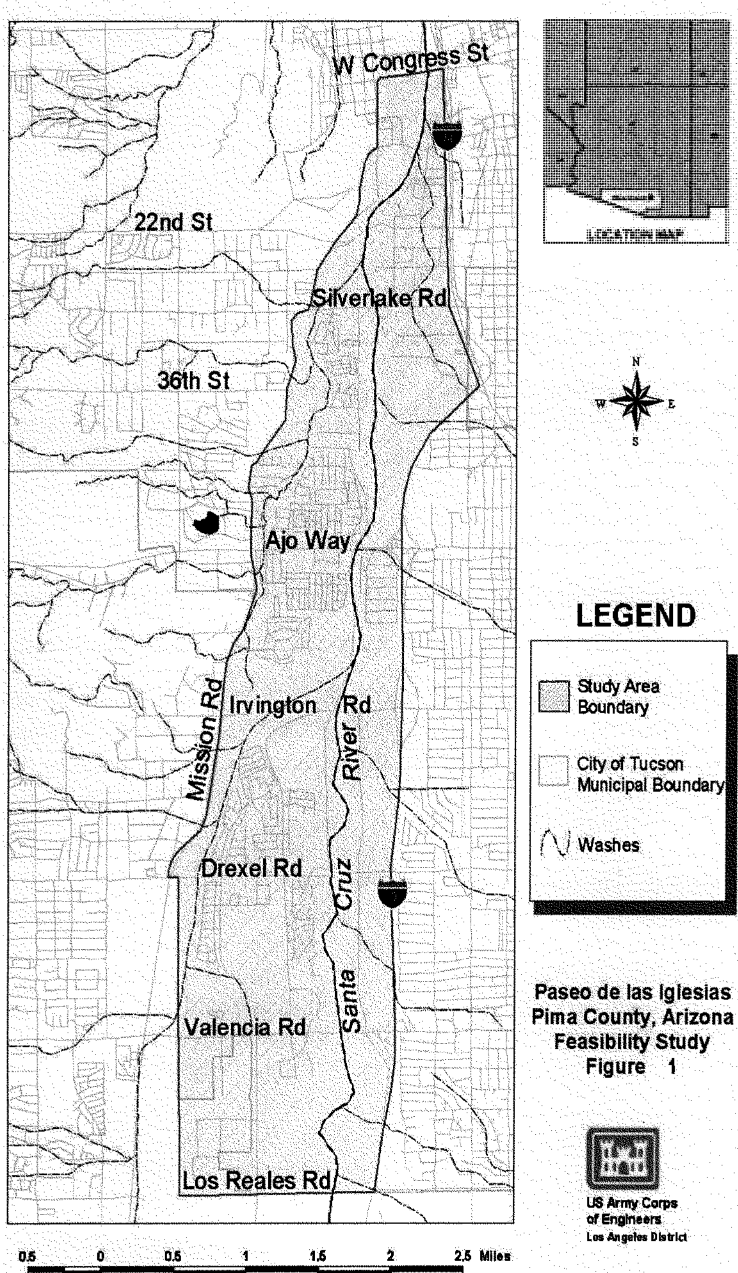
Methodology:

The methodology employed for this economic analysis is in accordance with current USACE Principles and Guidelines and standard economic practices. In agreement with these standards, benefits and costs will be computed at the current 5.625% interest rate, October 2004 price levels, a base year of 2012, and a 50-year period of analysis. In addition, the environmental restoration analysis will be completed in conformance with IWR Report #95-R-1—Evaluation of Environmental Investments Procedures Manual (May 1995).

Study Area:

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it reenters Arizona about six miles east of Nogales. The river continues northward to Tucson then northwest to its confluence with the Gila River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the study area. The Paseo de las Iglesias segment that lies within the study area extends 7 miles along the Santa Cruz River through the urbanized area of metropolitan Tucson. The boundaries are located between Los Reales Road and Congress Street and are considered to be the most suitable for flood damage reduction, bank stabilization, environmental restoration, and recreation opportunities. Other suitable areas for possible flood damage reduction are the Old West Branch of the Santa Cruz River (located along the second western tributary going north (Irvington Road to 22nd Street)) and the New West Branch, including the Los Reales Segment that originates at Los Reales Road and flows north along the first western tributary to the confluence of the Santa Cruz River at Irvington Road.

Figure 1: The Paseo de Las Iglesias, Old and New West Branches, and Los Reales Study Area



History:

The Paseo de las Iglesias, Old and New West Branches, and Los Reales portions of the Santa Cruz Rivers were historically perennial riparian areas of Southern Arizona, with highly productive cottonwoods, willows, and mesquite habitats. These areas were rich in habitat diversity, supporting a wide variety of wildlife species. As the watershed became developed with new homes, industry, and highways (Interstate 19 and Interstate10), riparian habitat degraded significantly displacing the last remnants of riparian vegetation once occupying the region.

Population:

The Paseo de las Iglesias study area is included in the Pima County Metropolitan Statistical Area (MSA). According to the 2000 Census, the Pima County MSA population was 843,746 (16.81% of Arizona population). This population figure for 2000 was 26.5 percent larger than the 666,880 residents in 1990 (18.9% of Arizona Population). During the previous decade, the Pima County MSA increased by 25.5 percent from 531,443 in 1980. In fact, the Pima County MSA has been growing at an average annual compound rate of about 2.3 compared to the national average of 1.1 percent. A summary of Metro Area Data is shown in Table 1 below.

Table 1: Population for Tucson-Pima County MSA

Year	Population
1980	531,443
1990	666,880
2000	843,746

The Pima County population growth illustrated above has been due primarily to net migration into the area. Two main factors contributing to the migration are employment opportunities and the low cost of housing. Because the Pima County area offers high skilled technical and professional jobs and a diversified occupational base, some people may find the area appealing. Residents also can purchase low cost housing, another lure, that may enhance their quality of living.

Employment:

Three primary areas of employment in Pima County are in education, government, and military. First, sources of employment in the educational sector include the University of Arizona, Pima County Community College, and the Tucson Unified School District. Second, government offices offer employment on the state, county, and city level. Third, two military establishments provide further employment opportunities. They are Davis-Monthan Air Force Base and Raytheon Missile Systems Company. All three areas of employment require a higher likelihood of professional and technical skill as well as some college education that account for some of the 24.70% of professional and technical occupations within Pima County.

This demand for high skilled labor may account for the reason why Pima County has enjoyed a low employment rate as much as 1.2 percentage points below Arizona. Table 2 shows major employers, employment type, and number of employees within Pima County. Table 3 lists the occupation type and the percentage of employees per occupation type.

Table 2: Employers, Employment Type, and Number of Employees

Employer	Employment Type	Number of Employees
University of Arizona	University of Colleges	10,520
State of Arizona	Government	9,694
Davis-Monthan Air Force Base	Military	8,352
Tucson Unified School District	Education	8,187
Raytheon Missiles Systems Co.	Military Manufacturing	7,700
Pima County	Government	7,028
City of Tucson	Government	5,497

Table 3: Percentage of Employees Divided by Occupation Type

Occupation Type	Percentage of Total
Managers & Administrative	6
Professional & Technical	25
Sales and Related Occupations	11
Clerical & Administrative Support	17
Service Occupations	20
Agriculture, Forestry & Fishing	1
Production, Maintenance & Material	20
Total	100

Housing Units & The Low Cost Housing:

To accommodate the population expansion in the area, 50,301 housing units were built over the previous nine years. A total of about 348,508 housing units were constructed in Pima County before 1999. This figure is up from 298,207 housing units built before 1990. According to the 1999 American Community Survey Profile for Pima County, Arizona, about 21 percent of the existing housing stock within Pima County has been constructed in the past ten years. Most of the newer homes, constructed in master planned communities, are reasonably priced compared to other metropolitan areas. The average cost of a new single family home is about $109,102, and this is a primary factor making the overall cost of living in Pima County among the lowest of major US metropolitan areas.

WITHOUT PROJECT CONDITIONS

Flood Damage Analysis:

Floodplain Description:

Four floodplains for this analysis are described in detail below. Plates 12 through 16 in the Hydrology and Hydraulics Appendix show each floodplain, plus reach delineations by cross-section.

1. *The Paseo de las Iglesias Segment of the Santa Cruz River--* Certain areas of Paseo de las Iglesias have been channelized and embanked to combat the destruction resulting from flooding. Soil cement bank protection has been constructed upstream and downstream of the Valencia Road Bridge, from Irvington Road to Ajo Way, and from Silverlake Road up to Grant Road. The stretches of the Paseo de las Iglesias that lack channel stabilization are located from Los Reales Road to Irvington Road and Ajo Way to Silverlake Road. Currently, the Santa Cruz channel contains the 100-year flood throughout most of the study area. However, some localized areas are still susceptible to floods that are lower probability floods. One area is located on the west bank of the river from Congress Street but switches to the east bank toward 22nd Street. A second area is located on both banks of the river south of 22nd Street, but most of the flooding in on the west bank of the river near the Old West Branch of the Santa Cruz River and the Paseo de las Iglesias confluence. A third area is located on both banks of the river just south of Ajo Way. A fourth area susceptible to 500-year flooding is located on the west side of the river south of Drexel Road.

2. *The Old West Branch of the Santa Cruz River*[1]*--The* Old West Branch, located to the west of the Santa Cruz, is located from Irvington Road to 22nd Street. This river does not have any channel embankment and 100-year flows flood the area between the Old West Branch and the Santa Cruz River. The crossroads where most of the 100-year flood flows is between Silverlake Road and Ajo Way. (Since discharge frequency values other than the 100-year were unobtainable, the US Army Corps of Engineers and the local sponsor have agreed to limit the analysis to 100-year flow data. Analysis up to the 500 year will not be performed for the Old West Branch.)

[1] Analysis is limited along the Old West Branch because previous proposals, by the non-federal sponsor, for structural improvements along the Old West Branch resulted in a high degree of public opposition. A structural improvement may result in the loss of the most highly valued riparian habitat and Mesquite Bosque within the study area. In addition, 73 acres of the Old West Branch channel and floodplain must be maintained as a natural floodplain under the mitigation provisions of an existing Section 404 permit and structural modifications of the natural channel are prohibited.

3. *The New West Branch of the Santa Cruz River*--The New West Branch located to the west of the Santa Cruz from Valencia Road to Irvington Road has been channelized and embanked combating the destruction from flooding. At Irvington Road, the New West Branch channel merges with the Santa Cruz River. The entire stretch contains the 2 through 50-year flood events. Breakouts begin to occur at 100-year flood events resulting in residential flooding.

4. *The Los Reales Area*--A small area just south of the New West Branch between Valencia Road to the north and Los Reales Road to the south experiences shallow flooding.

Reach Delineations:

Economics, Hydrology, and Hydraulics study team members participated in the segmenting of the Santa Cruz, the Old and New West Branches, and Los Reales floodplains into distinct reaches of homogeneous characteristics. Critical factors for differentiation included: the discharge-frequency characteristic, the overflow spatial characteristic, and economic activity. Tables 4 & 5 provide a summary of reach delineations (each starts at the downstream end of each stream and moves upstream), including stream name, and beginning and ending cross-sections for each reach. By segmenting the floodplains into reaches each segment can be described separately and in more detail.

Table 4: Reach Delineation Breakdown: The Santa Cruz Floodplain

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
1 SC	Congress St. 22nd Street	Santa Cruz River	32.61	33.38
2 SC	22nd Street Ajo Way	Santa Cruz River	33.38	35.77
3 SC	Ajo Way Irvington Rd.	Santa Cruz River	35.77	36.63
4 SC[1]	Irvington Rd. Drexel Rd.	Santa Cruz River	36.63	37.87
5 SC	Drexel Rd. Valencia Rd.	Santa Cruz River	37.87	38.96

[1] 4 SC will not be listed on tables following this one because this reach produced no damages.

**Table 5: Reach Delineation Breakdown:
The Old & New West Branches and Los Reales Floodplains**

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
OWB	22nd Street Ajo Way	Old West Branch	0.50	29.00
1 NWB	Irvington Rd. Drexel Rd	New West Branch	1.00	17.00
2 NWB	Drexel Rd Valencia Rd	New West Branch	17.00	26.00
LR	Valencia Rd. Los Reales Rd.	Los Reales	51.00	78.10

Number of Structures:

Pima County Tax Assessor data aided in further description of the floodplain by providing the number and type of structures affected in each respective floodplain. Because property delineations in the tax assessor's data are by parcel and not by the number of structures, the individual parcel for residential and non-residential categories may include more than one structure. For example, a residential parcel may include more than one apartment building. Likewise, a non-residential parcel may include more than one office building. In these cases, aerial maps and information gathered during the visit to the study area were relied upon to obtain the number of structures by reach and structure type for the 500 year floodplain (100 year floodplain for Old West Branch), shown in Tables 6 and 7. The number of structures shown by frequency is shown in Table 8.

**Table 6: Number of Structures by Reach and Structure Type:
The Santa Cruz Floodplain**

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
1 SC	231	13	5	2	0	251
2 SC	103	18	441	15	5	582
3 SC	129	26	594	5	1	755
5 SC	383	1	0	0	0	384
Total	846	58	1040	22	6	1972

**Table 7: Number of Structures by Reach and Structure Type:
The Old & New West Branches and Los Reales Floodplains**

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
OWB	52	0	528	2	1	583
1 NWB	0	0	985	0	0	985
2 NWB	140	0	0	0	1	141
LR	44	1	66	6	2	119
Total	236	1	1579	8	4	1828

Table 8: Number of Structures by Frequency for Each Floodplain

Floodplain	50 yr	100 yr	200 yr	500 yr
Santa Cruz	0	0	132	1972
Old West Branch	NA[1]	583	NA	NA
New West Branch	0	222	503	1126
Los Reales	24	47	62	119

[1]NA means overflows were not available for the frequencies listed; therefore structures could not be counted and included in Table 8.

The numbers of structures were evaluated to obtain a dollar value of structures and their contents.

Value of Structures:

The total values of structures in the floodplain were estimated using the following methodology.

1. Data from the field survey was input into the spreadsheet.

2. Square footage estimates were made based upon TRW Redi Real Estate Data Base.

3. The total value of structures was computed using dollars per square foot for each structure and condition type from Marshall and Swift Valuation Service.

4. Structure values were then adjusted to reflect condition and age of structures for depreciated replacement values.

5. Depreciated replacement value were adjusted to reflect local and current cost multipliers for the area.

Value of Contents:

Content values were calculated using the Commercial Content Inventory (CCI) Program developed by Marshall & Swift. To use the program as few as three variables for each business can be input to determine comprehensive equipment and inventory cost estimates. Key inputs include: zip code, square footage, type of establishment, estimated revenue, and the number of employees. Once entered, the program uses an algorithm based on a variety of government, commercial, and proprietary databases.

1. Oxford Information Technology LTd.'s databases include:
    a. Financial statements and balance sheets from over 12 million companies
    a. Services and equipment purchases tracked in over 1,100 industries
    b. Square footage, number of employees, and sales per square foot in six million companies

2. Marshall & Swift / Boeckh's databases include:
   a. Current building cost information for over 150 types of buildings, localized by zip code
   b. Over 32,000 construction component costs and labor rates, localized by zip code.

Content ratios were then derived as a percentage of corresponding replacement values of structures. The following ratios were applied in Table 9.

Table 9: Content Ratios

Category	Structure Type	Ratio
SFR	SFR	0.50
MFR	Duplex	0.50
	Apartment	0.50
	Motel	0.50
	Triplex	0.50
MH	MH	0.50
Commercial	Retail	0.94
	Service Station	1.07
	Office	0.41
	Industry	1.07
	Warehouse	1.72
	Restaurant	0.30
	Dental Office	0.32
Public	Government	0.24
	Church	0.24

Tables 10 and 11 provide a detail of the total structure value and content value by category and reach for the 500-year floodplain (100 year floodplain for the Old West Branch).

Table 10: Structure & Content Values: The Santa Cruz Floodplain (October 2004 Price Levels)

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
1 SC Structure	$16,217,337	$9,167,975	$160,906	$324,718	$0	$25,870,937
1 SC Content	$8,108,581	$4,583,988	$80,453	$119,336	$0	$12,892,358
2 SC Structure	$6,293,536	$10,676,129	$16,457,456	$3,087,051	$630,018	$37,144,190
2 SC Content	$3,146,768	$5,338,065	$8,228,728	$3,364,992	$151,204	$20,229,757
3 SC Structure	$9,516,644	$11,923,417	$22,166,892	$1,761,999	$2,783,569	$48,152,521
3 SC Content	$4,758,322	$5,961,708	$11,083,446	$2,591,465	$668,057	$25,062,998
5 SC Structure	$32,081,040	$1,558,322	$0	$0	$0	$33,639,362
5 SC Content	$16,040,416	$779,161	$0	$0	$0	$16,819,577
Total	$96,162,644	$49,988,765	$58,177,881	$11,249,561	$4,232,848	$219,811,699

Table 11: Structure & Content Values: The Old & New West Branch and Los Reales Floodplains (October 2004 Price Levels)

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
OWB Structure	$2,929,776	$0	$19,703,904	$1,022,924	$90,308	$23,746,912
OWB Content	$1,464,888	$0	$9,851,952	$961,548	$22,577	$12,300,965
1 NWB Structure	$0	$0	$36,758,230	$0	$0	$36,758,230
1 NWB Content	$0	$0	$18,379,115	$0	$0	$18,379,115
2 NWB Structure	$10,187,398	$0	$0	$0	$3,090,101	$13,277,499
2 NWB Content	$5,093,699	$0	$0	$0	$741,624	$5,835,323
LR Structure	$3,904,143	$161,454	$2,490,025	$3,137,369	$566,562	$10,259,553
LR Content	$1,952,072	$80,727	$1,245,012	$4,268,656	$135,974	$7,682,441
Total	$25,531,976	$242,181	$88,428,238	$9,390,497	$4,647,146	$128,240,038

Structure & Content Damages:

Without project structure and content damages were computed utilizing the HEC-FDA (Hydologic Engineering Center - Flood Damage Analysis) model. The model computes equivalent annual damages based upon the following input parameters.

1. Structure data includes: structure name, category (SFR, MFR, MH, Commercial, and Public), stream location, bank, stream name, number of structures, ground elevation, first floor elevation, structure value, and content value.

   This data was developed in a Microsoft Excel spreadsheet, converted into a text file, and imported into the HEC-FDA program.

2. Hydrologic and Hydraulic data includes: frequency-discharges and stage-discharge relationships. This data, furnished by Engineering Division, was developed utilizing the HEC-2 Water Surface Profiles program. The output files were imported into the HEC-FDA program. Data was input for the base.

3. Depth-damage relationships for residential structures were obtained from Economic Guidance Memorandum (EGM) 01-03: Generic Depth-Damage Relationships. Commercial and MH depth damage relationships were obtained by FEMA and entered directly into the program.

4. Risk and Uncertainty (R&U) variables. The two variables subject to R&U variations for the economic determination of stage-damage functions are first floor elevation (FFE) and depreciated replacement cost (DRC). For FFE uncertainty, a normal distribution with a mean of 0 and a standard deviation of .6 feet was assumed (based upon guidance contained in EM 1110-2-1619). For DRC uncertainty, a normal distribution with a mean of 0 and a standard deviation of 10% of structure base value was assumed (based upon variations in Marshall & Swift valuation multipliers for various structure types and conditions. Assuming a normal distribution with a mean of 0 and a standard deviation of 10% of structure base value was assumed.

   The hydrologic engineering relationships allowed by the HEC-FDA model to fluctuate are frequency-discharge and stage-discharge. For the frequency-discharge relationship, a statistical distribution was computed. This method is called the "graphical" approach, based upon data contained in the water surface profiles and equivalent record lengths for each reach, was furnished by Engineering Division. For the stage-discharge relationship, a normal distribution is assumed.

Exceedance Probabilities for the Santa Cruz River (SC), the Old West Branch (OWB) and the New West Branch (NWB), and the Los Reales (LR) areas are shown by probability for each reach in Tables 12 and 13 and 14. The tables show that damages have less than an assigned probability likelihood of exceeding the associated damage amount. For example, Reach 1 along the Santa Cruz River has a .004 probability likelihood of exceeding $7,871,050.

Table 12: Santa Cruz Floodplain Exceedance Probabilities for Each Reach

Reach	133 Year	250 Year	500 Year
1SC	$1,671,380	$7,871,050	$14,257,150
2SC	$2,364,620	$12,165,630	$23,545,430
3SC	$3,304,470	$36,951,080	$55,670,380
5SC	$2,833,510	$7,660,270	$16,543,640

Table 13: Old & New West Branches
Floodplain Exceedance Probabilities for Each Reach

Reach	100 Year	133 Year	250 Year	500 Year
OWB	$4,275,909	NA	NA	NA
1 NWB	$9,341,250	$9,487,850	$9,510,580	$9,510,580
2 NWB	$3,591,640	$3,956,910	$3,956,910	$3,956,910

Table 14: Los Reales Floodplain Exceedance Probabilities for Each Reach

Reach	50 Year	66 Year	100 Year	133 Year	250 Year	500 Year
LR	$1,293,880	$1,304,440[1]	$1,304,440	$1,304,440	$1,304,440	$1,304,440

[1]The stage discharge function shows the same standard deviations and same stages for discharges corresponding to the 250- and 500-year event for 4 NWB, 133-, 250-, and 500 year event for 5 NWB, and for discharges corresponding to the 66- through 500-year event for 6 LR; therefore, computed damages are the same.

The HEC-FDA model computes expected annual damages using a Monte Carlo simulation process. Expected annual damages are calculated for a 2012 base year by damage reach in multiple iterations using standard discounting procedures. Future conditions are assumed to be the same as Base Year.

Table 15: Total Without Project Condition Expected Annual Damages

Santa Cruz River		Old & New West Brach Rivers And Los Reales Floodplains	
Reach	Base Year	Reach	Base Year
1 SC	$69,870	OWB	$406,212
2 SC	$110,950	1 NWB	$141,330
3 SC	$258,480	2 NWB	$64,260
5 SC	$81,940	LR	$107,740
Total	$521,250	Total	$719,542

Tables 16 and 17 summarize without project expected annual damages by reach for base year conditions for the Santa Cruz, the Old & New West Branches, and Los Reales floodplains, respectively.

Table 16: Without Project Conditions:
The Santa Cruz Floodplain Expected Annual Damages

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
1 SC	$38,030	$29,390	$310	$2,140	$0	$69,870
2 SC	$24,770	$39,730	$24,970	$19,770	$1,710	$110,950
3 SC	$27,690	$97,960	$106,150	$15,600	$11,100	$258,480
5 SC	$77,810	$4,140	$0	$0	$0	$81,940
Total	$168,300	$171,210	$131.42	$37,510	$12,810	$521,250

Table 17: Without Project Conditions
The Old & New West Branch Rivers and Los Reales Floodplain Expected Annual Damages

Reach	Residential			Nonresidential		Total
	SFR	MFR	MH	Commercial	Public	
OWB	$48,075	$0	$357,820	$317	$0	$406,212
1 NWB	$0	$0	$141,330	$0	$0	$141,330
2 NWB	$51,000	$0	$0	$0	$13,260	$64,260
LR	$99,320	$3,190	$3,100	$980	$1,150	$107,740
Total	$198,395	$3,190	$622,910	$1,297	$14,410	$719,542

Emergency Response Damages:

Due to the limited amount of information available concerning emergency response costs along the Santa Cruz River, the Old West Branch, and the New West Branch areas, emergency response cost estimates will be based on estimates derived in the January 1993 Flood Damage Summary Report written by the Pima County Department of Transportation and Flood Control District. In the report, Pima County has provided limited information on the emergency response cost to residents as they evacuate, relocate and, reoccupy their residence during a flood event. Based on the experience of residents who were flooded in the 1993 flood, the temporary relocation cost was approximately $1,400 per resident. This number was applied to the number of residences in the 500-year floodplain and was used along with a non-damaging frequency of a 100-year event (Paseo de las Iglesias) and 25-year event (New West Branch including Los Reales) to perform equivalent annual damages. The equivalent annual damages (EAD) to residents due to flooding along the Paseo de las Iglesias portion of the Santa Cruz River is $11,043, along the Old West Branch of the Santa Cruz River is $77,539, and along the New West Branch including the Los Reales area of the Santa Cruz River is $33,117.

Traffic Damages:

Typically, expected annual traffic damages are estimated based upon delineations of floodplain areas with inundation levels exceeding one foot and durations of flooding. However, Hydrology and Hydraulics used the steady state or peak flow method in computing overflows. This method does not allow for a means to estimate durations of flooding by flooding event; therefore, traditional methods of computing traffic damages will not be used. Instead, traffic damages are estimated as a single event assuming traffic flow will be disrupted for a day no matter what the duration. Even if the duration is of a 500-year flood lasts less than a day, traffic is expected to be affected and roads blocked for approximately a day.

Vehicle delay and operation damages are calculated using procedures detailed in US Army Corps of Engineers Guidance entitled ER 1105-2-100. The procedures used to determine vehicle delay and operation costs are detailed below.

Vehicle Delays:

1. Vehicles per Day * Detour Miles = Total Vehicle Detour Miles

2. Total Vehicle Detour Miles/ 55 mph = Time of Total Detour Vehicles

3. Time of Total Detour Vehicles * Traffic Delay Costs (derived using a predetermined percentage of before tax income depending on the purpose of the trip and time of delay) = Potential Damages Resulting from Delays

Operating Costs:

1. Operating Costs (determined by the American Automobile Association) * Vehicles per Day * Detour Miles = Total Operating Costs

According to this analysis, the Santa Cruz River could cause temporary closures of Drexel Road, Ajo Way, Silverlake Road, 22nd Street, and Congress Street. These roads carry 5,400, 34,600, 12,000, 21,700, and 17,200 vehicles per day respectively, while vehicle detour miles traveled from closures along these roads are: 2.7, 3.7, 7.0, 7.9, and 10.0, respectively. Total vehicle detour miles traveled per day are: Drexel Road: 14,580, Ajo Way: 128,020, Silverlake Road: 84,000, 22nd Street: 171,430, and Congress Road: 172,000. At a detour speed limit of 55 miles per hour, the time involved is 265 along Drexel Road, 2,327 along Ajo Way, 1,527 hours along Silverlake Road, 3,116 hours along 22nd Street, and 3,127 hours along Congress Road. Using a traffic delay cost of $1.40 and $7.06 per hour depending on the length of the delay, potential damages resulting from delays are $371, $3,257, $10,780, $21,998, $22,076 respectively for the five roads. At an operation cost of 38 cents per mile, the potential annual damage is $216,611. Total vehicle delay and operation damages equal $275,093 while average annual vehicle delay and operation damages equal $24,134.

Table 18: Vehicle Delay and Operation Damages

Street	Vehicle Delay Damages	Vehicle Operation Damages	Total
Drexel Road	$371	$5,540	$5,911
Ajo Way	$3,257	$48,648	$51,905
Silverlake Road	$10,780	$31,920	$42,700
22nd Street	$21,998	$65,143	$87,141
Congress Street	$22,076	$65,360	$87,436
Total	$58,482	$216,611	$275,093
Expected Annual Damages[1]	$3,556	$20,578	$24,134

[1]EAD determined based upon 100-year non-damaging and delays based upon 500-year flood.

Erosion Analysis:

Background:

This bank erosion study is limited to the Santa Cruz River. The Old West Branch was not analyzed due to environmental and public acceptability constraints. The New West Branch and Los Reales channels have existing structural bank protection and were not analyzed.

History:

The following describes the channel changing process that occurred along the Santa Cruz River. Between 1915 and 1929, extensive arroyo widening occurred during 1914 through 1915 floods throughout the Congress Street area. During this time the Congress Bridge was destroyed. Between 1930 and 1959, extensive widening occurred between Speedway Boulevard and Grant Road (The area is north of the study area.) and channel degradation began during the later years. Between 1960 and 1986 the arroyo widths were generally stable. There was apparent narrowing at some locations caused by channels and landfill operations. As much as 15 ft of channel incision occurred. There was substantial channel bank wall migration along unprotected segments as a result of the 1983 flood.

Existing Bank Protection:

Excluded from the lateral erosion analysis assessment were the areas where the banks have already been stabilized with soil cement. These specific areas are located along both sides of the Santa Cruz River channel from Congress Street to 300 feet upstream to Silverlake Road and between Ajo Way and Irvington Road and near Valencia Road.

Damage Analysis:

In the areas without bank protection, the channel will eventually migrate and erode the foundation material below adjacent single-family residences and mobile homes. Below is Table 19 which shows the number of structures affected by reach.

Table 19: Affected Structures Along the Santa Cruz River

Reach	Cross Streets	Number of Structures Affected
SC 2	22nd Street Ajo Way	53
SC 4	Irvington Road Drexel Road	7
SC 5	Drexel Road Valencia Road	10
Total		70

Structure and content values are computed for affected structures and are estimated upon square footage obtained from tax assessor records. (Steps 1 through 5 were followed from the flood control analysis section, value of structures subsection on Page 8). For single- family residences average square footage is 1,555 while average square footage for mobile homes is 1,250. Total structure and content value and average structure and content value are listed in Table 20.

Table 20: Structure & Content Values of Affected Structures

Reach	Number	Total Structure Value[1]	Total Content Value	Average Structure Value	Average Content Value
SC 2	53	$1,977,854	$988,927	$37,318	$18,659
SC 4	7	$832,594	$416,297	$118,942	$59,471
SC 5	10	$1,189,420	$594,710	$118,942	$59,471
Total		$3,999,868	$1,999,934	$275,202	$137,601

[1]Sturcture Value includes an $11,000 demolition cost.

With structure and content value determined, damages can be assessed using an estimated erosion rate detailed in Table 21 and setback distances. Table 21 summarizes the amount of bank erosion between 1941 and 2002. The erosion rate per year for each bank was determined by dividing the migration amount by the number of years between the photographs. In other words, the migration rate was placed in linear form from the historical data.

Table 21: Bank Erosion Between 1941-2002

Year	Bank Width[1]	Lt. Bank Erosion	Rt. Bank Erosion	Lt. Bank Erosion Rate Per Year	Rt Bank Erosion Rate Per Year
Station 34.43					
1941	180				
1960	130	40	60	2	3
2002	650	350	170	8	4
Station 35.66					
1941	220				
1960	250	420	380	22	20
2002	330	380	460	9	11
Station 37.50					
1941	610				
1960	360	340	680	18	36
2002	890	380	850	9	20

[1]Bank width does not increase over time because the channel does not remains stationary and does not increase uniformly. The Santa Cruz River meanders and changes locations over time. Over time one bank may decrease in width while the other may increase. For this reason, erosion for the left and right bank also does not add up to bank width.

The determination of setback distances, the distances from the edge of structures to the bank sides, is estimated from aerial photographs. For this analysis, a ten-foot minimum is assumed before a particular structure will be vulnerable to slippage or collapse into the Santa Cruz River. Once erosion line reaches within 10 feet of the structure it is considered totally destroyed and demolished. This study also assumes homeowners will have enough time to remove half of their personnel contents from their homes before the homes are destroyed. In addition, this study assumes homeowners will be responsible for demolition of these homes when the property setback distance equals the vulnerable distance. Demolition costs are estimated to be $11,000 per structure. Relocation is also assumed because a portion of the homeowners is expected to relocate at an estimate of $10,000 per structure.

The setback distance is divided by the annual erosion rate for a given location to compute how many years it will take before a structure is destroyed. In that given year, the structure is considered destroyed and demolished. The present value is than taken and annualized over 50 year using the current discount rate of 5.625%. Table 22 shows annualized damages for affected structures in three reaches.

Table 22: Present Value and Annualized Damages for Affected Structures

Reach	Present Value	Annualized Damages
SC 2	$671,329	$40,379
SC 4	$82,558	$4,966
SC 5	$130,482	$7,848
Total	$884,370	$53,193

Environmental Restoration Analysis:

Hydrogeomorphic (HGM) Description:

The HydroGeoMorphic Assessment of Wetlands approach (HGM) was developed specifically to reduce the level of variability exhibited by significant changes in wetland function. HGM identifies groups of wetlands that function similarly using three criteria (geomorphic setting, water source, and hydrodynamics) that fundamentally influence how wetlands function. Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of its geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process. Classifying wetlands based on how they function, narrows the focus of attention to a specific type or subclass of wetland, the functions that wetlands within the subclass are most likely to perform, and the landscape/ecosystem factors that are most likely to influence how wetlands in the subclass function.

Arizona Riverine Model Development

Since there is not a regional guidebook completed specifically for the arid riverine environment in Arizona, existing models were studied. The focus was narrowed to how the functions of a particular riverine overbank subclass would perform and the characteristics of the ecosystem and landscape controls of those functions. Since the riverine over bank subclass is the most applicable to the environment, the riverine overbank subclass was further modified to apply to Arizona's low gradient rivers.

A workshop was held to bring together regional experts and seek their input on modifying the model to be applicable to Arizona Rivers. Workshop participants included the Environmental Lab (EL) of the Engineering Research and Development Center (ERDC), the US Army Corps of Engineers (Los Angeles District Corps staff), local sponsor representatives from the City of Phoenix, City of Tucson, Town of Marana, Pima County Flood Control District, and Salt River Pima Maricopa Community, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and representatives from the scientific community.

The workshop identified ten functions that were deemed important to the success of the riverine overbank subclass. They were selected on the basis of their representation of ongoing critical ecosystem processes within the riverine overbank. The top three functions rated according to their importance in the riverine overbank subclass are Functions 2, 4, and 8.

Table 23: Riverine Overbank Subclass Functions

Functions Related to the Hydrologic Processes	Description
1. Maintenance of Characteristic Dynamics	The 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).
2. Dynamic Surface Water Storage and Energy Dissipation	The dynamic water storage and dissipation of energy at bank full 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.
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.
4. Dynamic Subsurface Water Storage	The availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic draw down of water table.
Functions Related to Biogeochemical Processes	**Description**
5. Nutrient Cycling	The abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
6. Detention of Imported Elements and Compounds	The detention of imported nutrients, contaminants, and other elements or compounds.
7. Detention of Particles	The deposition and detention of inorganic and organic particulates (>0.45 um) from the Water column, primarily through physical processes.
Functions Related to Habitat	**Description**
8. Maintain Characteristic Plant Communities	The 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.
9. Maintain Spatial Structure of Habitat	The capacity of a wetland to support animal populations and guilds by providing Heterogeneous habitats.
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.

All ten functions are associated with each cover type. Cover types are designated by Partial Wetland Assessment Areas (PWAAs). They are homogenous zones of vegetation, geographic similarities, and physical conditions that make the area unique. PWAAs are defined on the basis of species recognition and dependence, soils types, and topography. Out of nineteen designated cover types, four major cover types are ranked in order as follows:

1. *Mesquite Woodlands (Bosque)*--Mesquite woodlands historically occurred over large areas within the river floodplain and on higher terraces along Arizona rivers. These communities have been nearly eliminated from these riparian ecosystems by changes to natural processes.

2. *Cottonwood-Willow Gallery 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. In terms of height, basal area, and density, Fremont Cottonwood (*Populus fremontii, sp.*) and Gooding's Willow (*Salix gooddingii*) are dominant canopy species in the Cottonwood-Willow associations with many of the original stands being replaced by the invasive and non-native Salt Cedar (*Tamarix, sp.*). They are further characterized by having diverse assemblages of plant and animal species in comparison with adjacent upland areas. 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.

3. *Scrub-Shrub Vegetative Associations*--Scrub-Shrub plant communities are common along Arizona Rivers and streams, and are often present within the active channel. They are dominated by various combinations of Burrobush (*Hymenoclea, sp.)*, Bursage (*Ambrosia dumosa*), Quailbush (*Atriplex lentiformis*), Four-wing Saltbush (*Atriplex canescens*), and occasionally by Creosote bush (*Larrea tridentata*). Many of these areas have been highly disturbed from off-road vehicle traffic and sand and gravel mining activities, and contain little or no vegetation cover.

4. *Riverbottom*--The riverbottom had gravel and sandbars within the channel and any grassland or other emergents existing within the channel.

Table 24 shows a more detailed breakdown of cover type by PWAA. Of the 5,005 acres in the Paseo de las Iglesias study area, the US Army Corps of Engineers, LA District identified 19 distinct cover types. These cover types and their respective without project baseline acreages can be found in the table below.

Table 24: Detailed Breakdown of Cover Type by PWAA

Number	Code	Partial Wetland Assessment Areas (PWAAs)	Target Year PWAAs (PWAA Relative Acres)				
			Yr 0	Yr 1	Yr 6	Yr 26	Yr 51
1	AGCROP	Farms and Cropland—Dairy, Cotton, and Alfalfa; Hobby Farms, Fallow Grounds	416.00	416.00	354.00	354.00	354.00
2	BUFFER	Existing Buffer Zones—Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Arcacia, Palo Verde, and Creosote	0.00	0.00	0.00	0.00	0.00
3	CTWFOR	Existing Cottonwood-Willow Forest in the Study Area	0.00	0.00	0.00	0.00	0.00
4	DESERT	Desert Areas—Cacti, Rabbitbush, Acacia, and Creosote	237.00	237.00	159.00	81.00	0.00
5	DITCHES	Ditches	99.00	99.00	115.00	131.00	148.00
6	MESQUITE	Existing Mesquite Woodlands—on the Terraces and in the Project Area	160.00	160.00	73.00	0.00	0.00
7	NEWBUFFER	Newly Developed Upland Buffer Zones—Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00	0.00	0.00	0.00	0.00
8	NEWCWWFOR	Newly Developed Cottonwood—Willow Forests in Project Area	0.00	0.00	0.00	0.00	0.00
9	NEWMESQUIT	Newly Developed Mesquite Woodlands—on the Terraces and in the Project Area	0.00	0.00	0.00	0.00	0.00
10	NEWOPENWATER	Newly Developed Open Water Areas in the Project Area	0.00	0.00	0.00	0.00	0.00
11	NEWRVRBOTTOM	Newly Developed River Bottom Areas in the Project Area—Largely Unvegetated (Includes Emergents)	0.00	0.00	0.00	0.00	0.00
12	NEWSCRUB	Newly Developed Scrub—Shrublands in the Project Area	0.00	0.00	0.00	0.00	0.00
13	OPEN WATER	Existing Open Water Areas in the Project Area	0.00	0.00	0.00	0.00	0.00
14	PARKS	Parks and Recreation Areas	86.00	86.00	86.00	86.00	86.00
15	RIVERBOTTOM	Existing River Bottom Areas in the Project Area—Largely Unvegetated (Includes Emergents, Low Flow Channel, and shallow pools)	173.00	173.00	173.00	173.00	173.00
16	SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Project Area	0.00	0.00	0.00	0.00	0.00
17	SCRUBSHRUB	Existing Scrub-Shrublands in the Project Area—Rabbitbush, Quailbush, Ironwood, Saltbush, Desert Broom, and Burrobrush	256.00	256.00	172.00	86.00	0.00
18	SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Project Area	21.00	21.00	32.00	32.00	32.00
19	URBAN	Existing Residential, Industrial, and Transportation Avenue, Bare Earth, Landfills	3557	3557	3841	4062	4212
Total			5005	5005	5005	5005	5005

Table 24 shows that out of the four main categories of cover types, Mesquite woodland, the most valuable, is expected to decline by approximately half by target year (TY) 6 before declining to zero by TY 26 while Cottonwood forest, ranked second, will remain at zero throughout the project life. The third rated cover type, Scrub-Shrub, will maintain the same PWAA until TY 1 than decline by one third by TY 6 and than decline another one third by TY 26. Scrub-Shrub will eventually decline to zero by year 50. The forth and last rated cover type, riverbottom, will remain at 173 throughout the project life.

HGM Methodology

In HGM, wetland functions represent the currency or units of the wetland system for assessment purposes, but the integrity of the system is not disconnected from each function, rather it represents the collective interaction of all wetland functions. Functional capacity is simply the ability of a wetland to perform a function compared to the level of performance in reference standard wetlands. The HGM methodology is based on a series of predictive Functional Capacity Indices (FCIs). An index capacity is how a wetland performs a function relative to other wetlands from a regional wetland subclass in a reference domain. FCIs are by definition scaled from 0.0 to 1.0. 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. 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.

HGM combines both the wetland functionality (FCIs) and quantity (PWAA) of a site to generate a measure of change referred to as Functional Capacity Units (FCUs). Once the FCI and Partial Wetland Assessment Area (PWAA) quantities have been determined, the FCU values can be mathematically derived with the following equation: FCU = FCI x Area (measured in acres). Under the HGM methodology, 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 TYs. In such analyses, future wetland conditions are estimated for both the 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. Table 25 below shows AAFCUs by function for the Paseo de las Iglesias study area.

HGM will be used to evaluate future conditions and the long-term affects of proposed alternatives by generating FCUs for wetland functions over the project life. In such analyses, future conditions are estimated for both the without project and with project conditions. Projected long-term outputs of the project are reported in terms of AAFCUs. Outputs of each alternative will be compared with the goal to maximize project benefits.

Table 25: FCI, Applicable Acres, and AAFCUs by Function

Target Year	Function Name	Weighted Functional Capacity Index (FCI)	Applicable Acres	Cumulative Average Annual Functional Capacity Units (CUM AAFCUs)	Average Annual Functional Capacity Units (AAFCUs)
0	Fxn 01: Maintenance of Characteristic Dynamics	0.200	589.00	117.80	59.91
1	Fxn 01: Maintenance of Characteristic Dynamics	0.200	589.00	503.50	
6	Fxn 01: Maintenance of Characteristic Dynamics	0.200	418.00	1354.00	
26	Fxn 01: Maintenance of Characteristic Dynamics	0.200	259.00	1080.00	
51	Fxn 01: Maintenance of Characteristic Dynamics	0.200	173.00	-	
0	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.692	589.00	407.86	204.12
1	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.692	589.00	1761.30	
6	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.708	418.00	4682.08	
26	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.673	259.00	3558.96	
51	Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.643	173.00	-	
0	Fxn 03: Long Term Surface Water Storage	0.188	589.00	110.75	56.32
1	Fxn 03: Long Term Surface Water Storage	0.188	589.00	473.37	
6	Fxn 03: Long Term Surface Water Storage	0.188	418.00	1272.96	
26	Fxn 03: Long Term Surface Water Storage	0.188	259.00	1015.36	
51	Fxn 03: Long Term Surface Water Storage	0.188	173.00	-	
0	Fxn 04: Dynamic Subsurface Water Storage	0.000	589.00	0.00	0.00
1	Fxn 04: Dynamic Subsurface Water Storage	0.000	589.00	0.00	
6	Fxn 04: Dynamic Subsurface Water Storage	0.000	418.00	0.00	
26	Fxn 04: Dynamic Subsurface Water Storage	0.000	259.00	0.00	
51	Fxn 04: Dynamic Subsurface Water Storage	0.000	173.00	-	
0	Fxn 05: Nutrient Cycling	0.339	589.00	199.88	72.97
1	Fxn 05: Nutrient Cycling	0.339	589.00	861.98	
6	Fxn 05: Nutrient Cycling	0.346	418.00	1970.75	
26	Fxn 05: Nutrient Cycling	0.227	259.00	689.07	
51	Fxn 05: Nutrient Cycling	0.014	173.00	-	
0	Fxn 06: Detention of Imported Elements and Compounds	0.297	589.00	174.93	79.39
1	Fxn 06: Detention of Imported Elements and Compounds	0.297	589.00	745.25	
6	Fxn 06: Detention of Imported Elements and Compounds	0.295	418.00	1893.48	
26	Fxn 06: Detention of Imported Elements and Compounds	0.262	259.00	1235.25	
51	Fxn 06: Detention of Imported Elements and Compounds	0.191	173.00	-	
0	Fxn 07: Detention of Particles	0.329	589.00	193.61	95.15
1	Fxn 07: Detention of Particles	0.329	589.00	843.62	
6	Fxn 07: Detention of Particles	0.342	418.00	2213.83	
26	Fxn 07: Detention of Particles	0.309	259.00	1601.39	
51	Fxn 07: Detention of Particles	0.282	173.00	-	
0	Fxn 08: Maintain Characteristic Plant Communities	0.168	589.00	98.72	41.18
1	Fxn 08: Maintain Characteristic Plant Communities	0.168	589.00	419.51	
6	Fxn 08: Maintain Characteristic Plant Communities	0.166	418.00	1013.73	
26	Fxn 08: Maintain Characteristic Plant Communities	0.131	259.00	567.98	
51	Fxn 08: Maintain Characteristic Plant Communities	0.075	173.00	-	
0	Fxn 09: Maintain Spatial Structure of Habitat	0.204	589.00	120.40	51.19
1	Fxn 09: Maintain Spatial Structure of Habitat	0.204	589.00	514.30	
6	Fxn 09: Maintain Spatial Structure of Habitat	0.204	418.00	1249.72	
26	Fxn 09: Maintain Spatial Structure of Habitat	0.162	259.00	726.36	
51	Fxn 09: Maintain Spatial Structure of Habitat	0.103	173.00	-	
0	Fxn 10: Maintain Interspersion and Connectivity	0.197	589.00	115.88	49.33
1	Fxn 10: Maintain Interspersion and Connectivity	0.197	589.00	475.39	
6	Fxn 10: Maintain Interspersion and Connectivity	0.180	418.00	1152.25	
26	Fxn 10: Maintain Interspersion and Connectivity	0.159	259.00	772.06	
51	Fxn 10: Maintain Interspersion and Connectivity	0.125	173.00	-	

Recreation Analysis:

For the purpose of this analysis, local parks will be surveyed to show existing recreation in the area. One more park, the Santa Cruz River Park will be added to the list and discussed in detail because a portion of it exists within the Paseo de las Iglesias study area. The Santa Cruz River Park may represent a model for a possible future plan to extend the existing park within the Paseo de las Iglesias study area. Another possible future plan, identified by the City of Tucson, to restore a segment of the Paseo de las Iglesias that lies within the Rio Nuevo District may overlap in some aspects with the scope of this Feasibility Study. The future recreational needs of the Paseo de las Iglesias can be supported through a discussion of recreational demand and the unit day value method.

Parks Within Study Area:

The following shows the names of parks in close vicinity to the Paseo de las Iglesias. (See addendum for a complete list of County and City Parks in the Pima County/Tucson metropolitan area.)

Sentinel Peak Park--Sentinel Peak Park is located at 1000 S. Sentinel Peak Road and is a regional park approximately 272.93 acres.

El Presidio Plaza Park--El Presidio Plaza Park is located at 160 W. Alameda Street and is classified as a neighborhood park. It has drinking fountains, dusk to dawn lights, and public art. The area of the park is 2.75 acres.

Oaktree Park--Oaktree Park is located at 5433 S. Oaktree Drive. It has a basketball court, a multiple use field, two picnic sites, a playground, a ramada, a drinking fountain, and a BBQ grill. This neighborhood park is about 7.29 acres.

Ormsby Park--Ormsby Park, a neighborhood park, is located at 24th street and Verdugo Avenue. The facilities include: bathrooms, a recreation center, a basketball court, a picnic site, a playground, a softball field, a volleyball court, two drinking fountains, and a BBQ grill. These facilities are on a 4.77 acres parcel.

Richey Elementary School--Richey elementary school is located at 2209 N. 15th Avenue. Even though, the park is part of the school grounds it is still considered a neighborhood park. The park offers two basketball courts, a multi-use path, a playground, a ramada. Total acres equal 3.67.

Veinte De Agosto Park--Veinte De Agosto Park is located at the intersection of Broadway Boulevard and Church Avenue. This neighborhood park offers public art on 1.02 acres.

Garden of Gethsemane--The Garden of Gethsemane, a mini park on .27 acres, is located at 602 W. Congress Avenue. It has life-size concrete religious statues on display.

Verdugo Park--Verdugo Park is located at the intersection of 19th street and Verdugo Avenue. It is a mini park, approximately .47 acres, with a picnic site, a playground, a drinking fountain, and a BBQ grill.

John F. Kennedy Park--John F. Kennedy Park is located at Ajo Way and Mission Road and is considered a metro park. The park has two basketball courts, five restrooms, soccer fields, private boating, fishing lake, a basketball court, two multi-use fields, an amphitheatre, six picnic sites, three playgrounds, thirty nine ramadas, a swimming pool, two tennis courts, seventeen drinking fountains, and forty five BBQ grills. The park encompasses 167.59 acres.

Paseo De Los Arboles Commemorative Park--The Park is located on the west side of the Santa Cruz River Park and Irvington. The Park offers a multi-use trail and water fountains.

Paseo De Lupe Eckstrom (Tucson Diversion Channel)--Paseo De Lupe Eckstrom Park is located at 10th avenue near 39th street. The park is ADA accessible. It also has a multi-use path, restrooms, drinking fountains, picnic areas, ramadas, and public art.

Cardinal Neighborhood Park--Cardinal Neighborhood Park is located at 6925 S. Cardinal Avenue. The park has baseball and softball fields, a walking path, a playground, a picnic area, an exercise station, a horseshoe pit, a lighted basketball court, a ramada, restrooms, and drinking water fountains.

Mission Ridge Neighborhood Park--At 3300 W. Tucker Street, Mission Ridge Neighborhood Park has basketball courts, a baseball field, a picnic area, a ramada, a playground, restrooms, and drinking water fountains.

Winston Reynolds-Manzanita District Park--Located at 5200 S. Westover Avenue, the park has tennis courts, a volleyball court lighted baseball, football, and soccer fields, a lighted basketball court, a playground, a swimming pool, ramadas, a BMX track, a concession building, horseshoe pits and restrooms.

Santa Cruz River Park:

In addition to the parks listed above, there is one more park: the Santa Cruz River Park. The Santa Cruz River Park is located west of Interstate 10 and 19. It was constructed in stages. The most recent section, Silverlake Road to Grant Road (Congress to Silverlake is within the study area), was completed in 1993. This river park includes pedestrian and bicycle trails, a frisbee golf course, exercise courses, restrooms, drinking fountains, ramadas, picnic sites, BBQ grills, playgrounds, parking, and art projects. The section between Irvington Road and Ajo Way (all within the study area) was completed in 1992 and includes pedestrian and bicycle trails, a picnic area, and an exercise course.

Table 26 lists visitation figures for the Santa Cruz River Park River Park by month for three years, 1999 through 2001. The Pima County Parks and Recreation Department provided this data. It was collected through the use of a laser counting device located at one point along the Santa Cruz River Park. The data shows attendance figure declined substantially along the Santa Cruz River Park.

Table 26: Attendance Figures for the Santa Cruz River Parks

Month	Santa Cruz River Park		
	1999	2000	2001
January	21,682	3,667	3,588
February	16,530	5,272	3,546
March	18,721	6,437	4,584
April	13,288	5,017	4,186
May	Broken	3,507	4,155
June	9,633	3,961	3,229
July	10,113	2,058	1,321
August	7,471	4,936	2,531
September	9,256	2,364	3,143
October	8,502	4,302	2,126
November	2,794	2,798	2,533
December	4,670	4,286	1,683
Totals	122,660[1]	48,605	36,625

[1]The large drop in attendance from 1999 to 2000 may be due to the completion of the Rillito River Park a larger park located northeast from the Santa Cruz River Park. Also, there may be an error in the method used to calculate attendance during 1999.

Future river parks are planned for Tanque Verde Creek and Pantano Wash. Design work has been completed for sections of River Park along Canada del Oro from Thornydale Rd. to Magee Rd., along Tanque Verde Creek from Sabino Canyon to Tanque Verde Rd. and along Pantano Wash from Tanque Verde Rd to Golf Links Rd. Together the Santa Cruz, Rillito, Tanque Verde Creek, and Pantano Wash River Parks will function as one large unified trail system.

Future Recreation Facilities:

The City of Tucson has produced the Rio Nuevo Master Plan, which will create "a network of unique experience areas, linked by shaded plazas which connect new cultural, civic, entertainment, and business uses interwoven in a historically accurate and aesthetically pleasing manner throughout the Rio Nuevo District." Some of the environmental restoration and recreation aspects of this plan may be applied to future plans detailed later in the Feasibility process. The boundaries of this revitalization effort are Congress Street to the North, 22nd Street to the South, I-10 to the East, and Mission Road to the West.

Central to this project is the Santa Cruz River that may be converted into a linear greenbelt. Included in this effort are restored river terraces, islands and sandbars, and new weirs and ponds to slow and collect reclaimed water to ensure a healthy ecosystem and wildlife corridor through the core of downtown Tucson. Cottonwoods, Willows, Arizona Ash and other riparian trees and shrubs are planned for planting along the River to provide habitat for wildlife and contribute to pollination and seed dispersal.

Sentinel Peak Mountain over looks the City of Tucson and is included in the Rio Nuevo Plan. The proposal is to restore the mesquite shrub land that existed when Indian burials occurred there. Additionally, the plan proposes that the mountain be connected to the river through the creation of restored mesquite/paloverde upland habitat. This upland habitat will function as a wilderness park with nature paths that cross a series of carefully recreated habitats that interpret the pertinent Sonoran Habitats.

At the base of Shook-Shon Mountain, a natural Cienega of Sonoran Desert Marsh will be created to provide a watering hole for reintroduced wildlife. This Cienega will function as a sanctuary for flora and fauna and provide opportunities for interactive recreation such as bird watching and learning.

As part of the recreation development effort detailed by the City the following three parks have been introduced as part of the Rio Nuevo Project. They are located in close proximity to and immediately west of the Santa Cruz River. They are not likely to be a part of plan development for this Feasibility Study because they are not directly related to the restoration project along the Santa Cruz River..

1. Tucson Origins Cultural Park (2002-2005)
   Requiring: approx. 10 acres
   Attendance: 200,00 visitors per year

2. Sentinel Peak Nature Park (2006)
   Requiring: approx. 20-30 acres
   Attendance: 100,000 visitors per year

3. Rancho Chuk-Shon (2003-2006)
   Requiring: approx. 2-3 acres
   Attendance: 50,000-100,000 visitors per year

Recreation Demand:

Many factors contribute to make the proposed riparian habitat area along the Paseo de las Iglesias and New and Old West Branch study areas attractive in terms of recreation potential and unmet demand. They include:

1. *Recreation Experience*--Proposed general recreation activities that may be included in plans formulated later in the study process include trails for hiking, biking, and jogging. These activities are the fastest growing activities throughout Arizona according to the Arizona Trails 2000 document. Throughout Arizona walking and hiking ranks at 78% annually followed by bicycling at 36% and jogging at 28%. All activities rank higher than the national average except for jogging. Nationally, walking ranks at 67%, hiking at 33%, bicycling at 31%, and jogging at 70%. Among the activities identified, most have significant unmet demand.

2. *Availability of Opportunity*--In the past, demand for trail opportunities was fulfilled by the County's many back trails. But, as the County continues to grow, the demand has increased for urban trails and other recreation opportunities close to home. Future facilities along the Paseo de las Iglesias and New West Branch would likely provide opportunity for many urban individuals to recreate close to their homes, work, and downtown. Currently, several parks exist within on hour of travel time and a few exist within 30 minutes travel time for most urban individuals living in Tucson, but only one river park trail system exists which will provide a unique availability. According to Arizona Trails 2000 published under the authority of the Arizona State Parks Board, the number one reason given by trail users for preferring a particular area is its proximity to home (56%).

3. *Carrying Capacity*--As previously discussed, Pima County has experienced rapid population growth. Pima County's MSA population is 843,746 at year 2000 and is expected to reach 1,518,000 by year 2025—a difference of 674,254 over 25 years. With this increase in population comes and increased demand for recreational facilities proposed for this study. At present, facilities at the park are adequate to conduct activities and promote public health and safety at the park, but as population grows, the need for more facilities may grow.

4. *Accessibility*--According to 43% of the Arizona Tails 2000 survey respondents, loss of access to trails is the top three most important issues facing trails today. This is not the case for the facilities that are easily and quickly accessible to the public. There are also two interstates (10 and 19) and several crossroads that intersect the study areas. This provides a park area in high demand with considerable access not only by automobile but also by pedestrians.

5. *Environmental*--As demonstrated earlier, there are several recreation areas located in the study area. Of these parks, there are no significant thriving riparian areas. The Paseo de las Iglesias and New and Old West Branch Areas of the Santa Cruz have pockets of riparian vegetation but remain significantly degraded and are not considered to be a thriving habitat for plants and animals. Other parks in the area have dessert terrain and are not in riparian areas. This lack of riparian habitat is expected to result in significant unmet recreational demand.

According to County and City officials with the Park and Recreation Department the use of population based standards represents one of the most widely used methods for assessing community demand and the need for open space and recreation. This is attributed to the fact that they are easily understood and convenient. Such standards are considered most useful as a means for determining whether the supply of recreational resources is lacking behind demand that is supported by population growth. These standards also aid in supporting visitation data. The City of Tucson Parks and Recreation Department describes national standards for park type (mini park, neighborhood park, community park, metro park, and regional park) that have been established. The National Recreation and Parks Association (NRPA) set these standards. They are compared to current service levels and set by the City of Tucson for the Core/Mid City region and the Edge/Future City region. The following tables summarize this data.

Table 27: Park Type, Standard Park Size, and Service Radius

Park Type	Park Size	Service Radius
Mini Park	0-1 acre	¼ mile
Neighborhood Park	1-15 acres	½ mile
Community Park	15-40 acres	1 mile
Metro Park	40-200 acres	2 ½ miles
Regional Park	>200 acres	7 miles

Table 28: Recreation Demand

Facility Type	Current Ratio	National Guidelines	COT Core/Mid-City Guidelines	COT Edge/Future City Guidelines
Mini Park[1]	.01 ac/1,000	N/A	N/A	N/A
Neighborhood Park	1.1 ac/1,000	2.5 ac/1,000	2.5 ac/1,000	2.5 ac/1,000
Community Park	1.0 ac/1,000	3.0 ac/1,000	3.0 ac/1,000	3.0 ac/1,000
Metro Park	3.0 ac/1,000	N/A[2]	3.0 ac/1,000	3.5 ac/1,000
Regional Park	1.3 ac/1,000	2.0 ac/1,000	1.0 ac/1,000	2.0 ac/1,000
Total	5.9 ac/1,000	10.0 ac/1,000	9.5 ac/1,000	11.0 ac/1,000

[1]N/A is placed in the row of cells for mini park because the City of Tucson Park and Recreation Department no longer plans to construct this type of park; therefore, any acre per population guideline is no longer applicable.

[2]There are no national guidelines for metro park, so this guideline is not applicable.

As the above data indicates, the current ratio of acres per 1,000 population is lower in most cases than the National and City Guidelines. A lack of sufficient recreation resources exists for all the types of parks except for metro and regional parks. Currently, existing metro parks have met population needs in the core/mid-city area but not the edge/future city region. Regional parks have also met demand for the Core/Mid City area but not the Edge/Future City. Unless a significant number of recreation facilities are built, the projected population growth (2010) will make the existing deficit and surplus become worse.

Table 29: Additional Park Facilities Needed to Achieve Guidelines

Facility Type	Existing 2001	COT Core/Mid-City 2010	COT Edge/Future City 2010	Total 2010
Mini Park	5 acres	N/A	N/A	N/A
Neighborhood Park	515 acres	176 acres	333 acres	509 acres
Community Park	504 acres	745 acres	364 acres	1,109 acres
Metro Park	1,450 acres	0 acres	188 acres	188 acres
Regional Park	619 acres	0 acres	0 acres	0 acres
Total	3,093 acres	921 acres	885 acres	1,806 acres

Multi-Use Path	37 miles

Table 29 shows an estimate of the additional park facilities needed to achieve demand guidelines by 2010. For most of the facility types there is a need for additional parks except for Metro and Regional parks. Metro parks have met guidelines for the Core/Mid-City area so no new projections were estimated. Regional parks, on the other hand, have not met guidelines for both Core/Mid-City and Edge/Future City, but the City of Tucson Parks Department has decided to limit additional parks in this category. The estimated number of total park acres needed to fill demand by 2010 is 1,806. Also, an estimate of 37 miles of multi-use path is needed by 2010 to meet demand guidelines. The need will be even higher throughout the study period.

Unit Day Value Method:

For this analysis the Unit Day Value (UDV) method is used for the economic evaluation of the recreational features along the Paseo de Las Iglesias. The method uses administratively set dollar values to determine the worth of recreational experiences and calculates the value of recreation. This value is an approximation of the area under the site demand curve or otherwise known as willingness to pay. To obtain this value you must first select specific points from a range of values provided in Planning, Principles, and Guidelines (ER-1105-2-100). A table of criteria and point values is shown below:

Table 30: Criteria and Point Values

Criteria	Key Variable	Range of Point Values
Recreation Experience	Number of key activities	0-30
Availability of Opportunity	# of similar opportunities nearby	0-18
Carrying Capacity	Adequacy of facilities for activities	0-14
Accessibility	Ease if access to and within site	0-18
Environmental	Esthetic quality of site	0-20
Total		0-100

Second, point values for without project conditions are calculated and converted into equivalent dollar amount. Based upon the total number of points assigned, the equivalent dollar amount is obtained. UDVs range from $3.00 to $9.01 per recreation day. This dollar amount is the value per visit of UDV. Third, the value is multiplied by the annual number of visitors to get an estimate of annual recreation value.

Evaluation of the Paseo de las Iglesias Study Area:

Point values for the existing Santa Cruz River Park of which a portion is located within the Paseo de las Iglesias study area are estimated with the aid of Pima County Park and Recreation Department, available literature describing the nature of recreation in the area, and site visits made by the US Army Corps of Engineers study team. These numbers do not consider any possible future expansion of the park and are assigned using information described earlier on Page 27 in this report under the recreation demand section of the report.

Table 31: Point Values for Without Project Conditions
Paseo de las Iglesias

Recreation Criteria	Value Range	Point Values
Recreation Experience	0-30	8
Availability of Opportunity	0-18	3
Carrying Capacity	0-14	6
Accessibility	0-18	8
Environmental	0-21	2
Total		27

The point values described above are totaled and converted into equivalent a UDV amount. The total point value from Table 31 is 27 for the five recreational criteria. The equivalent UDV amount for 27 points is $4.33. This UDV amount represents how much a visit to the park is worth in dollar amount for the without project condition.

Because visitation figures already exist for a portion of the Paseo de las Iglesias, they will be applied, but they will be altered slightly, first to eliminate double counting and second to project visitation growth. First, visitation figures are divided in half to eliminate double counting. This seems to be a reasonable assumption given the nature of trail usage. When a visitor begins to use a trail and crosses the laser beam counter he will inevitably cross it again when he returns. Second, visitation is projected over 50 years by using annual compound rates for population growth. These adjusted visitation figures will than be compared to capacity limits established by the National Recreation Parks Association (NRPA). The capacity limit set by NRPA is 14,600 users per mile per year. If visitation reaches the capacity figures established by the NRPA visitation is assumed to remain constant. The rational used is: visitation will increase at a decreasing rate until a capacity threshold is reached. At the threshold visitation begins to remain stable, all else being equal. But, after projections were made, visitation figures did not reach the capacity threshold; therefore, projections continued to increase over the 50-year period of analysis.

Table 32: Projected Visitation

Location	Original 2001	Half 2001	2012	2020	2030	2040	2050	2060	2062
Santa Cruz River Park (one bank)	36,625	18,312	23,015	26,338	31,174	35,824	39,966	43,712	44,502
Annual Growth Rate			1.021	1.017	1.017	1.014	1.011	1.009	1.009

To calculate the recreational value for with project conditions, the UDV is multiplied by annual visitation. The product of the UDV and average annual visitations over 50 years can be seen in the below table.

Table 33: Projected Recreation Value

Location	2012	2020	2030	2040	2050	2060	2062
Santa Cruz River Park (one bank)	$99,657	$114,045	$134,985	$155,118	$173,051	$189,272	$192,694

The stream of recreation values over 50 years was discounted (NPV = $2,114,132 (one bank)) and annualized for a recreation value of $120,390. This number is added to 75% its value for an estimate of recreation value along both banks of the Santa Cruz River Park. Recreation is assumed to be metered along the most used bank and to vary along the other bank by 25%. Recreation value is therefore $210,682.

WITH PROJECT CONDITIONS

Introduction:

The proposed alternatives for Paseo de las Iglesias were developed to consider three factors: 1) the evaluation of flood and erosion damage reduction opportunities given the results established in the without project condition; 2) the restoration of the study area to support natural riparian vegetation and wildlife communities; 3) the development of recreation opportunities to minimize the impact of human interference on newly restored habitat.

Evaluation of Flood Damage Reduction Opportunities:

Flood Damage Reduction Evaluation:

The primary purpose of this feasibility study is National Ecosystem Restoration (NER). Flood damage reduction or National Economic Development (NED) opportunities were also evaluated to determine if a federal interest existed in participating in a combined NER and NED plan. Structural and non-structural measures and alternatives were developed and evaluated for four floodplains in the study area (the Santa Cruz River, the Old and New West Branches, and the Los Reales area) to determine if expected annual economic damages for the baseline and without-project conditions were great enough to warrant a detailed analysis. Based on the evaluation and screening processes, flood damage reduction could not be justified as a project purpose within the study area. The results of this evaluation and screening process are summarized in this section.

The total number of structures by flood frequency for each of the above referenced reaches and respective Expected Annual Damages (EAD) are provided in Tables 34 and 35 below:

Table 34: Number of Impacted Structures by Frequency and Floodplain

Floodplain	50 yr	100 yr	200 yr	500 yr
Santa Cruz	0	0	132	1972
Old West Branch	NA[1]	583	NA	NA
New West Branch	0	222	503	1126
Los Reales	24	47	62	119

[1]NA means overflows were not available for the frequencies listed; therefore structures could not be counted and included in Table 1.

Table 35: Total Without Project Condition Expected Annual Damages

Santa Cruz River		Old & New West Brach Rivers and Los Reales Floodplains	
Reach	*EAD*	*Reach*	EAD
1 SC	$69,870	OWB	$406,212
2 SC	$110,950	1 NWB	$141,330
3 SC	$258,480	2 NWB	$64,260
5 SC	$81,940	LR	$107,740
Total:	$521,250	Total:	$719,542

Evaluation of Flood Damage Reduction Measures

A variety of non-structural flood damage reduction measures were identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Non-Structural Flood Damage Reduction Measures:

Floodplain Management Regulations

The City of Tucson and Pima County participate in the National Flood Insurance Program (NFIP), which is administered through the Federal Emergency Management Agency (FEMA). FEMA has published Flood Insurance Rate Maps (FIRMs) for both jurisdictions that identify Special Flood Hazard Areas for the Santa Cruz River and tributaries. For local jurisdictions to maintain eligibility in the NFIP, minimum levels of floodplain management regulations must be adopted and enforced.

Due to the existence of floodplain management regulations and enforcement, this measure was not carried forward for alternative evaluation.

Flood Warning Systems

A flood warning and preparedness system is often the most cost effective flood mitigation measure comprised of computer hardware, software, technical activities and/or organizational arrangements aimed at decreasing flood hazards. Advanced warning is not generally effective in reducing structural damages (outside of sandbagging efforts given early warning); the primary benefits of such a system are credited for providing early evacuation of residents and reduction in damages to vehicles and structure contents.

Pima County owns and operates an extensive flood-warning network. This network operates in the National Weather Service ALERT (Automated Local Evaluation in Real Time) format and is part of the Arizona Statewide Flood Warning System previously developed and constructed by the Corps under Section 205 of the Continuing Authorities Program.

Due to the existence the statewide and local flood warning systems, this measure was not carried forward for alternative evaluation.

Flood Proofing

Flood proofing offers the opportunity to provide flood protection on an individual structure-by-structure basis or a group of structures. Flood proofing techniques typically include buyouts, relocation, elevation, floodwalls or levees, and dry flood proofing. Elevation, buyout, and relocation are the most dependable of these flood proofing methods. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the structure(s). Flood proofing techniques considered for alternative development are:

1) Relocation of Existing Structures: Relocation is perhaps the most dependable flood proofing technique since it totally eliminates flood damages, minimizes the need for flood insurance and allows for the restoration/reclamation of the floodplain. This technique requires the physical relocation of flood prone structures outside of the identified flood hazard area. This also requires purchase of the flood prone property; selecting and purchasing a new site; and lifting/moving the structure to the new site.

2) Buyout or Acquisition: This technique requires the purchase of the flood prone property and structure; demolition of the structure; relocation assistance; and applicable compensation required under Federal and State law. This alternative typically requires voluntary relocation by the property owners and/or eminent domain rights exercised by the non-federal sponsor.

3) Retrofitting or Dry Flood Proofing: Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Installation of temporary closures or flood shields is a commonly used flood proofing technique. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to expected flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. It would also not be applicable to mobile homes, which comprise sixty-nine percent of the flood prone structures in the study area, due to the type of construction and typical lack of anchoring to a foundation.

Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution and, this action would have to occur in a relatively short time frame. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

4) Localized Levees or Floodwalls: Ring levees or floodwalls can be built around individual structures to protect single or small groups of structures. Ring levees are earthen embankments with stable or protected side slopes and a wide top. Floodwalls are generally constructed of masonry or concrete and are designed to withstand varying heights of floodwaters and hydrostatic pressure. Closures (e.g., for driveway access) are typically manually operated based on flood forecasting and prediction that would alert the operator.

Disadvantages of levees or berms are: 1) can impede or divert flow of water in a floodplain; 2) can block natural drainage; 3) susceptible to scour and erosion; 4) give a false sense of security; and 5) take up valuable property space.

Disadvantages of floodwalls are: 1) high cost; 2) closures for openings required, and 3) give a false sense of security.

5) Elevation of Structures: Existing structures can be elevated or raised above the potential flood elevation. Structures can be raided on concrete columns, metal posts, piles, compacted earth fill, or extended foundation walls. Elevated structures must be designed and constructed to withstand anticipated hydrostatic and hydrodynamic forces and debris impact resulting from flooding. The access and utility systems of the structures to be raised would need to be modified to ensure they are safe from flooding.

Structural Flood Damage Reduction Measures:

A variety of structural flood damage reduction measures were also identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Detention:

This measure would require construction of on-line (i.e., in-stream) or off-line regional detention facilities upstream of the study area designed to detain flood flows and release then at a lower rate. There are no lands identified for upstream detention that would provide adequate storage volume to detain the 100 through 500 year flood events. In addition, any such location would fall outside the study area and outside Pima County jurisdiction either on Tribal Lands or in Santa Cruz County. The location of a large-scale detention facility relative to the entire 22,222 square mile contributing watershed would have to be evaluated to determine what impacts, if any, there are on flood hydrographs through the study area. This measure was not carried forward for alternative evaluation.

Lined Channels & Covered Channels:

1) Rectangular Concrete Channels: Preliminary evaluation of this measure revealed no practical location along the large, entrenched Santa Cruz River channel where such a solution would be practical. Rectangular concrete channels are not carried forward for alternative evaluation.

2) Trapezoidal Rip-Rap/Soil Cement/Vegetation Lined Channels: A preliminary evaluation was performed for the potential for utilizing trapezoidal lined channels, due to the reduced construction costs and improved aesthetics of such channels. The Santa Cruz River contains the 100-year flood, and several reaches within the study area are currently protected from erosion with soil cement lined banks. This measure was carried forward for alternative evaluation.

3) Covered Channels: A preliminary evaluation indicated that there is no specific location where covered channels could be utilized and this measure is not carried forward for the alternative evaluation.

Levees and/or Floodwalls:

1) Levees: Levees can provide significant levels of protection in a cost effective manner, however, there are disadvantages such as increases of flood stages, real estate costs and access considerations, environmental impacts, and the potential for failure due to scour/erosion or overtopping. This measure was carried for alternative evaluation.

2) Floodwalls: Consideration was given to protective floodwalls in place of levees. Floodwalls may be provided at a lower cost than levees and provide significant levels of protection over and above the current channels, with or without widening and deepening. This measure was carried forward for alternative evaluation.

Alternative Evaluation and Screening:

Alternatives were evaluated and screened using preliminary cost estimates based on costs developed for similar measures in other studies conducted in the region. Detailed cost estimates were not prepared because none of the alternatives were near enough to being justified to warrant more precise analysis.

Old West Branch (OWB):

The Old West Branch is an entrenched natural channel. The average base width is 20 ft and the average bank height is 10 ft. There is a significant amount of vegetation (e.g., Mesquite) growing along the banks and some vegetation growing in the channel bed. There is a large concrete drop structure at the confluence of with the Santa Cruz River. Bridge crossings are located at Silverlake Road, Ajo Way, and Via Engresso.

Structural flood damage reduction alternatives along the OWB would result in the loss of the most highly valued riparian habitat and Mesquite Bosque within the study area, which is in direct conflict with the primary ecosystem restoration purpose. Previous proposals, by the non-federal sponsor, for structural flood control channel improvements along the OWB resulted in a high degree of public opposition. In addition, 73 acres of the OWB channel and floodplain must be maintained as a "natural floodplain" under the mitigation provisions of an existing USACE Section 404 Permit and structural modifications of the natural channel are prohibited. Based on aforementioned constraints, structural flood damage reduction alternatives for the OWB were not developed and evaluated.

In light of the above, only non-structural flood damage alternatives were evaluated for the OWB. Approximately 583 structures are potentially damaged in the 100-year flood event and the expected annual damages are $406,212. The non-structural alternatives evaluated are:

OWB-1	Buyouts and/or Relocation
OWB-2	Elevation of Structures
OWB-3	Localized Floodwalls or Levees

Alternative OWB-1 (Buyouts/Relocation): Estimates for structure values (not including relocation assistance and demolition costs) in the OWB 100-year floodplain exceeded $23,000,000 (See Economic Appendix). This figure was then converted to an annual average equivalent value for purposes of comparison on a common basis with the estimate of the average annual benefits. The cost estimate was amortized over a 50-year project life using a financial discount rate of 5.625%. The average annual cost of alternative OWB-1 is $1,383,413. The resulting B/C ratio is .29. Alternative OWB-1 is clearly not economically justified and was eliminated from further consideration.

Relocation would depend on whether alternative sites for 583 structures are available, the willingness of the residents to relocate, and other non-technical factors. There are no identified sites with equivalent zoning, existing infrastructure, and lot configuration that could accommodate relocating 583 structures. Assuming that such relocation sites were available, the cost to relocate these structures was estimated at $10 per square foot to move the structures several miles. 10% contractor profit was also assumed per USACE National Flood Proofing Committee guidelines. Total relocation and profit costs are estimated at $6,400,000. The average annual cost is $384,949 for a B/C of 1.05 at a 5.625% interest rate. Required additional costs not incorporated would include cost of the new lot, new foundations, landscaping, and pertinent indirect costs that are estimated at an additional $15,000 per structure. Based on this required additional costs estimates and lack of relocation sites, relocation was eliminated from further consideration.

Alternative OWB-2 (Elevation): The economic benefits associated with elevating existing structures are measured by subtracting the value of the expected annual damages under improved conditions from the expected annuals damages under the without project conditions.

Construction costs were estimated for raising structures with piers for manufactured/ mobile homes and stem walls for slab on grade homes. The mobile homes also require adequate tie-downs to prevent flotation. These costs considered the condition of the structure to be raised, the site preparations required, mobilization costs, and the approximate square footage of the structure. A constant cost of per square foot was used whether the structure is raised one foot or three feet. Commonly, the cost per square foot increases for each additional foot the structure is elevated. These cost (per NFPC data) are:

Table 36: Construction Costs Per Square Foot

Wood Frame Building on Piles, Posts or Piers[1]	$26 per square foot
Wood Frame Building on Foundation Walls[1]	$19 per square foot
Brick Building[1]	$32 per square foot

[1]These costs include foundation, extending utilities, and miscellaneous items, such as sidewalks and driveways. They do not include the cost of fill or landscaping.

A profit of 10% also needed to be included, as well as fixed engineering design, mobilization, and relocation cost of $7,000 for the mobile homes and $14,000 for the each single family residential homes. All costs were based on a typical 1,000 square foot wood framed structure.

The cost to elevate 52 SFR and 528 MH residential structures was estimated at $15,451,000. This figure was then converted to an annual average equivalent value for purposes of comparison on a common basis with the estimate of the average annual benefits. The cost estimate was amortized over a 50-year project life using a financial discount rate of 5.625%. The average annual cost of Alternative OWB-2 is $929,353.

The economic justification was determined by subtracting the expected annual costs from the annual benefits. The difference between these two figures represents net benefits associated with the project. If net benefits are zero or positive, then the project is economically justified. The benefit-to-cost ratio is a number representing the expected annual benefits divided by the expected annual costs. An economically justified project will show a benefit-to-cost ratio of 1.0 or greater.

The analysis shows that the net benefits generated by the alternative are -$523,141; therefore, the B/C ratio is .43. Thus, this alternative is not economically justified and was not carried forward.

Alternative OWB-3 (Floodwalls): Installation of individual or groups of floodwalls or levees was analyzed for the residential structures only. Based on the small lot sizes, configuration of the subdivision(s) and clustered nature of the residential structures, construction of individual floodwalls or ring levees are not physically possible. Floodwalls constructed around the perimeter of individual subdivisions would act as ineffective flow areas that increase water surface elevations and divert flood flows onto adjacent properties, thus inducing damages. Based on this evaluation, this alternative was eliminated from further consideration.

New West Branch (NWB):

The New West Branch (NWB) is an entrenched partially bank protected trapezoidal channel. The channel has a natural bottom with 3 on 1 concrete lined side slopes. The base width varies from 100 to 120 ft. The average bank height is 8 ft. There is a large concrete drop structure/energy dissipator at the confluence of with the Santa Cruz River; with another drop structure located approximately 1,925 feet upstream. Bridge crossings are located at Irvington, Drexel, and Valencia Roads.

503 structures are potentially damaged in the 100- and 200-year flood events and 1,126 structures are damaged in the 500-year event. The total expected annual damages are $205,590. Non-structural alternatives (i.e. dry flood proofing, elevation, and relocation) were eliminated from further consideration based on the non-structural alternatives analysis performed for the 583 structures on the Old West Branch.

Potential structural alternatives evaluated for the New West Branch were:

NWB-1: Channel Dredging,
NWB-2: Reconstruction of Existing Levees, and
NWB-3: Floodwalls.

Alternative NWB-1 (Channel Dredging): The without project hydraulic model was modified to determine the impacts of channel dredging. The following impacts or concerns were identified:

a) Excavation can increase the conveyance of the New West Branch up to the 100-yr flood event only. Up to two (2) ft of excavation is necessary.
b) Excavation alone would not contain the 200- and 500-yr flood events.
c) The existing grade control structure at Station 6.0 would need to be modified (lowered) as well as the existing bank protection.
d) The existing footbridge upstream of Drexel Road would need to be removed or replaced.
e) Excavation may result in undermining of the existing soil cement bank protection. The toe down depth(s) of the existing soil cement bank protection is unknown and cannot be verified. Additional field exploration will be required to determine structural integrity, toe-down depths, and subsurface conditions behind and under the soil cement.

For cost estimating purposes and alternatives analysis, the assumption was made that the existing soil cement would require structural measures to prevent undermining. At this time, a preliminary cost estimate cannot be developed without knowledge of toe-down depth. This alternative is unlikely to be justified even if excavation is the primary cost and structural modifications to the existing bank protection are not required. Cost for excavation alone is estimated at $2,838,486. Annualized over 50 years and a 5.625% interest is $170,730. This estimate does not include modification of the existing grade control structure, removal or replacement of existing pedestrian bridge or bridge improvements to Drexel and Irvington. Benefits were calculated using HEC-FDA without project output and an EAD spreadsheet. Benefits for the New West Branch floodplain are $85,781. If this preliminary analysis showed possible justification HEC-FDA would have been used for detailed analysis. However, the resulting benefit-to-cost ratio for excavation on Alternative NWB-1 is .50. Therefore, this alternative was not economically justified.

Alternative NWB-2 (Replace Levees): Levees (or berms) currently exist along both channel banks, however they do not contain the 100 to 500-year flows. An analysis was performed to determine what effects raising the existing levees to protect homes would have. As built drawings for the existing levee are not available therefore, for engineering design and cost estimating purposes, the existing levees were assumed to be structurally inadequate and completely new engineering levees were assumed. Due to the high velocities and possibility of run-up at the curve, rigid armoring (i.e., soil cement) would be required on the insides slopes of the levees. Costs for soil cement bank protection assumed a 14-foot bank height and 5-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by Pima County.

The cost (excluding additional real estate requirements) for reconstruction of approximately 14,200 lineal feet of new levee system on both sides of channel was estimated at $11,809,801. Annualized cost equal $710,340. With benefits equaling $55,110 for Levee 1, $145,230 for Levee 2, and $169,550 for Levee 3, the resulting B/C ratio for Alternative NWB-2 and NWB-3 (described below) is .12, .25, and .28; therefore, they are not economically justified.

Benefits from the proposed alternative consist of reduction in damages to structures and contents. Damage reduction was measured by a reduction in levee overtopping due to the increased height of a levee or floodwall. Expected annual damages were calculated using the HEC-FDA program developed by the Hydrologic Engineering Center in Davis, California. Benefits derived from flood damage reduction are presented in the following table.

Table 37: Benefits from Flood Inundation Reduction

Reach	Without Project Damages	Damages Prevented Levee 1	Damages Prevented Levee 2	Damages Prevented Levee 3
WB 4	$141,330	$39,180	$122,530	$139,480
WB 5	$ 64,260	$15,930	$22,700	$30,070
Total	$205,590	$55,110	$145,230	$169,550

For better evaluation of alternatives, HEC-FDA results are detailed in the following tables. Table 38 and 39 will display information about the hydrologic and hydraulic performance of each plan while Table 40 and 41 will show economic performance. Before each table is a brief explanation of the statistics represented in the tables that follow.

Statistics shown in Table 38 show the expected annual probability that the capacity of the channel within each reach will be exceeded. The median estimate of annual exceedance probability represents the flood stage at which significant damages begin to occur. Table 38 shows that for the alternatives there is less than a .001 to .003 chance of being overtopped annually. With the introduction of uncertainty these probabilities increase.

Long-Term Risk represents the probability of the target stage being exceeded (or exceeding the capacity of the levee) over a given time period. Table 38 displays the long-term risk for 10, 25, and 50 periods for the without and with project conditions. For the without project conditions, there is over 50% chance that the capacity of both reaches in the study area will be exceeded during a 50 year period of analysis. For the alternatives, long-term risk over a 50-year period of analysis range from 40% to 1% chance that the levee will be exceeded. Exceedance probabilities for the alternatives is lower than the without project condition and the exceedance probabilities increase over time as should be expected.

Table 38: Annual Performance and Equivalent Long-Term Risk

Plan	Annual Estimate of Annual Exceedance Probability	Annual Exceedance Probability With Uncertainty Analysis	Long Term Risk		
			10 Year	25 Year	50 Year
Without Project					
Reach 4	.022	.035	.2979	.5869	.8294
Reach 5	.005	.016	.1511	.3360	.5592
Levee 1					
Reach 4	.001	.011	.1008	.2332	.4121
Reach 5	.003	.011	.1027	.2374	.4184
Levee 2					
Reach 4	.001	.002	.0199	.0491	.0958
Reach 5	.002	.009	.0851	.1994	.03591
Levee 3					
Reach 4	.001	.001	.0028	.0071	.0141
Reach 5	.001	.007	.0674	.1601	.2946

The conditional non-exceedance probability by event represents the probability of a reach containing the given probability event within the target stage. Table 39 shows that the conditional non-exceedance probabilities for the alternative is larger than the without project condition as to be expected. Non-exceedance is greater than 97% contained during the 10-year event and greater than 63% contained during the 500-year event. This means the alternatives proposed perform well in containing most events.

Table 39: Conditional Non-Exceedance by Probability Events

	Conditional Probability of Design Containing Indicated Event					
	10%	4%	2%	1%	.4%	.2%
Without Project						
Reach 4	.8923	.6637	.5131	.4632	.3469	.3162
Reach 5	.9801	.8560	.7216	.6197	.5241	.4811
Levee 1						
Reach 4	.9765	.8954	.8291	.8048	.7451	.7285
Reach 5	.9885	.9081	.8137	.7398	.6691	.6375
Levee 2						
Reach 4	.9964	.9810	.9674	.9623	.9492	.9454
Reach 5	.9908	.9244	.8455	.7839	.7244	.6972
Levee 3						
Reach 4	.9997	.9982	.9967	.9962	.9949	.9944
Reach 5	.9931	.9415	.8787	.8294	.7820	.7603

Finally, the project performance is analyzed in economic terms. Table 40 and 41 presents the probabilities of the value of net benefits and probabilities that the benefit and cost ratio exceeds indicated percentages. All indicators show negative net benefits and a B/C ratio of less than 1 for all the alternatives evaluated.

Table 40: Performance of Net Benefits

Plan	Expected Annual NED Benefits and NED Cost			Probability Net Benefits Exceeds Indicated Percentages		
	Benefits[1]	Costs	Net Benefits	75%	50%	25%
Levee 1	$88,227	$710,340	($622,113)	($674,033)	($673,333)	($557,203)
Levee 2	$178,347	$710,340	($531,993)	($668,093)	($666,073)	($516,883)
Levee 3	$202,667	$710,340	($507,673)	($663,963)	($661,023)	($496,873)

[1]Benefits include emergency response damages. Traffic is not impacted in this area; therefore, traffic damages are not included.

Table 41: Performance of B/C Ratio

Plan	Expected B/C Ratio[1]	B/C >1	Probability Benefit/Cost Ratio Exceeds Indicated Percentages		
			75%	50%	25%
Levee 1	.1242	B/C<1	.0511	.0521	.2155
Levee 2	.2510	B/C<1	.0595	.0623	.2723
Levee 3	.2853	B/C<1	.0653	.0694	.3005

[1]Benefits include emergency response damages. Traffic is not impacted in this area; therefore, traffic damages are not included.

Alternative NWB-3 (Floodwall): Based on the analysis for Alternative NWB-2, a floodwall determined to be impractical given the fact that the costs of floodwalls are typically in the range of five to seven (5-7) times the cost of the soil cement levee.

Santa Cruz River (SCR):

The Santa Cruz River main stem is characterized by a partially bank protected ephemeral river with a narrow 100-year floodplain. There is soil cement bank protection on both banks between Congress Street and Silverlake Road, Irvington Road and Ajo Way, and near Valencia Road. The rest of the study reach is unprotected. The river is entrenched with widths varying from 200 to 1000 ft. Bridge crossings are located at Congress Street, 22nd Street, Silverlake Road, Ajo Way, Irvington Road, Drexel Road, and Valencia Road. The Old West Branch joins the Santa Cruz River between 22nd Street and Silverlake Road. The New West Branch joins the Santa Cruz River between Ajo Way and Irvington Road.

The Santa Cruz River incised channel contains the 2 through 100-year flood events for the majority of the study area and no structures are affected by these flood frequencies. 132 structures are affected in the 200-year flood frequency and 1,972 structures are affected in the 500-year flood frequency. The total expected annual damages are $521,250 (see Table 34) for the four sub-reaches on the Santa Cruz River.

Non-structural Alternatives: Dry flood proofing was not considered due to the fact that 1,040 of the existing 1,972 structures are mobile homes, which are not conducive to this technique. Non-structural alternatives (i.e., dry flood proofing, elevation, and relocation) were eliminated from further consideration based on the costs determined by the non-structural alternatives analysis performed for the 583 structures on the Old West Branch.

Structural Alternatives: Structural alternatives considered for the Santa Cruz River are:

SCRiver-A Channel Improvements / Widening
SCRiver-B Levee or Floodwalls

Table 42: Reach Delineation Breakdown: The Santa Cruz Floodplain

Reach Name	Cross Streets	Stream	Beginning Cross-Section	Ending Cross-Section
1 SC	Congress St. 22nd Street	Santa Cruz River	32.61	33.38
2 SC	22nd Street Ajo Way	Santa Cruz River	33.38	35.77
3 SC	Ajo Way Irvington Rd.	Santa Cruz River	35.77	36.63
4 SC[1]	Irvington Rd. Drexel Rd.	Santa Cruz River	36.63	37.87
5 SC	Drexel Rd. Valencia Rd.	Santa Cruz River	37.87	38.96

[1]4 SC produced no damages.

Alternative SCRiver-A (Channel Widening): Channel improvements along the Santa Cruz River main stem would entail widening of existing vertical eroded banks and then constructing soil cement bank protection at 1 (horizontal):1 (vertical). Referencing Table 36, both river banks for sub-reaches 1 SC and 3 SC are protected with soil cement and would require removal of the existing soil cement to accommodate channel widening and new soil cement protection would then have to be reconstructed. Sub-reach 2 SC is bank protected from 22nd Street to Silverlake Road.

A preliminary lump sum cost estimate for bank protection was previously developed for the Gila River, Santa Cruz River Watershed Pima County, Arizona Final Feasibility Report (dated August 2001) for the remaining unprotected channel banks. Costs for soil cement bank protection assumed a 20-foot bank height and 10-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by the Pima County. The initial cost estimate, not including real estate and contingencies, was in excess of $14,960,000.

Channel widening alone will not provide a complete flood protection solution. The eight (8) existing roadway bridges would require improvements or replacement to convey design floods without overtopping.

Based on expected annual damage levels for the Santa Cruz River sub-reaches, the initial cost estimate of $14,960,000, the impracticality of removing existing soil cement for channel widening, construction of new soil cement, and bridge replacements, Alternative SCRiver-A was not carried forward for detailed evaluation.

Alternative SCRiver-B (Levees or Floodwalls): Based on the cost estimates developed for the New West Branch Alternative NWB-2, construction of levees or floodwalls along both banks of the Santa Cruz River was deemed impractical. In addition, all bridge crossing would have to reconstructed and elevated to accommodate the top of any new levee or floodwall. This alternative was not carried forward.

Los Reales (LR):

The Pima County Department of Transportation (PCDOT) and the Flood Control District (FCD) formed the Los Reales Improvement District in 1987 in order to construct a flood-control levee and associated drainage ways. The purpose of this project was to divert flows around the development and dispose of these flood flows either into the Santa Cruz River or into the New West Branch channel. Along the south boundary of this Improvement District, there is a 4 ft high, 1400 ft long floodwall, which extends between the Tohono O'Odham Indian Reservation Boundary and Indian Agency Road. On the west end of this floodwall, there is a partially lined concrete channel that would divert a portion of the flood flows northward into the New West Branch channel. A partially lined concrete channel is aligned along the south edge of the development and diverts all remainder flood flows into the Santa Cruz River approximately opposite Hughes Wash.

Forty-seven (47) structures are affected in the 100-yeat event and 119 structures are affected (primarily from shallow overland flows) in the 500-year event. Total expected annual damages are $107,740. Alternatives evaluated are:

LR-1 Flood Proofing
LR-2 Elevation of Structures

Alternative LR-1 (Flood Proofing): Sixty-six (66) of the existing structures a classified as mobile homes. Dry flood proofing techniques such as flood shields and sealing of exterior walls would not be applicable for mobile homes due to the type of construction and lack of adequate anchoring to a foundation. Therefore, this alternative was not carried forward.

Alternative LR-2 (Elevation): Costs to properly elevate and anchor the residential structures was estimated at $3,187,000. $191,693 is the annualized costs at a 5.625% interest rate. The resulting benefit-to-cost ration is .56 with benefits potentially equaling $107,740; therefore, this alternative is not economically justified.

Evaluation of Erosion Damage Reduction Opportunities:

Erosion Damage Evaluation:

The bank erosion study was limited to the Santa Cruz River. The New West Branch was not studied since its banks are lined with concrete/soil cement. This was the same case for the Los Reales floodplain. The Old West Branch was not studied due to plan formulation constrains that preclude structural channel modifications.

Santa Cruz River Results:

Approximately 70 structures could be affected based on the historic annual erosion rates, in areas without soil cement bank protection. The total annualized expected annual damages for these 70 structures is estimated at $53,193 (see Table 43). At this level of economic damage, an estimated $963,385 project might be economically justified.

Table 43: Present Value and Annualized Damages for Affected Structures

Reach	Present Value	Annualized Damages
SC 2	$671,329	$40,379
SC 4	$82,558	$4,966
SC 5	$130,482	$7,848
Total	$884,370	$53,193

A preliminary lump sum cost estimate for bank protection was previously developed for the Gila River, Santa Cruz River Watershed Pima County, Arizona Final Feasibility Report, dated August 2001. This estimate for bank protection was made based on similar projects on the study area.

Costs for soil cement bank protection assumed a 20-foot bank height and 10-foot toe-down. Major elements include earthwork, borrow material, manufacturing of soil cement, cement materials, handrails, and utility relocations. Lesser items include traffic control, removal of obstructions, clearing/grubbing, and off-site drainage facilities. Typical unit costs for earthwork, manufacturing of soil cement, and cement materials were provided by the Pima County. The initial cost estimate, not including real estate and contingencies, was in excess of $14,960,000. Based on the low EAD value of $56,440 and a resulting benefit-to-cost ratio of $899,820, a soil cement bank protection project would not be economically justified with a B/C ratio at .06.

Environmental Restoration Analysis:

Alternative Development:

In the process of developing the initial array of alternatives for environmental restoration, the importance of water availability became an important factor even in the early stages of alternative development because of scarcity and cost of water. With this is mind, the US Army Corps of Engineers project team developed three broad concepts of restoration that were characterized by xero (low), meso (medium) and hydro (high) riparian water demand. The three riparian concepts (Xeroriparian, Mesoriparian, and Hydroriparian) are described as follows: Xeroriparian communities experience infrequent flows of shorter duration; Mesoriparian communities experience frequent prolonged water flow; and Hydroriparian communities occur where water flows at all, or nearly all times of the year.

These riparian (xero, meso, and hydro riparian) feature groupings are associated with three regions in the geomorphic setting: the active channel, the adjoining terraces, and the historic floodplain. The active channel refers to the area where water flows most frequently and where perennial flow would be found if it existed. The terraces are the adjacent land features, which are elevated only slightly above the active channel. Lower terraces might be flooded by a 2 through 5 year event and the upper terraces would be flooded by a 5 through 10 year event. The historic floodplain is the area adjacent to the entrenched channel of the Santa Cruz River. Although it has been cut off from the river due to down cutting resulting from human activities, in the past this is the area that would have been flooded by infrequent events in the range of 10 year and greater.

Both riparian and geomorphic concepts were combined by associating water needs with geomorphic settings on the premise that different plant community types grow in different regions of geomorphic setting depending on water availability. Xeroriparian would be found in the upper terraces or the historic floodplain. Mesoriparian plants would be found in the lower or upper terraces and Hydroriparian plants are most often found adjacent to the active channel or in the adjoining lower terraces. While diminished flows might lead to drier communities occurring nearing the active channel one would never expect to find Hydroriparian plants in the historic floodplain or to find a drier community near the channel with a wetter one above it at a greater distance from the channel.

Using the concepts of riparian communities and geomorphic setting a matrix of grouped features is created. This matrix is included as Table 44. The matrix allowed initial consideration of every potential combination of feature groups, including no action, to create forty-seven potential alternatives.

Table 44: Alternative Features Matrix

	Active Channel Features	Floodplain Terrace Features	Historic Floodplain Features
No Action* (Without Project) *Listed items are anticipated consequences rather than measures to be implemented as in the other rows.	1. Continued instability of channel due to erosion. 2. Continued refuse dumping. 3. Continued degraded habitat.	1. Continued erosion loss of lower terraces creating cliff-like banks. 2. Eventual application of soil cement on unprotected banks armoring entire reach.	1. With expanded soil cement bank protection, continued historic floodplain encroachment by development.
Xero-Riparian (Establishment & Emergency Irrigation)	1. Construct aquitards upstream of existing and new grade control structures. 2. Divert low flow from New West Branch into remnant headwaters of Old West Branch. 3. Plantings of riparian grasses/shrubs	1. Water harvesting from local runoff. 2. Create tributary aquitard deltas with two-tiered aquitards. 3. Plantings on terraces and aquitards.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Water harvesting from local runoff. 3. Replace steep banks with stabilized planted terraces
Meso-Riparian (Irrigation)	1. Construct and provide supplemental irrigation to aquitards upstream of existing and new grade control structures. 2. Introduce periodic flow into the Old West Branch just upstream of its confluence with the Enchanted Hills Wash and on other tributaries downstream of that point. 3. Plantings of riparian grasses	1. Create tributary single-tiered aquitard deltas. 2. Irrigate and plant terraces with mesquite along upper terrace. 3. Stabilize active channel banks by establishing thickly rooted mesquite at the edge of the lower terraces.	1. Amend soil with nutrients, moisture trapping, contouring. 2. Plant and irrigate historic floodplain. 3. Replace steep banks with stabilized planted terraces
Hydro-Riparian (Perennial Flow With Irrigation)	1. Restore perennial flow with multiple points of distribution into the main Santa Cruz and tributary channels. 2. Plant cottonwood-willow bundles at edges of perennial flow where erosion protection needed. 3. Construct perennial channel features (e.g., pools, runs, and riffles).	1. Create tributary aquitard deltas with hydraulic link to perennial flow. 2. Irrigate and plant low terraces with riparian grasses to maintain flood conveyance and discourage colonization by invasive species. 3. Irrigate and plant upper terraces with mesquite/cottonwood-willow.	Hydro Riparian plants do not occur in areas of the floodplain that are not subject to frequent inundation. Even so, measure 3 from the Mesoriparian floodplain is carried forward to mitigate greater erosion risks associated with increased channel roughness in combinations where "No Action" is paired with Perennial Flow.

Table 45: Alternative Screening

Active Channel	Terrace	Floodplain	Screen Out	Reason
No Action	Xero	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	Xero	Meso	Yes	Not Consistent with Natural Pattern
No Action	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Meso	Xero		
No Action	Meso	Meso		
No Action	Meso	No Action	Yes	Fails to provide sufficient habitat diversity
No Action	Hydro	Xero	Yes	Not Consistent with Natural Pattern
No Action	Hydro	Meso	Yes	Not Consistent with Natural Pattern
No Action	Hydro	No Action	Yes	Not Consistent with Natural Pattern
No Action	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
No Action	No Action	Meso	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Xero	Yes	Fails to provide sufficient habitat diversity
Xero	No Action	Meso	Yes	Not Consistent with Natural Pattern
Xero	Xero	No Action	Yes	Fails to provide sufficient habitat diversity
Xero	Xero	Xero		
Xero	Xero	Meso	Yes	Not Consistent with Natural Pattern
Xero	Meso	No Action	Yes	Not Consistent with Natural Pattern
Xero	Meso	Xero	Yes	Not Consistent with Natural Pattern
Xero	Meso	Meso	Yes	Not Consistent with Natural Pattern
Xero	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Xero	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Meso	No Action	No Action	Yes	Fails to provide sufficient habitat diversity
Meso	No Action	Xero	Yes	Not Consistent with Natural Pattern
Meso	No Action	Meso	Yes	Not Consistent with Natural Pattern
Meso	Xero	No Action		
Meso	Xero	Xero		
Meso	Xero	Meso	Yes	Not Consistent with Natural Pattern
Meso	Meso	No Action		
Meso	Meso	Xero		
Meso	Meso	Meso		
Meso	Hydro	No Action	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Xero	Yes	Not Consistent with Natural Pattern
Meso	Hydro	Meso	Yes	Not Consistent with Natural Pattern
Hydro	No Action	No Action		
Hydro	No Action	Xero	Yes	Not Consistent with Natural Pattern
Hydro	No Action	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Xero	No Action		
Hydro	Xero	Xero		
Hydro	Xero	Meso	Yes	Not Consistent with Natural Pattern
Hydro	Meso	No Action	Yes	Too much reduction in conveyance
Hydro	Meso	Xero	Yes	Too much reduction in conveyance
Hydro	Meso	Meso	Yes	Too much reduction in conveyance
Hydro	Hydro	No Action		
Hydro	Hydro	Xero		
Hydro	Hydro	Meso		

Alternative Descriptions:

As can be seen in Table 45, combinations of the four riparian categories with the three geomorphic regions form groups of management measures that designate alternatives. The combinations detailed in Table 45 are labeled with letters in this section for simplicity. The letters used are N for no action, X for Xeroriparian, M for Mesoriparian and H for Hydroriparian. Each letter represents a row from the Alternative Features Matrix with the order of the letter aligned to the columns. For example, alternative HMN would be the result of combining Hydroriparian active channel features and Mesoriparian terrace features with no action in the historic floodplain. A brief description of each alternative remaining after prescreening is provided below. (For more detail, view Table 45 for reasons why thirty-three out of forty-seven possible alternatives were screened out of consideration).

No Action Within Active Channel

Alternatives NNN, NMX, and NMM remain after all combinations were made with no action remaining constant in the active channel. NNN calls for no action in the active channel, no action in the terraces, and no action in the historic floodplain. NMX implements no features in the active channel, a Mesoriparian environment in the terraces, and Xeroriparian features for the historic floodplain. NMM does nothing within the channel but implements Mesoriparian action for both the terraces and historic floodplain.

NNN is considered the no action option and is one of the alternatives required by USACE in order to comply with the requirements of NEPA. No Action assumes that no project would be implemented by the federal government or by local interests to achieve the study area planning objectives. No action also takes into account the future without project condition likely to occur over the period of study. The No Action Plan forms the basis from which all other alternative plans are measured.

NMX and NMM, the two other remaining alternatives with no action in the active channel, represent a departure from the screening criteria. These alternatives are not consistent with natural patterns likely to occur given a Mesoriparian environment in the terraces because one would normally find a Hydoriparian or Mesoriparian plant community in the active channel if flow were frequent enough to support a Mesoriparian community on the terraces. However, they remain within consideration because of the need to avoid unacceptable reductions in flood conveyance. By leaving the active channel undisturbed, this has the least possible impact to conveyance.

Common features of both alternatives include:

1. The construction and planting of aquitards at the confluences of 13 tributaries. The aquitard features would involve excavating in the area where the tributaries enter the terraces. Excavation would be to a depth of approximately four feet, a liner membrane would be laid, and the excavated area would be filled with layers of appropriately sized gravel covered with granular fill.

2. The implementation of a permanent irrigation system for Mesoriparian areas. Permanent irrigation would combine construction of feeder pipelines to move water through the project area with use of open channels and level spreaders to distribute water at specific locations. In some cases, such as the tributary aquitards, a simple outflow would be sufficient.

3. The installation of temporary irrigation for Xeroriparian areas and stabilized terraces in areas with steep unprotected banks.

4. The amendment of soil would be common to both Mesoriparian and Xeroriparian areas with the latter having additional surface treatments to improve the grounds ability to concentrate rainfall.

5. The cutting back into the historic floodplain would create gentler and more stabile slopes and would modify reaches of steep natural banks. The method of stabilization would be a function of the amount of land available for the new terrace area. Where available land is not a constraint banks will be graded at a 5-foot horizontal to 1-foot vertical slope and planted. Vegetated slopes of this grade are considered stable. A different treatment will be used in areas where there is not enough land to create a 5:1 slope but sufficient space exists to create slopes between 5:1 and 2:1. In those cases the banks will be laid back to the minimum slope that can be fit into the available space. These slopes will also be vegetated however; a geotextile layer will be installed prior to planting to ensure slope stability. In areas where insufficient space exists to accommodate 2:1 slopes placement of rip rap or soil cement may be necessary for bank protection. Such applications will be decided on a case-by-case basis.

6. The restoration or enhancement of 1,119 acres of habitat. Xeroriparian Shrub (Shrub-Scrub) and Mesquite with a few small pockets of Cottonwood-Willow dominate both NMX and NMM. NMX is comprised of 693 acres of Xeroriparian Shrub, 416 acres of Mesquite and ten acres of Cottonwood-Willow. In NMM the addition of irrigation to the historic floodplain reverses the dominant Xeroriparian plants producing 638 acres of Mesquite, 471 acres of Shrub-Scrub and 10 acres of Cottonwood-Willow.

A difference between NMM and NMX is that for NMX there is no permanent irrigation in the historic floodplain. Two features added to compensate for this are the addition efforts at surface treatment and the creation of a number of shallow depressions to concentrate local run-off.

Xeroriparian Within Active Channel

One alternative including Xeroriparian features in the active channel was carried forward. This alternative, XXX, pairs Xeroriparian channel features with Xeroriparian restorations on the terraces and in the historic floodplain.

Features of alternative include:

1. The construction of a low flow diversion to direct water from the New West Branch back into the Old West Branch.

2. The construction of aquitards on the upstream side of six existing grade structures. The implementation of aquitard features would involve excavating upstream of each grade control structure to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill. The areas would be seeded with riparian grasses and would be maintained as emergent marsh with larger shrubs or medium sized trees periodically cut back to preclude significant impacts on flood flows. The aquitards would be expanded in size since, without irrigation, plants would be much more dependent on water harvesting.

3. The diversion of low flows would be accomplished by placing a diversions structure in the New West Branch channel to pond low flows through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel.

4. The soil amendment of terrace and floodplain areas would include finish grading to provide micro-topography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. Also, the off channel areas to concentrate local runoff would be created in the floodplain.

5. The restoration of 1,125 acres of habitat. It is dominated by 867 acres of Xeroriparian shrub (Shrub-Scrub) with 252 acres of Mesquite and 6 acres of Emergent Marsh (riverbottom).

Mesoriparian Within Active Channel

Five alternatives including Mesoriparian features in the active channel were carried forward. Each of these alternatives places Mesoriparian measures in the channel in combination with terrace and floodplain measures described above. They are MXN, MMN, MXX, MMX, and MMM.

Two of the five Mesoriparian channel alternatives (MXN and MMN) have Mesoriparian habitat within the channel and no restoration in the historic floodplain. The difference is the treatment of the terraces. One plan calls for Xeroriparian while the other calls for Mesoriparian restoration treatment for the terraces. Both plans produce only 199 acres of restored or enhance habitat. MXN restores or enhances 6 acres of Emergent Marsh, 174 acres of Xeroriparian Shrub and 19 acres of Mesquite while MMN restores the same 6 acres of Emergent Marsh with the remaining 193 acres consisting of Mesquite.

The other three alternatives (MXX, MMX and MMM) have Mesoriparian restoration within the channel for all three plans while two plans have Xeroriparian treatment in the floodplain and two plans have Mesoriparian improvements along the terraces. One plan has Mesoriparian areas in the floodplain while the remaining plan has Xeroriparian treatment along the terraces. All three plans produce 1,125 acres of restored or enhanced habitat. Alternative MXX is dominated by 862 acres of Xeroriparian Shrub with 257 acres of Mesquite and 6 acres of Emergent Marsh. MMX is predominantly Xeroriparian Shrub at 688 acres with 421 acres of Mesquite, 10 acres of Cottonwood-Willow and 6 acres of Emergent Marsh, MMM continues the trend with Mesquite becoming dominant at 643 acres, 466 acres of Xeroriparian Shrub, 10 acres of Cottonwood-Willow and 6 acres of Emergent Marsh.

The major changes in channel features from the one outlined for the Xeroriparian alternatives consists of deletion of the diversion to the Old West Branch since irrigation reduces the need to establish this link; introduction of irrigation water into the lower reach of the Old West Branch and irrigation of the grade control aquitards. The irrigation would not be constant but would consist of adding water to extend the flow period following natural events. In this way the volume and duration of flow in these areas would be increased to mimic Mesoriparian conditions.

Hydroriparian Within the Active Channel

Six alternatives including Hydroriparian features in the active channel were carried forward. Three of the six alternatives (HNN, HXN and HHN) involve no action in the historic floodplain. The differences occur in the treatment of the terraces. One plan calls for no action, the second plan calls for Xeroriparian, and the third plan calls for Hydroriparian restoration in the terraces. HNN produces 319 restored acres with 122 acres of Mesquite, 69 acres of Cottonwood-Willow, 69 acres of Riparian Shrub and 59 acres of Emergent Marsh. HXN produces 507 restored or enhanced acres with 243 acres of Riparian Shrub, 136 acres of Mesquite, 69 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. HHN produces 487 restored or enhanced acres with 181 acres of Riparian Shrub, 168 acres of Mesquite, 79 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. The other three alternatives are HXX, HHX and HHM. Three use Xeroriparian treatment in the floodplain while one uses Mesoriparian treatment. Two apply restoration of the terraces by Xeroriparian treatment and two by Hydroriparian treatment. HXX produces 1247 restored acres with 867 acres of Riparian Shrub, 253 acres of Mesquite, 69 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. HHX produces 1227 restored or enhanced acres with 805 acres of Riparian Shrub, 284 acres of Mesquite, 79 acres of Cottonwood-Willow and 59 acres of Emergent Marsh. HHM produces 1227 restored or enhanced acres with 577 acres of Riparian Shrub, 512 acres of Mesquite, 79 acres of Cottonwood-Willow and 59 acres of Emergent Marsh.

Implementation of these alternatives involves replacing the channel features with a perennial flow channel. It would require grading the active create low flow averaging six feet in width and one-half foot in depth. Grading would also create depress ional areas on each side of the low flow channel about ten feet in width where soil saturation conditions resulting from infiltration would be conducive to Emergent Marsh. Finally, a band of Cottonwood-Willow varying in width from ten to twenty feet would be positioned adjacent to the emergent marsh to further utilize infiltrating water from the perennial channel.

Because of the conveyance impacts that would result from the creation of perennial flows, terrace features are limited to either Xeroriparian or Hydroriparian. In the Xeroriparian terrace features, both upper and lower level terraces would include finish grading to provide microtopography suitable for concentration of rainfall along with placement of rocks and coarse woody debris to facilitate moisture retention and provide sun and wind shade. In the Hydroriparian terrace features, the upper level terraces are irrigated and planted with Mesquite and pockets of Ccottonwood-Willow. The lower terraces would be planted with riparian grasses and would be maintained as Xeroriparian Shrub with larger shrubs or medium sized trees periodically cut back to retain cross-sectional area for conveyance of larger flood flows.

Finally, the alternatives including no action in the historic floodplain include the stabilized terraces described for the Xeroriparian and Mesoriparian floodplain. While this measure produces significant restoration benefits, it is carried forward her to mitigate greater erosion risks associated with increased channel roughness.

HGM With Project Condition:

With the general trends of the without project condition (i.e. the no action alternative) in mind, the Biological Team developed acreage and variable projections for the fourteen alternatives proposed by the US Army Corps of Engineers, Los Angeles District. When possible, the Team offered suggestions to enhance the alternatives given the goals and objectives developed earlier in the process. As a general rule, the biological team assumed that much of the land made for the project would be converted to productive riparian settings, and the existing Cottonwood and Mesquite would diminish from urban development. Alternatives that incorporated the deployment of detention basins as well as those alternatives that opted for a vegetative watercourse were assumed to have high habitat quality. Regardless of the manner in which it was achieved, the biological team assumed vegetative growth, and the health of wildlife. The biological team also attempted to capture the vegetative succession of this area in increments over time (low quality early in the life of the project, and higher quality later in the life of the project). By restoring, developing, and protecting these areas, the Biological Team assumed the habitat would be buffered from human disturbance factors, thereby improving the overall value of the habitat in the urban setting.

Overall HGM Results:

The overall HGM results per alternative are summarized in Table 46. The results show that alternative HHM (519 AAFCUs)(the restoration alternative calls for Hydroriparian approach in the active channel and in the floodplain terraces and Mesoriparian approaches deployed in the historic floodplain) produced the highest net AAFCUs across the suite of functions. The second and third highest alternatives were HXX (491 AAFCUs) (the restoration alternative calls for Hydroriparian approaches in the active channel and Xeroriparian approach deployed in the floodplain terraces and historic floodplain) and HHX (490 AAFCUs)(the restoration alternative calls for Hydroriparian approaches in the active channel and floodplain terraces and Xeroriparian approach deployed in the historic floodplain). The least productive alternatives were MMN (the restoration alternative calls for Mesoriparian approaches in the active channel and floodplain terraces and no action being taken in the historic floodplain and MXN (the restoration alternative calls for Mesoriparian approach taken in the active channel, Xeroriparian approach deployed in the floodplain terraces, and no action being taken in the historic floodplain. Both least productive alternatives generated 115 and 62 AAFCUs respectively) across the functions evaluated. No alternative resulted in a loss of functionality in the assessment.

Table 46: Alternatives and Average Net AAFCUs

			NET AAFCUs									
			WATER				BIOGEOCHEM			HABITAT		
Alternative Description	Alternative Code	Average Net AAFCUs	FXN 1: CHANNELDYN	FXN 2: WATSTORENR	FXN 3: WATSTORLNG	FXN 4: WATSTORSUB	FXN 5: NUTRIENT	FXN 6: ELEMENTS	FXN 7: DETPARTICL	FXN 8: PLANTS	FXN 9: HABSTRUCT	FXN 10: INTERSPERS
Locations of Activity are reported in following order:[1]	N-M-X	406	527	841	363	211	571	566	603	110	132	137
1. Active Channel Treatment	N-M-M	451	703	896	457	320	464	550	721	112	143	149
2. Floodplain Terrace Treatment	X-X-X	402	524	836	358	206	579	562	600	109	121	122
3. Historic Floodplain Treatment	M-X-N	62	67	114	46	25	115	96	79	26	28	23
	M-X-X	375	406	810	297	130	670	581	523	103	115	115
	M-M-N	115	209	189	129	112	69	112	186	39	54	47
	M-M-X	409	537	849	369	216	586	569	611	105	125	126
	M-M-M	454	713	903	462	326	474	554	728	107	136	138
	H-N-N	155	233	198	165	160	181	178	198	77	91	64
Codes for Selected Measures Per Location:	H-X-N	188	262	273	164	166	249	233	217	105	124	86
N = No Action in the Location	H-X-X	491	473	821	358	210	740	634	560	344	399	372
X = Xero-Riparian Activities in the Location[2]	H-H-N	194	284	260	201	187	211	217	249	105	128	96
M = Meso-Riparian Activites in the Location[3]	H-H-X	490	496	812	371	231	706	620	570	353	386	360
H = Hydro-Riparian Activitites in the Location[4]	H-H-M	519	676	868	467	344	592	604	690	294	340	318

Table 47: Average Net AAFCUs and HGM Ranking

Alternative Description	Alternative Code	Average Net AAFCUs	HGM Ranking
	N-M-X	406	7
	N-M-M	451	5
	X-X-X	402	8
	M-X-N	62	14
Locations of Activity are reported in following order:[1] 1. Active Channel Treatment 2. Floodplain Terrace Treatment 3. Historic Floodplain Treatment Codes for Selected Measures Per Location: N = No Action in the Location X = Xero-Riparian Activities in the Location[2] M = Meso-Riparian Activites in the Location[3] H = Hydro-Riparian Activitites in the Location[4]	M-X-X	375	9
	M-M-N	115	13
	M-M-X	409	6
	M-M-M	454	4
	H-N-N	155	12
	H-X-N	188	11
	H-X-X	491	2
	H-H-N	194	10
	H-H-X	490	3
	H-H-M	519	1

Costs:

Cost Engineering provided cost estimates for each alternative. These estimates incorporate all costs associated with each alternative and will be used to perform the incremental cost analysis and to select recommended plans for the Paseo de las Iglesias study area.

Table 48: Costs by Alternative

		NMX	NMM	XXX	MXN	MXX	MMN	MMX	MMM	HNN	HXN	HXX	HHN	HHX	HHM
First Cost															
Construction Costs		$34,957,246	$39,745,057	$28,191,262	$9,806,378	$35,384,625	$9,075,675	$34,012,721	$39,926,981	$24,308,004	$24,259,102	$40,104,369	$34,573,054	$45,159,929	$43,258,505
Real Estate Costs		$14,740,828	$14,740,828	$14,687,660	$2,379,268	$14,687,660	$2,432,436	$14,740,828	$14,740,828	$2,286,224	$4,785,120	$14,873,748	$4,638,908	$14,342,068	$14,342,068
Contingency	25%	$12,424,518	$13,621,471	$10,719,731	$3,046,412	$12,518,071	$2,877,028	$12,188,387	$13,666,952	$6,648,557	$7,261,056	$13,744,529	$9,802,990	$14,875,499	$14,400,143
Planning, Survey, Engineering and Design	10%	$3,495,725	$3,974,506	$2,819,126	$980,638	$3,538,462	$907,567	$3,401,272	$3,992,698	$2,430,800	$2,425,910	$4,010,437	$3,457,305	$4,515,993	$4,325,850
Engineering During Construction	1%	$349,572	$397,451	$281,913	$98,064	$353,846	$90,757	$340,127	$399,270	$243,080	$242,591	$401,044	$345,731	$451,599	$432,585
Supervision and Administration	6.5%	$2,272,221	$2,583,429	$1,832,432	$637,415	$2,300,001	$589,919	$2,210,827	$2,595,254	$1,580,020	$1,576,842	$2,606,784	$2,247,249	$2,935,395	$2,811,803
Adaptive Management	3%	$1,048,717	$1,192,352	$845,738	$294,191	$1,061,539	$272,270	$1,020,382	$1,197,809	$729,240	$727,773	$1,203,131	$1,037,192	$1,354,798	$1,297,755
Total First Costs		$69,288,827	$76,255,092	$59,377,862	$17,242,365	$89,844,204	$16,245,652	$67,914,545	$76,519,793	$38,225,928	$41,278,394	$76,944,042	$56,102,428	$83,635,282	$80,868,710
IDC		$3,765,634	$4,144,229	$3,227,004	$937,069	$3,795,817	$882,901	$3,690,946	$4,158,615	$2,077,461	$2,243,353	$4,181,671	$3,048,994	$4,545,320	$4,394,965
Gross Investment		$73,054,462	$80,399,322	$62,604,865	$18,179,435	$73,640,021	$17,128,553	$71,605,491	$80,678,407	$40,303,387	$43,521,747	$81,125,713	$59,151,422	$88,180,602	$85,283,675
Average Annual Cost		$4,394,110	$4,835,892	$3,765,583	$1,093,464	$4,429,331	$1,030,255	$4,306,957	$4,852,678	$2,424,185	$2,617,764	$4,879,583	$3,557,864	$5,303,923	$5,128,475
O&M															
Annual O&M		$549,915	$550,619	$87,495	$97,737	$152,371	$528,828	$583,460	$559,016	$887,500	$847,357	$942,252	$1,007,112	$1,074,122	$1,308,294
Periodic O&M		$343,948	$338,131	$341,023	$135,173	$341,023	$107,578	$313,427	$307,610	$308,886	$428,928	$434,745	$350,315	$356,132	$350,315
Total O&M		$893,863	$888,749	$428,518	$232,910	$493,394	$636,403	$896,887	$866,625	$1,196,386	$1,276,285	$1,376,997	$1,357,426	$1,430,254	$1,658,608
Total Average Annual Cost		$5,287,973	$5,724,641	$4,194,101	$1,326,375	$4,922,724	$1,666,659	$5,203,844	$5,719,304	$3,620,570	$3,894,049	$6,256,580	$4,915,291	$6,734,177	$6,787,083
Average Annual FCUs		406.00	451.00	402.00	62.00	375.00	115.00	409.00	454.00	155.00	188.00	491.00	194.00	490.00	519.00

Incremental Cost Analysis (ICA) Overview:

IWR-Plan uses two techniques address the question: is the alternative worth it in the cost evaluation process? First, the results of the habitat assessment were compared using Cost Effectiveness Analysis (CEA). When comparing alternatives using CEA, those alternatives that produce increased levels of output (AAFCUs) for the same or lesser costs were considered "effective" solutions and were retained. These alternatives were, in turn, compared on the basis of cost efficiency (i.e. those alternatives that produce similar levels of output (AAFCUs at a lesser expense). The "efficient" solutions were submitted to Incremental Cost Analysis (ICA) (i.e. determining changes in costs for increasing levels of outputs). Once evaluated, through a computer program called IWR-Plan, on the basis of cost effectiveness and incremental cost analysis, the best buy solutions were revealed (those that are both cost effective and incrementally effective).

Final Array of Alternatives (1st Run):

The results of the 1st ICA run are displayed in the Table below along with rankings of average cost (annual costs per AAFCU) and HGM: The top average cost alternative and incrementally effective and efficient solution evaluated was XXX. The second ranked average cost and cost effective plan was MMM; however, MMM did not come out as a best buy. The third ranked average cost plan was not cost efficient and effective as shown in the CEA ranking and did not rank as a best buy plan.

Table 49: Average Cost, ICA and HGM Rankings

Total Average Annual Cost	Average Cost	Cost Effectiveness Analysis (CEA) Ranked by Average Cost	ICA Ranking	HGM Ranking	Alternative	Average Net AAFCUs	Average Annual Cost	Average Cost (Cost Per AAFCU)
1	12	8		14	MXN	62	$1,326,375	$21,393
2	10	6		13	MMN	115	$1,666,659	$14,492
3	13	9		12	HNN	155	$3,620,570	$23,358
4	11	7		11	HXN	188	$3,894,049	$20,713
5	1	1	1	8	XXX	402	$4,194,101	$10,433
6	14			10	HHN	194	$4,915,291	$25,336
7	8			9	MXX	375	$4,922,724	$13,127
8	4	3		6	MMX	409	$5,203,844	$12,723
9	6			7	NMX	406	$5,287,973	$13,024
10	2	2		4	MMM	454	$5,719,304	$12,597
11	3			5	NMM	451	$5,724,641	$12,693
12	5	4		2	HXX	491	$6,256,580	$12,742
13	9			3	HHX	490	$6,734,177	$13,743
14	7	5	2	1	HHM	519	$6,787,083	$13,077

A detailed breakdown of the ICA results is listed below in Table 50.

Table 50: Final Incremental Cost Analysis Results

Alt.	AAFCUs	Annual Cost	Average Cost	Incremental Cost	Incremental Output	Incremental Avg. Cost
XXX	402	$4,194,101	$10,433	$4,194,101	402	10,433
HHM	519	$6,787,083	$13,077	$2,602,982	117	22,247

Figure 2: Final Incremental Cost Results For Paseo de Las Iglesias (Incremental Average Cost by Incremental Output)

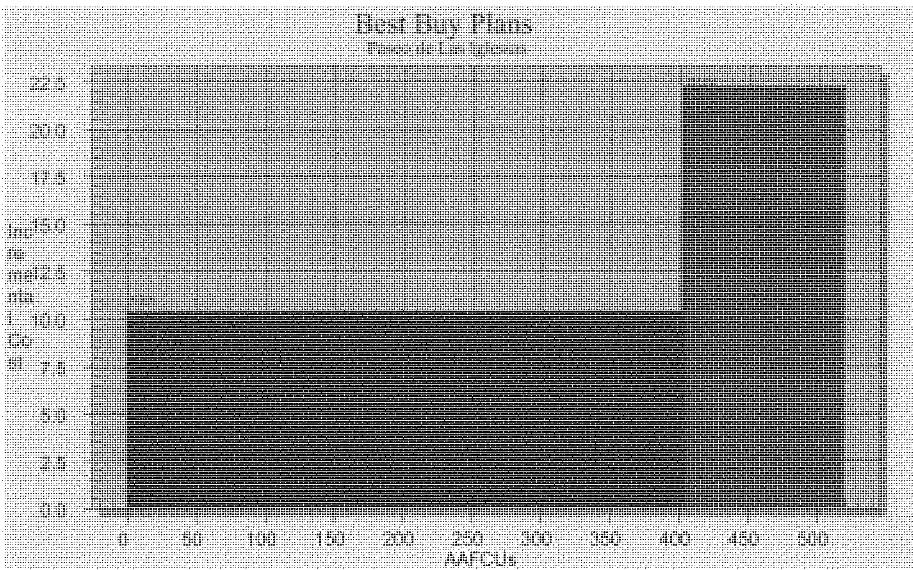
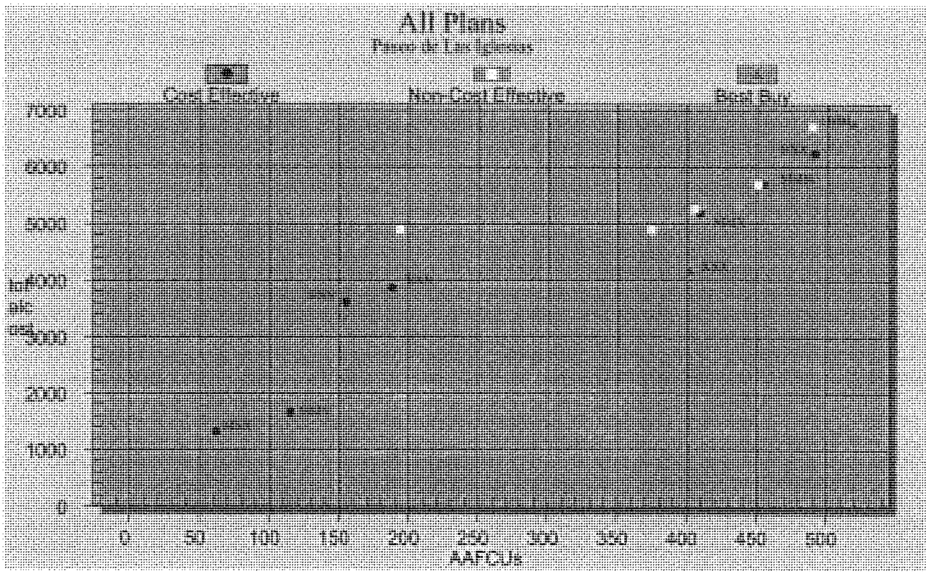


**Figure 3: All Plans Differentiated
(CEA Plans and Best Buy Plans Labeled)**



The incremental cost analysis indicates that alternatives listed in Table 45 are cost efficient and cost effective. Of the best buy plans, XXX is the least costly to build at $4,194,101 but also produces the least amount of AAFCUs (402) at $10,433 per AAFCU. HHM will cost an additional $2,602,982 on an average annual basis and produce 117 additional AAFCUs for an incremental cost of $22,247 on an average annual basis per additional AAFCU. This means HHM can be implemented for only 117 more units but the incremental cost per additional incremental AAFCU will be 100% greater than XXX at $10,433.

XXX has the least average cost, is the ICA best buy and is cost effective. It produces 402 AAFCUs and is ranked 8th place in the HGM. XXX's rates 5th overall in total average annual cost. On the other hand, HHM is the largest plan at 14th place overall in total average annual cost. It is 7th place in average cost and 5th place in cost effective analysis. It is the second best buy plan and the biggest most expensive plan. It will always end up on the final ICA list of best buy plans. It is not necessarily a good buy but is simply an end point. HHM provides 117 extra AAFCUs but at double the incremental cost of XXX and a first cost of more than 20 million more than XXX.

Upon further evaluation, a quantified water constraint was applied. This would eliminate all the Hyrdoriparian alternatives from consideration and thereby remove one of the best buy alternatives from the 1st run. The reason the initial evaluation included all the alternatives is: an array of possibilities needed to be fully developed and established to better know what important elements should remain and what elements should be excluded from further analysis.

Final Array of Alternatives (2nd Run):

The results of the 2nd ICA run are displayed in the Table below along with rankings of average cost (annual costs per AAFCU) and HGM: The top average cost alternative and incrementally effective and efficient solution evaluated was XXX. The second ranked average cost and cost effective plan was MMM; it also came out as a best buy. The third ranked average cost plan was not cost efficient and effective as shown in the CEA ranking and did not rank as a best buy plan.

Table 49: Average Cost, ICA and HGM Rankings

Total Average Annual Cost	Average Cost	Cost Effectiveness Analysis (CEA) Ranked by Average Cost	ICA Ranking	HGM Ranking	Alternative	Average Net AAFCUs	Average Annual Cost	Average Cost (Cost Per AAFCU)
1	8	5		8	MXN	62	$1,326,375	$21,393
2	7	4		7	MMN	115	$1,666,659	$14,492
3	1	1	1	5	XXX	402	$4,194,101	$10,433
4	6			6	MXX	375	$4,922,724	$13,127
5	4	3		3	MMX	409	$5,203,844	$12,723
6	5			4	NMX	406	$5,287,973	$13,024
7	2	2	2	1	MMM	454	$5,719,304	$12,597
8	3			2	NMM	451	$5,724,641	$12,693

A detailed breakdown of the ICA results is listed below in Table 50.

Table 50: Final Incremental Cost Analysis Results

Alt.	AAFCUs	Annual Cost	Average Cost	Incremental Cost	Incremental Output	Incremental Avg. Cost
XXX	402	$4,194,101	$10,433	$4,194,101	402	10,433
MMM	454	$5,719,304	$12,597	$1,525,203	52	29,330

Figure 2: Final Incremental Cost Results For Paseo de Las Iglesias (Incremental Average Cost by Incremental Output)

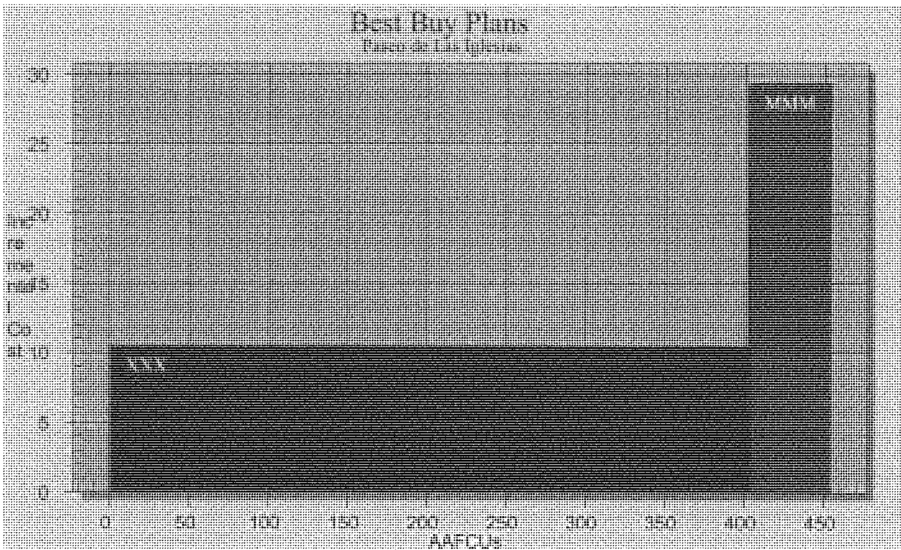
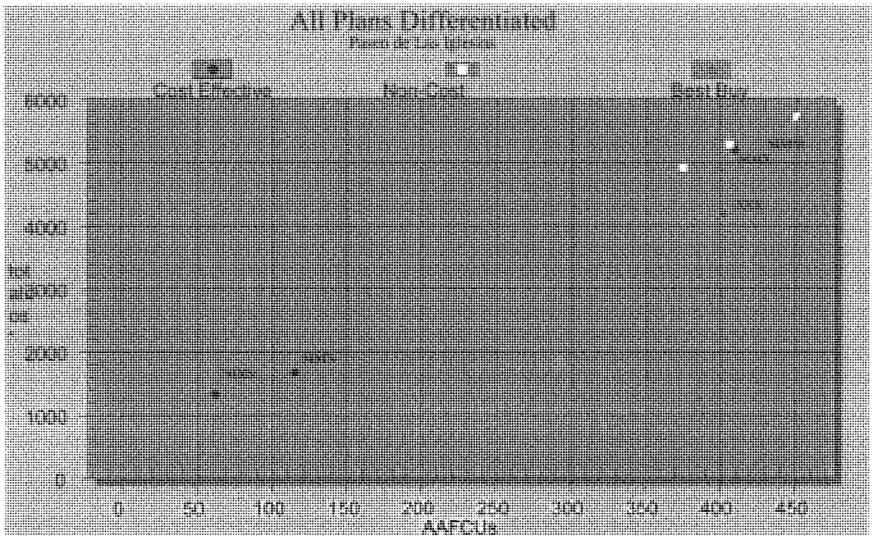


Figure 3: All Plans Differentiated
(CEA Plans and Best Buy Plans Labeled)



The incremental cost analysis indicates that alternatives listed in Table 50 are cost efficient and cost effective. Of the best buy plans, XXX is the least costly to build at $4,194,101 but also produces the least amount of AAFCUs (402) at $10,433 per AAFCU. MMM will cost an additional $1,525,203 on an average annual basis and produce 52 additional AAFCUs for an incremental cost of $29,330 on an average annual basis per additional AAFCU. This means MMM can be implemented for an additional 52 more units but the incremental cost per additional incremental AAFCU will be 300% greater than XXX at $10,433.

XXX has the least average cost, is the ICA best buy and is cost effective. It produces 402 AAFCUs and is ranked 8th place in the HGM. XXX's rates 5th overall in total average annual cost. On the other hand, MMM is one of the largest plans at 7th place overall in total average annual cost. It is 2nd place in average cost and 2nd place in cost effective analysis. It is the second best buy plan and the biggest most expensive plan. It will always end up on the final ICA list of best buy plans. It is not necessarily a good buy but is simply an end point. MMM provides 52 extra AAFCUs but at triple the incremental cost of XXX and a first cost of more than 17 million more than XXX.

The following presents summary results from MCACES level cost estimates for the Recommended Plan. These costs are not directly comparable to the preliminary cost estimates included in the Incremental Cost Analysis, since they have been refined and include additional items not included in the preliminary estimates.

Table 51: MCACES for Alternative MMM

Benefits	
First Cost	
Construction & Real Estate	$72,828,371
Construction Costs	$46,586,265
Real Estate Costs	$26,242,106
Contingency	$6,987,940
PED	$4,658,627
Eng. During Construction	$465,863
Construction Mgmt	$3,482,323
Adaptive Mgmt	$1,870,205
Monitoring	$623,304
Total First Costs	$90,916,632
IDC	$4,941,039
Gross Investment	$95,857,671
Average Annual Costs	$5,765,687
OMRRR	$1,869,961
Total Average Annual	$7,414,600

Recreation Analysis:

As mentioned earlier in the Santa Cruz River Park subsection of the Recreation Analysis section under without project conditions in this report, the Santa Cruz River Park already exists. It runs along the Santa Cruz River in two segments. One segment is from Silverlake to Grant Road while the second segment runs from Irvington road to Ajo Way. The park facilities include: pedestrian and bicycle trails, a Frisbee golf course, exercise courses, restrooms, drinking fountains, ramadas, picnic sites, BBQ grills, playgrounds, parking and art projects.

Any proposed plan to promote recreation within the already established park area would be minimal when compared to the larger environmental restoration project because there will undoubtedly be impacts upon the environment. Whenever the encroachment of humans is involved in the form of recreation adverse impact may result especially to a newly developed environment. However, these impacts can be minimized in ways that promote environmental ecosystems and still promote human interaction with nature. Special care must be taken to insure that the nature habitat and character of the restored area is preserved while still allowing appropriate recreational activities to occur.

These are considerations that have to be met when formulating recreation opportunities. They have been considered greatly and at this juncture in the study process a recreation plan has been developed around the restoration features of the tentatively selected NER plan.

Recreation Improvements:

Even though the Santa Cruz River Park already exists along the Santa Cruz River, some changes can be made to the park to increase recreation value and perhaps visitation along the River. Decomposed granite (DG) and parking serve a recreation purpose by providing opportunities to a variety of recreational users. Signs interpret the environment thereby enhancing recreation experience of the user. Comfort stations, rest stops, and benches serve the basic needs of the recreational user. Other changes to the park can serve the ecosystem restoration purpose by reducing safety and maintenance concerns stemming from the project. All road segments and ramps designated as maintenance provide access to areas in case of emergencies such as flooding and fire. Access will also provide a means to maintain vegetation in the newly restored area and park facilities. Warning signs are also added to direct pedestrians off the newly restored area and basically guide pedestrians away from any potential danger.

Table 27 below shows how changes made to the park have been separated by purpose. The changes separated into the recreation purpose will be discussed in detail in this section while changes separated into the ecosystem purpose will be added to the restoration cost of the project and no longer discussed within this section.

Table 52: Allocation of Features

Recreation	Ecosystem Restoration
DG Trail North Bank	Compacted Earth Road (Infrequent Use)
Comfort Stations	Gravel Road (Frequent Use)
Rest Stops	Paved Road (Maintenance Road)
Concrete Benches	Bridges
Signage	
Parking	

Unit Day Value Method:

With the recreation improvements identified and described above, the unit day value (method described in the recreation component of this report under the without project condition) can be derived by selecting point values for recreation criteria and with the input of the US Army Corps of Engineers, LA District and local government agencies. These values are then applied to projected visitation. Because visitation figures have already been adjusted for double counting and projected over fifty years using a relationship to projected population growth, they will be used as a basis. But, further adjustments will be made to account for changes in visitation due to the construction of the project. These adjusted visitation figures will again be compared to capacity limits established by the National Recreation Parks Association.

The recreation criteria described in the Recreation Demand Section of this report remain the same for the with project condition. The only changes will include impacts of the proposed recreation improvements along the Santa Cruz River. They include:

1. ***Recreation Experience***--Same as Without Project Condition
2. ***Availability of Opportunity***--Same as Without Project Condition
3. ***Carrying Capacity***--As previously discussed, Pima County will experience rapid population growth. To accommodate this increase in population additional parking lots, along with areas three comfort stations and twenty benches are being proposed for the Rillito River Park. DG multipurpose trail segments will also enhance carrying capacity along the Santa Cruz River. These proposed facilities would allow for future population growth.
4. ***Accessibility***--Same as without project
5. ***Environmental***--Since there is no significant thriving riparian areas located in the study area, the restoration of the Santa Cruz River would prove to be a highly valued recreational area. Visitors could recreate near a thriving habitat for plants and animals. Restoration of this area could mean some of the significant unmet recreational demand for riparian areas could be met. Restoration features would also create more passive opportunities for wildlife viewing, aesthetic experience, and education. Recreational trails, signs, and access will be located so as to allow for recreation activities in such a way as to discourage interference and recreation in habitat areas.

Point values for the five recreation criteria listed above are estimated for the proposed Rillito River Park features.

Table 53: Point Values for Without Project Conditions
Paseo de las Iglesias

Recreation Criteria	Value Range	Point Values Without Project	Point Values With Project
Recreation Experience	0-30	8	8
Availability of Opportunity	0-18	3	3
Carrying Capacity	0-14	6	10
Accessibility	0-18	8	8
Environmental	0-21	2	12
Total		27	41

The point values described above are totaled and converted into an equivalent UDV amount. The total point value for Santa Cruz River Park is 41 for the five recreational criteria. The equivalent UDV amount for 41 points is $5.71. This UDV amount represents how much a visit to the park is worth in dollar amount for the with project condition.

Projected Visitation:

To calculate the recreational value for with project conditions, the UDV is multiplied by projected annual visitation. Projected annual visitation includes anticipated increases in visitation due to the addition increases to carrying capacity and the changes in the environmental experience. Projected visitation also includes additional visits due to the improvements, population growth, and the Paseo de las Iglesias restoration.

Table 54: Projected Visitation
Santa Cruz River Park Extension

Location	Original 2001	Half + Adjustment 2001	2012	2020	2030	2040	2050	2060	2062
Visitors (OneBank)	18,312	24,812	28,697	29,681	35,131	40,371	45,039	49,260	52,921
Annual Growth Rate			1.021	1.017	1.017	1.014	1.011	1.009	1.009

Recreation Value:

To calculate the recreational value for with project conditions, the UDV is multiplied by annual visitation. The product of the UDV and average annual visitations over 50 years can be seen in the below table.

Table 55: Projected Recreation Value
Santa Cruz River Park Extension

Location	2008	2010	2020	2030	2040	2050	2058
Recreation Value (One Bank)	$163,718	$169,332	$200,424	$230,318	$256,945	$281,029	$301,913

The stream of recreation values over 50 years was discounted (NPV = $3,199,450) for Santa Cruz River Park Extension. Annualized recreation value is $182,193 for one bank of the Santa Cruz River Park. The other bank is approximately $163,973 for a total of $346,166. Benefits equal $135,484 for the Santa Cruz River Park.

Costs:

The US Army Corps of Engineers, Los Angeles District prepared cost estimates for the recreation project improvements.

Table 56: Recreation Plan
Santa Cruz River Park Extension

Improvements	Quantity	Description	Cost
DG Trail	255,249 Sq. Ft.	Decomposed Granite Path	$135,281.78
Comfort Stations	3 Stations	One rest room every two miles	$110,000.00
Rest Stops	5 Stops	Rest areas at 1 per mile	$99,700.00
Concrete Benches	20 Benches	Benches at 1 per quarter mile	$2,400.00
Signage	10 Signs	Signs at 1 per half mile	$777.50
Parking	5 Parking Lots	5 lots along the Santa Cruz	$67,072.20
Total			$415,231.00

The following presents summary results from cost estimates for the Recreation Plan. These costs are based on MCACES cost estimates. When are refined cost estimates and may have additional costs included within the estimate. MCACES are not directly comparable to the preliminary cost estimates.

Table 57: Summary of Benefits and MCACES

Recreation Value	
Recreation Value W/O	$210,682
Recreation Value W	$346,166
Total Benefits	$135,484
First Cost	
Construction & Real Estate	$854,566
Construction Costs	$854566
Real Estate Costs	$0
Contingency	$128,185
PED	$85,457
Eng. During Construction	$9,828
Construction Mgmt	$63,879
Total First Costs	$1,141,914
Interest During Construction	$13,123
Gross Investment	$1,155,037
Average Annual Costs	$69,474
OMRRR	$36,260
Total Average Annual Costs	$105,074
B/C	1.29
Net Benefits	$30,410

US Army Corps of Engineers Guidance (PGL 36) specifies that the level of financial participation in recreation development by the Corps may not increase the Federal cost of the project by more than ten percent. The total first cost for the recommended restoration project is $90,916,632. This cost would be cost shared on a 65%/35% basis between the Corps and the local sponsor. Hence, the Corps share of the restoration project cost totals about $59,095,810. Recreation costs are cost shared on a 50%/50% basis between the Corps and the local sponsor. Fifty percent of the first cost of the recreation plan is $570,957 that would only increase the level of Federal financial participation by less than 1%.

ADDENDUM

Existing Recreational Resources:

The following presents the primary recreation facilities within Pima County/Tucson metropolitan area.

National Parks (Tucson Metropolitan Area):

- Coronado National Forest
- Saguro National Park
  - Rincon Mountain District
  - Tucson Mountain District
- Santa Catalina Ranger District
  - Pusch Ridge Wilderness
  - Ricon Mountain Wilderness

State Parks (Tucson Metropolitan Area):

- Catalina State Park

BLM Lands (Tucson Metropolitan Area):

- Empire-Ciencga Conservation Area

County Parks:

- Augie Acuna Los Ninos Neighborhood Park
- Cicnega Creek Natural Preserve
- John A Valenzuela Community Center
- Southeast Regional Park
- Coronado Middle School Park
- Emily Gray Jr. High School
- George Mehl Foothills District Park
- McDonald District Park
- Lew Sorensen Tanque Verde Center
- Kino Veterans Memorial
  Community Center and Sports Complex
- Kino Teen Center
- Old Spanish Trail Bicycle and Hiking Trail
- Thomas Jay Regional Park
- Murphey Multi-Use Field
- Rillito River Park
- Roy P. Drachman- Agua Caliente Regional Park
- Arthur Pack Regional Park
- Casas Adobes Neighborhood Park
- Catalina Neighborhood Park and Recreation Center
- Children's Memorial Neighborhood Park
- Denny Dunn Neighborhood Park
- Feliz Paseos
- Flowing Wells Jr. High School
- Linda Vista Neighborhood Park
- Meadowbrook Neighborhood Park
- Overton Arts Center
- Pegler Recreation Area
- Picture Rocks
  Community Center and District Park
- Richardson Neighborhood Park
- Rillito Vista
  Neighborhood Park and Recreation Center
- Sunset Point Neighborhood Park
- Ted Walker District Park
- Wildwood Neighborhood Park
- Branding Iron Neighborhood Park
- Cardinal Neighborhood Park
- Centro Del Sur Community Center
- Lawrence District Park
- Mission Ridge Neighborhood Park
- Paseo De Los Arboles Commemorative Park
- Paseo De Lupe Eckstrom
  (Tucson Diversion Channel)
- Santa Cruz River Park
- Southwest Community Center
- Three Points Veterans
  Memorial Neighborhood Park
- Vesey Neighborhood Park
- Winston Reynolds-Manzanita
  District Park
- Ajo Regional Park
- E.S. "Bud" Walker Neighborhood Park
- Gibson Neighborhood Park
- Palo Verde Neighborhood Park
- Anamax Neighborhood Park and Recreation Center
- Continental Community Center
- Kay Stupy-Sopori Neighborhood Park
- Tucson Mountain Park
- Sahuarita District Park and
- Cienega Creek Natural Preserve
- Tortolita Mountain Park
- Colossal Cave Mountain Park
  Joan M. Swetland Community Center

City Parks:

- Christopher Columbus Park
- Sentinel Peak Park
- Case Park
- Fort Lowell Park
- Golf Links Sports Complex
- Greasewood Park
- Houghton Park
- Jacobs Park
- John F. Kennedy Park
- Kino& 36th St. Park
- Lakeside (Charles Ford) Park
- Lincoln Park
- Gene C. Reid Park
- Rodeo Park
- Santa Cruz River Park
- Morris K Udall Park
- Valle Allegre Park
- Freedom Park
- Himmel Park
- Juhan Park
- Mansfield Park
- McCormick Park
- Mission Manor Park
- Joaquin Murrieta Park
- North Central Park
- Jesse Owens Park
- Palo Verde Park
- Michael Perry Park
- Purple Heart Park
- Rodeo Grounds
- San Juan Park
- Santa Rita Park
- Sunnyside Park
- 20/30 Park
- Alvernon Park
- Balboa Heights Park
- Bravo Park
- Catalina Park
- Cherry Avenue Park
- Connor Park
- Country Club Annex Park
- De Anza Park
- Desert Aire Park
- Desert Shadows Park
- Eastmoor Park
- El Presidio Plaza Park
- El Pueblo Park
- Escalante Park
- Francisco E. Esquer Park
- Estevan Park
- Fiesta Park
- Stefan Gollob Park
- Groves Park
- Hoffman Park
- Don Hummel Park
- Iron Horse Park
- Jacinto Park
- Harriet Johnson Park
- La Madera Park
- La Mar Park
- Linden Park
- Menlo Park
- Mesa Village Park
- Military Plaza Park
- Miracle Mile Manor Park
- Mirasol Park
- Mitchell Park
- Oaktree Park
- Ormsby Park
- Oury Park
- Parkview Park
- Pinecrest Park
- Pueblo Gardens Park
- Rodeo Wash Park
- Rolling Hills Park
- Santa Rosa Park
- Sears Park
- Swan Park
- Swanway Park
- Tahoe Park
- Terra Del Sol Park
- James Thomas Park
- Toumey Park
- Veinte De Agosto Park
- Villa Serena Park
- Vista Del Prado Park
- Vista Del Pueblo Park
- Vista Del Rio Park
- Wilshire Heights Park
- Harold Bell Wright Park
- Amphitheater High School
- Amphitheater Middle School
- E.C. Nash Elementary School
- Flowing Wells High School
- Pima Community College
- Sunnyside High School
- Booth-Fickett Middle School
- Catalina High School
- Cholla High School
- Doolen Middle School
- Jefferson Park Elementary School
- John B. Wright Elementary School
- Magee Middle School
- Manzo Elementary School
- Palo Verde High School
- Richey Elementary School
- Rincon High School
- Rollin Gridley Middle School
- Sahuaro High School
- Santa Rita High School
- Townsend Middle School
- Tucson Magnet High School
- Utterback Middle School
- Vail Middle School
- Manuel Valenzuela Alvarez Park
- Cherokee Avenue Park
- El Tiradito Wishing Shrine
- Garden of Gethsemane
- Jardin Cesar Chavez Park
- Mariposa Park
- Riverview Park
- San Augustine Park
- Seminole Park
- Street Scene Park
- Sunset Park
- Verdugo Park

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report

APPENDIX I

REAL ESTATE PLAN

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

EXECUTIVE SUMMARY

1. Project Location:

The Paseo de las Iglesias Feasibility Study Area consists of a 7.5-mile reach of the Santa Cruz River and adjacent lands, totaling 5,005 acres, within the City of Tucson and Pima County, Arizona. More specifically, the study area consists of the Santa Cruz River Valley between Los Reales Road and West Congress Street. Interstate highways 10 and 19 define the eastern boundary of the study area and Mission Road the western boundary. The proposed project area consists of approximately 1,223 acres of undeveloped lands situated within the larger study area (Figure 1).

2. Real Estate Requirements Summary:

The project would encompass 1,223 acres situated within the river channel and historic floodplain of the Santa Cruz River and the West Branch tributaries. Some associated side drainages and channels that feed these rivers are also included in the project. The land is all subject to floodplain and floodway restrictions that place significant limitations on its highest and best use or development. According to the project gross appraisal, the property is within the historic floodplain and the highest and best use of these properties is for flood control purposes. Zoning is for a "River Park" according to the Santa Cruz Area Plan.

A table of the real estate or Lands, Easements, Rights-of-way, Relocation, and Disposal Areas (LERRDs) requirements in summary fashion is presented as follows:

Land Category	Number of Parcels	Acreage	Gross Appraisal Est. ($)
City of Tucson	64	512	3,322,296
Pima County (NFS)	27	110	4,717,140
Unnumbered Parcels-include storm drains and drainage ROW in project area	22	30	97,069
Private Tracts	77	557	15,170,007
State of Arizona	I	14	635,594
TOTALS	191	1,223	23,942,106

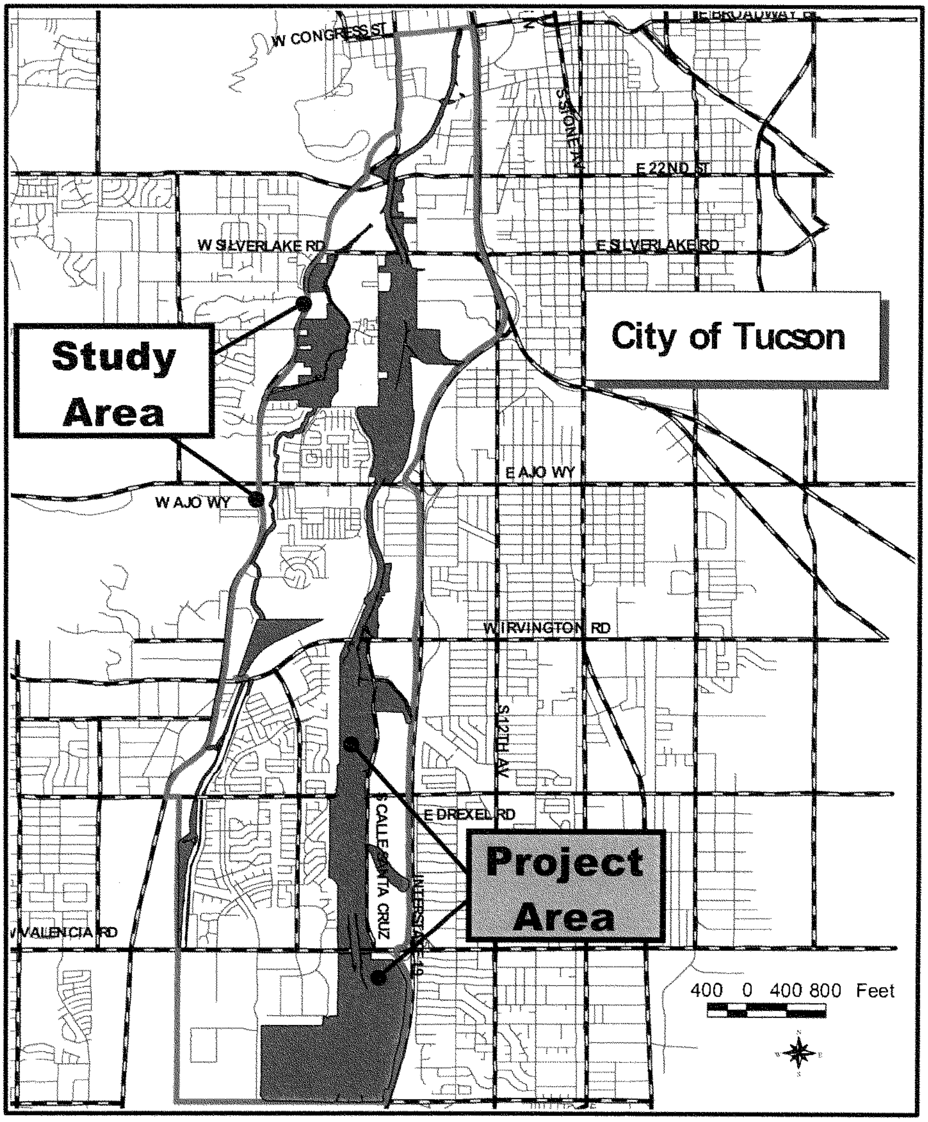


Figure 1: Study and Project Area Boundaries

Appendix I: Real Estate Plan

Santa Cruz River, Paseo de las Iglesias, Arizona Feasibility Study

Abstract of Project Data:

Project Name: Santa Cruz River, Paseo de las Iglesias, Arizona

Location: Pima County, Arizona

Project Purpose: Ecosystem Restoration and Recreation

Acreage: 1,223 Acres

Gross Appraisal Estimate: $23,942,106

Estimate with Contingency: $26,242,106

Non-Federal Sponsor: Pima County Dept. of Transportation and Flood Control District.

1. Introduction:

The Santa Cruz River (Paseo de las Iglesias), Arizona Feasibility Study is being performed to investigate water resources related problems and provide potential solutions to these identified problems. The primary problem identified is ecosystem degradation, which is the focus of the Feasibility Study and this Real Estate Plan (REP).

The Paseo de las Iglesias project area consists of a 7.5-mile reach of the Santa Cruz River and its tributary washes, beginning where Congress Street crosses the river in downtown Tucson and extending upstream along the river to Los Reales Road. Los Reales Road is the northern boundary of the San Xavier District of the Tohono O'odham Nation. The eastern boundary of the study is Interstates 10 and 19. The western study boundary coincides with Mission road. The study area comprises urban and suburban Tucson and unincorporated areas of Pima County and is depicted in Figure 1.

The Santa Cruz River has experienced large-scale channel degradation and lateral migration over the last century. Extensive groundwater overdraft and the impacts of urbanization have resulted in the loss of critical Sonoran Desert riparian habitat and overall ecosystem degradation. Without a project, this trend is expected to continue with the continued urbanization of Tucson. The project would establish the corridor as a restored and protected riparian area, maintained for its environmental benefits and attributes.

2. Authority:

The statutory authority for this project is contained in the following enacted laws:

Paseo de las Iglesias, Pima County, Arizona Feasibility Report was specifically authorized by section 212 of the Water Resources and Development Act of 1999, Pub. L. No. 106-53, 33 U.S.C. 2332. Section 2332(a) states:

The Secretary [of the Army] may undertake a program for the purpose of conducting projects to reduce flood control hazards and restore the natural functions and values of rivers throughout the United States.

Subsection (b)(1), 33 U.S.C. 2332(b)(1), provides authority to conduct specific studies "to identify appropriate flood damage reduction, conservation, and restoration measures." Subsection (c), 33 U.S.C. 2332(c), states the cost-sharing requirement applicable to studies and project conducted pursuant to section 2332. Subsection (e), 33 U.S.C. 2332(e), identifies priority areas. It states in pertinent part:

In carrying out this section, the Secretary shall examine appropriate locations, including--

(1) Pima County, Arizona, at Paseo de las Iglesias and Rillito River; . . . .

Authority for project implementation would be sought in an upcoming Water Resources Development Act as a separately authorized civil works project.

3. Purpose of this Report:

The purpose of this Real Estate Plan (REP) is to support the Santa Cruz River Paseo de las Iglesias, Arizona Feasibility Study decision document to be submitted as the basis of project authorization in the next Water Resources Development Act.

4. Sponsor Capability:

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 Rillito River Flood Control and Bank Stabilization Project, and has demonstrated their capabilities in acquiring real estate and performing the related obligations of a Non-Federal Sponsor.

5. Description of Recommended Plan:

The Recommended Plan, Alternative 3E, is characterized by the commitment of water to create an intermittent flow channel supporting adjacent growth of emergent wetlands and cottonwood-willow gallery forest. Additional areas on terraces above the channels and in the historic floodplain would be irrigated to sustain mesquite bosques interspersed with riparian shrub. Reclaimed water is the recommended water source to support the ecosystem restoration. Water harvesting (delaying and temporarily storing or rerouting rain and storm events) is also a source of supplemental water.

There are no associated "LERRD" costs with these water sources that have been identified at this time. Providing sustainable water to the project is a non-Federal responsibility for operating and maintaining the project, similar to providing any other utility or service.

Implementation of this alternative involves constructing a low flow channel that would convey released flows through the entire length of the Santa Cruz River within the project boundaries. This feature would be constructed in a manner to help direct infiltration losses from the intermittent flow toward restored habitat areas to be created on either side of the channel.

The areas on each side of the low flow channel would include a narrow band where soil saturation conditions resulting from infiltration would be conducive to emergent marsh. Cottonwood and willow would be planted on low terraces adjacent to the emergent marsh to further utilize infiltrating water from the intermittent channel.

To prevent conveyance impacts that could result from such features, plantings on lower terraces in the channel would be limited to riparian grasses and managed to limit growth of denser, more resistant vegetation. The higher terraces would be planted with mesquite and riparian shrubs. The plan also includes construction and planting of stormwater harvesting basins at the confluences of 8 tributaries, and permanent irrigation systems for all planted areas including the aquitards.

Cutting back into the historic floodplain to create gentler and more stable slopes would modify the reaches of steep, eroded banks. Where the sponsor enjoys sufficient existing lands to accommodate this measure, banks would be graded at a 5-foot horizontal to 1-foot vertical slope and planted. In those areas where sufficient land is not available, the banks would be laid back to the minimum slope that can fit into the available space. These slopes would also be vegetated. However, a geotextile layer would be installed before planting to increase slope stability. This treatment is not intended to prevent lateral channel migration during catastrophic events. However, it would reestablish a hydrologic connection to the river and reduce the frequency of bank failure during intermediate events.

The estimated Fair Market Value of approximately 200 parcels in the project is $23,942,106. Additional incidental costs associated with acquisition would include, but are not limited to, administration, title, closing, appraisals, survey, attorneys and mapping. These are estimated at 10% of acquisitions total Fair Market Value, or $2.3 million. This provides a grand total LERRD acquisition and estimated LERRD cost of $26,242,106.

6. Land Use and Acreage Allocations:

Application of sound real estate principles, including blocking out along regular and definable boundaries, minimizing severance, and maintaining usable and economic remainders outside the project area, have designated the project footprint. The project footprint is deemed sufficient to accommodate the construction, operation, maintenance, repair and replacement of the proposed project.

A summary of the real estate land requirements is as follows:

Land Category	Number of Parcels	Acreage	Gross Appraisal Est. ($)		
City of Tucson	64	512	3,322,296	6500	7K
Pima County (NFS)	27	110	4,717,140	42,900	43K
Unnumbered Parcels- include storm drains and drainage ROW in project area	22	30	97,069	3,235	3K
Private Tracts	77	557	15,170,007	27,235	27K
State of Arizona	1	14	635,594	45,339	45K
TOTALS	191	1,223	23,942,106	[illegible]	[illegible]

All of the acreage recommended to support the project is allocated to the purposes of ecosystem restoration. There are no separable recreation lands involved in this project.

It is recommended here that the lands to be acquired from the City of Tucson and the State of Arizona be acquired in fee simple title (see also Section 14). In the event that the Non-Federal Sponsor is unable to acquire lands owned by the State of Arizona, these lands should be removed from the project area and restoration measures identified for the state lands be relocated elsewhere within the project area. Currently, no future development plans or facilities have been identified for the State and City owned lands.

7. Federal Lands, Interests or Reservations:

There are no Federally owned lands, interests or reservations within the study or project area.

8. Navigational Servitude:

The Santa Cruz River main stem and associated tributaries are ephemeral and non-navigable. They do not and cannot sustain navigation. Therefore, there is no availability of a navigational servitude for this project.

9. Description of Lands:

a. <u>General Description</u>:

The proposed project area consists of 1,223 acres located in and around the Santa Cruz River, West Branch and tributaries. The project area is within the City of Tucson. The area is an irregular shape, and includes the river channel, terraces, and adjacent lands. The northern boundary is Congress Street. The southern boundary is the Los Reales

Road alignment. The surrounding study environs are surrounded by residential zoning, but also include commercial, industrial, and public use zoning. Lands included in the delineated project area are not improved.

b. Lands Owned by Non-Federal Sponsor:

Properties owned by the Non-Federal Sponsor, Pima County, include retired agricultural lands, flood prone lands, drainage ways, and open space properties located in and around the Santa Cruz River, West Branch and tributaries.

10. Project Maps:

Project maps are included in Chapters V and VI of the Main Feasibility Report and in the Design Appendix.

11. Crediting for LERRD's:

Crediting would follow standard procedures as set out in a model Project Cooperation Agreement (PCA). No Credit would be afforded to any lands or interests previously acquired and credited for any applicable Corps of Engineers Project.

Credit would only be applied to the acreage within the "project footprint", namely the lands or corridor required to implement the recommended ecosystem 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. Only lands deemed necessary for project completion have been included.

Corps policy prescribes that credit would not afforded for lands purchased with Federal funds or grants where the granting of such credit is not permissible, either as prescribed by statute, or as determined by the head of the Federal agency administering such grants or programs. The Federal Emergency Management Agency's (FEMA's) floodplain hazard mitigation and elimination grants are examples of such Federal grant programs where credit would not be allocated.

12. Facility Relocations:

Preliminary review of existing utility maps did not reveal significant conflicts which would result in utility relocations in the project area. Further engineering and design work would refine requirements for facility relocations during subsequent phases of the study and Pre-Construction Engineering and Design (PED), if approved for implementation. Because the objectives and aims of this project are for ecosystem restoration, riparian habitat and similar benefits, the approach taken during feasibility is to leave utilities, river and bridge crossings and infrastructure in place. The engineering and design for riparian restoration would "work around" and consider the constraints of all existing infrastructure. The project is aimed at producing the maximum outputs for ecosystem restoration while minimizing or avoiding unneeded expenditures to replace or relocate existing utility infrastructure.

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 and that is required for the project and which will be performed by, and credited to, the Non-Federal Sponsor under the definitions and terms of the PCA.

13. Mineral Activity:

The impacts of sand and gravel extraction are present at two locations within the study area. The currently inactive Cottonwood Lane pit is located in Township 14, Range 13, Section 26 on a 10.7 acre parcel that entirely contains the 3.5 acre pit. The pit is located approximately 1000 feet east of the river channel invert and the pit bottom is approximately 25 feet below the invert elevation. The parcel is owned by a group of private individuals. On Sept. 5, 2002, the City of Tucson denied a request to resume operations that was submitted by the owner's agent, Dale A. Deming, P.E. Past permits have expired. Due to the current lack of activity and the prohibition to resume activity, the acquisition of this parcel is not anticipated to be problematic.

The San Xavier Pit is made up of numerous parcels within Township 15, Range 13, Sections 14 and 15. The pit and associated processing land occupy almost 400 acres, although the Santa Cruz River and its banks bisect the operation. The operators, Union Rock Materials, own the bulk of area although some properties in the northwest area of the pit are leased. Leased properties within the study area (south of Cheney Road) would also be pursued for acquisition. The total area of the pit includes approximately 240 acres. Mineral excavation has taken place on both sides of the Santa Cruz River, approximately 200 feet away from the river channel. The pit bottom is approximately 25 feet below the invert elevation. On Sept. 5, 2002, the City of Tucson denied a request to expand operations that was submitted by the owner's agent, Kent A. Delph, P.E. Past sand and gravel extraction permits have expired. The property is currently undergoing some remediation and is also being used for limited industrial purposes. Due to the current waning of activity and the prohibition to resume sand and gravel extraction, the acquisition of this parcel is not anticipated to be problematic. The gross appraisal has taken the existing mineral uses, where they occur, into consideration.

14. Recommended Estate:

The recommended estates for ecosystem restoration are fee simple title or fee dedicated right-of-way.

15. Construction-Induced Flooding:

This river is ephemeral and dry. Appropriate measures would be taken for the care and diversion of water, if needed, during construction. There would be no construction-induced flooding.

16. Baseline Cost Estimate:

Baseline cost estimate for all lands, easements, and rights-of-way included in the recommended plan and including contingencies is $26,242,106

Actual LERRD crediting, should a project be authorized, would be governed by subsequent appraisals and reviewed and approved pursuant to the PCA.

This is deemed fully sufficient to cover any incidental and administrative costs as well, given the fact that 42 percent of the project acreage is owned by the City of Tucson. Pima County TFCD can acquire the necessary interests from the City of Tucson in a packaged real estate transaction, (one deed) minimizing incidental and administrative costs.

This is an estimate of potential project costs only for purposes of project feasibility and the total project cost estimate. It is not a representation of actual credit that may be approved should the project be approved and proceed toward implementation. Actual crediting shall follow the crediting and appraisals procedures set forth in a signed Project Cooperation Agreement, should the project proceed to that stage.

17. Relocation Assistance (URA Relocations):

The Non-Federal Sponsor 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 needed for the project footprint is largely unimproved and within the vacant floodplain and floodway. The project has been formulated such that there would not be any displacements of businesses or residences triggering relocation assistance benefits.

18. Other Matters, Other Property Interests, Use of Zoning:

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:

The Geotechnical Section(s) of the Feasibility Report and Technical Appendix F has been reviewed to determine possible impacts to real estate issues or values in the study area. There are some adjacent former existing landfills located outside of the project area, and project formulation has taken these into consideration so as to avoid impacts to the maximum extent possible. The following are some highlighted portions of the Geotechnical discussion of hazardous waste In Section IV of the Feasibility Report:

"Five landfills have been documented within the study area boundaries ...... however it does not appear that the river channel has been subject to prolonged commercial or industrial waste disposal activities."

"The landfills are located in the overall 5,005-acre study area, as distinct from the selected 1,223-acre project area. The project area has been delineated to avoid these landfills."

"Seventy two aerial photographs were reviewed..... The aerial photograph review did not reveal evidence of Reportable Environmental Conditions (RECs)."

"The site reconnaissance did not reveal evidence of any RECs"

The summary recommendation of the geotechnical reports is to utilize proper engineering and design, remove any uncompacted fill material or solid waste to address potential problems with lack of compaction or voids where any project structures may be located.

Based on the Phase 1 Environmental Site Assessment and Geotechnical evaluation of the project location(s), there do not appear to be any concerns of known or designated CERCLA regulated HTRW concerns affecting the project lands.

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. 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 ecosystem restoration.

21. Attitude of Landowners:

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 explain how the landowners would be affected

22. Report Content:

This report follows the requirements of ER-405-1-12, Chapter 12, and has been prepared using the information on the project formulation that has been provided.

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX J

BASIS OF COST ESTIMATES

July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

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PLAN FORMULATION BASIS OF COST ESTIMATES
PASEO DE LAS IGLESIAS
FEASIBILITY REPORT

PIMA COUNTY
TUCSON, ARIZONA

JULY 2004

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 Paseo de las Iglesias Feasibility Study.

Where possible, unit cost information was established from actual cost data provided by manufacturers. Additional historical data were derived from similar projects.

A. CONSTRUCTION COSTS

The basis for each estimated quantity item and unit cost is as follows:

1. Site Preparation/Planting: All alternatives make use, to varying degrees, of the basic dry-land restoration practices of water harvesting, soil patterning, mulch and fertilizer amendment, surface grading. As alternative water budgets are increased, less use is made of these measures. All measures, however, are applied for xeroriparian plantings. Less effort is expended on modifying micro-topography for mesoriparian planting as the digging of planting pits and placement of coarse debris to facilitate capture and retention of precipitation is reduced. This trend is continued for hydroriparian plantings. Similarly, planting cost are higher for alternatives with smaller water budgets as more mature plants are used in drier planting schemes to enhance survival rates. The costs listed below include both site preparation and planting. Costs were not added for riverbottom planting on the expectation that seeding will occur naturally. Details supporting the costs identified below can be found in Attachment B.

a. Xeroriparian Areas

(1) Riverbottom - $6,367/acre

(2) Mesquite - $18,364/acre

(3) Shrubscrub - $18,920/acre

b. Mesoriparian Areas

(1) Riverbottom - $6,367/acre

(2) Cottonwood-willow - $14,750/acre

(3) Mesquite - $15,306/acre

(4) Shrubscrub - $18,403/acre

c. Hydroriparian Areas

(1) Riverbottom - $6,367/acre

(2) Cottonwood-willow - $10,413

(3) Mesquite - $10,970

(4) Shrubscrub - $14,504

2. Subsurface Water Harvesting Basins: These features would involve excavating to a depth of approximately four feet, placing a liner membrane, and filling the excavated area with layers of appropriately sized gravel covered with granular fill.

a. Tributary Confluence – Two costs were developed for tributary basins. Deeper basins were envisioned for xeroriparian plans than for meso- and hydroriparian alternatives. Xeroriparian basin costs were increased by 40% to allow for the increase in size. In addition to components described above, tributary basins included costs for excavating and placing concrete on the downgrade side of the basin. Details supporting the costs identified below can be found in Attachment B.

(1) Xeroriparian Basin - $140,000/acre

(2) Meso/Hydroriparian Basin - $100,000/acre

b. Grade Control Basin – $108,000/acre

3. Bank Treatments: Reaches of steep natural banks are modified by cutting back into the overbank to create more stable slopes. Three variations were applied as a function of the amount of land available in the overbank. Where available land is not a constraint, banks are graded to a 5-to-1 horizontal-to-vertical slope (5:1 H:V) and then vegetated. Where there is not enough land to create a 5:1 slope but sufficient space exists to create slopes between 5:1 and 2:1the banks will be laid back to the minimum slope that can be fit into the available space. These slopes will also be vegetated however; a geotextile layer will be installed before planting to increase slope stability. In areas where insufficient space exists to accommodate 2:1 slopes, placement of rip rap or soil cement may be necessary for bank protection. Such applications will be decided on a case-by-case basis. The following unit costs were used for computing costs of vegetated banks:

a. Vegetated Bank Unit Costs –

(1) Excavation - $3.75/cubic yard

(2) Geotextile - $1.00/square yard

(3) Geogrid - $3.50/square yard

(4) Labor - $6,000/acre

(5) Haul Fill - $9.00/cubic yard

(6) Finish Grading - $0.10/square foot

b. Soil Cement – Stabilized non-vegetated banks were estimated at $350.00/linear foot.

5. Perennial Flow Channel: The existing low flow channel would require grading to create a new low flow channel averaging six feet in width and one-half foot in depth. The soil comprising the bed of the new low flow channel would be amended to accelerate formation of a near surface aquitard below the streambed. This feature will help direct infiltration losses from the perennial flow laterally toward restored habitat areas to be created on either side of the channel. Grading would also create depressional areas on each side of the low flow channel approximately ten feet in width where soil saturation conditions resulting from lateral percolation would support emergent marsh communities. A cost of $80.00 per linear foot was applied to a channel length of 39,500 feet and a lump sum of $400,000 was added for hauling. This resulted in an estimated cost of $3,560,000 for the perennial flow channel.

6. Irrigation: Irrigation system costs were projected by first estimating the cost of a main line running through the project, adding an estimate for feeder lines running off the main and then installing subsurface drip irrigation to planted areas. Temporary irrigation was estimated based on

either using center pivot system or gated pipe system, depending upon the site conditions. Details supporting the costs below can be found in Attachment B.

a. Main Irrigation Line - $4,000,000/L.S.

b. Primary Distribution from Main - $7,509,350/L.S.

c. Secondary Distribution to plants - $1,000/acre

d. Temporary Irrigation - $400/acre or $50/acre

7. Diversion: The low flow diversion would be accomplished by placing a diversion structure in the New West Branch channel to pond low flows and placing culvert storm water pipes through the bank to the newly excavated reach of channel between the NWB bank and remaining OWB channel. The cost of this feature was estimated at $158,000. Details supporting this cost can be found in Attachment B.

8. Contingency: A 25% contingency was added, in accordance with Corps of Engineers regulations for feasibility study construction cost estimates.

9. Planning, Engineering & Design (PED) and Engineering During Construction

(EDC): The PED and EDC were 10% and 1%, respectively.

10. Supervision & Administration (S&A): A 6.5% S&A cost was taken on the construction cost. This percentage is required by the Corps of Engineers regulations.

B. OPERATION AND MAINTENANCE COSTS

The wetland areas will be designed to closely approximate a natural riparian ecosystem and should be self-sustaining as long as sufficient amounts of water are provided. However, as in any man-made controlled system, maintenance will be required. Over time, some restored vegetated areas will require periodic pruning to reduce impacts on channel flow conveyance. The assumed maintenance schedule for the various features is shown in the table below:

1. Invasive Control: $59/acre as recommended by Parks & Recreation, Pima County.

2. Biological Survey/Vegetation Management:

• Qualitative Survey - Assume one biologist reviews site one day per month and writes report. Total cost = 16hr/month or 192hr/year at $30/hr or $5,760/year

• Quantitative Survey – Assume 2 biologists sample for 2 weeks, twice a year and writes report. Total cost = 320hr/year at $30/hr or $9,600/year

• Vegetation Management – Assume 2 labors for 1 day, twice a year and $200 per day equipment. Total cost = $360/acre/year

3. Irrigation System Regular Maintenance:

• Assumed 1% of system cost per year for irrigation main and primary distribution systems.

4. Paved Trail Maintenance: Aprroximately 1,000 tons every five yesars at @ 36.50/ton.
5. Comfrot Station Maintenance: Crew of 2 laborers @ $160/day, 1.5 times/week, and $75 materials.

4. Periodic O&M: Assumed that features in the active channel or on the terraces above the active channel but between the banks would be replaced at full cost in year 25 and 40.

Attachment A
Alternative Cost Details

ALTERNATIVE COST SUMMARY

		1A	1B	2	3A	3B	3C	3D	3E	4A	4B	4C	4D	4E	4F
Construction Costs		$34,957,246	$39,745,057	$28,191,262	$9,806,378	$35,384,625	$9,075,675	$34,012,721	$39,926,981	$24,308,004	$24,259,102	$40,104,369	$34,573,054	$45,159,929	$43,258,505
Real Estate Costs		$14,740,828	$14,740,828	$14,687,660	$2,379,268	$14,687,660	$2,432,436	$14,740,828	$14,740,828	$2,286,224	$4,785,120	$14,873,748	$4,638,908	$14,342,068	$14,342,068
Contingency	25%	$12,424,518	$13,621,471	$10,719,731	$3,046,412	$12,518,071	$2,877,028	$12,188,387	$13,666,952	$6,648,557	$7,261,056	$13,744,529	$9,802,990	$14,875,499	$14,400,143
Planning, Survey, Engineering and Design	10%	$3,495,725	$3,974,506	$2,819,126	$980,638	$3,538,462	$907,567	$3,401,272	$3,992,698	$2,430,800	$2,425,910	$4,010,437	$3,457,305	$4,515,993	$4,325,850
Engineering During Construction	1%	$349,572	$397,451	$281,913	$98,084	$353,846	$90,757	$340,127	$399,270	$243,080	$242,591	$401,044	$345,731	$451,599	$432,585
Supervision and Administration	6.5%	$2,272,221	$2,583,429	$1,832,432	$637,415	$2,300,001	$589,919	$2,210,827	$2,595,254	$1,580,020	$1,576,842	$2,606,784	$2,247,249	$2,935,395	$2,811,803
Adaptive Management	3%	$1,048,717	$1,192,352	$845,738	$294,191	$1,061,539	$272,270	$1,020,382	$1,197,809	$729,240	$727,773	$1,203,131	$1,037,192	$1,354,798	$1,297,755
Total First Costs		**$69,288,827**	**$76,255,092**	**$59,377,862**	**$17,242,365**	**$69,844,204**	**$16,245,652**	**$67,914,545**	**$76,519,793**	**$38,225,926**	**$41,278,394**	**$76,944,042**	**$56,102,428**	**$83,635,282**	**$80,868,710**
IDC		$3,765,634	$4,144,229	$3,227,004	$937,069	$3,795,817	$882,901	$3,690,946	$4,158,615	$2,077,461	$2,243,353	$4,181,671	$3,048,994	$4,545,320	$4,394,985
Gross Investment		**$73,054,462**	**$80,399,322**	**$62,604,865**	**$18,179,435**	**$73,640,021**	**$17,128,553**	**$71,605,491**	**$80,678,407**	**$40,303,387**	**$43,521,747**	**$81,125,713**	**$59,151,422**	**$88,180,602**	**$85,263,675**
Average Annual Cost		**$4,394,110**	**$4,835,892**	**$3,765,583**	**$1,093,484**	**$4,429,331**	**$1,030,255**	**$4,306,957**	**$4,852,678**	**$2,424,185**	**$2,617,764**	**$4,879,583**	**$3,557,864**	**$5,303,923**	**$5,128,475**
O&M															
Annual O&M (Including Water)		$549,915	$550,619	$87,495	$97,737	$152,371	$528,826	$583,460	$559,016	$887,500	$847,357	$942,252	$1,007,112	$1,074,122	$1,308,294
Periodic O&M		$343,948	$338,131	$341,023	$135,173	$341,023	$107,578	$313,427	$307,610	$308,886	$428,928	$434,745	$350,315	$356,132	$350,315
Total O&M		**$893,863**	**$888,749**	**$428,518**	**$232,910**	**$493,394**	**$836,403**	**$896,887**	**$866,625**	**$1,196,386**	**$1,276,285**	**$1,376,997**	**$1,357,426**	**$1,430,254**	**$1,858,608**
Total Average Annual Cost		**$5,287,973**	**$5,724,641**	**$4,194,101**	**$1,326,375**	**$4,922,724**	**$1,666,659**	**$5,203,844**	**$5,719,304**	**$3,820,570**	**$3,894,049**	**$6,256,580**	**$4,915,291**	**$6,734,177**	**$6,787,083**

26-Jul-04

PASEO DE LAS IGLESIAS FEASIBILITY STUDY MCACES SUMMARY TABLE

CODE OF ACCT		QTY	UNIT	UNIT PRICE	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENTAGE Note (1)
01----	**Real Estate**	1	LS	$26,242,106	26,242,106	0	26,242,106	0%
	Construction							
09----	Historic Floodplain	1	EA	12,429,160	12,429,160	1,864,374	14,293,533	15%
09----	Graded Slope	1	EA	11,449,481	11,449,481	1,717,422	13,166,903	15%
09----	Natural Slope	1	EA	1,027,626	1,027,626	154,144	1,181,770	15%
09----	Second Bench	1	EA	6,824,456	6,824,456	1,023,668	7,848,124	15%
09----	First Bench	1	EA	2,890,600	2,890,600	433,590	3,324,190	15%
09----	Tributary Basins	1	EA	534,132	534,132	80,120	614,252	15%
09----	Grade Control Basins	1	EA	167,217	167,217	25,083	192,300	15%
09----	Hardened Slopes	1	EA	3,306,717	3,306,717	496,008	3,802,725	15%
09----	Irrigation Piping	1	EA	4,591,880	4,591,880	688,782	5,280,662	15%
09----	Paved Maintenance Roads	1	EA	1,378,125	1,378,125	206,719	1,584,844	15%
09----	Gravel Maintenance Roads	1	LS	195,201	195,201	29,280	224,481	15%
09----	Compacted Earth Maintenance Roads	1	LS	24,319	24,319	3,648	27,967	15%
09----	Bridges	1	LS	1,485,733	1,485,733	222,860	1,708,593	15%
09----	Let Down Structures	1	LS	281,619	281,619	42,243	323,862	15%
14----	**Recreation**							
14----	Parking Areas	1	LS	218,932	218,932	32,840	251,772	15%
14----	DG Trails	1	LS	192,894	192,894	28,934	221,828	15%
14----	Comfort Stations	3	EA	130,000	390,000	58,500	448,500	15%
14----	Paved Trail ammenities, curb splice, ADA ramps, signs, markings	1	LS	13,000	13,000	1,950	14,950	15%
14----	Signage	21	EA	40	840	126	966	15%
14----	Rest Stops	5	EA	4,000	20,000	3,000	23,000	15%
14----	Concrete Benches	21	EA	900	18,900	2,835	21,735	15%
	SUBTOTAL				73,682,937	7,116,125	80,799,062	
					47,440,831		54,556,956	
30----	**PE&D - Note (2)**							
	Restoration	1	LS				4,658,627	10%
	Recreation	1	LS				85,457	10%
	TOTAL PED						4,744,083	
31----	**EDC - Note (3)**							
	Restoration	1	LS				465,863	1%
	Recreation	1	LS				9,828	1%
	TOTAL EDC						475,690	
32----	S&A - Note (4)	1	LS				3,546,202	6.5%
33----	Adaptive Management - Note (5)	1	LS				1,870,205	
34----	Monitoring - Note 6	1	LS				623,304	
	TOTAL PROJECT COSTS($) (Including contingency)						92,058,546	

NOTE (1) Total Contingency is 15%
(2) Total PE&D at 10%
(3) Total EDC at 1%
(4) Six and five tenths percent (6.5%) for S&A
(5) Three percent (3%) for Adaptive Management, (applied to total with contingency).
(6) One percent (1%) for monitoring, (applied to total with contingency)

RESTORATION

First Costs	
Construction & Real Estate	$72,828,371
Construction Costs	$46,586,265
Real Estate Costs	$26,242,106
Contingency	$6,987,940
PED	$4,658,627
Eng. During Construction	$465,863
Construction Mgmt	$3,482,323
Adaptive Mgmt	$1,870,205

Paseo_ MCACES Summary

Total First Costs		$90,916,632	
Interest During Construction		$4,941,039	
Gross Investment		$95,857,671	
Average Annual Costs		$5,765,687	
OMRRR		$1,869,961	
Total Average Annual Costs		$7,635,648	
	454		$16,819

RECREATION

First Costs		
Construction & Real Estate	$854,566	2013500
Construction Costs	$854,566	
Real Estate Costs	$0	
Contingency	$128,185	
PED	$85,457	
Eng. During Construction	$9,828	
Construction Mgmt	$63,879	
Total First Costs	$1,141,914	
Interest During Construction	$13,123	
Gross Investment	$1,155,037	
Average Annual Costs	$69,474	
OMRRR	$36,260	
Total Average Annual Costs	$105,734	
	$92,058,546	

Paseo de las Iglesias Feas Study
Los Reals Road to Congress Road
Santa Cruz River, City of
Tucson, Pima County, Arizona

Designed By: DMA, Inc.
Estimated By: US Army Corps Of Engineers

Prepared By: Phillip Eng
USACE, Los Angeles District

Preparation Date: 07/19/04
Effective Date of Pricing: 07/19/04
Est Construction Time: 360 Days

Sales Tax: 0.00%

This project is located in eastern Pima County, Arizona. The study area extends along the Santa Cruz River between Congress Street downstream to Los Reals Road upstream for a total length of approximately 7.5 miles. The study area varies from 0.5 miles to 1.6 miles wide and encompasses approximately 5005 acres.

See Paseo_MCACES Summary.xls for the input amounts)

Escalation, (Inflation/Interest During Construction) = $4,941,039
Contingency, Restoration = $6,987,940

	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01. LANDS AND DAMAGES (REAL ESTATE)											
Lands and Damages = $26,242,106 (See Paseo_MCACES Summary.xls)											
TOTAL LANDS AND DAMAGES (REAL ESTATE)	1.00	EA			0	0	0	0	26,200,000	26,200,000	26200000
09. CONSTRUCTION (RESTORATION)											
09. 01. IRRIGATION PLANTING											
09. 01.001. Historic Floodplain Excavate furrows for flood irrigation, assume furrows on 8' centers, slope not greater than 0.5%, for max. 600 lf distance, 65 acres of existing mesquite will not be disturbed, 15 acres of road (9.5 paved, 4.4 compacted earth, 1.1 gravel) will not be planted. Furrows will be seeded but not subject to other planting activities.											
09. 01.001. 1. Fencing for Erosion Control 656 acres = 28,575,360 sf Square root of 28,575,360 = 5346 lf 5346 lf x 4 = 21,384 LF (perimeter)											
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5'					0.16	3.54	0.00	3.58	0.00	7.12	
high	21384	LF	ALABCLAB2	12.50	3,421	75,723	0	76,555	0	152,278	7.12
TOTAL Fencing for Erosion Control	656.00	ACR			3,421	75,723	0	76,555	0	152,278	232.13
09. 01.001. 2. Clearing & Grubbing, Debris -- Removal, etc.											
AF GC <02109 0420 > Clear & grub, burning,					14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	656.00	ACR	UOEHB40A	0.28	9,338	271,648	202,076	0	0	473,723	722.14
TOTAL Clearing & Grubbing, Debris	328.00	ACR			9,338	271,648	202,076	0	0	473,723	1444.28
09. 01.001. 3. Site Preparation											
09. 01.001. 3.01. Ripping, discing to prepare (cont'd) surface.											
RSM GC <02238 0010 > Ripping, trap rock, soft, 200 HP					0.02	0.51	0.74	0.00	0.00	1.25	
dozer, ideal conditions	5900.00	CY	CODTB10B	88.75	100	2,987	4,383	0	0	7,369	1.25
Assume 10 cy/acre											
TOTAL Ripping, discing to prepare	590.00	ACR			100	2,987	4,383	0	0	7,369	12.49

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.001. 3.02. Regrade to req'd slopes, flatten (cont'd) balance cut material onsite.											
MIL GC <02224 7020 > Excavating, bulk, dozer, 300 HP,					0.01	0.15	0.33	0.00	0.00	0.48	
large area, open site, rough grade	2950.00	CY	CODTB10M	300.00	15	442	980	0	0	1,421	0.48
Assume 10 cy/acre											
TOTAL Regrade to req'd slopes, flatten	295.00	ACR			15	442	980	0	0	1,421	4.82
09. 01.001. 3.03. Regrade Surface, scraper-grader (cont'd) balance, max depth 36"											
MIL GC <02226 3110 > Excavation, bulk, 9 cycle/hr,					0.02	0.49	1.18	0.00	0.00	1.67	
push loaded self prop scraper, 16 BCY	14455	CY	CODSB33D	112.50	231	7,077	17,083	0	0	24,160	1.67
TOTAL Regrade Surface, scraper-grader	1445500	CY			231	7,077	17,083	0	0	24,160	0.02
TOTAL Site Preparation	1.00	EA			346	10,505	22,445	0	0	32,950	32950.50
09. 01.001. 4. Excavation											
CIV GC <02224 2500 > Excavating, bulk, light matl,					0.04	1.16	0.77	0.00	0.00	1.93	
150' push, dozer, open site, 90 HP	176990	CY	CODTB10W	38.75	6,850	205,185	136,229	0	0	341,414	1.93
TOTAL Excavation	176990	CY			6,850	205,185	136,229	0	0	341,414	1.93
09. 01.001. 5. Compaction (tractor wheel, one (COFCB10G) (cont'd) pass.											
Assume the roller speed is 7 mph.											
MIL GC <02220 5900 > Compaction of backfill,					0.01	0.38	0.40	0.00	0.00	0.78	
structural, SP roller, 6" lift	529173	CY	COFCB10F	117.50	6,773	202,303	209,553	0	0	411,855	0.78
656 acres = 28,575,360 sf x 6" = 529,173 cy											
MIL GC < > Equip. Operators, Medium					1.00	33.86	0.00	0.00	0.00	33.86	
	96.37	HR	B-EQOPRMED	1.00	96	3,263	0	0	0	3,263	33.86
MIL GC < > Laborers, (Semi-Skilled)					1.00	22.13	0.00	0.00	0.00	22.13	
	48.19	HR	B-LABORER	1.00	48	1,066	0	0	0	1,066	22.13

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
GEN GC < > ROLLER, VIB, SD, SP 13.0T					0.00	0.00	54.79	0.00	0.00	54.79	
(11.8MT), 84"(2.1M)W,SHEEPS FOOT	96.37	HR	R45Z5580	1.00	0	0	5,280	0	0	5,280	54.79
TOTAL Compaction (tractor wheel, one	3561940	LF			6,918	206,632	214,833	0	0	421,465	0.12
09. 01.001. 6. Trenching for Water Supply Pipes											
MIL GC <02228 0200 > Excavate trench, light soil,					0.02	0.66	0.65	0.00	0.00	1.32	
4'-6' D, 1 CY gradall	17050	CY	COFGB12K	96.00	355	11,265	11,159	0	0	22,424	1.32
TOTAL Trenching for Water Supply Pipes	17050	CY			355	11,265	11,159	0	0	22,424	1.32
09. 01.001. 7. Pipe bedding, crushed stone											
M MIL GC <02704 0300 > Drainage, drainage matl, 3/4"					0.09	2.31	0.47	46.94	0.00	49.72	
gravel fill in trench	13110	CY	CODLB6	32.50	1,210	30,281	6,100	615,383	0	651,765	49.72
TOTAL Pipe bedding, crushed stone	13110	CY			1,210	30,281	6,100	615,383	0	651,765	49.72
09. 01.001. 8. Install gated 12" PVC pipe for (cont'd) furrow flooding											
B MIL GC <02667 4560 > Piping, water dist, PVC, class					0.08	2.67	0.00	2.87	1.20	6.74	
150, SDR 18, AWWA C900, 12"	114720	LF	ULABB20A	50.00	9,178	306,245	0	329,246	137,664	773,155	6.74
M=$2.87/lf, Delivery = $1.20/lf See Kim Gavigan's e-mail dated 07/20/04.											
TOTAL Install gated 12" PVC pipe for	114720	LF			9,178	306,245	0	329,246	137,664	773,155	6.74
09. 01.001. 9. Install "U" outlet tubes with (cont'd) fittings, one per furrow.											
M MIL GC <02667 4430 > Piping, water dist, 3/4", PVC,					0.28	9.37	0.00	0.14	0.00	9.51	
press pipe, CL200, SDR 21 coupling	5940.00	EA	ULABB20A	14.25	1,667	55,638	0	832	0	56,469	9.51

This cost item is for "U"
outlet tubes. To be used for
furrows, and there are 5940
furrows, each furrow requires
600 lf of tubes, then,
5940 x 600 = 3,564,000 lf
3564000 / 50' per coil = 71,280
71,280 ea x $4.50(*) = $320,760

09. 01. IRRIGATION PLANTING		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	$320,760 / 5940 = $54.00/ea											
	(* Ryan Herco Products, (800) 848-1141, www.tygon.com, Tygon UV Resistant Tubing Formulation R3400, AAE00046, ID = 5/8, OD=7/8)											
	TOTAL Install "U" outlet tubes with	5940.00	EA			1,667	55,638	0	832	0	56,469	9.51
09. 01.001.!0. Backfill pipe trench, side cast (cont'd) surplus cut on site.												
MIL GC <02215 1215	> Backfill, trench, dozer, no					0.01	0.16	0.23	0.00	0.00	0.39	
	compaction, 200 HP	4590.00	CY	CODTB10B	284.38	24	725	1,064	0	0	1,789	0.39
	TOTAL Backfill pipe trench, side cast	4590.00	CY			24	725	1,064	0	0	1,789	0.39
09. 01.001.!1. Planting & Seeding												
09. 01.001.!1.01. Mulching, hay, 1" deep, power (cont'd) mulcher, large												
	Productivity is quoted from Means Crew B65. Material cost = $19.15/MSF x 43.56 MSF/acr = $834.17/acr (See Eldon Kraft's spreadsheet attachment e-mailed on 07/14/04)											
M MIL GC <	> Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
		367.11	HR	X-LABORER	1.00	367	7,515	0	33	0	7,548	20.56
MIL GC <	> Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
		367.11	HR	X-TRKDVRLT	1.00	367	9,317	0	0	0	9,317	25.38
EP GC <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
		367.11	HR	T50F0009	1.00	0	0	5,701	0	0	5,701	15.53
GEN GC <	> HYDROMULCHER, 3,000 GAL(11,356L)					0.00	0.00	29.04	0.00	0.00	29.04	
	TRK MTD (W/ 56,000GVW TRK)	367.11	HR	L15Z3880	1.00	0	0	10,662	0	0	10,662	29.04
USR GC <	> Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
		558.00	ACR	N/A	0.00	0	0	0	465,467	0	465,467	834.17
	TOTAL Mulching, hay, 1" deep, power	558.00	ACR			734	16,833	16,363	465,500	0	498,695	893.72

09. 01. IRRIGATION PLANTING		QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.001.!1.02. Crimping, Tilling topsoil, (cont'd) 20 HP tractor, disk harrow, 6" deep										
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA			0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	2232.00 HR T10LE001	1.00	0	0	2,879	0	0	2,879	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4			0.00	0.00	7.67	0.00	0.00	7.67	
		2232.00 HR T25JD005	1.00	0	0	17,112	0	0	17,112	7.67
MIL GC <	> Outside Equip. Operator, Light			1.00	30.80	0.00	0.00	0.00	30.80	
		2232.00 HR X-EQOPRLT	1.00	2,232	68,754	0	0	0	68,754	30.80
	TOTAL Crimping, Tilling topsoil,	558.00 ACR		2,232	68,754	19,991	0	0	88,745	159.04
09. 01.001.!1.03. Seeding, athletic fld mix,										
M RSM GC <02932 0010	> Seeding, athletic field mix,			1.00	22.13	0.00	47.42	0.00	69.55	
	8#/MSFpush spreader	27138 MSF ALABCLAB1	1.00	27,138	600,618	0	1286884	0	1,887,502	69.55
	623 acres = 27,137,880 sf = 27,138 MSF									
	TOTAL Seeding, athletic fld mix,	623.00 ACR		27,138	600,618	0	1286884	0	1,887,502	3029.70
09. 01.001.!1.04. Place Coarse Woody debris/rocks										
M MIL GC <	> Outside Laborer (4)			1.00	20.47	0.00	0.00	0.00	20.47	
		17856 HR X-LABORER	1.00	17,856	365,541	0	0	0	365,541	20.47
USR GC <	> Material and equipment			0.00	0.00	50.00	50.00	0.00	100.00	
		558.00 ACR N/A	0.00	0	0	27,900	27,900	0	55,800	100.00
	TOTAL Place Coarse Woody debris/rocks	558.00 ACR		17,856	365,541	27,900	27,900	0	421,341	755.09
09. 01.001.!1.05. Plant Mesquite/Shrub mix using (cont'd) 5 gallon plants.										
USR GC <	> Planting of 5-gallon plants			0.00	0.00	0.00	0.00	15.00	15.00	
	See bid result of Rio Salado Ph 1A	250729 EA	0.00	0	0	0	0	3,760,935	3,760,935	15.00
	TOTAL Plant Mesquite/Shrub mix using	250729 EA		0	0	0	0	3,760,935	3,760,935	15.00
	TOTAL Planting & Seeding	558.00 ACR		47,960	1051746	64,254	1780284	3,760,935	6,657,218	11930.50
	TOTAL Historic Floodplain	1.00 EA		87,267	2225592	658,160	2802300	3,898,599	9,584,651	9584651

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.005. Graded Slope Grade steep banks to 5:1 slope (20%), install 8" PVC leach field pipe for subsurface irrigation, pipes 10' c-c.											
09. 01.005. 1. Fencing for Erosion Control 102 acr = 4,443,120 sf Square root of 4,443,120 = 2108 lf 2108 lf x 4 = 8,432 lf (perimeter)											
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5'					0.16	3.54	0.00	3.58	0.00	7.12	
high	8432.00	LF	ALABCLAB2	12.50	1,349	29,859	0	30,187	0	60,045	7.12
TOTAL Fencing for Erosion Control	102.00	ACR			1,349	29,859	0	30,187	0	60,045	588.68
09. 01.005. 2. Clearing & Grubbing, debris (cont'd) removal, etc.											
AF GC <02109 0420 > Clear & grub, burning,					14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	51.00	ACR	UOEHB40A	0.28	726	21,119	15,710	0	0	36,829	722.14
TOTAL Clearing & Grubbing, debris	51.00	ACR			726	21,119	15,710	0	0	36,829	722.14
09. 01.005. 3. Excavation, strl, mach excav. (cont'd) sand/loam, 2 cy bkt											
MIL GC <02228 0372 > Excavate trench, mdm soil,					0.01	0.25	0.28	0.00	0.00	0.53	
6'-10' D, 2 CY excavator	1213390	CY	CODEB12C	256.50	9,464	300,071	341,812	0	0	641,883	0.53
TOTAL Excavation, strl, mach excav.	1213390	CY			9,464	300,071	341,812	0	0	641,883	0.53
09. 01.005. 4. Excavation, steep slopes, 5:1											
09. 01.005. 4.01. Hauling, no loading, 16.5 cy (cont'd) dump trailer, 10 mile RT											
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6					0.03	0.77	1.44	0.00	0.00	2.22	
mi round trip @ 40 MPH (2.1 cyc/hr)	1213390	CY	CTDHB34C	35.00	34,703	937,101	1753227	0	0	2,690,328	2.22
TOTAL Hauling, no loading, 16.5 cy	1213390	CY			34,703	937,101	1753227	0	0	2,690,328	2.22
09. 01.005. 4.02. Fill, spread dumped material, (cont'd) by dozer, no compaction											
MIL GC <02215 1215 > Backfill, trench, dozer, no					0.01	0.16	0.23	0.00	0.00	0.39	
compaction, 200 HP	1213390	CY	CODTB10B	284.38	6,431	191,716	281,264	0	0	472,979	0.39

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Fill, spread dumped material,	1213390	CY			6,431	191,716	281,264	0	0	472,979	0.39
09. 01.005. 4.03. Compaction, sheepfoot/wobbly (cont'd) whl rlr, 12" lifts, 2 passes											
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2					0.01	0.14	0.16	0.00	0.00	0.29	
passes, sheepsfoot/wobbly wheel roller	1213390	CY	COFCB32F	600.00	6,067	167,933	189,046	0	0	356,979	0.29
TOTAL Compaction, sheepfoot/wobbly	1213390	CY			6,067	167,933	189,046	0	0	356,979	0.29
TOTAL Excavation, steep slopes, 5:1	1213390	CY			47,201	1296750	2223537	0	0	3,520,287	2.90
09. 01.005. 5. Fine grading to 20% slope, (cont'd) for irregular areas, adverse cond.											
MIL GC <02226 4100 > Excavation, bulk, fine grade, 3					1.00	27.99	17.66	0.00	0.00	45.65	
passes w/grader	5324.00	CSY	COFGB11L	2.00	5,324	149,044	93,995	0	0	243,040	45.65
110 acre = 5324 CSY											
TOTAL Fine grading to 20% slope,	110.00	ACR			5,324	149,044	93,995	0	0	243,040	2209.45
09. 01.005. 6. Header Pipe Laying											
09. 01.005. 6.01. Excavate header trench, 12" dep. (con't) by 18", 1-1/2 CY hoe											
MIL GC <02228 0340 > Excavate trench, lt soil, 6'-10'					0.01	0.26	0.24	0.00	0.00	0.50	
D, 1.5 CY excavator	2540.00	CY	CODEB12B	242.50	21	664	615	0	0	1,279	0.50
TOTAL Excavate header trench, 12" dep.	2540.00	CY			21	664	615	0	0	1,279	0.50
09. 01.005. 6.02. Header Trench bedding, 3/4" (con't) gravel pipe support											
M MIL GC <02244 1510 > Base course,crushed stone, 3/4"					0.09	2.79	3.77	16.00	0.00	22.57	
max size, compacted, 12"D, large areas	1020.00	CY	COFGB36C	54.38	94	2,846	3,850	16,320	0	23,017	22.57
TOTAL Header Trench bedding, 3/4"	1020.00	CY			94	2,846	3,850	16,320	0	23,017	22.57

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.005. 6.03. Install medium diam. PVC Header (cont'd) pipe (8")											
M MIL GC <02667 4060 > Piping, water dist, 8", PVC, press pipe, class 200, SDR 21					0.10	3.34	0.00	9.46	0.00	12.80	
	7620.00	LF	ULABB20A	40.00	762	25,427	0	72,085	0	97,512	12.80
TOTAL Install medium diam. PVC Header	7620.00	LF			762	25,427	0	72,085	0	97,512	12.80
09. 01.005. 6.04. Backfill trench, FE loader, (cont') whl mtd., 1CY bkt, min haul											
MIL GC <02215 1220 > Backfill, trench, front-end loader, 40 - 60 HP, no compaction					0.03	0.90	0.74	0.00	0.00	1.64	
	1020.00	CY	CODFB10N	50.00	31	916	759	0	0	1,675	1.64
TOTAL Backfill trench, FE loader,	1020.00	CY			31	916	759	0	0	1,675	1.64
09. 01.005. 6.05. Hauling, surplus cut mat'l, (con't) no loading, 10 mile RT											
AF GC <02234 0555 > Hauling, hwy haulers, 12 CY, 12 mile round trip @ base wide rate					0.05	1.35	2.40	0.00	0.00	3.75	
	1530.00	CY	COEIB34B	20.00	77	2,068	3,666	0	0	5,734	3.75
TOTAL Hauling, surplus cut mat'l,	1530.00	CY			77	2,068	3,666	0	0	5,734	3.75
TOTAL Header Pipe Laying	7620.00	LF			984	31,922	8,890	88,405	0	129,218	16.96
09. 01.005. 7. 8" PVC Leach Pipe Laying											
09. 01.005. 7.01. Excavate trench, 12" depth by (cont'd) 36", 1-1/2" CY backhoe											
MIL GC <02228 0340 > Excavate trench, lt soil, 6'-10' D, 1.5 CY excavator					0.01	0.26	0.24	0.00	0.00	0.50	
	99020	CY	CODEB12B	242.50	812	25,894	23,973	0	0	49,866	0.50
TOTAL Excavate trench, 12" depth by	99020	CY			812	25,894	23,973	0	0	49,866	0.50
09. 01.005. 7.02. Install low perm geotextile in (cont'd) trench as pipe bedding											
M CIV GC <02250 2130 > Geotextile fabric, 60 mil thick, non-woven polypropylene					0.02	0.38	0.10	0.61	0.00	1.09	
	148700	SY	ULABA2	187.50	2,379	56,179	14,662	90,707	0	161,548	1.09
TOTAL Install low perm geotextile in	148700	SY			2,379	56,179	14,662	90,707	0	161,548	1.09

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.005. 7.03. Install 8" PVC leach pipe for (cont'd) subsurface irrigation											
B MIL GC <02667 4060 > Piping, water dist, 8", PVC,					0.08	2.67	0.00	1.40	0.30	4.37	
press pipe, class 200, SDR 21	445590	LF	ULABB20A	50.00	35,647	1189503	0	623,826	133,677	1,947,006	4.37
Productivity = 50lf/hr M=$1.40/lf, Delivery = $0.30/lf (See Gavigan's e-mail dated 07/20/04)											
TOTAL Install 8" PVC leach pipe for	445590	LF			35,647	1189503	0	623,826	133,677	1,947,006	4.37
09. 01.005. 7.04. Install leach pipe filter "sock" A call was made to Crumpler Plastic Pipe, Inc. www.cpp-pipe.com, (800) 334-5071 on 05/27/04 for a price quotation of "Silt Guard Filter Sock", part #0820020b, Farm Slots Sock, 20' lengths. "Emilee" quoted that the material cost is $1.21/lf, and the freight is about $1,770 to $2,100. A truckload can be 5000'. From their plant in North Carolina to Phoenix, AZ is about 1,000 mile in distance. Assume a medium freight cost of $2,000 per truckload, then, the cost per linear foot of the pipe filter sock is: $1.21 + ($2,000 / 5000') = $1.61/lf or transportation cost is $0.40/lf											
USR GC < > Leach Pipe Filter Sock					0.00	0.00	0.00	1.21	0.40	1.61	
	445590	LF		0.00	0	0	0	539,164	178,236	717,400	1.61
TOTAL Install leach pipe filter "sock"	445590	LF			0	0	0	539,164	178,236	717,400	1.61
09. 01.005. 7.05. Install pipe fittings as needed There is a total of 44560 pipe fittings for this cost item. Let's use Elbows = 50% x 44560 = 22,280 ea Tees = 30% x 44560 = 13,368 ea Couplings = 10% x 44560 = 4,456 ea Reducers = 10% x 44560 = 4,456 ea											
TOTAL Install pipe fittings as needed					0	12,000	0	15,000	0	27,000	
09. 01.005. 7.06. Backfill trench, FE loader, whl (cont'd) mtd, 1 CY bkt, min haul											
MIL GC <02215 1220 > Backfill, trench, front-end					0.03	0.90	0.74	0.00	0.00	1.64	
loader, 40 - 60 HP, no compaction	93380	CY	CODFB10N	50.00	2,801	83,902	69,465	0	0	153,367	1.64
TOTAL Backfill trench, FE loader, whl	93380	CY			2,801	83,902	69,465	0	0	153,367	1.64

09. 01. IRRIGATION PLANTING		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	09. 01.005. 7.07. Hauling, surplus cut matl, no (cont'd) loading, 10 mile RT											
AF GC <02234 0555	> Hauling, hwy haulers, 12 CY, 12					0.05	1.35	2.40	0.00	0.00	3.75	
	mile round trip @ base wide rate	5790.00	CY	COEIB34B	20.00	290	7,826	13,875	0	0	21,701	3.75
	TOTAL Hauling, surplus cut matl, no	5790.00	CY			290	7,826	13,875	0	0	21,701	3.75
	TOTAL 8" PVC Leach Pipe Laying	445590	LF			41,929	1375303	121,975	1268697	311,913	3,077,888	6.91
	09. 01.005. 8. Planting & Seeding											
	09. 01.005. 8.01. Mulch, hay, 1" deep, power (cont'd) mulcher, large											
M MIL GC <	> Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
		67.11	HR	X-LABORER	1.00	67	1,374	0	6	0	1,380	20.56
MIL GC <	> Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
		67.11	HR	X-TRKDVRLT	1.00	67	1,703	0	0	0	1,703	25.38
EP GC <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
		67.11	HR	T50FO009	1.00	0	0	1,042	0	0	1,042	15.53
GEN GC <	> HYDROMULCHER, 3,000 GAL(11,356L)					0.00	0.00	29.04	0.00	0.00	29.04	
	TRK MTD (W/ 56,000GVW TRK)	67.11	HR	L15Z3880	1.00	0	0	1,949	0	0	1,949	29.04
USR GC <	> Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
		102.00	ACR	N/A	0.00	0	0	0	85,085	0	85,085	834.17
	TOTAL Mulch, hay, 1" deep, power	102.00	ACR			134	3,077	2,991	85,091	0	91,159	893.72
	09. 01.005. 8.02. Crimping, tilling topsoil (cont'd) 20 HP tractor, disk harrow, 6" deep											
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA					0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	408.00	HR	T10LE001	1.00	0	0	526	0	0	526	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4					0.00	0.00	7.67	0.00	0.00	7.67	
		408.00	HR	T25JD005	1.00	0	0	3,128	0	0	3,128	7.67
MIL GC <	> Outside Equip. Operator, Light					1.00	30.80	0.00	0.00	0.00	30.80	
		408.00	HR	X-EQOPRLT	1.00	408	12,568	0	0	0	12,568	30.80
	TOTAL Crimping, tilling topsoil	102.00	ACR			408	12,568	3,654	0	0	16,222	159.04

09. 01. IRRIGATION PLANTING	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.010. 2. Clearing and Grubbing, debris (cont'd) removal, etc.										
AF GC <02109 0420 > Clear & grub, burning, incinerator, light				14.23	414.10	308.04	0.00	0.00	722.14	
	13.00 ACR	UOEHB40A	0.28	185	5,383	4,005	0	0	9,388	722.14
TOTAL Clearing and Grubbing, debris	13.00 ACR			185	5,383	4,005	0	0	9,388	722.14
09. 01.010. 3. Header Trenching										
09. 01.010. 3.01. Excavate header trench, 12" dep. (cont'd) by 18", 1-1/2 CY hoe										
MIL GC <02228 0340 > Excavate trench, lt soil, 6'-10' D, 1.5 CY excavator				0.01	0.26	0.24	0.00	0.00	0.50	
	86.00 CY	CODEB12B	242.50	1	22	21	0	0	43	0.50
TOTAL Excavate header trench, 12" dep.	86.00 CY			1	22	21	0	0	43	0.50
09. 01.010. 3.02. Header Trench bedding, 3/4" (cont'd) gravel pipe support										
M MIL GC <02244 1510 > Base course,crushed stone, 3/4" max size, compacted, 12"D, large areas				0.09	2.79	3.77	16.00	0.00	22.57	
	35.00 CY	COFGB36C	54.38	3	98	132	560	0	790	22.57
TOTAL Header Trench bedding, 3/4"	35.00 CY			3	98	132	560	0	790	22.57
09. 01.010. 3.03. Install med. diam. PVC Header (cont'd) pipe (8" ?)										
M MIL GC <02667 4060 > Piping, water dist, 8", PVC, press pipe, class 200, SDR 21				0.10	3.34	0.00	9.46	0.00	12.80	
	1520.00 LF	ULABB20A	40.00	152	5,072	0	14,379	0	19,451	12.80
TOTAL Install med. diam. PVC Header	1520.00 LF			152	5,072	0	14,379	0	19,451	12.80
09. 01.010. 3.04. Backfill trench, FE loader, (cont'd) whl mtd. 1cy bkt, min haul										
MIL GC <02215 1220 > Backfill, trench, front-end loader, 40 - 60 HP, no compaction				0.03	0.90	0.74	0.00	0.00	1.64	
	35.00 CY	CODFB10N	50.00	1	31	26	0	0	57	1.64
TOTAL Backfill trench, FE loader,	35.00 CY			1	31	26	0	0	57	1.64

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.010. 3.05. Hauling, surplus cut matl, no (cont'd) loading, 10 mile RT											
AF GC <02234 0555 > Hauling, hwy haulers, 12 CY, 12 mile round trip @ base wide rate					0.05	1.35	2.40	0.00	0.00	3.75	
	52.00	CY	COEIB34B	20.00	3	70	125	0	0	195	3.75
TOTAL Hauling, surplus cut matl, no	52.00	CY			3	70	125	0	0	195	3.75
TOTAL Header Trenching	1520.00	LF			160	5,294	304	14,939	0	20,537	13.51
09. 01.010. 4. 8" PVC Leach Pipe Laying											
09. 01.010. 4.01. Excavate trench, 12" depth by (cont'd) 36", 1-1/2" CY backhoe											
MIL GC <02228 0340 > Excavate trench, lt soil, 6'-10' D, 1.5 CY excavator					0.01	0.26	0.24	0.00	0.00	0.50	
	16780	CY	CODEB12B	242.50	138	4,388	4,062	0	0	8,450	0.50
TOTAL Excavate trench, 12" depth by	16780	CY			138	4,388	4,062	0	0	8,450	0.50
09. 01.010. 4.02. Install low perm geotextile in (cont'd) trench as pipe bedding											
M CIV GC <02250 2130 > Geotextile fabric, 60 mil thick, non-woven polypropylene					0.02	0.38	0.10	0.61	0.00	1.09	
	25200	SY	ULABA2	187.50	403	9,521	2,485	15,372	0	27,377	1.09
TOTAL Install low perm geotextile in	25200	SY			403	9,521	2,485	15,372	0	27,377	1.09
09. 01.010. 4.03. Install 8" PVC leach pipe for (cont'd) subsurface irrigation											
B MIL GC <02667 4060 > Piping, water dist, 8", PVC, press pipe, class 200, SDR 21					0.08	2.67	0.00	1.40	0.30	4.37	
	75510	LF	ULABB20A	50.00	6,041	201,574	0	105,714	22,653	329,941	4.37
TOTAL Install 8" PVC leach pipe for	75510	LF			6,041	201,574	0	105,714	22,653	329,941	4.37
09. 01.010. 4.04. Install leach pipe filter "sock"											
USR GC < > Leach Pipe Filter Sock					0.00	0.00	0.00	1.21	0.40	1.61	
	75510	LF		0.00	0	0	0	91,367	30,204	121,571	1.61
TOTAL Install leach pipe filter "sock"	75510	LF			0	0	0	91,367	30,204	121,571	1.61

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.010. 4.05. Install pipe fittings as needed											
Total count = 7,560 ea											
TOTAL Install pipe fittings as needed					0	12,000	0	8,000	0	20,000	
09. 01.010. 4.06. Backfill trench, FE loader, whl (cont'd) mtd, 1 CY bkt, min haul											
MIL GC <02215 1220 > Backfill, trench, front-end					0.03	0.90	0.74	0.00	0.00	1.64	
loader, 40 - 60 HP, no compaction	15830	CY	CODFB10N	50.00	475	14,223	11,776	0	0	25,999	1.64
TOTAL Backfill trench, FE loader, whl	15830	CY			475	14,223	11,776	0	0	25,999	1.64
09. 01.010. 4.07. Hauling, surplus cut matl, no (cont'd) loading, 10 mile RT											
AF GC <02234 0555 > Hauling, hwy haulers, 12 CY, 12					0.05	1.35	2.40	0.00	0.00	3.75	
mile round trip @ base wide rate	990.00	CY	COEIB34B	20.00	50	1,338	2,372	0	0	3,711	3.75
TOTAL Hauling, surplus cut matl, no	990.00	CY			50	1,338	2,372	0	0	3,711	3.75
TOTAL 8" PVC Leach Pipe Laying	75510	LF			7,106	243,044	20,696	220,453	52,857	537,049	7.11
09. 01.010. 5. Planting & Seeding											
09. 01.010. 5.01. Mulch, hay, 1" deep, power (cont'd) mulcher, large											
M MIL GC < > Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
	11.84	HR	X-LABORER	1.00	12	242	0	1	0	243	20.56
MIL GC < > Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
	11.84	HR	X-TRKDVRLT	1.00	12	301	0	0	0	301	25.38
EP GC < > TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
	11.84	HR	T50F0009	1.00	0	0	184	0	0	184	15.53
GEN GC < > HYDROMULCHER, 3,000 GAL(11,356L)					0.00	0.00	29.04	0.00	0.00	29.04	
TRK MTD (W/ 56,000GVW TRK)	11.84	HR	L15Z3880	1.00	0	0	344	0	0	344	29.04
USR GC < > Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
	18.00	ACR	N/A	0.00	0	0	0	15,015	0	15,015	834.17
TOTAL Mulch, hay, 1" deep, power	18.00	ACR			24	543	528	15,016	0	16,087	893.72

09. 01. IRRIGATION PLANTING		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	09. 01.010. 5.02. Crimping, tilling topsoil (cont'd) 20 HP tractor, disk harrow, 6" deep											
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA					0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	72.00	HR	T10LE001	1.00	0	0	93	0	0	93	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4					0.00	0.00	7.67	0.00	0.00	7.67	
		72.00	HR	T25JD005	1.00	0	0	552	0	0	552	7.67
MIL GC <	> Outside Equip. Operator, Light					1.00	30.80	0.00	0.00	0.00	30.80	
		72.00	HR	X-EQOPRLT	1.00	72	2,218	0	0	0	2,218	30.80
	TOTAL Crimping, tilling topsoil	18.00	ACR			72	2,218	645	0	0	2,863	159.04
	09. 01.010. 5.03. Seeding, athletic fld mix,											
M RSM GC <02932 0010	> Seeding, athletic field mix,					1.00	22.13	0.00	47.42	0.00	69.55	
	8#/MSFpush spreader	784.08	MSF	ALABCLAB1	1.00	784	17,353	0	37,181	0	54,534	69.55
	18 acres = 784.08 msf											
	TOTAL Seeding, athletic fld mix,	18.00	ACR			784	17,353	0	37,181	0	54,534	3029.69
	09. 01.010. 5.04. Place Coarse Woody debris/rocks											
M MIL GC <	> Outside Laborer (4)					1.00	20.47	0.00	0.00	0.00	20.47	
		576.00	HR	X-LABORER	1.00	576	11,792	0	0	0	11,792	20.47
USR GC <	> Material and equipment					0.00	0.00	50.00	50.00	0.00	100.00	
		18.00	ACR	N/A	0.00	0	0	900	900	0	1,800	100.00
	TOTAL Place Coarse Woody debris/rocks	18.00	ACR			576	11,792	900	900	0	13,592	755.09
	09. 01.010. 5.05. Plant Mesquite/Shrub mix using (cont'd) 5 gallon plants											
USR GC <	> Planting of 5-gallon plants					0.00	0.00	0.00	0.00	15.00	15.00	
	See bid result of Rio Salado Ph 1A	7740.00	EA		0.00	0	0	0	0	116,100	116,100	15.00
	TOTAL Plant Mesquite/Shrub mix using	7740.00	EA			0	0	0	0	116,100	116,100	15.00
	TOTAL Planting & Seeding	18.00	ACR			1,456	31,906	2,073	53,097	116,100	203,176	11287.54
	TOTAL Natural Slope	1.00	EA			9,473	298,169	27,076	301,170	168,957	795,373	795372.60

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.015. Second Bench Install 8"PVC leach field pipe for subsurface irrigation on the second bench riparian features; pipes set at 10' c-c											
09. 01.015. 1. Fencing for Erosion Control											
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5'					0.16	3.54	0.00	3.58	0.00	7.12	
high	9296.00	LF	ALABCLAB2	12.50	1,487	32,918	0	33,280	0	66,198	7.12
124 acres = 5,401,440 sf Perimeter = 9296 lf											
TOTAL Fencing for Erosion Control	124.00	ACR			1,487	32,918	0	33,280	0	66,198	533.85
09. 01.015. 2. Clearing and Grubbing, debris (con't) removal, etc.											
AF GC <02109 0420 > Clear & grub, burning,					14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	93.00	ACR	UOEHB40A	0.28	1,324	38,511	28,648	0	0	67,159	722.14
TOTAL Clearing and Grubbing, debris	93.00	ACR			1,324	38,511	28,648	0	0	67,159	722.14
09. 01.015. 3. Header Trenching											
09. 01.015. 3.01. Excavate header trench, 12" dep. (cont'd) by 18", 1-1/2 CY hoe											
MIL GC <02228 0340 > Excavate trench, lt soil, 6'-10'					0.01	0.26	0.24	0.00	0.00	0.50	
D, 1.5 CY excavator	500.00	CY	CODEB12B	242.50	4	131	121	0	0	252	0.50
TOTAL Excavate header trench, 12" dep.	500.00	CY			4	131	121	0	0	252	0.50
09. 01.015. 3.02. Header Trench bedding, 3/4" (cont'd) gravel pipe support											
M MIL GC <02244 1510 > Base course,crushed stone, 3/4"					0.09	2.79	3.77	16.00	0.00	22.57	
max size, compacted, 12"D, large areas	200.00	CY	COFGB36C	54.38	18	558	755	3,200	0	4,513	22.57
TOTAL Header Trench bedding, 3/4"	200.00	CY			18	558	755	3,200	0	4,513	22.57
09. 01.015. 3.03. Install med. diam. PVC Header (cont'd) pipe											
M MIL GC <02667 4060 > Piping, water dist, 8", PVC,					0.10	3.34	0.00	9.46	0.00	12.80	
press pipe, class 200, SDR 21	8080.00	LF	ULABB20A	40.00	808	26,962	0	76,437	0	103,399	12.80

09. 01. IRRIGATION PLANTING	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Install med. diam. PVC Header	8080.00 LF			808	26,962	0	76,437	0	103,399	12.80
09. 01.015. 3.04. Backfill trench, FE loader, (cont'd) whl mtd. 1cy bkt, min haul										
MIL GC <02215 1220 > Backfill, trench, front-end loader, 40 - 60 HP, no compaction				0.03	0.90	0.74	0.00	0.00	1.64	
	200.00 CY	CODFB10N	50.00	6	180	149	0	0	328	1.64
TOTAL Backfill trench, FE loader,	200.00 CY			6	180	149	0	0	328	1.64
09. 01.015. 3.05. Hauling, surplus cut matl, no (cont'd) loading, 10 mile RT										
AF GC <02234 0555 > Hauling, hwy haulers, 12 CY, 12 mile round trip @ base wide rate				0.05	1.35	2.40	0.00	0.00	3.75	
	300.00 CY	COEIB34B	20.00	15	405	719	0	0	1,124	3.75
TOTAL Hauling, surplus cut matl, no	300.00 CY			15	405	719	0	0	1,124	3.75
TOTAL Header Trenching	8080.00 LF			852	28,236	1,744	79,637	0	109,617	13.57
09. 01.015. 4. 8" PVC Leach Pipe Laying										
09. 01.015. 4.01. Excavate trench, 12" depth by (cont'd) 36", 1-1/2" CY backhoe										
MIL GC <02228 0340 > Excavate trench, lt soil, 6'-10' D, 1.5 CY excavator				0.01	0.26	0.24	0.00	0.00	0.50	
	121260 CY	CODEB12B	242.50	994	31,709	29,357	0	0	61,067	0.50
TOTAL Excavate trench, 12" depth by	121260 CY			994	31,709	29,357	0	0	61,067	0.50
09. 01.015. 4.03. Install 8" PVC leach pipe for (cont'd) subsurface irrigation										
B MIL GC <02667 4060 > Piping, water dist, 8", PVC, press pipe, class 200, SDR 21				0.08	2.67	0.00	1.40	0.30	4.37	
	545686 LF	ULABB20A	50.00	43,655	1456709	0	763,960	163,706	2,384,375	4.37
TOTAL Install 8" PVC leach pipe for	545686 LF			43,655	1456709	0	763,960	163,706	2,384,375	4.37
09. 01.015. 4.04. Install leach pipe filter "sock"										
USR GC < > Leach Pipe Filter Sock				0.00	0.00	0.00	1.21	0.40	1.61	
	545680 LF		0.00	0	0	0	660,273	218,272	878,545	1.61

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Install leach pipe filter "sock"	545680	LF			0	0	0	660,273	218,272	878,545	1.61
09. 01.015. 4.05. Install pipe fittings as needed Total count = 54,570 ea											
TOTAL Install pipe fittings as needed					0	15,000	0	10,000	0	25,000	
09. 01.015. 4.06. Backfill trench, FE loader, whl (cont'd) mtd, 1 CY bkt, min haul											
MIL GC <02215 1220 > Backfill, trench, front-end loader, 40 - 60 HP, no compaction					0.03	0.90	0.74	0.00	0.00	1.64	
	114360	CY	CODFB1ON	50.00	3,431	102,752	85,072	0	0	187,825	1.64
TOTAL Backfill trench, FE loader, whl	114360	CY			3,431	102,752	85,072	0	0	187,825	1.64
09. 01.015. 4.07. Hauling, surplus cut matl, no (cont'd) loading, 10 mile RT											
AP GC <02234 0555 > Hauling, hwy haulers, 12 CY, 12 mile round trip @ base wide rate					0.05	1.35	2.40	0.00	0.00	3.75	
	7090.00	CY	COEIB34B	20.00	355	9,583	16,990	0	0	26,573	3.75
TOTAL Hauling, surplus cut matl, no	7090.00	CY			355	9,583	16,990	0	0	26,573	3.75
TOTAL 8" PVC Leach Pipe Laying	545686	LF			48,435	1615754	131,420	1434233	381,978	3,563,384	6.53
09. 01.015. 5. Planting & Seeding											
09. 01.015. 5.01. Mulch, hay, 1" deep, power (cont'd) mulcher, large											
M MIL GC < > Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
	82.24	HR	X-LABORER	1.00	82	1,684	0	7	0	1,691	20.56
MIL GC < > Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
	82.24	HR	X-TRKDVRLT	1.00	82	2,087	0	0	0	2,087	25.38
EP GC < > TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
	82.24	HR	T50FO009	1.00	0	0	1,277	0	0	1,277	15.53
GEN GC < > HYDROMULCHER, 3,000 GAL(11,356L) TRK MTD (W/ 56,000GVW TRK)					0.00	0.00	29.04	0.00	0.00	29.04	
	82.24	HR	L15Z3880	1.00	0	0	2,388	0	0	2,388	29.04
USR GC < > Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
	125.00	ACR	N/A	0.00	0	0	0	104,271	0	104,271	834.17

	09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	TOTAL Mulch, hay, 1" deep, power	125.00	ACR			164	3,771	3,666	104,279	0	111,715	893.72
	09. 01.015. 5.02. Crimping, tilling topsoil (cont'd) 20 HP tractor, disk harrow, 6" deep											
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA					0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	500.00	HR	T10LE001	1.00	0	0	645	0	0	645	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4					0.00	0.00	7.67	0.00	0.00	7.67	
		500.00	HR	T25JD005	1.00	0	0	3,833	0	0	3,833	7.67
MIL GC <	> Outside Equip. Operator, Light					1.00	30.80	0.00	0.00	0.00	30.80	
		500.00	HR	X-EQOPRLT	1.00	500	15,402	0	0	0	15,402	30.80
	TOTAL Crimping, tilling topsoil	125.00	ACR			500	15,402	4,478	0	0	19,880	159.04
	09. 01.015. 5.03. Seeding, athletic fld mix,											
M RSM GC <02932 0010	> Seeding, athletic field mix,					1.00	22.13	0.00	47.42	0.00	69.55	
	8#/MSFpush spreader	5445.00	MSF	ALABCLAB1	1.00	5,445	120,509	0	258,202	0	378,711	69.55
	125 acres = 5,445 msf											
	TOTAL Seeding, athletic fld mix,	125.00	ACR			5,445	120,509	0	258,202	0	378,711	3029.69
	09. 01.015. 5.04. Place Coarse Woody debris/rocks											
M MIL GC <	> Outside Laborer (4)					1.00	20.47	0.00	0.21	0.00	20.68	
		4000.00	HR	X-LABORER	1.00	4,000	81,886	0	840	0	82,726	20.68
USR GC <	> Material and equipment					0.00	0.00	50.00	50.00	0.00	100.00	
		125.00	ACR	N/A	0.00	0	0	6,250	6,250	0	12,500	100.00
	TOTAL Place Coarse Woody debris/rocks	125.00	ACR			4,000	81,886	6,250	7,090	0	95,226	761.81
	09. 01.015. 5.05. Plant Mesquite/Shrub mix using (cont'd) 5 gallon plants											
USR GC <	> Planting of 5-gallon plants					0.00	0.00	0.00	0.00	15.00	15.00	
	See bid result of Rio Salado Ph 1A	55935	EA		0.00	0	0	0	0	839,025	839,025	15.00
	TOTAL Plant Mesquite/Shrub mix using	55935	EA			0	0	0	0	839,025	839,025	15.00

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Planting & Seeding	125.00	ACR			10,109	221,568	14,394	369,571	839,025	1,444,557	11556.46
TOTAL Second Bench	1.00	EA			62,207	1936987	176,205	1916720	1,221,003	5,250,915	5250915
09. 01.020. First Bench Install long reach (150') sprinkler heads at elevation above 25-year flood, connect to header main via small diam. pipes											
09. 01.020. 1. Excavate pipe trench, 18" depth (cont'd) ditch-witch w/ backhoe											
AF GC <02230 0450 > Excavate utility trench, 36" deep, 6" wide, 12HP, chain trencher					0.02	0.55	0.10	0.00	0.00	0.65	
	1.00	LF	CODBB53	56.25	0	1	0	0	0	1	0.65
TOTAL Excavate pipe trench, 18" depth	1.00	LF			0	1	0	0	0	1	0.65
09. 01.020. 2. Pipe Laying											
09. 01.020. 2.01. Install small diam pressure pipe (cont'd) for sprinkler irrigation											
M MIL GC <02667 4030 > Piping, water dist, 3", PVC, press pipe, class 200, SDR 21					0.06	2.05	0.00	1.72	0.00	3.77	
	31000	LF	ULABB20A	65.00	1,907	63,655	0	53,320	0	116,975	3.77
TOTAL Install small diam pressure pipe	31000	LF			1,907	63,655	0	53,320	0	116,975	3.77
09. 01.020. 2.02. Install small diam pipe fittings (cont'd) as needed											
M MIL GC <02667 4210 > Piping, water dist, 90 deg, 3", PVC, press pipe, CL200, SDR 21 elbow					0.70	23.21	0.00	11.87	0.00	35.08	
	500.00	EA	ULABB20A	5.75	348	11,606	0	5,935	0	17,541	35.08
Quantity assumed.											
M MIL GC <02667 4390 > Piping, water dist, 3", PVC, press pipe, CL200, SDR 21 tee					1.07	35.59	0.00	16.25	0.00	51.84	
	1500.00	EA	ULABB20A	3.75	1,600	53,390	0	24,375	0	77,765	51.84
Quantity assumed											
M MIL GC <02667 4480 > Piping, water dist, 3", PVC, press pipe, CL200, SDR 21 coupling					0.70	23.21	0.00	6.48	0.00	29.69	
	1100.00	EA	ULABB20A	5.75	765	25,534	0	7,128	0	32,662	29.69
Quantity assumed											

09. 01. IRRIGATION PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Install small diam pipe fittings	3100.00	EA			2,713	90,530	0	37,438	0	127,968	41.28
09. 01.020. 2.03. Install long reach (150') sprin- (cont'd) kler heads											
Should the UOM be "EA" ?											
M MIL GC <02810 1284 > Sprinkler,39'-99',30-100 PSI, pop-up full cir,w/plstc cs,met cov, coml					0.64	14.94	0.00	102.53	0.00	117.47	
	190.00	EA	USKCSKWK2	3.13	122	2,839	0	19,481	0	22,320	117.47
TOTAL Install long reach (150') sprin-	190.00	LF			122	2,839	0	19,481	0	22,320	117.47
09. 01.020. 2.04. Install pipe thrust blocks at (con't) fittings and bends											
TOTAL Install pipe thrust blocks at	238.00	EA			0	0	0	0	11,900	11,900	50.00
TOTAL Pipe Laying	31000	LF			4,741	157,025	0	110,239	11,900	279,163	9.01
09. 01.020. 3. Backfill pipe trench, compact											
MIL GC <02215 1220 > Backfill, trench, front-end loader, 40 - 60 HP, no compaction					0.03	0.90	0.74	0.00	0.00	1.64	
	31000	CY	CODFB10N	50.00	930	27,854	23,061	0	0	50,914	1.64
TOTAL Backfill pipe trench, compact	31000	LF			930	27,854	23,061	0	0	50,914	1.64
09. 01.020. 4. Install control valves for sprin (cont'd) kler groups or individuals											
M MIL GC <02810 1310 > Sprinkler irr sys, plstc, 1", 5-30 GPM, 15-125 PSI, elec rmt cntrl v					0.89	20.75	0.00	23.25	0.00	44.00	
	90.00	EA	USKCSKWK2	2.25	80	1,868	0	2,093	0	3,960	44.00
TOTAL Install control valves for sprin	90.00	EA			80	1,868	0	2,093	0	3,960	44.00
09. 01.020. 5. Install Programmable Logic (cont'd) Controllers, remote access, etc.											
TOTAL Install Programmable Logic	1.00	EA			0	0	0	0	500,000	500,000	500000.00

09. 01. IRRIGATION PLANTING		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.020. 6. Rough grade & scarify subsoil (cont'd) to receive topsoil, common earth, 200HP dozer												
	New quantity = 89 acres = 3,876,840 sf = 4,308 CSY (07/20/04) 125 acres = 5,445,000 sf = 6,050 CSY											
MIL GC <02224 7000	> Excavating, bulk, dozer, open					0.50	14.97	21.98	0.00	0.00	36.95	
	site, rough grade	4307.60	CSY	CODTB11R	3.00	2,154	64,504	94,663	0	0	159,167	36.95
	TOTAL Rough grade & scarify subsoil	89.00	ACR			2,154	64,504	94,663	0	0	159,167	1788.39
09. 01.020. 7. Planting & seeding												
09. 01.020. 7.01. Mulch, hay, 1" deep, power (cont'd) mulcher, large												
M MIL GC <	> Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
		58.55	HR	X-LABORER	1.00	59	1,199	0	5	0	1,204	20.56
MIL GC <	> Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
		58.55	HR	X-TRKDVRLT	1.00	59	1,486	0	0	0	1,486	25.38
EP GC <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
		58.55	HR	T50F0009	1.00	0	0	909	0	0	909	15.53
GEN GC <	> HYDROMULCHER, 3,000 GAL(11,356L)					0.00	0.00	29.04	0.00	0.00	29.04	
	TRK MTD (W/ 56,000GVW TRK)	58.55	HR	L15Z3880	1.00	0	0	1,701	0	0	1,701	29.04
USR GC <	> Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
		89.00	ACR	N/A	0.00	0	0	0	74,241	0	74,241	834.17
	TOTAL Mulch, hay, 1" deep, power	89.00	ACR			117	2,685	2,610	74,246	0	79,541	893.72
09. 01.020. 7.02. Crimping, tilling topsoil (cont'd) 20 HP tractor, disk harrow, 6" deep												
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA					0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	356.00	HR	T10LE001	1.00	0	0	459	0	0	459	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4					0.00	0.00	7.67	0.00	0.00	7.67	
		356.00	HR	T25JD005	1.00	0	0	2,729	0	0	2,729	7.67
MIL GC <	> Outside Equip. Operator, Light					1.00	30.80	0.00	0.00	0.00	30.80	
		356.00	HR	X-EQOPRLT	1.00	356	10,966	0	0	0	10,966	30.80
	TOTAL Crimping, tilling topsoil	89.00	ACR			356	10,966	3,189	0	0	14,155	159.04

09. 01. IRRIGATION PLANTING		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	09. 01.020. 7.03. Seeding, athletic fld mix,											
M RSM GC <02932 0010	> Seeding, athletic field mix,					1.00	22.13	0.00	47.42	0.00	69.55	
	8#/MSFpush spreader	3876.84	MSF	ALABCLAB1	1.00	3,877	85,802	0	183,840	0	269,642	69.55
	125 acres = 5,445 msf											
	TOTAL Seeding, athletic fld mix,	89.00	ACR			3,877	85,802	0	183,840	0	269,642	3029.69
	09. 01.020. 7.04. Place Coarse Woody debris/rocks											
M MIL GC <	> Outside Laborer (4)					1.00	20.47	0.00	0.21	0.00	20.68	
		712.00	HR	X-LABORER	1.00	712	14,576	0	150	0	14,725	20.68
USR GC <	> Material and equipment					0.00	0.00	50.00	50.00	0.00	100.00	
		89.00	ACR	N/A	0.00	0	0	4,450	4,450	0	8,900	100.00
	TOTAL Place Coarse Woody debris/rocks	89.00	ACR			712	14,576	4,450	4,600	0	23,625	265.45
	09. 01.020. 7.05. Plant Mesquite/Shrub mix using (cont'd) 5 gallon plants											
USR GC <	> Planting of 5-gallon plants					0.00	0.00	0.00	0.00	15.00	15.00	
	See bid result of Rio Salado Ph 1A	55935	EA		0.00	0	0	0	0	839,025	839,025	15.00
	TOTAL Plant Mesquite/Shrub mix using	55935	EA			0	0	0	0	839,025	839,025	15.00
	TOTAL Planting & seeding	89.00	ACR			5,062	114,029	10,248	262,686	839,025	1,225,988	13775.15
	TOTAL First Bench	1.00	EA			12,967	365,280	127,972	375,017	1,350,925	2,219,194	2219194
	TOTAL IRRIGATION PLANTING	1.00	EA			287,141	8210895	3807079	7083380	7,636,522	26,737,876	26737876

09. 05. BASINS PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 05. BASINS PLANTING											
09. 05.001. Tributary Infiltration Basins Construct infiltration basins at tributary (wash) outlets into SCR total basins = 8, depth = 4', side slopes at 4%											
09. 05.001. 1. Fencing for Erosion Control 18 acres = 784,080 sf Square root of 784,080 sf = 885.5 lf 885.5 x 4 = 3542 lf (perimeter)											
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5'					0.16	3.54	0.00	3.58	0.00	7.12	
high	3542.00	LF	ALABCLAB2	12.50	567	12,543	0	12,680	0	25,223	7.12
TOTAL Fencing for Erosion Control	18.00	ACR			567	12,543	0	12,680	0	25,223	1401.27
09. 05.001. 2. Clearing and Grubbing, debris (con't) removal, etc.											
AF GC <02109 0420 > Clear & grub, burning,					14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	13.00	ACR	UOEHB40A	0.28	185	5,383	4,005	0	0	9,388	722.14
TOTAL Clearing and Grubbing, debris	13.00	ACR			185	5,383	4,005	0	0	9,388	722.14
09. 05.001. 3. Excavate, mach exc., sand & grav (cont'd) 2CY bkt											
09. 05.001. 3.01. Stockpile useable cut matl, (cont'd) assume 25% total cut											
MIL GC <02241 0020 > Losm or topsoil, 200' haul, 6"					0.01	0.42	0.61	0.00	0.00	1.03	
deep, 200 HP dozer, remove/pile on site	830.00	CY	CODTB10B	108.13	12	345	506	0	0	851	1.03
TOTAL Stockpile useable cut matl,	830.00	CY			12	345	506	0	0	851	1.03
09. 05.001. 3.02. Hauling, surplus cut matl, no (cont'd) loading, 10 mile RT											
AF GC <02234 0555 > Hauling, hwy haulers, 12 CY, 12					0.05	1.35	2.40	0.00	0.00	3.75	
mile round trip @ base wide rate	2490.00	CY	COEIB34B	20.00	125	3,365	5,967	0	0	9,333	3.75
TOTAL Hauling, surplus cut matl, no	2490.00	CY			125	3,365	5,967	0	0	9,333	3.75

09. 05. BASINS PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 05.001. 3.03. Fill, spread cut matl at dump (cont'd) site, no compaction											
AF GC <02240 0030 > Fill, spread cut mat'l w/dozer at dump site, no compaction					0.01	0.36	0.53	0.00	0.00	0.89	
	2490.00	CY	CODTB10B	125.00	30	895	1,313	0	0	2,208	0.89
TOTAL Fill, spread cut matl at dump	2490.00	CY			30	895	1,313	0	0	2,208	0.89
09. 05.001. 3.04. Compaction at dump site, hl rlr, (cont'd) 12" lifts, 2 passes											
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2 passes, sheepsfoot/wobbly wheel roller					0.01	0.14	0.16	0.00	0.00	0.29	
	2490.00	CY	COFCB32F	600.00	12	345	388	0	0	733	0.29
TOTAL Compaction at dump site, hl rlr,	2490.00	CY			12	345	388	0	0	733	0.29
09. 05.001. 3.05. Compact Basin subgrade, existing (cont'd) earth, 2 passes 90%											
MIL GC <02239 0230 > Spread & compact, slope > 1 in 4, shape enbankment, by hand					0.10	2.23	0.00	0.00	0.00	2.23	
	86160	SY	ULABB2	50.00	8,616	192,413	0	0	0	192,413	2.23
TOTAL Compact Basin subgrade, existing	86160	SY			8,616	192,413	0	0	0	192,413	2.23
TOTAL Excavate, mach exc., sand & grav	8300.00	CY			8,794	197,362	8,174	0	0	205,537	24.76
09. 05.001. 4. Backfilling 840 cy x 4 (different layers) = 3,360 cy											
09. 05.001. 4.01. Fill, bottom layer, clean sand, 12" depth											
M USR GC < > Clean Sand See Means Construction Cost Data 2004, 04060-750-0200, Total Unit Cost is about $17.75/cy					0.00	0.00	0.00	0.00	17.75	17.75	
	840.00	CY	N/A	0.00	0	0	0	0	14,910	14,910	17.75
TOTAL Fill, bottom layer, clean sand,	840.00	CY			0	0	0	0	14,910	14,910	17.75

	09. 05. BASINS PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	09. 05.001. 4.02. Fill, middle layer, No. 57 blue-stone (or equiv)											
USR GC <	> Bluestone					0.00	0.00	0.00	0.00	1.00	1.00	
	See Means Construction Cost Data 2004, 04850-100-0500	840.00	CY		0.00	0	0	0	0	840	840	1.00
	Total Unit Cost is about $1.00/cy											
	TOTAL Fill, middle layer, No. 57 blue-	840.00	CY			0	0	0	0	840	840	1.00
	09. 05.001. 4.03. Fill, middle layer, No. 2 gravel											
USR GC <	> Bank-run Gravel					0.00	0.00	0.00	0.00	25.00	25.00	
	See Means Construction Cost Data 2004, 02060-150-0100 and 0900, including 5 mile haul	840.00	CY		0.00	0	0	0	0	21,000	21,000	25.00
	TOTAL Fill, middle layer, No. 2 gravel	840.00	CY			0	0	0	0	21,000	21,000	25.00
	09. 05.001. 4.04. Fill, top layer, mix of native topsoil plus amendments											
USR GC <	> Native Topsoil, weed free					0.00	0.00	0.00	0.00	30.00	30.00	
	See Means Construction Cost Data 2004, 02055-150-0800 and-0900, including 5 mile haul	840.00	CY		0.00	0	0	0	0	25,200	25,200	30.00
	TOTAL Fill, top layer, mix of native	840.00	CY			0	0	0	0	25,200	25,200	30.00
	TOTAL Backfilling	3360.00	CY			0	0	0	0	61,950	61,950	18.44
	09. 05.001. 5. Planting & Seeding											
	09. 05.001. 5.01. Mulch, hay, 1" deep, power (cont'd) mulcher, large											
M MIL GC <	> Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
		11.84	HR	X-LABORER	1.00	12	242	0	1	0	243	20.56
MIL GC <	> Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
		11.84	HR	X-TRKDVRLT	1.00	12	301	0	0	0	301	25.38
EP GC <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
		11.84	HR	T50FO009	1.00	0	0	184	0	0	184	15.53

09. 05. BASINS PLANTING		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
GEN GC <	> HYDROMULCHER, 3,000 GAL(11,356L)					0.00	0.00	29.04	0.00	0.00	29.04	
	TRK MTD (W/ 56,000GVW TRK)	11.84	HR	L15Z3880	1.00	0	0	344	0	0	344	29.04
USR GC <	> Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
		18.00	ACR	N/A	0.00	0	0	0	15,015	0	15,015	834.17
	TOTAL Mulch, hay, 1" deep, power	18.00	ACR			24	543	528	15,016	0	16,087	893.72
09. 05.001. 5.02. Crimping, tilling topsoil (cont'd) 20 HP tractor, disk harrow, 6" deep												
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA					0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	72.00	HR	T10LE001	1.00	0	0	93	0	0	93	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4					0.00	0.00	7.67	0.00	0.00	7.67	
		72.00	HR	T25JD005	1.00	0	0	552	0	0	552	7.67
MIL GC <	> Outside Equip. Operator, Light					1.00	30.80	0.00	0.00	0.00	30.80	
		72.00	HR	X-EQOPRLT	1.00	72	2,218	0	0	0	2,218	30.80
	TOTAL Crimping, tilling topsoil	18.00	ACR			72	2,218	645	0	0	2,863	159.04
09. 05.001. 5.03. Seeding, athletic fld mix,												
M RSM GC <02932 0010	> Seeding, athletic field mix,					1.00	22.13	0.00	47.42	0.00	69.55	
	8#/MSFpush spreader	784.08	MSF	ALABCLAB1	1.00	784	17,353	0	37,181	0	54,534	69.55
	125 acres = 5,445 msf											
	TOTAL Seeding, athletic fld mix,	18.00	ACR			784	17,353	0	37,181	0	54,534	3029.69
09. 05.001. 5.04. Plant Mesquite/Shrub mix using (cont'd) 5 gallon plants												
USR GC <	> Planting of 5-gallon plants					0.00	0.00	0.00	0.00	15.00	15.00	
	See bid result of Rio Salado Ph 1A	3204.00	EA		0.00	0	0	0	0	48,060	48,060	15.00
	TOTAL Plant Mesquite/Shrub mix using	3204.00	EA			0	0	0	0	48,060	48,060	15.00
	TOTAL Planting & Seeding	18.00	ACR			880	20,114	1,173	52,197	48,060	121,544	6752.45
	TOTAL Tributary Infiltration Basins	1.00	EA			10,426	235,402	13,352	64,878	110,010	423,641	423641.40

09. 05. BASINS PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 05.005. Grade Control Infiltration Basin Construct infiltration basins immediately upstream of existing grade control structure, total basins = 6, depth = 4', side slopes at 4%											
09. 05.005. 1. Fencing for Erosion Control 6 acres = 261,360 sf Square root of 261,360 = 511 lf 511 lf x 4 = 2,044 lf (perimeter)											
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5' high					0.16	3.54	0.00	3.58	0.00	7.12	
	2044.00	LF	ALABCLAB2	12.50	327	7,238	0	7,318	0	14,556	7.12
TOTAL Fencing for Erosion Control	6.00	ACR			327	7,238	0	7,318	0	14,556	2425.92
09. 05.005. 2. Clearing and Grubbing, debris removal, etc.											
AF GC <02109 0420 > Clear & grub, burning, incinerator, light					14.23	414.10	308.04	0.00	0.00	722.14	
	5.00	ACR	UOEHB40A	0.28	71	2,070	1,540	0	0	3,611	722.14
TOTAL Clearing and Grubbing, debris	5.00	ACR			71	2,070	1,540	0	0	3,611	722.14
09. 05.005. 3. Excavating, mach exc, sand & gr 2 cy bkt											
09. 05.005. 3.01. Stockpile useable cut mat'l assume 25% total cut											
MIL GC <02241 0020 > Loam or topsoil, 200' haul, 6" deep, 200 HP dozer, remove/pile on site					0.01	0.42	0.61	0.00	0.00	1.03	
	280.00	CY	CODTB10B	108.13	4	116	171	0	0	287	1.03
TOTAL Stockpile useable cut mat'l	280.00	CY			4	116	171	0	0	287	1.03
09. 05.005. 3.02. Hauling, surplus cut mat'l, no loading, 10 mile RT											
AF GC <02234 0555 > Hauling, hwy haulers, 12 CY, 12 mile round trip @ base wide rate					0.05	1.35	2.40	0.00	0.00	3.75	
	840.00	CY	COEIB34B	20.00	42	1,135	2,013	0	0	3,148	3.75
TOTAL Hauling, surplus cut mat'l, no	840.00	CY			42	1,135	2,013	0	0	3,148	3.75

09. 05. BASINS PLANTING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 05.005. 3.03. Fill, spread cut mat'l at dump site, no compaction											
AF GC <02240 0030 > Fill, spread cut mat'l w/dozer					0.01	0.36	0.53	0.00	0.00	0.89	
at dump site, no compaction	840.00	CY	CODTB10B	125.00	10	302	443	0	0	745	0.89
TOTAL Fill, spread cut mat'l at dump	840.00	CY			10	302	443	0	0	745	0.89
TOTAL Excavating, mach exc, sand & gr	1120.00	CY			56	1,554	2,627	0	0	4,180	3.73
09. 05.005. 4. Compaction at dump site, hl rlr 12" lifts, 2 passes											
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2					0.01	0.14	0.16	0.00	0.00	0.29	
passes, sheepsfoot/wobbly wheel roller	840.00	CY	COFCB32F	600.00	4	116	131	0	0	247	0.29
TOTAL Compaction at dump site, hl rlr	840.00	CY			4	116	131	0	0	247	0.29
09. 05.005. 5. Compact basin subgrade, existing earth, 2 passes 90%											
MIL GC <02239 0230 > Spread & compact, slope > 1 in					0.10	2.23	0.00	0.00	0.00	2.23	
4, shape enbankment, by hand	29040	SY	ULABB2	50.00	2,904	64,852	0	0	0	64,852	2.23
TOTAL Compact basin subgrade, existing	29040	CY			2,904	64,852	0	0	0	64,852	2.23
09. 05.005. 6. Backfilling See unit cost development at "Tributary Infiltration Basins"											
290 cy x 4 (different layers) = 1,160 cy											
TOTAL Backfilling	1160.00	CY			0	0	0	0	21,390	21,390	18.44
09. 05.005. 7. Planting & Seeding											
09. 05.005. 7.01. Mulch, hay, 1" deep, power (cont'd) mulcher, large											
M MIL GC < > Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
	3.95	HR	X-LABORER	1.00	4	81	0	0	0	81	20.56
MIL GC < > Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
	3.95	HR	X-TRKDVRLT	1.00	4	100	0	0	0	100	25.38
EP GC < > TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
	3.95	HR	T50F0009	1.00	0	0	61	0	0	61	15.53

09. 05. BASINS PLANTING		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
GEN GC <	> HYDROMULCHER, 3,000 GAL(11,356L)					0.00	0.00	29.04	0.00	0.00	29.04	
	TRK MTD (W/ 56,000GVW TRK)	3.95	HR	L15Z3880	1.00	0	0	115	0	0	115	29.04
USR GC <	> Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
		6.00	ACR	N/A	0.00	0	0	0	5,005	0	5,005	834.17
	TOTAL Mulch, hay, 1" deep, power	6.00	ACR			8	181	176	5,005	0	5,362	893.72
09. 05.005. 7.02. Crimping, tilling topsoil	(cont'd) 20 HP tractor, disk harrow, 6" deep											
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA					0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	24.00	HR	T10LE001	1.00	0	0	31	0	0	31	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4					0.00	0.00	7.67	0.00	0.00	7.67	
		24.00	HR	T25JD005	1.00	0	0	184	0	0	184	7.67
MIL GC <	> Outside Equip. Operator, Light					1.00	30.80	0.00	0.00	0.00	30.80	
		24.00	HR	X-EQOPRLT	1.00	24	739	0	0	0	739	30.80
	TOTAL Crimping, tilling topsoil	6.00	ACR			24	739	215	0	0	954	159.04
09. 05.005. 7.03. Seeding, athletic fld mix,												
M RSM GC <02932 0010	> Seeding, athletic field mix,					1.00	22.13	0.00	47.42	0.00	69.55	
	8#/MSFpush spreader	261.36	MSF	ALABCLAB1	1.00	261	5,784	0	12,394	0	18,178	69.55
	125 acres = 5,445 msf											
	TOTAL Seeding, athletic fld mix,	6.00	ACR			261	5,784	0	12,394	0	18,178	3029.69
	TOTAL Planting & Seeding	6.00	ACR			293	6,705	391	17,399	0	24,495	4082.45
	TOTAL Grade Control Infiltration Basin	1.00	EA			3,656	82,535	4,689	24,717	21,390	133,331	133330.84
	TOTAL BASINS PLANTING	1.00	EA			14,082	317,937	18,040	89,594	131,400	556,972	556972.24

09. 10. HARDENED BANKS	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 10. HARDENED BANKS Construct Soil Cement slopes on vertical sections of SCR banks. Typ application = 8' wide, 30' height (19' +10')										
09. 10.001. Hardened Slopes										
09. 10.001. 1. Fencing for Erosion Control 3.5 acres = 152,460 sf Square root of 152,460 sf = 390 lf 390 lf x 4 = 1,560 lf (perimeter)										
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5' high	1560.00 LF	ALABCLAB2	12.50	0.16 250	3.54 5,524	0.00 0	3.58 5,585	0.00 0	7.12 11,109	7.12
TOTAL Fencing for Erosion Control	3.50 ACR			250	5,524	0	5,585	0	11,109	3173.98
09. 10.001. 2. Clearing and Grubbing, debris removal										
AF GC <02109 0420 > Clear & grub, burning, incinerator, light	0.90 ACR	UOEHB40A	0.28	14.23 13	414.10 373	308.04 277	0.00 0	0.00 0	722.14 650	722.14
TOTAL Clearing and Grubbing, debris	0.90 ACR			13	373	277	0	0	650	722.14
09. 10.001. 3. Excavating, prepare slope & subgrade, 1:1 slope										
09. 10.001. 3.01. Stockpile subgrade cut matl for backfill										
MIL GC <02241 0020 > Loam or topsoil, 200' haul, 6" deep, 200 HP dozer, remove/pile on site	28200 CY	CODTB10B	108.13	0.01 392	0.42 11,717	0.61 17,194	0.00 0	0.00 0	1.03 28,911	1.03
TOTAL Stockpile subgrade cut matl for	28200 CY			392	11,717	17,194	0	0	28,911	1.03
09. 10.001. 3.02. Hauling, no loading, 16.5 cy dump trailer, 10 mile RT										
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6 mi round trip @ 40 MPH (2.1 cyc/hr)	18800 CY	CTDHB34C	35.00	0.03 538	0.77 14,519	1.44 27,164	0.00 0	0.00 0	2.22 41,683	2.22
TOTAL Hauling, no loading, 16.5 cy	18800 CY			538	14,519	27,164	0	0	41,683	2.22
TOTAL Excavating, prepare slope &	47000 CY			930	26,236	44,358	0	0	70,594	1.50

09. 10. HARDENED BANKS	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 10.001. 4. Fill, spread dumped mat'l, by dozer, no compaction										
09. 10.001. 4.01. Compaction, sheepfoot/wobbly whl rlr, 12" lifts, 2 passes										
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2 passes, sheepsfoot/wobbly wheel roller				0.01	0.14	0.16	0.00	0.00	0.29	
	18800 CY	COFCB32F	600.00	94	2,602	2,929	0	0	5,531	0.29
TOTAL Compaction, sheepfoot/wobbly	18800 CY			94	2,602	2,929	0	0	5,531	0.29
09. 10.001. 4.02. Fine grade to 1:1 slope, for irregular areas, adverse cond.										
MIL GC <02226 4100 > Excavation, bulk, fine grade, 3 passes w/grader				1.00	27.99	17.66	0.00	0.00	45.65	
	149.00 CSY	COFGB11L	2.00	149	4,171	2,631	0	0	6,802	45.65
TOTAL Fine grade to 1:1 slope, for	14900 SY			149	4,171	2,631	0	0	6,802	0.46
TOTAL Fill, spread dumped mat'l, by	18800 CY			243	6,773	5,560	0	0	12,333	0.66
09. 10.001. 5. Soil Cement application, 8" lifts at 8' width, 750 PSI										
TOTAL Soil Cement application,	61100 CY			0	733,200	611,000	1038700	0	2,382,900	39.00
09. 10.001. 6. Backfill and Compaction										
09. 10.001. 6.01. Backfill subgrade with cut matl										
MIL GC <02215 1220 > Backfill, trench, front-end loader, 40 - 60 HP, no compaction				0.03	0.90	0.74	0.00	0.00	1.64	
	28200 CY	CODFB10N	50.00	846	25,338	20,978	0	0	46,316	1.64
TOTAL Backfill subgrade with cut matl	28200 CY			846	25,338	20,978	0	0	46,316	1.64
09. 10.001. 6.02. Compaction, sheepfoot/wobbly whl rlr, 12" lifts, 2 passes										
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2 passes, sheepsfoot/wobbly wheel roller				0.01	0.14	0.16	0.00	0.00	0.29	
	28200 CY	COFCB32F	600.00	141	3,903	4,394	0	0	8,296	0.29
TOTAL Compaction, sheepfoot/wobbly whl	28200 CY			141	3,903	4,394	0	0	8,296	0.29

09. 10. HARDENED BANKS	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Backfill and Compaction	28200	CY			987	29,241	25,372	0	0	54,612	1.94
TOTAL Hardened Slopes	1.00	EA			2,422	801,347	686,566	1044285	0	2,532,198	2532198
TOTAL HARDENED BANKS	1.00	EA			2,422	801,347	686,566	1044285	0	2,532,198	2532198

09. 15. PIPING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 15. PIPING Install various sized piping for irrigation distribution throughout project area. Install fording culverts in historic floodplain											
09. 15.001. Irrigation Piping											
09. 15.001. 1. Trenching for Delivery Pipe											
09. 15.001. 1.01. Delivery pipe trench bedding, 3/4" gravel pipe support											
M MIL GC <02704 0300 > Drainage, drainage matl, 3/4"					0.09	2.31	0.47	46.94	0.00	49.72	
gravel fill in trench	1260.00	CY	CODLB6	32.50	116	2,910	586	59,144	0	62,641	49.72
TOTAL Delivery pipe trench bedding,	1260.00	CY			116	2,910	586	59,144	0	62,641	49.72
09. 15.001. 1.02. Delivery piping, large dia. say 12" PVC											
M MIL GC <02667 4560 > Piping, water dist, PVC, class					0.17	5.74	0.00	14.05	0.00	19.79	
150, SDR 18, AWWA C900, 12"	10440	LF	ULABB20A	23.25	1,796	59,934	0	146,682	0	206,616	19.79
TOTAL Delivery piping, large dia. say	10440	LF			1,796	59,934	0	146,682	0	206,616	19.79
09. 15.001. 1.03. Backfill delivery pipe trench, FE loader, whl mtd 1 CY bkt											
M MIL GC <02215 2460 > Backfill, sand bedding trenches,					0.03	0.95	0.78	15.46	0.00	17.19	
front-end loader, 1.5 CY	1260.00	CY	CODFB10N	47.50	40	1,192	987	19,480	0	21,658	17.19
TOTAL Backfill delivery pipe trench,	1260.00	CY			40	1,192	987	19,480	0	21,658	17.19
09. 15.001. 1.04. Hauling, Delivery pipe surplus cut matl, no loading, 10 mile RT											
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6					0.03	0.77	1.44	0.00	0.00	2.22	
mi round trip @ 40 MPH (2.1 cyc/hr)	1880.00	CY	CTDHB34C	35.00	54	1,452	2,716	0	0	4,168	2.22
TOTAL Hauling, Delivery pipe surplus	1880.00	CY			54	1,452	2,716	0	0	4,168	2.22
TOTAL Trenching for Delivery Pipe	3130.00	CY			2,006	65,488	4,289	225,306	0	295,083	94.28

09. 15. PIPING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 15.001. 2. Trenching for Main Pipe											
09. 15.001. 2.01. Main pipe trench bedding, 3/4" gravel pipe support											
M MIL GC <02704 0300 > Drainage, drainage matl, 3/4"					0.09	2.31	0.47	46.94	0.00	49.72	
gravel fill in trench	8400.00	CY	CODLB6	32.50	775	19,402	3,909	394,296	0	417,607	49.72
TOTAL Main pipe trench bedding,	8400.00	CY			775	19,402	3,909	394,296	0	417,607	49.72
09. 15.001. 2.02. Main piping, large dia. say 12" PVC											
M MIL GC <02667 4560 > Piping, water dist, PVC, class					0.17	5.74	0.00	14.05	0.00	19.79	
150, SDR 18, AWWA C900, 12"	69970	LF	ULABB20A	23.25	12,035	401,684	0	983,079	0	1,384,762	19.79
TOTAL Main piping, large dia. say	69970	LF			12,035	401,684	0	983,079	0	1,384,762	19.79
09. 15.001. 2.03. Backfill Main pipe trench, FE loader, whl mtd 1 CY bkt											
M MIL GC <02215 2460 > Backfill, sand bedding trenches,					0.03	0.95	0.78	15.46	0.00	17.19	
front-end loader, 1.5 CY	8400.00	CY	CODFB10N	47.50	265	7,945	6,577	129,864	0	144,386	17.19
TOTAL Backfill Main pipe trench,	8400.00	CY			265	7,945	6,577	129,864	0	144,386	17.19
09. 15.001. 2.04. Hauling, Main pipe surplus cut matl, no loading, 10 mile RT											
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6					0.03	0.77	1.44	0.00	0.00	2.22	
mi round trip @ 40 MPH (2.1 cyc/hr)	12600	CY	CTDHB34C	35.00	360	9,731	18,206	0	0	27,937	2.22
TOTAL Hauling, Main pipe surplus	12600	CY			360	9,731	18,206	0	0	27,937	2.22
TOTAL Trenching for Main Pipe	21000	CY			13,436	438,762	28,691	1507239	0	1,974,692	94.03
09. 15.001. 3. Trenching for Sub-main Pipe											
09. 15.001. 3.01. Sub-main pipe trench bedding, 3/4" gravel pipe support											
M MIL GC <02704 0300 > Drainage, drainage matl, 3/4"					0.09	2.31	0.47	46.94	0.00	49.72	
gravel fill in trench	3370.00	CY	CODLB6	32.50	311	7,784	1,568	158,188	0	167,540	49.72
TOTAL Sub-main pipe trench bedding,	3370.00	CY			311	7,784	1,568	158,188	0	167,540	49.72

09. 15. PIPING	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 15.001. 3.02. Sub-main piping, large dia. say 8" PVC											
M MIL GC <02667 4540 > Piping, water dist, PVC, class 150, SDR 18, AWWA C900, 8"					0.12	4.04	0.00	6.24	0.00	10.28	
	28010	LF	ULABB20A	33.00	3,395	113,292	0	174,782	0	288,074	10.28
TOTAL Sub-main piping, large dia. say	28010	LF			3,395	113,292	0	174,782	0	288,074	10.28
09. 15.001. 3.03. Backfill Sub-main pipe trench, FE loader, whl mtd 1 CY bkt											
M MIL GC <02215 2460 > Backfill, sand bedding trenches, front-end loader, 1.5 CY					0.03	0.95	0.78	15.46	0.00	17.19	
	3370.00	CY	CODFB10N	47.50	106	3,187	2,639	52,100	0	57,926	17.19
TOTAL Backfill Sub-main pipe trench,	3370.00	CY			106	3,187	2,639	52,100	0	57,926	17.19
09. 15.001. 3.04. Hauling, Sub-main pipe surplus cut matl, no loading, 10 mile RT											
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6 mi round trip @ 40 MPH (2.1 cyc/hr)					0.03	0.77	1.44	0.00	0.00	2.22	
	5050.00	CY	CTDHB34C	35.00	144	3,900	7,297	0	0	11,197	2.22
TOTAL Hauling, Sub-main pipe surplus	5050.00	CY			144	3,900	7,297	0	0	11,197	2.22
TOTAL Trenching for Sub-main Pipe	8420.00	CY			3,957	128,164	11,504	385,070	0	524,737	62.32
09. 15.001. 4. Trenching for Culvert CMP											
09. 15.001. 4.01. Culvert trench bedding, 3/4" gravel pipe support											
M MIL GC <02704 0300 > Drainage, drainage matl, 3/4" gravel fill in trench					0.09	2.31	0.47	46.94	0.00	49.72	
	4200.00	CY	CODLB6	32.50	388	9,701	1,954	197,148	0	208,803	49.72
TOTAL Culvert trench bedding,	4200.00	CY			388	9,701	1,954	197,148	0	208,803	49.72
09. 15.001. 4.02. Install 24" dia. CMP Culvert for truck traffic											
M MIL GC <02764 3200 > Piping, corr stl, 18" equiv, 21" x 15",16 ga, plain oval arch culv					0.27	6.51	0.69	11.84	0.00	19.04	
	23600	LF	CLABB14	21.88	6,473	153,697	16,317	279,424	0	449,438	19.04
TOTAL Install 24" dia. CMP Culvert for	23600	LF			6,473	153,697	16,317	279,424	0	449,438	19.04

09. 15. PIPING	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 15.001. 4.03. Backfill trench, FE Loader, whl mtd 1 CY bkt										
M MIL GC <02215 2460 > Backfill, sand bedding trenches,				0.03	0.95	0.78	15.46	0.00	17.19	
front-end loader, 1.5 CY	4200.00 CY	CODFB10N	47.50	133	3,972	3,289	64,932	0	72,193	17.19
TOTAL Backfill trench, FE Loader,	4200.00 CY			133	3,972	3,289	64,932	0	72,193	17.19
09. 15.001. 4.04. Hauling, Sub-main pipe surplus cut matl, no loading, 10 mile RT										
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6				0.03	0.77	1.44	0.00	0.00	2.22	
mi round trip @ 40 MPH (2.1 cyc/hr)	6300.00 CY	CTDHB34C	35.00	180	4,865	9,103	0	0	13,968	2.22
TOTAL Hauling, Sub-main pipe surplus	6300.00 CY			180	4,865	9,103	0	0	13,968	2.22
TOTAL Trenching for Culvert CMP	10500 CY			7,174	172,236	30,663	541,504	0	744,403	70.90
TOTAL Irrigation Piping	1.00 EA			26,572	804,650	75,147	2659119	0	3,538,916	3538916
TOTAL PIPING	1.00 EA			26,572	804,650	75,147	2659119	0	3,538,916	3538916

09. 20. ROADS & BRIDGES	QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 20. ROADS & BRIDGES									
09. 20.001. Compacted Earth Maintenance Road Construct gravel trails at various locations throughout project area, 10 foot width									
09. 20.001. 1. Clearing & Grubbing, debris removal, etc.									
AF GC <02109 0420 > Clear & grub, burning, incinerator, light	8.30 ACR UOEHB40A	0.28	14.23 118	414.10 3,437	308.04 2,557	0.00 0	0.00 0	722.14 5,994	722.14
TOTAL Clearing & Grubbing, debris	8.30 ACR		118	3,437	2,557	0	0	5,994	722.14
09. 20.001. 2. Site Preparation									
09. 20.001. 2.01. Ripping, discing to prepare surface									
RSM GC <02238 0010 > Ripping, trap rock, soft, 200 HP dozer, ideal conditions	83.00 CY CODTB10B	88.75	0.02 1	0.51 42	0.74 62	0.00 0	0.00 0	1.25 104	1.25
Assume 10 cy/acre									
TOTAL Ripping, discing to prepare	8.30 ACR		1	42	62	0	0	104	12.49
09. 20.001. 2.02. Regrade, flatten, balance cut matl. Onsite, 50% of area									
MIL GC <02224 7020 > Excavating, bulk, dozer, 300 HP, large area, open site, rough grade	2020.00 CY CODTB10M	300.00	0.01 10	0.15 302	0.33 671	0.00 0	0.00 0	0.48 973	0.48
TOTAL Regrade, flatten, balance cut	2020.00 CY		10	302	671	0	0	973	0.48
09. 20.001. 2.03. Compaction, riding, sheepfoot/ wobbly whl, 2 passes									
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2 passes, sheepsfoot/wobbly wheel roller	40260 CY COFCB32F	600.00	0.01 201	0.14 5,572	0.16 6,273	0.00 0	0.00 0	0.29 11,844	0.29
TOTAL Compaction, riding, sheepfoot/	40260 SY		201	5,572	6,273	0	0	11,844	0.29
TOTAL Site Preparation	8.30 ACR		213	5,916	7,005	0	0	12,921	1556.79

09. 20. ROADS & BRIDGES	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Compacted Earth Maintenance Road	8.30 ACR			331	9,353	9,562	0	0	18,915	2278.93
09. 20.002. Paved Maintenance Roads Construct paved trails at various locations throughout project area, 15 ft width, 52,087 lf, 781,305 sf, 18 acres.										
09. 20.002. 1. Clearing & Grubbing, debris removal, etc.										
AF GC <02109 0420 > Clear & grub, burning,				14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	9.00 ACR	UOEHB40A	0.28	128	3,727	2,772	0	0	6,499	722.14
TOTAL Clearing & Grubbing, debris	9.00 ACR			128	3,727	2,772	0	0	6,499	722.14
09. 20.002. 2. Site Preparation										
09. 20.002. 2.01. Ripping, discing to prepare surface										
RSM GC <02238 0010 > Ripping, trap rock, soft, 200 HP				0.02	0.51	0.74	0.00	0.00	1.25	
dozer, ideal conditions	180.00 CY	CODTB10B	88.75	3	91	134	0	0	225	1.25
Assume 10 cy/acre										
TOTAL Ripping, discing to prepare	18.00 ACR			3	91	134	0	0	225	12.49
09. 20.002. 2.02. Regrade, flatten, balance cut matl. Onsite, 25% of area										
MIL GC <02224 7020 > Excavating, bulk, dozer, 300 HP,				0.01	0.15	0.33	0.00	0.00	0.48	
large area, open site, rough grade	21880 CY	CODTB10M	300.00	109	3,275	7,266	0	0	10,542	0.48
TOTAL Regrade, flatten, balance cut	21880 CY			109	3,275	7,266	0	0	10,542	0.48
09. 20.002. 2.03. Compaction, riding, sheepfoot/ wobbly whl, 2 passes										
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2				0.01	0.14	0.16	0.00	0.00	0.29	
passes, sheepsfoot/wobbly wheel roller	86820 CY	COFCB32F	600.00	434	12,016	13,527	0	0	25,542	0.29
TOTAL Compaction, riding, sheepfoot/	86820 SY			434	12,016	13,527	0	0	25,542	0.29

09. 20. ROADS & BRIDGES		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	09. 20.002. 2.04. Asphalt Concrete Paving, (cont'd.) Base course, 4" thick, and 2" topping											
M MIL GC <02505 0813 >	Asphaltic conc pavement, highway, binder course, 4" thick					0.10	2.63	1.33	26.94	0.00	30.90	
		17363	TON	COKCB25	106.25	1,797	45,696	23,029	467,759	0	536,484	30.90
	Assume 45 sf/ton (See Means Construction Cost Data, 2004, 02740-310-0200, and -0813)											
	781,310 sf / 45 sf/ton = 17,363 tons											
M MIL GC <02505 0854 >	Asphaltic conc pavement, highway, wearing course, 2" thick					0.12	3.13	1.87	29.73	0.00	34.74	
		9528.00	TON	COKCB25B	100.00	1,143	29,869	17,860	283,267	0	330,997	34.74
	Assume 82 sf/ton (See Means Construction Cost Data, 2004, 02740-310-0380 and -0852)											
	Then, 781,310 sf / 82 sf/ton = 9,528 ton											
USR GC < >	Seal Oil (or Sealcoating)					0.00	0.10	0.11	0.44	0.00	0.65	
	781,310 sf = 86,812 sy	86812	SY	N/A	0.00	0	8,681	9,549	38,197	0	56,428	0.65
	See Means Construction Cost Data, 2004: 02785-250-0012 for pricing.											
	M=$0.44/sy, L=$0.10/sy, E=$0.11/sy											
USR GC < >	Asphalt Surface Treatment					0.00	0.19	0.14	0.69	0.00	1.02	
	See Means Construction Cost Data, 2004: 02785-250-1910 for pricing.	86812	SY	N/A	0.00	0	16,494	12,154	59,900	0	88,548	1.02
	M=$0.69/sy, L=$0.19/sy, E=$0.14/sy											
	TOTAL Asphalt Concrete Paving,	781310	SF			2,940	100,741	62,592	849,124	0	1,012,457	1.30
	TOTAL Site Preparation	18.00	ACR			3,487	116,123	83,518	849,124	0	1,048,766	58264.77
	TOTAL Paved Maintenance Roads	18.00	ACR			3,615	119,850	86,291	849,124	0	1,055,265	58625.84

09. 20. ROADS & BRIDGES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 20.003. Gravel Maintenance Road											
Construct gravel trails at various locations throughout project area, 10 ft width, 3" thickness, 35,575 lf, 355,750 sf, 8.2 acres.											
09. 20.003. 1. Clearing & Grubbing, debris removal, etc.											
AF GC <02109 0420 > Clear & grub, burning,					14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	4.10	ACR	UOEHB40A	0.28	58	1,698	1,263	0	0	2,961	722.14
TOTAL Clearing & Grubbing, debris	4.10	ACR			58	1,698	1,263	0	0	2,961	722.14
09. 20.003. 2. Site Preparation											
09. 20.003. 2.01. Ripping, discing to prepare surface											
RSM GC <02238 0010 > Ripping, trap rock, soft, 200 HP					0.02	0.51	0.74	0.00	0.00	1.25	
dozer, ideal conditions	82.00	CY	CODTB10B	88.75	1	42	61	0	0	102	1.25
Assume 10 cy/acre											
TOTAL Ripping, discing to prepare	8.20	ACR			1	42	61	0	0	102	12.49
09. 20.003. 2.02. Regrade, flatten, balance cut matl. Onsite, 25% of area											
MIL GC <02224 7020 > Excavating, bulk, dozer, 300 HP,					0.01	0.15	0.33	0.00	0.00	0.48	
large area, open site, rough grade	1980.00	CY	CODTB10M	300.00	10	296	658	0	0	954	0.48
TOTAL Regrade, flatten, balance cut	1980.00	CY			10	296	658	0	0	954	0.48
09. 20.003. 2.03. Compaction, riding, sheepfoot/ wobbly whl, 2 passes											
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2					0.01	0.14	0.16	0.00	0.00	0.29	
passes, sheepsfoot/wobbly wheel roller	39530	CY	COFCB32F	600.00	198	5,471	6,159	0	0	11,630	0.29
TOTAL Compaction, riding, sheepfoot/	39530	SY			198	5,471	6,159	0	0	11,630	0.29

09. 20. ROADS & BRIDGES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 20.003. 2.04. Gravel course, crushed 3/4" stone, compacted, 3" deep											
B RSM GC <02244 0050 > Base course, crushed 3/4" stone,					0.01	0.34	0.45	2.60	0.00	3.39	
compacted, 3"D, large areas	39530	SY	COFGB36C	452.17	439	13,266	17,943	102,778	0	133,987	3.39
For material and equipment cost, see Means Construction Cost Data, 2004: 02720-200-0050											
TOTAL Gravel course, crushed 3/4"	39530	SY			439	13,266	17,943	102,778	0	133,987	3.39
TOTAL Site Preparation	8.20	ACR			648	19,075	24,820	102,778	0	146,673	17886.96
TOTAL Gravel Maintenance Road	8.20	ACR			706	20,773	26,083	102,778	0	149,634	18248.03
09. 20.005. Bridges Pedestrian and maintenance bridges as site amenities, abutments to be CIP reinforced concrete											
09. 20.005. 1. Fencing for Erosion Control 9 acres = 392,040 sf Square root of 392,040 sf = 626 lf 626 lf x 4 = 2,504 lf (perimeter)											
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5'					0.16	3.54	0.00	3.58	0.00	7.12	
high	2504.00	LF	ALABCLAB2	12.50	401	8,867	0	8,964	0	17,831	7.12
TOTAL Fencing for Erosion Control	9.00	ACR			401	8,867	0	8,964	0	17,831	1981.25
09. 20.005. 2. Clearing and Grubbing, debris removal, etc.											
AF GC <02109 0420 > Clear & grub, burning,					14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	7.00	ACR	UOEHB40A	0.28	100	2,899	2,156	0	0	5,055	722.14
TOTAL Clearing and Grubbing, debris	7.00	ACR			100	2,899	2,156	0	0	5,055	722.14
09. 20.005. 3. Excavating, structural, sand/ loam, 2CY bkt											
09. 20.005. 3.01. Hauling, no loading, 16.5 cy dump trailer, 10 mile RT											
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6					0.03	0.77	1.44	0.00	0.00	2.22	
mi round trip @ 40 MPH (2.1 cyc/hr)	3366.00	CY	CTDHB34C	35.00	96	2,600	4,864	0	0	7,463	2.22

09. 20. ROADS & BRIDGES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Hauling, no loading, 16.5 cy	3366.00	CY			96	2,600	4,864	0	0	7,463	2.22
09. 20.005. 3.02. Fill, spread dumped matl, by dozer, no compaction											
RSM GC <02216 2000 > Backfill, strl, sand & gravel,					0.01	0.33	0.20	0.00	0.00	0.53	
no cmpct, 75 HP dozer, 50' haul	3366.00	CY	CODTB10L	137.50	37	1,100	674	0	0	1,774	0.53
TOTAL Fill, spread dumped matl, by	3366.00	CY			37	1,100	674	0	0	1,774	0.53
09. 20.005. 3.03. Compaction, sheepfoot/wobbly whl rlr, 12" lifts, 2 passes											
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2					0.01	0.14	0.16	0.00	0.00	0.29	
passes, sheepsfoot/wobbly wheel roller	3060.00	CY	COFCB32F	600.00	15	424	477	0	0	900	0.29
TOTAL Compaction, sheepfoot/wobbly	3060.00	CY			15	424	477	0	0	900	0.29
TOTAL Excavating, structural, sand/	3060.00	CY			148	4,123	6,014	0	0	10,137	3.31
09. 20.005. 4. Cast in Place reinforced concret. This is for bridge abutment construction. There are 18 abutments, and the dimensions of the abutment are: 25' (L) x 12' (W) x 15' (H). Assume 105 lb/cy for reinforcing steel quantity calculation. Then, 3060 cy x 105 lb/cy = 321,300 lbs.											
M MIL GC <03330 3600 > Concrete in place,dir chute,					0.32	8.14	0.00	52.20	0.00	60.34	
500psi, incl forms,reinf, flexural on grade	3060.00	CY	ULABC8A	18.75	979	24,922	0	159,732	0	184,654	60.34
M MIL GC <03217 0700 > Reinforcing in place, walls, #3					10.67	424.44	0.00	580.01	0.00	1004.45	
to #7	161.00	TON	SIWRRODM4	0.38	1,717	68,335	0	93,382	0	161,717	1004.45
321,300 lbs = 161 tons											
M CIV GC <03138 2100 > Forms in place, 12" w, plywood,					0.13	4.14	0.00	1.36	0.00	5.50	
3 use, interior beam, beams & girders	6750.00	SF	ACARC2	45.50	890	27,965	0	9,180	0	37,145	5.50
18 abutments x 25' (L) x 15' (H) = 6,750 SF											

09. 20. ROADS & BRIDGES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Cast in Place reinforced concret	3060.00	CY			3,587	121,222	0	262,294	0	383,516	125.33
09. 20.005. 5. Finished grading, tie in, stabl.											
MIL GC <02512 1100 > Fine grade, for slab on grade,					0.02	0.43	0.27	0.00	0.00	0.70	
machine	43560	SY	COFGB11L	130.00	671	18,761	11,831	0	0	30,592	0.70
TOTAL Finished grading, tie in, stabl.	9.00	ACR			671	18,761	11,831	0	0	30,592	3399.13

09. 20.005. 6. Prefab Bridges

09. 20.005. 6.01. Prefab Bridges (9 ea)

(07/23/04)
Quote of delivered price is obtained from Steadfast Bridges Company in Alabama.

Width = 10' (wide enough for a service truck to pass by)
Spans = 48' ($25,345), 56' ($29,857), 74' ($41,373), 68' ($38,610), 101' ($77,759), 104' ($78,235), 136' ($127,242), 148' ($142,795), 74' ($41,373)

Total delivered cost = $602,589 (to Phoenix, AZ area)
Assume 10% as delivery, then, M=$542,330, O=$60,259

Total square foot of all the bridges = 8,090 SF

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(07/27/04)
Another qoute from Excel Bridge Co. (www.excelbridge.com, Kenneth Longino, (562) 944-0701, 12001 Shoemaker Avenue, Santa Fe Springs, CA):

All widths = 12'
Spans = 48' ($40,320), 74' (2 ea) ($62,160/ea), 68' ($57,120), 101' ($100,600), 136' ($153,500), 56' ($47,040), 104' ($101,107), 79' ($66,360), 148' ($173,300)

Plus taxes, and F.O.B. Phoenix, AZ.

	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Prefab Bridges (9 ea)					0	0	0	542,330	60,259	602,589	
09. 20.005. 6.02. Unloading and Erection											
MIL GC < > Outside Steel Worker					1.00	43.93	0.00	0.00	0.00	43.93	
	161.80	HR	X-STRSTEEL	1.00	162	7,108	0	0	0	7,108	43.93
MIL GC < > Outside Steel Worker (4)					1.00	42.93	0.00	0.00	0.00	42.93	
	647.20	HR	X-STRSTEEL	1.00	647	27,783	0	0	0	27,783	42.93

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09. 20. ROADS & BRIDGES		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL GC <	> Outside Equip. Operator, Heavy					1.00	33.53	0.00	0.00	0.00	33.53	
	(for the crane)	161.80	HR	X-EQOPRHVY	1.00	162	5,425	0	0	0	5,425	33.53
MIL GC <	> Outside Equip. Oiler					1.00	26.58	0.00	0.00	0.00	26.58	
		161.80	HR	X-EQOPROIL	1.00	162	4,300	0	0	0	4,300	26.58
EP GC <	> CRANE,HYD,S/P,RT,4WD,100T/88'BM,					0.00	0.00	156.85	0.00	0.00	156.85	
	W/HOOK & BALL	161.80	HR	C75GV016	1.00	0	0	25,379	0	0	25,379	156.85
MIL GC <	> Outside Laborer (2 for loading)					1.00	21.47	0.00	0.00	0.00	21.47	
		323.60	HR	X-LABORER	1.00	324	6,948	0	0	0	6,948	21.47
MIL GC <	> Outside Equip. Operator, Medium					1.00	33.20	0.00	0.00	0.00	33.20	
	(for loader)	161.80	HR	X-EQOPRMED	1.00	162	5,372	0	0	0	5,372	33.20
EP GC <	> LDR,BH,WH, 1.25CY FE BKT,					0.00	0.00	23.10	0.00	0.00	23.10	
	24" DIP, EXTENDAHOE	161.80	HR	L50CS006	1.00	0	0	3,738	0	0	3,738	23.10
	TOTAL Unloading and Erection	8090.00	SF			1,618	56,936	29,117	0	0	86,053	10.64
	TOTAL Prefab Bridges	9.00	EA			1,618	56,936	29,117	542,330	60,259	688,642	76515.81
	TOTAL Bridges	1.00	EA			6,524	212,807	49,119	813,588	60,259	1,135,773	1135773
	TOTAL ROADS & BRIDGES	1.00	EA			11,176	362,784	171,054	1765490	60,259	2,359,587	2359587

09. 25. LET DOWN STRUCTURES	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 25. LET DOWN STRUCTURES Construct let down pipes to stabilize gullies in historic floodplain. Use 30" dia CMP with wingwalls, backfill gully										
09. 25.001. Let Down Structures										
09. 25.001. 1. Fencing for Erosion Control 2.5 acres = 108,900 sf Square root of 108,900 sf = 330 lf 330 lf x 4 = 1,320 lf (perimeter)										
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5'				0.16	3.54	0.00	3.58	0.00	7.12	
high	1320.00 LF	ALABCLAB2	12.50	211	4,674	0	4,726	0	9,400	7.12
TOTAL Fencing for Erosion Control	2.50 ACR			211	4,674	0	4,726	0	9,400	3759.94
09. 25.001. 2. Clearing & Grubbing, debris removal, etc.										
AF GC <02109 0420 > Clear & grub, burning,				14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	1.90 ACR	UOEHB40A	0.28	27	787	585	0	0	1,372	722.14
TOTAL Clearing & Grubbing, debris	1.90 ACR			27	787	585	0	0	1,372	722.14
09. 25.001. 3. Prep (excav) slope to receive let down pipe, assume 100 cy per acre. See "Hardened Slopes" for unit cost quote.										
TOTAL Prep (excav) slope to receive	500.00 CY			0	0	0	0	750	750	1.50
09. 25.001. 4. 30" Pipe Laying										
09. 25.001. 4.01. Install pipe bedding, gravel, 24" by 24"										
M MIL GC <02704 0300 > Drainage, drainage matl, 3/4"				0.09	2.31	0.47	46.94	0.00	49.72	
gravel fill in trench	150.00 CY	CODLB6	32.50	14	346	70	7,041	0	7,457	49.72
TOTAL Install pipe bedding, gravel,	150.00 CY			14	346	70	7,041	0	7,457	49.72
09. 25.001. 4.02. Install 30" dia CMP, 200 lf per location										
M MIL GC <02764 2160 > Piping, storm drain,30" dia,				0.47	11.67	6.31	22.11	0.00	40.09	
20'L,14ga, CMP, bitum ctd w/paved invert	1000.00 LF	CLABB13	15.00	467	11,672	6,312	22,110	0	40,094	40.09

09. 25. LET DOWN STRUCTURES	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Install 30" dia CMP, 200 lf per	1000.00 LF			467	11,672	6,312	22,110	0	40,094	40.09
09. 25.001. 4.03. Install wingwall deflectors on mitred pipe ends, 2 per pipe										
Cost assumed. See Eldon Kraft's e-mail dated 05/21/04										
TOTAL Install wingwall deflectors on	10.00 EA			0	0	0	0	30,000	30,000	3000.00
TOTAL 30" Pipe Laying	1000.00 LF			481	12,019	6,381	29,151	30,000	77,551	77.55
09. 25.001. 5. Backfilling & Compaction										
09. 25.001. 5.01. Hauling, no loading, 16.5 cy dump trailer, 10 mile RT										
MIL GC <02234 1115 > Hauling, hwy haulers, 16.5 CY, 6 mi round trip @ 40 MPH (2.1 cyc/hr)	30000 CY	CTDHB34C	35.00	0.03 858	0.77 23,169	1.44 43,347	0.00 0	0.00 0	2.22 66,516	2.22
TOTAL Hauling, no loading, 16.5 cy	30000 CY			858	23,169	43,347	0	0	66,516	2.22
09. 25.001. 5.02. Fill, spread dumped matl, by dozer, no compaction										
See "Hardened Slope" for cost quote.										
TOTAL Fill, spread dumped matl, by	30000 CY			0	0	0	0	19,500	19,500	0.65
09. 25.001. 5.03. Compaction, sheepfoot/wobbly whl rlr, 12" lifts, 2 passes										
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2 passes, sheepsfoot/wobbly wheel roller	30000 CY	COFCB32F	600.00	0.01 150	0.14 4,152	0.16 4,674	0.00 0	0.00 0	0.29 8,826	0.29
TOTAL Compaction, sheepfoot/wobbly	30000 CY			150	4,152	4,674	0	0	8,826	0.29
09. 25.001. 5.04. Fine grade filled area, for irregular areas, adverse cond.										
See "Hardened Slope" for cost quote.										
TOTAL Fine grade filled area, for	2.50 ACR			0	0	0	0	5,445	5,445	2178.00
TOTAL Backfilling & Compaction	30000 CY			1,008	27,321	48,021	0	24,945	100,287	3.34

09. 25. LET DOWN STRUCTURES		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 25.001. 6. Planting and Seeding												
09. 25.001. 6.01. Mulching, hay, 1" deep, power (cont'd) mulcher, large												
	Productivity is quoted from Means Crew B65. Material cost = $19.15/MSF x 43.56 MSF/acr = $834.17/acr											
M MIL GC <	> Outside Laborer					1.00	20.47	0.00	0.09	0.00	20.56	
		1.38	HR	X-LABORER	1.00	1	28	0	0	0	28	20.56
MIL GC <	> Outside Truck Driver, Light					1.00	25.38	0.00	0.00	0.00	25.38	
		1.38	HR	X-TRKDVRLT	1.00	1	35	0	0	0	35	25.38
EP GC <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE					0.00	0.00	15.53	0.00	0.00	15.53	
		1.38	HR	T50FO009	1.00	0	0	21	0	0	21	15.53
GEN GC <	> HYDROMULCHER, 3,000 GAL(11,356L)					0.00	0.00	29.04	0.00	0.00	29.04	
	TRK MTD (W/ 56,000GVW TRK)	1.38	HR	L1523880	1.00	0	0	40	0	0	40	29.04
USR GC <	> Material cost					0.00	0.00	0.00	834.17	0.00	834.17	
		2.10	ACR	N/A	0.00	0	0	0	1,752	0	1,752	834.17
	TOTAL Mulching, hay, 1" deep, power	2.10	ACR			3	63	62	1,752	0	1,877	893.72
09. 25.001. 6.02. Crimping, tilling topsoil (cont'd) 20 HP tractor, disk harrow, 6" deep												
EP GC <	> ROTARY HOE, 80" WIDE ROTERRA					0.00	0.00	1.29	0.00	0.00	1.29	
	(ADD 40 HP PTO TRACTOR)	8.40	HR	T10LE001	1.00	0	0	11	0	0	11	1.29
MAP GC <	> TRACTOR,WH,FARM, 40- 59HP, 2X4					0.00	0.00	7.67	0.00	0.00	7.67	
		8.40	HR	T25JD005	1.00	0	0	64	0	0	64	7.67
MIL GC <	> Outside Equip. Operator, Light					1.00	30.80	0.00	0.00	0.00	30.80	
		8.40	HR	X-EQOPRLT	1.00	8	259	0	0	0	259	30.80
	TOTAL Crimping, tilling topsoil	2.10	ACR			8	259	75	0	0	334	159.04
09. 25.001. 6.03. Seeding, athletic fld mix,												
M RSM GC <02932 0010	> Seeding, athletic field mix,					1.00	22.13	0.00	47.42	0.00	69.55	
	8#/MSFpush spreader	104.54	MSF	ALABCLAB1	1.00	105	2,314	0	4,957	0	7,271	69.55
	125 acres = 5,445 msf											
	TOTAL Seeding, athletic fld mix,	2.40	ACR			105	2,314	0	4,957	0	7,271	3029.69

09. 25. LET DOWN STRUCTURES		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
	09. 25.001. 6.04. Place Coarse Woody debris/rocks											
M MIL GC <	> Outside Laborer (4)					1.00	20.47	0.00	0.00	0.00	20.47	
		67.20	HR	X-LABORER	1.00	67	1,376	0	0	0	1,376	20.47
USR GC <	> Material and equipment					0.00	0.00	50.00	50.00	0.00	100.00	
		2.10	ACR	N/A	0.00	0	0	105	105	0	210	100.00
	TOTAL Place Coarse Woody debris/rocks	2.10	ACR			67	1,376	105	105	0	1,586	755.09
	09. 25.001. 6.05. Plant Mesquite/Shrub mix using (cont'd) 5 gallon plants											
USR GC <	> Planting of 5-gallon plants					0.00	0.00	0.00	0.00	15.00	15.00	
	See bid result of Rio Salado Ph 1A	1125.00	EA		0.00	0	0	0	0	16,875	16,875	15.00
	TOTAL Plant Mesquite/Shrub mix using	1125.00	EA			0	0	0	0	16,875	16,875	15.00
	TOTAL Planting and Seeding	2.10	ACR			183	4,012	242	6,814	16,875	27,943	13306.06
	TOTAL Let Down Structures	1.00	EA			1,910	48,812	55,230	40,691	72,570	217,303	217303.02
	TOTAL LET DOWN STRUCTURES	1.00	EA			1,910	48,812	55,230	40,691	72,570	217,303	217303.02
	TOTAL CONSTRUCTION (RESTORATION)	1.00	EA			343,303	10546426	4813116	12682559	7,900,751	35,942,852	35942852

14. 30. RECREATION FEATURES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. RECREATION											
14. 30. RECREATION FEATURES											
14. 30.001. Parking Areas Construct parking areas at various locations throughout project area with a total capacity of 60-80 spaces											
14. 30.001. 1. Fencing for Erosion Control 1.8 acres = 78,408 sf Square root of 78,408 sf = 280 lf 280 x 4 = 1,120 lf (perimeter)											
AF GC <01534 0010 > Fencing, 11 ga, chain link, 5'					0.16	3.54	0.00	3.58	0.00	7.12	
high	1120.00	LF	ALABCLAB2	12.50	179	3,966	0	4,010	0	7,976	7.12
TOTAL Fencing for Erosion Control	1.80	ACR			179	3,966	0	4,010	0	7,976	4430.91
14. 30.001. 2. Clearing & Grubbing, debris removal, etc.											
AF GC <02109 0420 > Clear & grub, burning,					14.23	414.10	308.04	0.00	0.00	722.14	
incinerator, light	1.90	ACR	UOEHB40A	0.28	27	787	585	0	0	1,372	722.14
TOTAL Clearing & Grubbing, debris	1.80	ACR			27	787	585	0	0	1,372	762.26
14. 30.001. 3. Site Preparation											
14. 30.001. 3.01. Ripping, discing to prepare surface											
RSM GC <02238 0010 > Ripping, trap rock, soft, 200 HP					0.02	0.51	0.74	0.00	0.00	1.25	
dozer, ideal conditions	18.00	CY	CODTB10B	88.75	0	9	13	0	0	22	1.25
Assume 10 cy/acre											
TOTAL Ripping, discing to prepare	1.80	ACR			0	9	13	0	0	22	12.49
14. 30.001. 3.02. Regrade to req'd slopes, flatten balance cut matl onsite											
MIL GC <02224 7020 > Excavating, bulk, dozer, 300 HP,					0.01	0.15	0.33	0.00	0.00	0.48	
large area, open site, rough grade	18.00	CY	CODTB10M	300.00	0	3	6	0	0	9	0.48
Assume 10 cy/acre											
TOTAL Regrade to req'd slopes, flatten	1.80	ACR			0	3	6	0	0	9	4.82

14. 30. RECREATION FEATURES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. 30.001. 3.03. Regrade surface, scraper-grader, balance, max depth 36"											
MIL GC <02226 3100 > Excavation, bulk, 9 cycle/hr, push loaded self prop scraper, 9 BCY					0.03	0.83	1.34	0.00	0.00	2.17	
	4410.00	CY	CODSB33F	66.25	120	3,666	5,920	0	0	9,587	2.17
TOTAL Regrade surface, scraper-grader,	4410.00	CY			120	3,666	5,920	0	0	9,587	2.17
14. 30.001. 3.04. Compaction, riding, sheepfoot or wobbly whl, 2 passes											
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2 passes, sheepsfoot/wobbly wheel roller					0.01	0.14	0.16	0.00	0.00	0.29	
	8810.00	CY	COFCB32F	600.00	44	1,219	1,373	0	0	2,592	0.29
TOTAL Compaction, riding, sheepfoot	8810.00	SY			44	1,219	1,373	0	0	2,592	0.29
14. 30.001. 3.05. Fine grade, grade subgrade for base course, roadways											
MIL GC <02512 0020 > Fine grade, for roadway, base or leveling course					11.76	329.35	207.71	0.00	0.00	537.06	
	8.81	MSY	COFGB11L	0.17	104	2,902	1,830	0	0	4,731	537.06
TOTAL Fine grade, grade subgrade for	8810.00	SY			104	2,902	1,830	0	0	4,731	0.54
TOTAL Site Preparation	1.80	ACR			268	7,799	9,142	0	0	16,941	9411.90
14. 30.001. 4. Asphalt Paving, 6" stone base, 2" base course, 1" topping											
See Means Construction Cost Data 2004, 02740-315-0020 for cost quote.											
TOTAL Asphalt Paving, 6" stone base,	79280	SF			0	11,892	14,270	103,064	0	129,226	1.63
14. 30.001. 5. Lines on pavement, parking stall paint, white, 4" wide											
TOTAL Lines on pavement, parking stall					0	0	0	0	1,500	1,500	
14. 30.001. 6. Parking Lot Amenities, lighting, curbs, drainage, etc.											
TOTAL Parking Lot Amenities, lighting,					0	0	0	0	10,000	10,000	
TOTAL Parking Areas	1.80	ACR			474	24,444	23,998	107,074	11,500	167,016	92786.39

14. 30. RECREATION FEATURES	QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. 30.005. Decomposed Granite Trails Construct DG trail at various locations throughout project area, 10 foot width									
14. 30.005. 1. Clearing & Grubbing, debris removal, etc.									
AF GC <02109 0420 > Clear & grub, burning, incinerator, light	2.00 ACR UOEHB40A	0.28	14.23 28	414.10 828	308.04 616	0.00 0	0.00 0	722.14 1,444	722.14
TOTAL Clearing & Grubbing, debris	2.00 ACR		28	828	616	0	0	1,444	722.14
14. 30.005. 2. Site Preparation									
14. 30.005. 2.01. Ripping, discing to prepare surface									
RSM GC <02238 0010 > Ripping, trap rock, soft, 200 HP dozer, ideal conditions	20.00 CY CODTB10B	88.75	0.02 0	0.51 10	0.74 15	0.00 0	0.00 0	1.25 25	1.25
Assume 10 cy/acre									
TOTAL Ripping, discing to prepare	2.00 ACR		0	10	15	0	0	25	12.49
14. 30.005. 2.02. Regrade, flatten, balance cut matl. Onsite, 50% of area									
MIL GC <02224 7020 > Excavating, bulk, dozer, 300 HP, large area, open site, rough grade	1540.00 CY CODTB10M	300.00	0.01 8	0.15 231	0.33 511	0.00 0	0.00 0	0.48 742	0.48
TOTAL Regrade, flatten, balance cut	1540.00 CY		8	231	511	0	0	742	0.48
14. 30.005. 2.03. Compaction, riding, sheepfoot/ wobbly whl, 2 passes									
AF GC <02220 5660 > Compaction, riding, 8" lifts, 2 passes, sheepsfoot/wobbly wheel roller	30640 CY COFCB32F	600.00	0.01 153	0.14 4,241	0.16 4,774	0.00 0	0.00 0	0.29 9,014	0.29
TOTAL Compaction, riding, sheepfoot/	30640 SY		153	4,241	4,774	0	0	9,014	0.29
TOTAL Site Preparation	2.00 ACR		161	4,481	5,300	0	0	9,781	4890.62

14. 30. RECREATION FEATURES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. 30.005. 3. Decomposed Granite course, crushed 3/4" stone, compacted, 3" deep											
In one sq ft, the volume is about 0.25 cf. Then, we need 275740 sf x 0.25 cf = 68,935 cf = 2,553 cy. Using the conversion factor of 1.50 ton/cy for the DG, then we get 3,830 tons.											
Per material cost quotation from Flamingo Sand and Gravel, (800) 777-6299, the total cost including tax and delivery is about $30/ton for Az area.											
TOTAL Material and Delivery	3830.00	TON			0	0	0	0	114,900	114,900	30.00
14. 30.005. 3.02. Spread and Compaction											
EP GC < > GRADER,MOTOR, ARTIC, CAT 12-H					0.00	0.00	38.17	0.00	0.00	38.17	
	38.30	HR	G15CA003	1.00	0	0	1,462	0	0	1,462	38.17
EP GC < > ROLLER,STATIC,DD,S/P,10T, 50"W					0.00	0.00	19.08	0.00	0.00	19.08	
	38.30	HR	R30HY005	1.00	0	0	731	0	0	731	19.08
EP GC < > TRK,HWY, 8,600GVW,4X2, 3/4T-PKUP					0.00	0.00	10.23	0.00	0.00	10.23	
	38.30	HR	T50GM006	1.00	0	0	392	0	0	392	10.23
MIL GC < > Outside Equip. Operator, Medium					1.00	32.20	0.00	0.00	0.00	32.20	
(grader)	38.30	HR	X-EQOPRMED	1.00	38	1,233	0	0	0	1,233	32.20
MIL GC < > Outside Equip. Operator, Medium					1.00	32.20	0.00	0.00	0.00	32.20	
(roller)	38.30	HR	X-EQOPRMED	1.00	38	1,233	0	0	0	1,233	32.20
MIL GC < > Outside Laborer					1.00	20.47	0.00	0.00	0.00	20.47	
	38.30	HR	X-LABORER	1.00	38	784	0	0	0	784	20.47
MIL GC < > Outside Equip. Operator, Medium					1.00	33.20	0.00	0.00	0.00	33.20	
	38.30	HR	X-EQOPRMED	1.00	38	1,272	0	0	0	1,272	33.20
TOTAL Spread and Compaction	3830.00	TON			153	4,522	2,584	0	0	7,106	1.86
TOTAL Decomposed Granite course,	275740	SF			153	4,522	2,584	0	114,900	122,006	0.44
14. 30.005. 4. Trail amenities, ADA ramps, sign markings, etc.											
TOTAL Trail amenities, ADA ramps, sign					0	0	0	0	10,000	10,000	
TOTAL Decomposed Granite Trails	1.00	EA			343	9,831	8,501	0	124,900	143,232	143231.98

14. 30. RECREATION FEATURES	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. 30.010. Other Recreation Features Additions to Paved Maintenance Road/DG Trail alignment to facilitate recreation use.											
14. 30.010. 1. Paved Trail amenities, curb splice, ADA ramps, signs, markings											
TOTAL Paved Trail amenities, curb	1.00	EA			0	0	0	0	10,000	10,000	10000.00
TOTAL Comfort Stations	3.00	EA			0	0	0	0	300,000	300,000	100000.00
TOTAL Rest Stops	5.00	EA			0	0	0	0	15,000	15,000	3000.00
14. 30.010. 4. Concrete Benches											
M MIL GC <02871 0100 > Benches, park, precast conc,					4.00	88.53	0.00	621.41	0.00	709.94	
w/backs, wood rails, 8' long	21.00	EA	ALABCLAB2	0.50	84	1,859	0	13,050	0	14,909	709.94
TOTAL Concrete Benches	21.00	EA			84	1,859	0	13,050	0	14,909	709.94
14. 30.010. 5. Signage											
M MIL GC <02842 0590 > Signs, reflectorized w/post, 12"					0.50	11.07	0.00	16.80	0.00	27.87	
x 18", guide & directional signs	21.00	EA	ALABCLAB1	2.00	11	232	0	353	0	585	27.87
TOTAL Signage	21.00	EA			11	232	0	353	0	585	27.87
TOTAL Other Recreation Features	1.00	EA			95	2,091	0	13,402	325,000	340,494	340493.88
TOTAL RECREATION FEATURES	1.00	EA			912	36,367	32,498	120,476	461,400	650,741	650741.37
TOTAL RECREATION	1.00	EA			912	36,367	32,498	120,476	461,400	650,741	650741.37

30.009. Construction	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
30. PLANNING, ENGINEERING, DESIGN and Engineering During Construction 30.009. Construction											
$4,658,626 + $465,863 = $5,124,490 TOTAL Construction	1.00	EA			0	0	0	0	5,120,000	5,120,000	5120000

30.014. Recreation	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
30.014. Recreation											
$85,457 + $9,828 = $95,285											
TOTAL Recreation	1.00	EA			0	0	0	0	95,285	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA			0	0	0	0	5,215,285	5,215,285	5215285

31.009. Construction (Restoration)	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
31. CONSTRUCTION MANAGEMENT											
(Supervision and Admininstration/Adaptive Management/Monitoring)											
31.009. Construction (Restoration)											
$3,482,323 + $1,870,205 + $623,304 = $5,975,832 (See Paseo_MCACES Summary.xls)											
TOTAL Construction (Restoration)	1.00	EA			0	0	0	0	5,980,000	5,980,000	5980000

31.014. Recreation	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Recreation	1.00	EA			0	0	0	0	63,879	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA			0	0	0	0	6,043,879	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA			344,214	10582793	4845615	12803035	45,821,315	74,052,757	74052757

Wed 12 Oct 2005 Tri-Service Automated Cost Engineering System (TRACES) TIME 14:36:09
Eff. Date 07/19/04 PROJECT PASE01: Paseo de las Iglesias Feas Study - Los Reals Road to Congress Road
PASEO DE LAS IGLESIAS Feasibility Study Estimate SUMMARY PAGE 1
** PROJECT OWNER SUMMARY - Scope **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	26,200,000	26200000	
09 CONSTRUCTION (RESTORATION)	1.00	EA	47,203,570	4,940,000	6,990,000	59,133,570	59133570	
14 RECREATION	1.00	EA	854,615	13,123	128,185	995,923	995923.43	
30 PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	5,215,285	5215285	
31 CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	6,043,879	6043879	
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	85,517,349	4,953,123	7,118,185	97,588,657	97588657	

LABOR ID: AZ0401 EQUIP ID: NAT99C Currency in DOLLARS CREW ID: NAT01A UPB ID: UP01EA

Wed 12 Oct 2005 | Tri-Service Automated Cost Engineering System (TRACES) | TIME 14:36:09
Eff. Date 07/19/04 | PROJECT PASE01: Paseo de las Iglesias Feas Study - Los Reals Road to Congress Road
PASEO DE LAS IGLESIAS Feasibility Study Estimate | SUMMARY PAGE 2
** PROJECT OWNER SUMMARY - Facility **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	26,200,000	26200000	
09 CONSTRUCTION (RESTORATION)								
09. 01 IRRIGATION PLANTING	1.00	EA	35,114,721	3,674,864	5,199,859	43,989,444	43989444	
09. 05 BASINS PLANTING	1.00	EA	731,469	76,550	108,317	916,337	916336.78	
09. 10 HARDENED BANKS	1.00	EA	3,325,523	348,026	492,450	4,165,999	4165999	
09. 15 PIPING	1.00	EA	4,647,640	486,390	688,232	5,822,262	5822262	
09. 20 ROADS & BRIDGES	1.00	EA	3,098,834	324,303	458,882	3,882,018	3882018	
09. 25 LET DOWN STRUCTURES	1.00	EA	285,383	29,866	42,260	357,509	357509.28	
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	47,203,570	4,940,000	6,990,000	59,133,570	59133570	
14 RECREATION								
14. 30 RECREATION FEATURES	1.00	EA	854,615	13,123	128,185	995,923	995923.43	
TOTAL RECREATION	1.00	EA	854,615	13,123	128,185	995,923	995923.43	
30 PLANNING, ENGINEERING, DESIGN								
30.009 Construction	1.00	EA	5,120,000	0	0	5,120,000	5120000	
30.014 Recreation	1.00	EA	95,285	0	0	95,285	95285.00	
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	5,215,285	5215285	
31 CONSTRUCTION MANAGEMENT								
31.009 Construction (Restoration)	1.00	EA	5,980,000	0	0	5,980,000	5980000	
31.014 Recreation	1.00	EA	63,879	0	0	63,879	63879.00	
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	6,043,879	6043879	
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	85,517,349	4,953,123	7,118,185	97,588,657	97588657	

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
01 LANDS AND DAMAGES (REAL ESTATE)	1.00 EA	26,200,000	0	0	26,200,000	26200000	
09 CONSTRUCTION (RESTORATION)							
09. 01 IRRIGATION PLANTING							
09. 01.001 Historic Floodplain	1.00 EA	12,587,475	1,317,318	1,863,979	15,768,772	15768772	
09. 01.005 Graded Slope	1.00 EA	11,672,230	1,221,535	1,728,447	14,622,212	14622212	
09. 01.010 Natural Slope	1.00 EA	1,044,559	109,316	154,680	1,308,556	1308556	
09. 01.015 Second Bench	1.00 EA	6,896,001	721,688	1,021,174	8,638,862	8638862	
09. 01.020 First Bench	1.00 EA	2,914,456	305,007	431,579	3,651,042	3651042	
TOTAL IRRIGATION PLANTING	1.00 EA	35,114,721	3,674,864	5,199,859	43,989,444	43989444	
09. 05 BASINS PLANTING							
09. 05.001 Tributary Infiltration Basins	1.00 EA	556,366	58,225	82,388	696,979	696979.43	
09. 05.005 Grade Control Infiltration Basin	1.00 EA	175,103	18,325	25,930	219,357	219357.35	
TOTAL BASINS PLANTING	1.00 EA	731,469	76,550	108,317	916,337	916336.78	
09. 10 HARDENED BANKS							
09. 10.001 Hardened Slopes	1.00 EA	3,325,523	348,026	492,450	4,165,999	4165999	
TOTAL HARDENED BANKS	1.00 EA	3,325,523	348,026	492,450	4,165,999	4165999	
09. 15 PIPING							
09. 15.001 Irrigation Piping	1.00 EA	4,647,640	486,390	688,232	5,822,262	5822262	
TOTAL PIPING	1.00 EA	4,647,640	486,390	688,232	5,822,262	5822262	
09. 20 ROADS & BRIDGES							
09. 20.001 Compacted Earth Maintenance Road	8.30 ACR	24,841	2,600	3,679	31,119	3749.33	
09. 20.002 Paved Maintenance Roads	18.00 ACR	1,385,874	145,036	205,223	1,736,134	96451.86	
09. 20.003 Gravel Maintenance Road	8.20 ACR	196,513	20,566	29,100	246,179	30021.85	
09. 20.005 Bridges	1.00 EA	1,491,605	156,101	220,880	1,868,586	1868586	
TOTAL ROADS & BRIDGES	1.00 EA	3,098,834	324,303	458,882	3,882,018	3882018	
09. 25 LET DOWN STRUCTURES							
09. 25.001 Let Down Structures	1.00 EA	285,383	29,866	42,260	357,509	357509.28	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
TOTAL LET DOWN STRUCTURES	1.00	EA	285,383	29,866	42,260	357,509	357509.28	
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	47,203,570	4,940,000	6,990,000	59,133,570	59133570	
14 RECREATION								
14. 30 RECREATION FEATURES								
14. 30.001 Parking Areas	1.80	ACR	219,341	3,368	32,899	255,608	142004.41	
14. 30.005 Decomposed Granite Trails	1.00	EA	188,106	2,888	28,214	219,209	219208.56	
14. 30.010 Other Recreation Features	1.00	EA	447,169	6,866	67,072	521,107	521106.93	
TOTAL RECREATION FEATURES	1.00	EA	854,615	13,123	128,185	995,923	995923.43	
TOTAL RECREATION	1.00	EA	854,615	13,123	128,185	995,923	995923.43	
30 PLANNING, ENGINEERING, DESIGN								
30.009 Construction	1.00	EA	5,120,000	0	0	5,120,000	5120000	
30.014 Recreation	1.00	EA	95,285	0	0	95,285	95285.00	
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	5,215,285	5215285	
31 CONSTRUCTION MANAGEMENT								
31.009 Construction (Restoration)	1.00	EA	5,980,000	0	0	5,980,000	5980000	
31.014 Recreation	1.00	EA	63,879	0	0	63,879	63879.00	
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	6,043,879	6043879	
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	85,517,349	4,953,123	7,118,185	97,588,657	97588657	

		QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
01	LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	26,200,000	26200000	
09	CONSTRUCTION (RESTORATION)								
09. 01	IRRIGATION PLANTING								
09. 01.001	Historic Floodplain								
09. 01.001. 1	Fencing for Erosion Control	656.00	ACR	199,985	20,929	29,614	250,529	381.90	
09. 01.001. 2	Clearing & Grubbing, Debris	328.00	ACR	622,138	65,109	92,128	779,375	2376.14	
09. 01.001. 3	Site Preparation	1.00	EA	43,274	4,529	6,408	54,211	54210.52	
09. 01.001. 4	Excavation	176990.00	CY	448,377	46,924	66,397	561,698	3.17	
09. 01.001. 5	Compaction (tractor wheel, one	3561940	LF	553,508	57,926	81,965	693,399	0.19	
09. 01.001. 6	Trenching for Water Supply Pipes	17050.00	CY	29,450	3,082	4,361	36,892	2.16	
09. 01.001. 7	Pipe bedding, crushed stone	13110.00	CY	855,960	89,579	126,752	1,072,291	81.79	
09. 01.001. 8	Install gated 12" PVC pipe for	114720.00	LF	1,015,381	106,263	150,360	1,272,004	11.09	
09. 01.001. 9	Install "U" outlet tubes with	5940.00	EA	74,161	7,761	10,982	92,904	15.64	
09. 01.001.10	Backfill pipe trench, side cast	4590.00	CY	2,350	246	348	2,944	0.64	
09. 01.001.11	Planting & Seeding	558.00	ACR	8,742,892	914,971	1,294,665	10,952,528	19628.19	
	TOTAL Historic Floodplain	1.00	EA	12,587,475	1,317,318	1,863,979	15,768,772	15768772	
09. 01.005	Graded Slope								
09. 01.005. 1	Fencing for Erosion Control	102.00	ACR	78,857	8,253	11,677	98,787	968.50	
09. 01.005. 2	Clearing & Grubbing, debris	51.00	ACR	48,367	5,062	7,162	60,592	1188.07	
09. 01.005. 3	Excavation, strl, mach excav.	1213390	CY	842,982	88,221	124,831	1,056,033	0.87	
09. 01.005. 4	Excavation, steep slopes, 5:1	1213390	CY	4,623,176	483,830	684,609	5,791,615	4.77	
09. 01.005. 5	Fine grading to 20% slope,	110.00	ACR	319,183	33,403	47,265	399,851	3635.01	
09. 01.005. 6	Header Pipe Laying	7620.00	LF	169,701	17,760	25,130	212,590	27.90	
09. 01.005. 7	8" PVC Leach Pipe Laying	445590.00	LF	4,042,175	423,026	598,573	5,063,774	11.36	
09. 01.005. 8	Planting & Seeding	102.00	ACR	1,547,789	161,981	229,200	1,938,969	19009.50	
	TOTAL Graded Slope	1.00	EA	11,672,230	1,221,535	1,728,447	14,622,212	14622212	
09. 01.010	Natural Slope								
09. 01.010. 1	Fencing for Erosion Control	18.00	ACR	33,125	3,467	4,905	41,497	2305.39	
09. 01.010. 2	Clearing and Grubbing, debris	13.00	ACR	12,329	1,290	1,826	15,445	1188.07	
09. 01.010. 3	Header Trenching	1520.00	LF	26,971	2,823	3,994	33,787	22.23	
09. 01.010. 4	8" PVC Leach Pipe Laying	75510.00	LF	705,304	73,812	104,443	883,560	11.70	
09. 01.010. 5	Planting & Seeding	18.00	ACR	266,830	27,925	39,513	334,267	18570.38	
	TOTAL Natural Slope	1.00	EA	1,044,559	109,316	154,680	1,308,556	1308556	
09. 01.015	Second Bench								
09. 01.015. 1	Fencing for Erosion Control	124.00	ACR	86,937	9,098	12,874	108,909	878.30	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 01.015. 2 Clearing and Grubbing, debris	93.00	ACR	88,200	9,230	13,061	110,491	1188.07	
09. 01.015. 3 Header Trenching	8080.00	LF	143,959	15,066	21,318	180,343	22.32	
09. 01.015. 4 8" PVC Leach Pipe Laying	545686.00	LF	4,679,775	489,753	692,991	5,862,519	10.74	
09. 01.015. 5 Planting & Seeding	125.00	ACR	1,897,130	198,541	280,931	2,376,601	19012.81	
TOTAL Second Bench	1.00	EA	6,896,001	721,688	1,021,174	8,638,862	8638862	
09. 01.020 First Bench								
09. 01.020. 1 Excavate pipe trench, 18" depth	1.00	LF	1	0	0	1	1.07	
09. 01.020. 2 Pipe Laying	31000.00	LF	366,624	38,368	54,290	459,283	14.82	
09. 01.020. 3 Backfill pipe trench, compact	31000.00	LF	66,866	6,998	9,902	83,765	2.70	
09. 01.020. 4 Install control valves for sprin	90.00	EA	5,201	544	770	6,516	72.39	
09. 01.020. 5 Install Programmable Logic	1.00	EA	656,648	68,720	97,238	822,605	822605.43	
09. 01.020. 6 Rough grade & scarify subsoil	89.00	ACR	209,033	21,876	30,954	261,863	2942.29	
09. 01.020. 7 Planting & seeding	89.00	ACR	1,610,084	168,500	238,424	2,017,009	22663.02	
TOTAL First Bench	1.00	EA	2,914,456	305,007	431,579	3,651,042	3651042	
TOTAL IRRIGATION PLANTING	1.00	EA	35,114,721	3,674,864	5,199,859	43,989,444	43989444	
09. 05 BASINS PLANTING								
09. 05.001 Tributary Infiltration Basins								
09. 05.001. 1 Fencing for Erosion Control	18.00	ACR	33,125	3,467	4,905	41,497	2305.39	
09. 05.001. 2 Clearing and Grubbing, debris	13.00	ACR	12,329	1,290	1,826	15,445	1188.07	
09. 05.001. 3 Excavate, mach exc., sand & grav	8300.00	CY	269,930	28,249	39,972	338,151	40.74	
09. 05.001. 4 Backfilling	3360.00	CY	81,359	8,514	12,048	101,921	30.33	
09. 05.001. 5 Planting & Seeding	18.00	ACR	159,623	16,705	23,637	199,966	11109.20	
TOTAL Tributary Infiltration Basins	1.00	EA	556,366	58,225	82,388	696,979	696979.43	
09. 05.005 Grade Control Infiltration Basin								
09. 05.005. 1 Fencing for Erosion Control	6.00	ACR	19,116	2,001	2,831	23,947	3991.15	
09. 05.005. 2 Clearing and Grubbing, debris	5.00	ACR	4,742	496	702	5,940	1188.07	
09. 05.005. 3 Excavating, mach exc, sand & gr	1120.00	CY	5,490	575	813	6,877	6.14	
09. 05.005. 4 Compaction at dump site, hl rlr	840.00	CY	325	34	48	407	0.48	
09. 05.005. 5 Compact basin subgrade, existing	29040.00	CY	85,170	8,913	12,612	106,695	3.67	
09. 05.005. 6 Backfilling	1160.00	CY	28,092	2,940	4,160	35,192	30.34	
09. 05.005. 7 Planting & Seeding	6.00	ACR	32,169	3,367	4,764	40,299	6716.48	
TOTAL Grade Control Infiltration Basin	1.00	EA	175,103	18,325	25,930	219,357	219357.35	
TOTAL BASINS PLANTING	1.00	EA	731,469	76,550	108,317	916,337	916336.78	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 10 HARDENED BANKS								
09. 10.001 Hardened Slopes								
09. 10.001. 1 Fencing for Erosion Control	3.50	ACR	14,589	1,527	2,160	18,277	5221.86	
09. 10.001. 2 Clearing and Grubbing, debris	0.90	ACR	854	89	126	1,069	1188.07	
09. 10.001. 3 Excavating, prepare slope &	47000.00	CY	92,711	9,702	13,729	116,142	2.47	
09. 10.001. 4 Fill, spread dumped mat'l, by	18800.00	CY	16,197	1,695	2,398	20,290	1.08	
09. 10.001. 5 Soil Cement application,	61100.00	CY	3,129,451	327,507	463,415	3,920,373	64.16	
09. 10.001. 6 Backfill and Compaction	28200.00	CY	71,722	7,506	10,621	89,848	3.19	
TOTAL Hardened Slopes	1.00	EA	3,325,523	348,026	492,450	4,165,999	4165999	
TOTAL HARDENED BANKS	1.00	EA	3,325,523	348,026	492,450	4,165,999	4165999	
09. 15 PIPING								
09. 15.001 Irrigation Piping								
09. 15.001. 1 Trenching for Delivery Pipe	3130.00	CY	387,531	40,556	57,386	485,474	155.10	
09. 15.001. 2 Trenching for Main Pipe	21000.00	CY	2,593,353	271,402	384,029	3,248,784	154.70	
09. 15.001. 3 Trenching for Sub-main Pipe	8420.00	CY	689,135	72,120	102,049	863,304	102.53	
09. 15.001. 4 Trenching for Culvert CMP	10500.00	CY	977,621	102,311	144,768	1,224,700	116.64	
TOTAL Irrigation Piping	1.00	EA	4,647,640	486,390	688,232	5,822,262	5822262	
TOTAL PIPING	1.00	EA	4,647,640	486,390	688,232	5,822,262	5822262	
09. 20 ROADS & BRIDGES								
09. 20.001 Compacted Earth Maintenance Road								
09. 20.001. 1 Clearing & Grubbing, debris	8.30	ACR	7,872	824	1,166	9,861	1188.07	
09. 20.001. 2 Site Preparation	8.30	ACR	16,970	1,776	2,513	21,258	2561.26	
TOTAL Compacted Earth Maintenance Road	8.30	ACR	24,841	2,600	3,679	31,119	3749.33	
09. 20.002 Paved Maintenance Roads								
09. 20.002. 1 Clearing & Grubbing, debris	9.00	ACR	8,535	893	1,264	10,693	1188.07	
09. 20.002. 2 Site Preparation	18.00	ACR	1,377,339	144,143	203,959	1,725,441	95857.83	
TOTAL Paved Maintenance Roads	18.00	ACR	1,385,874	145,036	205,223	1,736,134	96451.86	
09. 20.003 Gravel Maintenance Road								
09. 20.003. 1 Clearing & Grubbing, debris	4.10	ACR	3,888	407	576	4,871	1188.07	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 20.003. 2 Site Preparation	8.20	ACR	192,625	20,159	28,524	241,308	29427.82	
TOTAL Gravel Maintenance Road	8.20	ACR	196,513	20,566	29,100	246,179	30021.85	
09. 20.005 Bridges								
09. 20.005. 1 Fencing for Erosion Control	9.00	ACR	23,418	2,451	3,468	29,336	3259.57	
09. 20.005. 2 Clearing and Grubbing, debris	7.00	ACR	6,639	695	983	8,316	1188.07	
09. 20.005. 3 Excavating, structural, sand/	3060.00	CY	13,313	1,393	1,971	16,677	5.45	
09. 20.005. 4 Cast in Place reinforced concret	3060.00	CY	503,669	52,711	74,584	630,964	206.20	
09. 20.005. 5 Finished grading, tie in, stabl.	9.00	ACR	40,177	4,205	5,949	50,331	5592.29	
09. 20.005. 6 Prefab Bridges	9.00	EA	904,390	94,647	133,924	1,132,962	125884.63	
TOTAL Bridges	1.00	EA	1,491,605	156,101	220,880	1,868,586	1868586	
TOTAL ROADS & BRIDGES	1.00	EA	3,098,834	324,303	458,882	3,882,018	3882018	
09. 25 LET DOWN STRUCTURES								
09. 25.001 Let Down Structures								
09. 25.001. 1 Fencing for Erosion Control	2.50	ACR	12,345	1,292	1,828	15,465	6185.90	
09. 25.001. 2 Clearing & Grubbing, debris	1.90	ACR	1,802	189	267	2,257	1188.07	
09. 25.001. 3 Prep (excav) slope to receive	500.00	CY	985	103	146	1,234	2.47	
09. 25.001. 4 30" Pipe Laying	1000.00	LF	101,848	10,659	15,082	127,588	127.59	
09. 25.001. 5 Backfilling & Compaction	30000.00	CY	131,706	13,783	19,503	164,993	5.50	
09. 25.001. 6 Planting and Seeding	2.10	ACR	36,697	3,840	5,434	45,972	21891.28	
TOTAL Let Down Structures	1.00	EA	285,383	29,866	42,260	357,509	357509.28	
TOTAL LET DOWN STRUCTURES	1.00	EA	285,383	29,866	42,260	357,509	357509.28	
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	47,203,570	4,940,000	6,990,000	59,133,570	59133570	
14 RECREATION								
14. 30 RECREATION FEATURES								
14. 30.001 Parking Areas								
14. 30.001. 1 Fencing for Erosion Control	1.80	ACR	10,474	161	1,571	12,206	6781.26	
14. 30.001. 2 Clearing & Grubbing, debris	1.80	ACR	1,802	28	270	2,100	1166.59	
14. 30.001. 3 Site Preparation	1.80	ACR	22,249	342	3,337	25,928	14404.38	
14. 30.001. 4 Asphalt Paving, 6" stone base,	79280.00	SF	169,712	2,606	25,455	197,774	2.49	
14. 30.001. 5 Lines on pavement, parking stall			1,970	30	295	2,296		
14. 30.001. 6 Parking Lot Amenities, lighting,			13,133	202	1,970	15,304		
TOTAL Parking Areas	1.80	ACR	219,341	3,368	32,899	255,608	142004.41	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
14. 30.005 Decomposed Granite Trails								
14. 30.005. 1 Clearing & Grubbing, debris	2.00	ACR	1,897	29	284	2,210	1105.19	
14. 30.005. 2 Site Preparation	2.00	ACR	12,846	197	1,927	14,970	7484.82	
14. 30.005. 3 Decomposed Granite course,	275740.00	SF	160,230	2,460	24,033	186,724	0.68	
14. 30.005. 4 Trail amenities, ADA ramps, sign			13,133	202	1,970	15,304		
TOTAL Decomposed Granite Trails	1.00	EA	188,106	2,888	28,214	219,209	219208.56	
14. 30.010 Other Recreation Features								
14. 30.010. 1 Paved Trail amenities, curb	1.00	EA	13,133	202	1,970	15,304	15304.44	
14. 30.010. 2 Comfort Stations	3.00	EA	393,989	6,050	59,095	459,133	153044.43	
14. 30.010. 3 Rest Stops	5.00	EA	19,699	302	2,955	22,957	4591.33	
14. 30.010. 4 Concrete Benches	21.00	EA	19,580	301	2,937	22,817	1086.52	
14. 30.010. 5 Signage	21.00	EA	769	12	115	896	42.65	
TOTAL Other Recreation Features	1.00	EA	447,169	6,866	67,072	521,107	521106.93	
TOTAL RECREATION FEATURES	1.00	EA	854,615	13,123	128,185	995,923	995923.43	
TOTAL RECREATION	1.00	EA	854,615	13,123	128,185	995,923	995923.43	
30 PLANNING, ENGINEERING, DESIGN								
30.009 Construction	1.00	EA	5,120,000	0	0	5,120,000	5120000	
30.014 Recreation	1.00	EA	95,285	0	0	95,285	95285.00	
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	5,215,285	5215285	
31 CONSTRUCTION MANAGEMENT								
31.009 Construction (Restoration)	1.00	EA	5,980,000	0	0	5,980,000	5980000	
31.014 Recreation	1.00	EA	63,879	0	0	63,879	63879.00	
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	6,043,879	6043879	
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	85,517,349	4,953,123	7,118,185	97,588,657	97588657	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	26,200,000	26200000	
09 CONSTRUCTION (RESTORATION)								
09. 01 IRRIGATION PLANTING								
09. 01.001 Historic Floodplain								
09. 01.001. 1 Fencing for Erosion Control	656.00	ACR	199,985	20,929	29,614	250,529	381.90	
09. 01.001. 2 Clearing & Grubbing, Debris	328.00	ACR	622,138	65,109	92,128	779,375	2376.14	
09. 01.001. 3 Site Preparation								
09. 01.001. 3.01 Ripping, discing to prepare	590.00	ACR	9,678	1,013	1,433	12,124	20.55	
09. 01.001. 3.02 Regrade to req'd slopes, flatten	295.00	ACR	1,867	195	276	2,338	7.93	
09. 01.001. 3.03 Regrade Surface, scraper-grader	1445500	CY	31,729	3,321	4,699	39,748	0.03	
TOTAL Site Preparation	1.00	EA	43,274	4,529	6,408	54,211	54210.52	
09. 01.001. 4 Excavation	176990.00	CY	448,377	46,924	66,397	561,698	3.17	
09. 01.001. 5 Compaction (tractor wheel, one	3561940	LF	553,508	57,926	81,965	693,399	0.19	
09. 01.001. 6 Trenching for Water Supply Pipes	17050.00	CY	29,450	3,082	4,361	36,892	2.16	
09. 01.001. 7 Pipe bedding, crushed stone	13110.00	CY	855,960	89,579	126,752	1,072,291	81.79	
09. 01.001. 8 Install gated 12" PVC pipe for	114720.00	LF	1,015,381	106,263	150,360	1,272,004	11.09	
09. 01.001. 9 Install "U" outlet tubes with	5940.00	EA	74,161	7,761	10,982	92,904	15.64	
09. 01.001.!0 Backfill pipe trench, side cast	4590.00	CY	2,350	246	348	2,944	0.64	
09. 01.001.!1 Planting & Seeding								
09. 01.001.!1.01 Mulching, hay, 1" deep, power	558.00	ACR	654,934	68,541	96,984	820,459	1470.36	
09. 01.001.!1.02 Crimping, Tilling topsoil,	558.00	ACR	116,548	12,197	17,259	146,004	261.66	
09. 01.001.!1.03 Seeding, athletic fld mix,	623.00	ACR	2,478,847	259,419	367,073	3,105,339	4984.49	
09. 01.001.!1.04 Place Coarse Woody debris/rocks	558.00	ACR	553,345	57,909	81,940	693,195	1242.28	
09. 01.001.!1.05 Plant Mesquite/Shrub mix using	250729.00	EA	4,939,217	516,904	731,409	6,187,531	24.68	
TOTAL Planting & Seeding	558.00	ACR	8,742,892	914,971	1,294,665	10,952,528	19628.19	
TOTAL Historic Floodplain	1.00	EA	12,587,475	1,317,318	1,863,979	15,768,772	15768772	
09. 01.005 Graded Slope								
09. 01.005. 1 Fencing for Erosion Control	102.00	ACR	78,857	8,253	11,677	98,787	968.50	
09. 01.005. 2 Clearing & Grubbing, debris	51.00	ACR	48,367	5,062	7,162	60,592	1188.07	
09. 01.005. 3 Excavation, strl, mach excav.	1213390	CY	842,982	88,221	124,831	1,056,033	0.87	
09. 01.005. 4 Excavation, steep slopes, 5:1								
09. 01.005. 4.01 Hauling, no loading, 16.5 cy	1213390	CY	3,533,195	369,760	523,203	4,426,157	3.65	
09. 01.005. 4.02 Fill, spread dumped material,	1213390	CY	621,162	65,006	91,983	778,151	0.64	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 01.005. 4.03 Compaction, sheepfoot/wobbly	1213390	CY	468,819	49,063	69,424	587,306	0.48	
TOTAL Excavation, steep slopes, 5:1	1213390	CY	4,623,176	483,830	684,609	5,791,615	4.77	
09. 01.005. 5 Fine grading to 20% slope,	110.00	ACR	319,183	33,403	47,265	399,851	3635.01	
09. 01.005. 6 Header Pipe Laying								
09. 01.005. 6.01 Excavate header trench, 12" dep.	2540.00	CY	1,680	176	249	2,104	0.83	
09. 01.005. 6.02 Header Trench bedding, 3/4"	1020.00	CY	30,227	3,163	4,476	37,867	37.12	
09. 01.005. 6.03 Install medium diam. PVC Header	7620.00	LF	128,063	13,402	18,964	160,428	21.05	
09. 01.005. 6.04 Backfill trench, FE loader,	1020.00	CY	2,200	230	326	2,756	2.70	
09. 01.005. 6.05 Hauling, surplus cut mat'l,	1530.00	CY	7,531	788	1,115	9,434	6.17	
TOTAL Header Pipe Laying	7620.00	LF	169,701	17,760	25,130	212,590	27.90	
09. 01.005. 7 8" PVC Leach Pipe Laying								
09. 01.005. 7.01 Excavate trench, 12" depth by	99020.00	CY	65,489	6,854	9,698	82,041	0.83	
09. 01.005. 7.02 Install low perm geotextile in	148700.00	SY	212,160	22,203	31,417	265,780	1.79	
09. 01.005. 7.03 Install 8" PVC leach pipe for	445590.00	LF	2,556,993	267,597	378,645	3,203,235	7.19	
09. 01.005. 7.04 Install leach pipe filter "sock"	445590.00	LF	942,158	98,600	139,517	1,180,274	2.65	
09. 01.005. 7.05 Install pipe fittings as needed			35,459	3,711	5,251	44,421		
09. 01.005. 7.06 Backfill trench, FE loader, whl	93380.00	CY	201,417	21,079	29,826	252,322	2.70	
09. 01.005. 7.07 Hauling, surplus cut matl, no	5790.00	CY	28,500	2,983	4,220	35,703	6.17	
TOTAL 8" PVC Leach Pipe Laying	445590.00	LF	4,042,175	423,026	598,573	5,063,774	11.36	
09. 01.005. 8 Planting & Seeding								
09. 01.005. 8.01 Mulch, hay, 1" deep, power	102.00	ACR	119,719	12,529	17,728	149,976	1470.36	
09. 01.005. 8.02 Crimping, tilling topsoil	102.00	ACR	21,304	2,230	3,155	26,689	261.66	
09. 01.005. 8.03 Seeding, athletic fld mix,	102.00	ACR	405,845	42,473	60,098	508,416	4984.47	
09. 01.005. 8.04 Place Coarse Woody debris/rocks	102.00	ACR	101,149	10,586	14,978	126,713	1242.28	
09. 01.005. 8.05 Plant Mesquite/Shrub mix using	45675.00	EA	899,771	94,164	133,240	1,127,175	24.68	
TOTAL Planting & Seeding	102.00	ACR	1,547,789	161,981	229,200	1,938,969	19009.50	
TOTAL Graded Slope	1.00	EA	11,672,230	1,221,535	1,728,447	14,622,212	14622212	
09. 01.010 Natural Slope								
09. 01.010. 1 Fencing for Erosion Control	18.00	ACR	33,125	3,467	4,905	41,497	2305.39	
09. 01.010. 2 Clearing and Grubbing, debris	13.00	ACR	12,329	1,290	1,826	15,445	1188.07	
09. 01.010. 3 Header Trenching								
09. 01.010. 3.01 Excavate header trench, 12" dep.	86.00	CY	57	6	8	71	0.83	

		QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 01.010. 3.02	Header Trench bedding, 3/4"	35.00	CY	1,037	109	154	1,299	37.12	
09. 01.010. 3.03	Install med. diam. PVC Header	1520.00	LF	25,545	2,673	3,783	32,001	21.05	
09. 01.010. 3.04	Backfill trench, FE loader,	35.00	CY	75	8	11	95	2.70	
09. 01.010. 3.05	Hauling, surplus cut matl, no	52.00	CY	256	27	38	321	6.17	
	TOTAL Header Trenching	1520.00	LF	26,971	2,823	3,994	33,787	22.23	
09. 01.010. 4	8" PVC Leach Pipe Laying								
09. 01.010. 4.01	Excavate trench, 12" depth by	16780.00	CY	11,098	1,161	1,643	13,903	0.83	
09. 01.010. 4.02	Install low perm geotextile in	25200.00	SY	35,954	3,763	5,324	45,041	1.79	
09. 01.010. 4.03	Install 8" PVC leach pipe for	75510.00	LF	433,310	45,347	64,165	542,822	7.19	
09. 01.010. 4.04	Install leach pipe filter "sock"	75510.00	LF	159,659	16,709	23,643	200,010	2.65	
09. 01.010. 4.05	Install pipe fittings as needed			26,266	2,749	3,890	32,904		
09. 01.010. 4.06	Backfill trench, FE loader, whl	15830.00	CY	34,145	3,573	5,056	42,774	2.70	
09. 01.010. 4.07	Hauling, surplus cut matl, no	990.00	CY	4,873	510	722	6,105	6.17	
	TOTAL 8" PVC Leach Pipe Laying	75510.00	LF	705,304	73,812	104,443	883,560	11.70	
09. 01.010. 5	Planting & Seeding								
09. 01.010. 5.01	Mulch, hay, 1" deep, power	18.00	ACR	21,127	2,211	3,129	26,466	1470.36	
09. 01.010. 5.02	Crimping, tilling topsoil	18.00	ACR	3,760	393	557	4,710	261.66	
09. 01.010. 5.03	Seeding, athletic fld mix,	18.00	ACR	71,620	7,495	10,606	89,720	4984.47	
09. 01.010. 5.04	Place Coarse Woody debris/rocks	18.00	ACR	17,850	1,868	2,643	22,361	1242.28	
09. 01.010. 5.05	Plant Mesquite/Shrub mix using	7740.00	EA	152,474	15,957	22,579	191,009	24.68	
	TOTAL Planting & Seeding	18.00	ACR	266,830	27,925	39,513	334,267	18570.38	
	TOTAL Natural Slope	1.00	EA	1,044,559	109,316	154,680	1,308,556	1308556	
09. 01.015	Second Bench								
09. 01.015. 1	Fencing for Erosion Control	124.00	ACR	86,937	9,098	12,874	108,909	878.30	
09. 01.015. 2	Clearing and Grubbing, debris	93.00	ACR	88,200	9,230	13,061	110,491	1188.07	
09. 01.015. 3	Header Trenching								
09. 01.015. 3.01	Excavate header trench, 12" dep.	500.00	CY	331	35	49	414	0.83	
09. 01.015. 3.02	Header Trench bedding, 3/4"	200.00	CY	5,927	620	878	7,425	37.12	
09. 01.015. 3.03	Install med. diam. PVC Header	8080.00	LF	135,793	14,211	20,109	170,113	21.05	
09. 01.015. 3.04	Backfill trench, FE loader,	200.00	CY	431	45	64	540	2.70	
09. 01.015. 3.05	Hauling, surplus cut matl, no	300.00	CY	1,477	155	219	1,850	6.17	
	TOTAL Header Trenching	8080.00	LF	143,959	15,066	21,318	180,343	22.32	
09. 01.015. 4	8" PVC Leach Pipe Laying								

		QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 01.015. 4.01	Excavate trench, 12" depth by	121260.00	CY	80,198	8,393	11,876	100,467	0.83	
09. 01.015. 4.03	Install 8" PVC leach pipe for	545686.00	LF	3,131,388	327,709	463,702	3,922,800	7.19	
09. 01.015. 4.04	Install leach pipe filter "sock"	545680.00	LF	1,153,789	120,748	170,855	1,445,391	2.65	
09. 01.015. 4.05	Install pipe fittings as needed			32,832	3,436	4,862	41,130		
09. 01.015. 4.06	Backfill trench, FE loader, whl	114360.00	CY	246,669	25,815	36,527	309,012	2.70	
09. 01.015. 4.07	Hauling, surplus cut matl, no	7090.00	CY	34,899	3,652	5,168	43,719	6.17	
	TOTAL 8" PVC Leach Pipe Laying	545686.00	LF	4,679,775	489,753	692,991	5,862,519	10.74	
09. 01.015. 5	Planting & Seeding								
09. 01.015. 5.01	Mulch, hay, 1" deep, power	125.00	ACR	146,715	15,354	21,726	183,795	1470.36	
09. 01.015. 5.02	Crimping, tilling topsoil	125.00	ACR	26,108	2,732	3,866	32,707	261.66	
09. 01.015. 5.03	Seeding, athletic fld mix,	125.00	ACR	497,359	52,050	73,650	623,059	4984.47	
09. 01.015. 5.04	Place Coarse Woody debris/rocks	125.00	ACR	125,060	13,088	18,519	156,668	1253.34	
09. 01.015. 5.05	Plant Mesquite/Shrub mix using	55935.00	EA	1,101,887	115,316	163,170	1,380,373	24.68	
	TOTAL Planting & Seeding	125.00	ACR	1,897,130	198,541	280,931	2,376,601	19012.81	
	TOTAL Second Bench	1.00	EA	6,896,001	721,688	1,021,174	8,638,862	8638862	
09. 01.020	First Bench								
09. 01.020. 1	Excavate pipe trench, 18" depth	1.00	LF	1	0	0	1	1.07	
	TOTAL Excavate pipe trench, 18" depth	1.00	LF	1	0	0	1	1.07	
09. 01.020. 2	Pipe Laying								
09. 01.020. 2.01	Install small diam pressure pipe	31000.00	LF	153,623	16,077	22,749	192,449	6.21	
09. 01.020. 2.02	Install small diam pipe fittings	3100.00	EA	168,060	17,588	24,887	210,535	67.91	
09. 01.020. 2.03	Install long reach (150') sprin-	190.00	LF	29,312	3,068	4,341	36,721	193.27	
09. 01.020. 2.04	Install pipe thrust blocks at	238.00	EA	15,628	1,636	2,314	19,578	82.26	
	TOTAL Pipe Laying	31000.00	LF	366,624	38,368	54,290	459,283	14.82	
09. 01.020. 3	Backfill pipe trench, compact	31000.00	LF	66,866	6,998	9,902	83,765	2.70	
09. 01.020. 4	Install control valves for sprin	90.00	EA	5,201	544	770	6,516	72.39	
09. 01.020. 5	Install Programmable Logic	1.00	EA	656,648	68,720	97,238	822,605	822605.43	
09. 01.020. 6	Rough grade & scarify subsoil	89.00	ACR	209,033	21,876	30,954	261,863	2942.29	
09. 01.020. 7	Planting & seeding								
09. 01.020. 7.01	Mulch, hay, 1" deep, power	89.00	ACR	104,461	10,932	15,469	130,862	1470.36	
09. 01.020. 7.02	Crimping, tilling topsoil	89.00	ACR	18,589	1,945	2,753	23,287	261.66	
09. 01.020. 7.03	Seeding, athletic fld mix,	89.00	ACR	354,119	37,060	52,439	443,618	4984.47	
09. 01.020. 7.04	Place Coarse Woody debris/rocks	89.00	ACR	31,027	3,247	4,595	38,869	436.73	

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 01.020. 7.05 Plant Mesquite/Shrub mix using	55935.00 EA	1,101,887	115,316	163,170	1,380,373	24.68	
TOTAL Planting & seeding	89.00 ACR	1,610,084	168,500	238,424	2,017,009	22663.02	
TOTAL First Bench	1.00 EA	2,914,456	305,007	431,579	3,651,042	3651042	
TOTAL IRRIGATION PLANTING	1.00 EA	35,114,721	3,674,864	5,199,859	43,989,444	43989444	
09. 05 BASINS PLANTING							
09. 05.001 Tributary Infiltration Basins							
09. 05.001. 1 Fencing for Erosion Control	18.00 ACR	33,125	3,467	4,905	41,497	2305.39	
09. 05.001. 2 Clearing and Grubbing, debris	13.00 ACR	12,329	1,290	1,826	15,445	1188.07	
09. 05.001. 3 Excavate, mach exc., sand & grav							
09. 05.001. 3.01 Stockpile useable cut matl,	830.00 CY	1,118	117	165	1,400	1.69	
09. 05.001. 3.02 Hauling, surplus cut matl, no	2490.00 CY	12,256	1,283	1,815	15,354	6.17	
09. 05.001. 3.03 Fill, spread cut matl at dump	2490.00 CY	2,900	303	429	3,633	1.46	
09. 05.001. 3.04 Compaction at dump site, hl rlr,	2490.00 CY	962	101	142	1,205	0.48	
09. 05.001. 3.05 Compact Basin subgrade, existing	86160.00 SY	252,694	26,445	37,419	316,559	3.67	
TOTAL Excavate, mach exc., sand & grav	8300.00 CY	269,930	28,249	39,972	338,151	40.74	
09. 05.001. 4 Backfilling							
09. 05.001. 4.01 Fill, bottom layer, clean sand,	840.00 CY	19,581	2,049	2,900	24,530	29.20	
09. 05.001. 4.02 Fill, middle layer, No. 57 blue-	840.00 CY	1,103	115	163	1,382	1.65	
09. 05.001. 4.03 Fill, middle layer, No. 2 gravel	840.00 CY	27,579	2,886	4,084	34,549	41.13	
09. 05.001. 4.04 Fill, top layer, mix of native	840.00 CY	33,095	3,463	4,901	41,459	49.36	
TOTAL Backfilling	3360.00 CY	81,359	8,514	12,048	101,921	30.33	
09. 05.001. 5 Planting & Seeding							
09. 05.001. 5.01 Mulch, hay, 1" deep, power	18.00 ACR	21,127	2,211	3,129	26,466	1470.36	
09. 05.001. 5.02 Crimping, tilling topsoil	18.00 ACR	3,760	393	557	4,710	261.66	
09. 05.001. 5.03 Seeding, athletic fld mix,	18.00 ACR	71,620	7,495	10,606	89,720	4984.47	
09. 05.001. 5.04 Plant Mesquite/Shrub mix using	3204.00 EA	63,117	6,605	9,346	79,069	24.68	
TOTAL Planting & Seeding	18.00 ACR	159,623	16,705	23,637	199,966	11109.20	
TOTAL Tributary Infiltration Basins	1.00 EA	556,366	58,225	82,388	696,979	696979.43	
09. 05.005 Grade Control Infiltration Basin							

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 05.005. 1 Fencing for Erosion Control	6.00 ACR	19,116	2,001	2,831	23,947	3991.15	
09. 05.005. 2 Clearing and Grubbing, debris	5.00 ACR	4,742	496	702	5,940	1188.07	
09. 05.005. 3 Excavating, mach exc, sand & gr							
09. 05.005. 3.01 Stockpile useable cut mat'l	280.00 CY	377	39	56	472	1.69	
09. 05.005. 3.02 Hauling, surplus cut mat'l, no	840.00 CY	4,135	433	612	5,180	6.17	
09. 05.005. 3.03 Fill, spread cut mat'l at dump	840.00 CY	978	102	145	1,226	1.46	
TOTAL Excavating, mach exc, sand & gr	1120.00 CY	5,490	575	813	6,877	6.14	
09. 05.005. 4 Compaction at dump site, hl rlr	840.00 CY	325	34	48	407	0.48	
09. 05.005. 5 Compact basin subgrade, existing	29040.00 CY	85,170	8,913	12,612	106,695	3.67	
09. 05.005. 6 Backfilling	1160.00 CY	28,092	2,940	4,160	35,192	30.34	
09. 05.005. 7 Planting & Seeding							
09. 05.005. 7.01 Mulch, hay, 1" deep, power	6.00 ACR	7,042	737	1,043	8,822	1470.36	
09. 05.005. 7.02 Crimping, tilling topsoil	6.00 ACR	1,253	131	186	1,570	261.66	
09. 05.005. 7.03 Seeding, athletic fld mix,	6.00 ACR	23,873	2,498	3,535	29,907	4984.47	
TOTAL Planting & Seeding	6.00 ACR	32,169	3,367	4,764	40,299	6716.48	
TOTAL Grade Control Infiltration Basin	1.00 EA	175,103	18,325	25,930	219,357	219357.35	
TOTAL BASINS PLANTING	1.00 EA	731,469	76,550	108,317	916,337	916336.78	
09. 10 HARDENED BANKS							
09. 10.001 Hardened Slopes							
09. 10.001. 1 Fencing for Erosion Control	3.50 ACR	14,589	1,527	2,160	18,277	5221.86	
09. 10.001. 2 Clearing and Grubbing, debris	0.90 ACR	854	89	126	1,069	1188.07	
09. 10.001. 3 Excavating, prepare slope &							
09. 10.001. 3.01 Stockpile subgrade cut matl for	28200.00 CY	37,968	3,973	5,622	47,564	1.69	
09. 10.001. 3.02 Hauling, no loading, 16.5 cy	18800.00 CY	54,743	5,729	8,106	68,578	3.65	
TOTAL Excavating, prepare slope &	47000.00 CY	92,711	9,702	13,729	116,142	2.47	
09. 10.001. 4 Fill, spread dumped mat'l, by							
09. 10.001. 4.01 Compaction, sheepfoot/wobbly	18800.00 CY	7,264	760	1,076	9,100	0.48	
09. 10.001. 4.02 Fine grade to 1:1 slope, for	14900.00 SY	8,933	935	1,323	11,190	0.75	
TOTAL Fill, spread dumped mat'l, by	18800.00 CY	16,197	1,695	2,398	20,290	1.08	
09. 10.001. 5 Soil Cement application,	61100.00 CY	3,129,451	327,507	463,415	3,920,373	64.16	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 10.001. 6 Backfill and Compaction								
09. 10.001. 6.01 Backfill subgrade with cut matl	28200.00	CY	60,826	6,366	9,007	76,199	2.70	
09. 10.001. 6.02 Compaction, sheepfoot/wobbly whl	28200.00	CY	10,896	1,140	1,613	13,649	0.48	
TOTAL Backfill and Compaction	28200.00	CY	71,722	7,506	10,621	89,848	3.19	
TOTAL Hardened Slopes	1.00	EA	3,325,523	348,026	492,450	4,165,999	4165999	
TOTAL HARDENED BANKS	1.00	EA	3,325,523	348,026	492,450	4,165,999	4165999	
09. 15 PIPING								
09. 15.001 Irrigation Piping								
09. 15.001. 1 Trenching for Delivery Pipe								
09. 15.001. 1.01 Delivery pipe trench bedding,	1260.00	CY	82,266	8,609	12,182	103,058	81.79	
09. 15.001. 1.02 Delivery piping, large dia. say	10440.00	LF	271,348	28,397	40,182	339,927	32.56	
09. 15.001. 1.03 Backfill delivery pipe trench,	1260.00	CY	28,443	2,977	4,212	35,632	28.28	
09. 15.001. 1.04 Hauling, Delivery pipe surplus	1880.00	CY	5,474	573	811	6,858	3.65	
TOTAL Trenching for Delivery Pipe	3130.00	CY	387,531	40,556	57,386	485,474	155.10	
09. 15.001. 2 Trenching for Main Pipe								
09. 15.001. 2.01 Main pipe trench bedding,	8400.00	CY	548,441	57,396	81,214	687,051	81.79	
09. 15.001. 2.02 Main piping, large dia. say	69970.00	LF	1,818,601	190,322	269,302	2,278,226	32.56	
09. 15.001. 2.03 Backfill Main pipe trench,	8400.00	CY	189,621	19,844	28,080	237,545	28.28	
09. 15.001. 2.04 Hauling, Main pipe surplus	12600.00	CY	36,689	3,840	5,433	45,962	3.65	
TOTAL Trenching for Main Pipe	21000.00	CY	2,593,353	271,402	384,029	3,248,784	154.70	
09. 15.001. 3 Trenching for Sub-main Pipe								
09. 15.001. 3.01 Sub-main pipe trench bedding,	3370.00	CY	220,029	23,027	32,582	275,638	81.79	
09. 15.001. 3.02 Sub-main piping, large dia. say	28010.00	LF	378,327	39,593	56,023	473,943	16.92	
09. 15.001. 3.03 Backfill Sub-main pipe trench,	3370.00	CY	76,074	7,961	11,265	95,301	28.28	
09. 15.001. 3.04 Hauling, Sub-main pipe surplus	5050.00	CY	14,705	1,539	2,178	18,421	3.65	
TOTAL Trenching for Sub-main Pipe	8420.00	CY	689,135	72,120	102,049	863,304	102.53	
09. 15.001. 4 Trenching for Culvert CMP								
09. 15.001. 4.01 Culvert trench bedding,	4200.00	CY	274,221	28,698	40,607	343,526	81.79	
09. 15.001. 4.02 Install 24" dia. CMP Culvert for	23600.00	LF	590,245	61,771	87,405	739,421	31.33	
09. 15.001. 4.03 Backfill trench, FE Loader,	4200.00	CY	94,811	9,922	14,040	118,773	28.28	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 15.001. 4.04 Hauling, Sub-main pipe surplus	6300.00	CY	18,345	1,920	2,717	22,981	3.65	
TOTAL Trenching for Culvert CMP	10500.00	CY	977,621	102,311	144,768	1,224,700	116.64	
TOTAL Irrigation Piping	1.00	EA	4,647,640	486,390	688,232	5,822,262	5822262	
TOTAL PIPING	1.00	EA	4,647,640	486,390	688,232	5,822,262	5822262	
09. 20 ROADS & BRIDGES								
09. 20.001 Compacted Earth Maintenance Road								
09. 20.001. 1 Clearing & Grubbing, debris	8.30	ACR	7,872	824	1,166	9,861	1188.07	
TOTAL Clearing & Grubbing, debris	8.30	ACR	7,872	824	1,166	9,861	1188.07	
09. 20.001. 2 Site Preparation								
09. 20.001. 2.01 Ripping, discing to prepare	8.30	ACR	136	14	20	171	20.55	
09. 20.001. 2.02 Regrade, flatten, balance cut	2020.00	CY	1,278	134	189	1,601	0.79	
09. 20.001. 2.03 Compaction, riding, sheepfoot/	40260.00	SY	15,555	1,628	2,303	19,487	0.48	
TOTAL Site Preparation	8.30	ACR	16,970	1,776	2,513	21,258	2561.26	
TOTAL Compacted Earth Maintenance Road	8.30	ACR	24,841	2,600	3,679	31,119	3749.33	
09. 20.002 Paved Maintenance Roads								
09. 20.002. 1 Clearing & Grubbing, debris	9.00	ACR	8,535	893	1,264	10,693	1188.07	
TOTAL Clearing & Grubbing, debris	9.00	ACR	8,535	893	1,264	10,693	1188.07	
09. 20.002. 2 Site Preparation								
09. 20.002. 2.01 Ripping, discing to prepare	18.00	ACR	295	31	44	370	20.55	
09. 20.002. 2.02 Regrade, flatten, balance cut	21880.00	CY	13,844	1,449	2,050	17,343	0.79	
09. 20.002. 2.03 Compaction, riding, sheepfoot/	86820.00	SY	33,545	3,511	4,967	42,023	0.48	
09. 20.002. 2.04 Asphalt Concrete Paving,	781310.00	SF	1,329,654	139,152	196,898	1,665,705	2.13	
TOTAL Site Preparation	18.00	ACR	1,377,339	144,143	203,959	1,725,441	95857.83	
TOTAL Paved Maintenance Roads	18.00	ACR	1,385,874	145,036	205,223	1,736,134	96451.86	
09. 20.003 Gravel Maintenance Road								

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 20.003. 1 Clearing & Grubbing, debris	4.10	ACR	3,888	407	576	4,871	1188.07	
TOTAL Clearing & Grubbing, debris	4.10	ACR	3,888	407	576	4,871	1188.07	
09. 20.003. 2 Site Preparation								
09. 20.003. 2.01 Ripping, discing to prepare	8.20	ACR	135	14	20	168	20.55	
09. 20.003. 2.02 Regrade, flatten, balance cut	1980.00	CY	1,253	131	186	1,569	0.79	
09. 20.003. 2.03 Compaction, riding, sheepfoot/	39530.00	SY	15,273	1,598	2,262	19,133	0.48	
09. 20.003. 2.04 Gravel course, crushed 3/4"	39530.00	SY	175,964	18,415	26,057	220,437	5.58	
TOTAL Site Preparation	8.20	ACR	192,625	20,159	28,524	241,308	29427.82	
TOTAL Gravel Maintenance Road	8.20	ACR	196,513	20,566	29,100	246,179	30021.85	
09. 20.005 Bridges								
09. 20.005. 1 Fencing for Erosion Control	9.00	ACR	23,418	2,451	3,468	29,336	3259.57	
09. 20.005. 2 Clearing and Grubbing, debris	7.00	ACR	6,639	695	983	8,316	1188.07	
09. 20.005. 3 Excavating, structural, sand/								
09. 20.005. 3.01 Hauling, no loading, 16.5 cy	3366.00	CY	9,801	1,026	1,451	12,278	3.65	
09. 20.005. 3.02 Fill, spread dumped matl, by	3366.00	CY	2,329	244	345	2,918	0.87	
09. 20.005. 3.03 Compaction, sheepfoot/wobbly	3060.00	CY	1,182	124	175	1,481	0.48	
TOTAL Excavating, structural, sand/	3060.00	CY	13,313	1,393	1,971	16,677	5.45	
09. 20.005. 4 Cast in Place reinforced concret	3060.00	CY	503,669	52,711	74,584	630,964	206.20	
09. 20.005. 5 Finished grading, tie in, stabl.	9.00	ACR	40,177	4,205	5,949	50,331	5592.29	
09. 20.005. 6 Prefab Bridges								
09. 20.005. 6.01 Prefab Bridges (9 ea)			791,377	82,820	117,189	991,386		
09. 20.005. 6.02 Unloading and Erection	8090.00	SF	113,013	11,827	16,735	141,576	17.50	
TOTAL Prefab Bridges	9.00	EA	904,390	94,647	133,924	1,132,962	125884.63	
TOTAL Bridges	1.00	EA	1,491,605	156,101	220,880	1,868,586	1868586	
TOTAL ROADS & BRIDGES	1.00	EA	3,098,834	324,303	458,882	3,882,018	3882018	
09. 25 LET DOWN STRUCTURES								
09. 25.001 Let Down Structures								
09. 25.001. 1 Fencing for Erosion Control	2.50	ACR	12,345	1,292	1,828	15,465	6185.90	
09. 25.001. 2 Clearing & Grubbing, debris	1.90	ACR	1,802	189	267	2,257	1188.07	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
09. 25.001. 3 Prep (excav) slope to receive	500.00	CY	985	103	146	1,234	2.47	
09. 25.001. 4 30" Pipe Laying								
09. 25.001. 4.01 Install pipe bedding, gravel,	150.00	CY	9,794	1,025	1,450	12,269	81.79	
09. 25.001. 4.02 Install 30" dia CMP, 200 lf per	1000.00	LF	52,655	5,511	7,797	65,963	65.96	
09. 25.001. 4.03 Install wingwall deflectors on	10.00	EA	39,399	4,123	5,834	49,356	4935.63	
TOTAL 30" Pipe Laying	1000.00	LF	101,848	10,659	15,082	127,588	127.59	
09. 25.001. 5 Backfilling & Compaction								
09. 25.001. 5.01 Hauling, no loading, 16.5 cy	30000.00	CY	87,355	9,142	12,936	109,433	3.65	
09. 25.001. 5.02 Fill, spread dumped matl, by	30000.00	CY	25,609	2,680	3,792	32,082	1.07	
09. 25.001. 5.03 Compaction, sheepfoot/wobbly	30000.00	CY	11,591	1,213	1,716	14,521	0.48	
09. 25.001. 5.04 Fine grade filled area, for	2.50	ACR	7,151	748	1,059	8,958	3583.27	
TOTAL Backfilling & Compaction	30000.00	CY	131,706	13,783	19,503	164,993	5.50	
09. 25.001. 6 Planting and Seeding								
09. 25.001. 6.01 Mulching, hay, 1" deep, power	2.10	ACR	2,465	258	365	3,088	1470.36	
09. 25.001. 6.02 Crimping, tilling topsoil	2.10	ACR	439	46	65	549	261.66	
09. 25.001. 6.03 Seeding, athletic fld mix,	2.40	ACR	9,549	999	1,414	11,963	4984.47	
09. 25.001. 6.04 Place Coarse Woody debris/rocks	2.10	ACR	2,082	218	308	2,609	1242.28	
09. 25.001. 6.05 Plant Mesquite/Shrub mix using	1125.00	EA	22,162	2,319	3,282	27,763	24.68	
TOTAL Planting and Seeding	2.10	ACR	36,697	3,840	5,434	45,972	21891.28	
TOTAL Let Down Structures	1.00	EA	285,383	29,866	42,260	357,509	357509.28	
TOTAL LET DOWN STRUCTURES	1.00	EA	285,383	29,866	42,260	357,509	357509.28	
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	47,203,570	4,940,000	6,990,000	59,133,570	59133570	
14 RECREATION								
14. 30 RECREATION FEATURES								
14. 30.001 Parking Areas								
14. 30.001. 1 Fencing for Erosion Control	1.80	ACR	10,474	161	1,571	12,206	6781.26	
14. 30.001. 2 Clearing & Grubbing, debris	1.80	ACR	1,802	28	270	2,100	1166.59	
14. 30.001. 3 Site Preparation								
14. 30.001. 3.01 Ripping, discing to prepare	1.80	ACR	30	0	4	34	19.12	
14. 30.001. 3.02 Regrade to req'd slopes, flatten	1.80	ACR	11	0	2	13	7.37	

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
14. 30.001. 3.03 Regrade surface, scraper-grader,	4410.00	CY	12,590	193	1,888	14,672	3.33	
14. 30.001. 3.04 Compaction, riding, sheepfoot	8810.00	SY	3,404	52	511	3,967	0.45	
14. 30.001. 3.05 Fine grade, grade subgrade for	8810.00	SY	6,214	95	932	7,241	0.82	
TOTAL Site Preparation	1.80	ACR	22,249	342	3,337	25,928	14404.38	
14. 30.001. 4 Asphalt Paving, 6" stone base,	79280.00	SF	169,712	2,606	25,455	197,774	2.49	
14. 30.001. 5 Lines on pavement, parking stall			1,970	30	295	2,296		
14. 30.001. 6 Parking Lot Amenities, lighting,			13,133	202	1,970	15,304		
TOTAL Parking Areas	1.80	ACR	219,341	3,368	32,899	255,608	142004.41	
14. 30.005 Decomposed Granite Trails								
14. 30.005. 1 Clearing & Grubbing, debris	2.00	ACR	1,897	29	284	2,210	1105.19	
TOTAL Clearing & Grubbing, debris	2.00	ACR	1,897	29	284	2,210	1105.19	
14. 30.005. 2 Site Preparation								
14. 30.005. 2.01 Ripping, discing to prepare	2.00	ACR	33	1	5	38	19.12	
14. 30.005. 2.02 Regrade, flatten, balance cut	1540.00	CY	974	15	146	1,136	0.74	
14. 30.005. 2.03 Compaction, riding, sheepfoot/	30640.00	SY	11,838	182	1,776	13,796	0.45	
TOTAL Site Preparation	2.00	ACR	12,846	197	1,927	14,970	7484.82	
14. 30.005. 3 Decomposed Granite course,								
14. 30.005. 3.01 Material and Delivery	3830.00	TON	150,898	2,317	22,633	175,848	45.91	
14. 30.005. 3.02 Spread and Compaction	3830.00	TON	9,333	143	1,400	10,876	2.84	
TOTAL Decomposed Granite course,	275740.00	SF	160,230	2,460	24,033	186,724	0.68	
14. 30.005. 4 Trail amenities, ADA ramps, sign			13,133	202	1,970	15,304		
TOTAL Decomposed Granite Trails	1.00	EA	188,106	2,888	28,214	219,209	219208.56	
14. 30.010 Other Recreation Features								
14. 30.010. 1 Paved Trail amenities, curb	1.00	EA	13,133	202	1,970	15,304	15304.44	
14. 30.010. 2 Comfort Stations	3.00	EA	393,989	6,050	59,095	459,133	153044.43	
14. 30.010. 3 Rest Stops	5.00	EA	19,699	302	2,955	22,957	4591.33	
14. 30.010. 4 Concrete Benches	21.00	EA	19,580	301	2,937	22,817	1086.52	
14. 30.010. 5 Signage	21.00	EA	769	12	115	896	42.65	
TOTAL Other Recreation Features	1.00	EA	447,169	6,866	67,072	521,107	521106.93	

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	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST	NOTES
TOTAL RECREATION FEATURES	1.00 EA	854,615	13,123	128,185	995,923	995923.43	
TOTAL RECREATION	1.00 EA	854,615	13,123	128,185	995,923	995923.43	
30 PLANNING, ENGINEERING, DESIGN							
30.009 Construction	1.00 EA	5,120,000	0	0	5,120,000	5120000	
30.014 Recreation	1.00 EA	95,285	0	0	95,285	95285.00	
TOTAL PLANNING, ENGINEERING, DESIGN	1.00 EA	5,215,285	0	0	5,215,285	5215285	
31 CONSTRUCTION MANAGEMENT							
31.009 Construction (Restoration)	1.00 EA	5,980,000	0	0	5,980,000	5980000	
31.014 Recreation	1.00 EA	63,879	0	0	63,879	63879.00	
TOTAL CONSTRUCTION MANAGEMENT	1.00 EA	6,043,879	0	0	6,043,879	6043879	
TOTAL Paseo de las Iglesias Feas Study	1.00 EA	85,517,349	4,953,123	7,118,185	97,588,657	97588657	

** PROJECT INDIRECT SUMMARY - Scope **

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	0	0	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)	1.00	EA	35,942,852	3,594,285	3,162,971	4,270,011	233,451	47,203,570	47203570
14 RECREATION	1.00	EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
30 PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	0	0	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	0	0	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	74,052,757	3,659,359	3,220,236	4,347,319	237,678	85,517,349	85517349
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

** PROJECT INDIRECT SUMMARY - Facility **

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	0	0	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)									
09. 01 IRRIGATION PLANTING	1.00	EA	26,737,876	2,673,788	2,352,933	3,176,460	173,664	35,114,721	35114721
09. 05 BASINS PLANTING	1.00	EA	556,972	55,697	49,014	66,168	3,618	731,469	731468.90
09. 10 HARDENED BANKS	1.00	EA	2,532,198	253,220	222,833	300,825	16,447	3,325,523	3325523
09. 15 PIPING	1.00	EA	3,538,916	353,892	311,425	420,423	22,986	4,647,640	4647640
09. 20 ROADS & BRIDGES	1.00	EA	2,359,587	235,959	207,644	280,319	15,326	3,098,834	3098834
09. 25 LET DOWN STRUCTURES	1.00	EA	217,303	21,730	19,123	25,816	1,411	285,383	285382.98
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	35,942,852	3,594,285	3,162,971	4,270,011	233,451	47,203,570	47203570
14 RECREATION									
14. 30 RECREATION FEATURES	1.00	EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
TOTAL RECREATION	1.00	EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
30 PLANNING, ENGINEERING, DESIGN									
30.009 Construction	1.00	EA	5,120,000	0	0	0	0	5,120,000	5120000
30.014 Recreation	1.00	EA	95,285	0	0	0	0	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	0	0	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT									
31.009 Construction (Restoration)	1.00	EA	5,980,000	0	0	0	0	5,980,000	5980000
31.014 Recreation	1.00	EA	63,879	0	0	0	0	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	0	0	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	74,052,757	3,659,359	3,220,236	4,347,319	237,678	85,517,349	85517349
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00 EA	26,200,000	0	0	0	0	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)								
09. 01 IRRIGATION PLANTING								
09. 01.001 Historic Floodplain	1.00 EA	9,584,651	958,465	843,449	1,138,657	62,253	12,587,475	12587475
09. 01.005 Graded Slope	1.00 EA	8,887,743	888,774	782,121	1,055,864	57,727	11,672,230	11672230
09. 01.010 Natural Slope	1.00 EA	795,373	79,537	69,993	94,490	5,166	1,044,559	1044559
09. 01.015 Second Bench	1.00 EA	5,250,915	525,091	462,081	623,809	34,105	6,896,001	6896001
09. 01.020 First Bench	1.00 EA	2,219,194	221,919	195,289	263,640	14,414	2,914,456	2914456
TOTAL IRRIGATION PLANTING	1.00 EA	26,737,876	2,673,788	2,352,933	3,176,460	173,664	35,114,721	35114721
09. 05 BASINS PLANTING								
09. 05.001 Tributary Infiltration Basins	1.00 EA	423,641	42,364	37,280	50,329	2,752	556,366	556366.16
09. 05.005 Grade Control Infiltration Basin	1.00 EA	133,331	13,333	11,733	15,840	866	175,103	175102.74
TOTAL BASINS PLANTING	1.00 EA	556,972	55,697	49,014	66,168	3,618	731,469	731468.90
09. 10 HARDENED BANKS								
09. 10.001 Hardened Slopes	1.00 EA	2,532,198	253,220	222,833	300,825	16,447	3,325,523	3325523
TOTAL HARDENED BANKS	1.00 EA	2,532,198	253,220	222,833	300,825	16,447	3,325,523	3325523
09. 15 PIPING								
09. 15.001 Irrigation Piping	1.00 EA	3,538,916	353,892	311,425	420,423	22,986	4,647,640	4647640
TOTAL PIPING	1.00 EA	3,538,916	353,892	311,425	420,423	22,986	4,647,640	4647640
09. 20 ROADS & BRIDGES								
09. 20.001 Compacted Earth Maintenance Road	8.30 ACR	18,915	1,892	1,665	2,247	123	24,841	2992.91
09. 20.002 Paved Maintenance Roads	18.00 ACR	1,055,265	105,527	92,863	125,365	6,854	1,385,874	76993.02
09. 20.003 Gravel Maintenance Road	8.20 ACR	149,634	14,963	13,168	17,776	972	196,513	23965.04
09. 20.005 Bridges	1.00 EA	1,135,773	113,577	99,948	134,930	7,377	1,491,605	1491605
TOTAL ROADS & BRIDGES	1.00 EA	2,359,587	235,959	207,644	280,319	15,326	3,098,834	3098834
09. 25 LET DOWN STRUCTURES								
09. 25.001 Let Down Structures	1.00 EA	217,303	21,730	19,123	25,816	1,411	285,383	285382.98

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
TOTAL LET DOWN STRUCTURES	1.00	EA	217,303	21,730	19,123	25,816	1,411	285,383	285382.98
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	35,942,852	3,594,285	3,162,971	4,270,011	233,451	47,203,570	47203570
14 RECREATION									
14. 30 RECREATION FEATURES									
14. 30.001 Parking Areas	1.80	ACR	167,016	16,702	14,697	19,841	1,085	219,341	121855.91
14. 30.005 Decomposed Granite Trails	1.00	EA	143,232	14,323	12,604	17,016	930	188,106	188105.85
14. 30.010 Other Recreation Features	1.00	EA	340,494	34,049	29,963	40,451	2,212	447,169	447168.94
TOTAL RECREATION FEATURES	1.00	EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
TOTAL RECREATION	1.00	EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
30 PLANNING, ENGINEERING, DESIGN									
30.009 Construction	1.00	EA	5,120,000	0	0	0	0	5,120,000	5120000
30.014 Recreation	1.00	EA	95,285	0	0	0	0	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	0	0	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT									
31.009 Construction (Restoration)	1.00	EA	5,980,000	0	0	0	0	5,980,000	5980000
31.014 Recreation	1.00	EA	63,879	0	0	0	0	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	0	0	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	74,052,757	3,659,359	3,220,236	4,347,319	237,678	85,517,349	85517349
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

Item	Description	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01	LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	0	0	26,200,000	26200000
09	CONSTRUCTION (RESTORATION)									
09. 01	IRRIGATION PLANTING									
09. 01.001	Historic Floodplain									
09. 01.001. 1	Fencing for Erosion Control	656.00	ACR	152,278	15,228	13,400	18,091	989	199,985	304.86
09. 01.001. 2	Clearing & Grubbing, Debris	328.00	ACR	473,723	47,372	41,688	56,278	3,077	622,138	1896.76
09. 01.001. 3	Site Preparation	1.00	EA	32,950	3,295	2,900	3,915	214	43,274	43273.73
09. 01.001. 4	Excavation	176990.00	CY	341,414	34,141	30,044	40,560	2,218	448,377	2.53
09. 01.001. 5	Compaction (tractor wheel, one	3561940	LF	421,465	42,146	37,089	50,070	2,737	553,508	0.16
09. 01.001. 6	Trenching for Water Supply Pipes	17050.00	CY	22,424	2,242	1,973	2,664	146	29,450	1.73
09. 01.001. 7	Pipe bedding, crushed stone	13110.00	CY	651,765	65,176	57,355	77,430	4,233	855,960	65.29
09. 01.001. 8	Install gated 12" PVC pipe for	114720.00	LF	773,155	77,316	68,038	91,851	5,022	1,015,381	8.85
09. 01.001. 9	Install "U" outlet tubes with	5940.00	EA	56,469	5,647	4,969	6,709	367	74,161	12.48
09. 01.001.10	Backfill pipe trench, side cast	4590.00	CY	1,789	179	157	213	12	2,350	0.51
09. 01.001.11	Planting & Seeding	558.00	ACR	6,657,218	665,722	585,835	790,878	43,239	8,742,892	15668.27
	TOTAL Historic Floodplain	1.00	EA	9,584,651	958,465	843,449	1,138,657	62,253	12,587,475	12587475
09. 01.005	Graded Slope									
09. 01.005. 1	Fencing for Erosion Control	102.00	ACR	60,045	6,005	5,284	7,133	390	78,857	773.11
09. 01.005. 2	Clearing & Grubbing, debris	51.00	ACR	36,829	3,683	3,241	4,375	239	48,367	948.38
09. 01.005. 3	Excavation, strl, mach excav.	1213390	CY	641,883	64,188	56,486	76,256	4,169	842,982	0.69
09. 01.005. 4	Excavation, steep slopes, 5:1	1213390	CY	3,520,287	352,029	309,785	418,210	22,865	4,623,176	3.81
09. 01.005. 5	Fine grading to 20% slope,	110.00	ACR	243,040	24,304	21,387	28,873	1,579	319,183	2901.66
09. 01.005. 6	Header Pipe Laying	7620.00	LF	129,218	12,922	11,371	15,351	839	169,701	22.27
09. 01.005. 7	8" PVC Leach Pipe Laying	445590.00	LF	3,077,888	307,789	270,854	365,653	19,991	4,042,175	9.07
09. 01.005. 8	Planting & Seeding	102.00	ACR	1,178,554	117,855	103,713	140,012	7,655	1,547,789	15174.40
	TOTAL Graded Slope	1.00	EA	8,887,743	888,774	782,121	1,055,864	57,727	11,672,230	11672230
09. 01.010	Natural Slope									
09. 01.010. 1	Fencing for Erosion Control	18.00	ACR	25,223	2,522	2,220	2,996	164	33,125	1840.29
09. 01.010. 2	Clearing and Grubbing, debris	13.00	ACR	9,388	939	826	1,115	61	12,329	948.38
09. 01.010. 3	Header Trenching	1520.00	LF	20,537	2,054	1,807	2,440	133	26,971	17.74
09. 01.010. 4	8" PVC Leach Pipe Laying	75510.00	LF	537,049	53,705	47,260	63,801	3,488	705,304	9.34
09. 01.010. 5	Planting & Seeding	18.00	ACR	203,176	20,318	17,879	24,137	1,320	266,830	14823.87
	TOTAL Natural Slope	1.00	EA	795,373	79,537	69,993	94,490	5,166	1,044,559	1044559
09. 01.015	Second Bench									
09. 01.015. 1	Fencing for Erosion Control	124.00	ACR	66,198	6,620	5,825	7,864	430	86,937	701.11

		QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 01.015. 2	Clearing and Grubbing, debris	93.00 ACR	67,159	6,716	5,910	7,978	436	88,200	948.38
09. 01.015. 3	Header Trenching	8080.00 LF	109,617	10,962	9,646	13,022	712	143,959	17.82
09. 01.015. 4	8" PVC Leach Pipe Laying	545686.00 LF	3,563,384	356,338	313,578	423,330	23,144	4,679,775	8.58
09. 01.015. 5	Planting & Seeding	125.00 ACR	1,444,557	144,456	127,121	171,613	9,383	1,897,130	15177.04
	TOTAL Second Bench	1.00 EA	5,250,915	525,091	462,081	623,809	34,105	6,896,001	6896001
09. 01.020	First Bench								
09. 01.020. 1	Excavate pipe trench, 18" depth	1.00 LF	1	0	0	0	0	1	0.85
09. 01.020. 2	Pipe Laying	31000.00 LF	279,163	27,916	24,566	33,165	1,813	366,624	11.83
09. 01.020. 3	Backfill pipe trench, compact	31000.00 LF	50,914	5,091	4,480	6,049	331	66,866	2.16
09. 01.020. 4	Install control valves for sprin	90.00 EA	3,960	396	349	470	26	5,201	57.79
09. 01.020. 5	Install Programmable Logic	1.00 EA	500,000	50,000	44,000	59,400	3,248	656,648	656647.54
09. 01.020. 6	Rough grade & scarify subsoil	89.00 ACR	159,167	15,917	14,007	18,909	1,034	209,033	2348.69
09. 01.020. 7	Planting & seeding	89.00 ACR	1,225,988	122,599	107,887	145,647	7,963	1,610,084	18090.83
	TOTAL First Bench	1.00 EA	2,219,194	221,919	195,289	263,640	14,414	2,914,456	2914456
	TOTAL IRRIGATION PLANTING	1.00 EA	26,737,876	2,673,788	2,352,933	3,176,460	173,664	35,114,721	35114721
09. 05	BASINS PLANTING								
09. 05.001	Tributary Infiltration Basins								
09. 05.001. 1	Fencing for Erosion Control	18.00 ACR	25,223	2,522	2,220	2,996	164	33,125	1840.29
09. 05.001. 2	Clearing and Grubbing, debris	13.00 ACR	9,388	939	826	1,115	61	12,329	948.38
09. 05.001. 3	Excavate, mach exc., sand & grav	8300.00 CY	205,537	20,554	18,087	24,418	1,335	269,930	32.52
09. 05.001. 4	Backfilling	3360.00 CY	61,950	6,195	5,452	7,360	402	81,359	24.21
09. 05.001. 5	Planting & Seeding	18.00 ACR	121,544	12,154	10,696	14,439	789	159,623	8867.95
	TOTAL Tributary Infiltration Basins	1.00 EA	423,641	42,364	37,280	50,329	2,752	556,366	556366.16
09. 05.005	Grade Control Infiltration Basin								
09. 05.005. 1	Fencing for Erosion Control	6.00 ACR	14,556	1,456	1,281	1,729	95	19,116	3185.95
09. 05.005. 2	Clearing and Grubbing, debris	5.00 ACR	3,611	361	318	429	23	4,742	948.38
09. 05.005. 3	Excavating, mach exc, sand & gr	1120.00 CY	4,180	418	368	497	27	5,490	4.90
09. 05.005. 4	Compaction at dump site, hl rlr	840.00 CY	247	25	22	29	2	325	0.39
09. 05.005. 5	Compact basin subgrade, existing	29040.00 CY	64,852	6,485	5,707	7,704	421	85,170	2.93
09. 05.005. 6	Backfilling	1160.00 CY	21,390	2,139	1,882	2,541	139	28,092	24.22
09. 05.005. 7	Planting & Seeding	6.00 ACR	24,495	2,449	2,156	2,910	159	32,169	5361.46
	TOTAL Grade Control Infiltration Basin	1.00 EA	133,331	13,333	11,733	15,840	866	175,103	175102.74
	TOTAL BASINS PLANTING	1.00 EA	556,972	55,697	49,014	66,168	3,618	731,469	731468.90

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 10 HARDENED BANKS									
09. 10.001 Hardened Slopes									
09. 10.001. 1 Fencing for Erosion Control	3.50	ACR	11,109	1,111	978	1,320	72	14,589	4168.37
09. 10.001. 2 Clearing and Grubbing, debris	0.90	ACR	650	65	57	77	4	854	948.38
09. 10.001. 3 Excavating, prepare slope &	47000.00	CY	70,594	7,059	6,212	8,387	459	92,711	1.97
09. 10.001. 4 Fill, spread dumped mat'l, by	18800.00	CY	12,333	1,233	1,085	1,465	80	16,197	0.86
09. 10.001. 5 Soil Cement application,	61100.00	CY	2,382,900	238,290	209,695	283,089	15,477	3,129,451	51.22
09. 10.001. 6 Backfill and Compaction	28200.00	CY	54,612	5,461	4,806	6,488	355	71,722	2.54
TOTAL Hardened Slopes	1.00	EA	2,532,198	253,220	222,833	300,825	16,447	3,325,523	3325523
TOTAL HARDENED BANKS	1.00	EA	2,532,198	253,220	222,833	300,825	16,447	3,325,523	3325523
09. 15 PIPING									
09. 15.001 Irrigation Piping									
09. 15.001. 1 Trenching for Delivery Pipe	3130.00	CY	295,083	29,508	25,967	35,056	1,917	387,531	123.81
09. 15.001. 2 Trenching for Main Pipe	21000.00	CY	1,974,692	197,469	173,773	234,593	12,826	2,593,353	123.49
09. 15.001. 3 Trenching for Sub-main Pipe	8420.00	CY	524,737	52,474	46,177	62,339	3,408	689,135	81.85
09. 15.001. 4 Trenching for Culvert CMP	10500.00	CY	744,403	74,440	65,507	88,435	4,835	977,621	93.11
TOTAL Irrigation Piping	1.00	EA	3,538,916	353,892	311,425	420,423	22,986	4,647,640	4647640
TOTAL PIPING	1.00	EA	3,538,916	353,892	311,425	420,423	22,986	4,647,640	4647640
09. 20 ROADS & BRIDGES									
09. 20.001 Compacted Earth Maintenance Road									
09. 20.001. 1 Clearing & Grubbing, debris	8.30	ACR	5,994	599	527	712	39	7,872	948.38
09. 20.001. 2 Site Preparation	8.30	ACR	12,921	1,292	1,137	1,535	84	16,970	2044.53
TOTAL Compacted Earth Maintenance Road	8.30	ACR	18,915	1,892	1,665	2,247	123	24,841	2992.91
09. 20.002 Paved Maintenance Roads									
09. 20.002. 1 Clearing & Grubbing, debris	9.00	ACR	6,499	650	572	772	42	8,535	948.38
09. 20.002. 2 Site Preparation	18.00	ACR	1,048,766	104,877	92,291	124,593	6,812	1,377,339	76518.83
TOTAL Paved Maintenance Roads	18.00	ACR	1,055,265	105,527	92,863	125,365	6,854	1,385,874	76993.02
09. 20.003 Gravel Maintenance Road									
09. 20.003. 1 Clearing & Grubbing, debris	4.10	ACR	2,961	296	261	352	19	3,888	948.38

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 20.003. 2 Site Preparation	8.20	ACR	146,673	14,667	12,907	17,425	953	192,625	23490.85
TOTAL Gravel Maintenance Road	8.20	ACR	149,634	14,963	13,168	17,776	972	196,513	23965.04
09. 20.005 Bridges									
09. 20.005. 1 Fencing for Erosion Control	9.00	ACR	17,831	1,783	1,569	2,118	116	23,418	2601.96
09. 20.005. 2 Clearing and Grubbing, debris	7.00	ACR	5,055	505	445	601	33	6,639	948.38
09. 20.005. 3 Excavating, structural, sand/	3060.00	CY	10,137	1,014	892	1,204	66	13,313	4.35
09. 20.005. 4 Cast in Place reinforced concret	3060.00	CY	383,516	38,352	33,749	45,562	2,491	503,669	164.60
09. 20.005. 5 Finished grading, tie in, stabl.	9.00	ACR	30,592	3,059	2,692	3,634	199	40,177	4464.06
09. 20.005. 6 Prefab Bridges	9.00	EA	688,642	68,864	60,601	81,811	4,473	904,390	100487.83
TOTAL Bridges	1.00	EA	1,135,773	113,577	99,948	134,930	7,377	1,491,605	1491605
TOTAL ROADS & BRIDGES	1.00	EA	2,359,587	235,959	207,644	280,319	15,326	3,098,834	3098834
09. 25 LET DOWN STRUCTURES									
09. 25.001 Let Down Structures									
09. 25.001. 1 Fencing for Erosion Control	2.50	ACR	9,400	940	827	1,117	61	12,345	4937.91
09. 25.001. 2 Clearing & Grubbing, debris	1.90	ACR	1,372	137	121	163	9	1,802	948.38
09. 25.001. 3 Prep (excav) slope to receive	500.00	CY	750	75	66	89	5	985	1.97
09. 25.001. 4 30" Pipe Laying	1000.00	LF	77,551	7,755	6,825	9,213	504	101,848	101.85
09. 25.001. 5 Backfilling & Compaction	30000.00	CY	100,287	10,029	8,825	11,914	651	131,706	4.39
09. 25.001. 6 Planting and Seeding	2.10	ACR	27,943	2,794	2,459	3,320	181	36,697	17474.79
TOTAL Let Down Structures	1.00	EA	217,303	21,730	19,123	25,816	1,411	285,383	285382.98
TOTAL LET DOWN STRUCTURES	1.00	EA	217,303	21,730	19,123	25,816	1,411	285,383	285382.98
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	35,942,852	3,594,285	3,162,971	4,270,011	233,451	47,203,570	47203570
14 RECREATION									
14. 30 RECREATION FEATURES									
14. 30.001 Parking Areas									
14. 30.001. 1 Fencing for Erosion Control	1.80	ACR	7,976	798	702	948	52	10,474	5819.09
14. 30.001. 2 Clearing & Grubbing, debris	1.80	ACR	1,372	137	121	163	9	1,802	1001.07
14. 30.001. 3 Site Preparation	1.80	ACR	16,941	1,694	1,491	2,013	110	22,249	12360.60
14. 30.001. 4 Asphalt Paving, 6" stone base,	79280.00	SF	129,226	12,923	11,372	15,352	839	169,712	2.14
14. 30.001. 5 Lines on pavement, parking stall			1,500	150	132	178	10	1,970	
14. 30.001. 6 Parking Lot Amenities, lighting,			10,000	1,000	880	1,188	65	13,133	
TOTAL Parking Areas	1.80	ACR	167,016	16,702	14,697	19,841	1,085	219,341	121855.91

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
14. 30.005 Decomposed Granite Trails								
14. 30.005. 1 Clearing & Grubbing, debris	2.00 ACR	1,444	144	127	172	9	1,897	948.38
14. 30.005. 2 Site Preparation	2.00 ACR	9,781	978	861	1,162	64	12,846	6422.83
14. 30.005. 3 Decomposed Granite course,	275740.00 SF	122,006	12,201	10,737	14,494	792	160,230	0.58
14. 30.005. 4 Trail amenities, ADA ramps, sign		10,000	1,000	880	1,188	65	13,133	
TOTAL Decomposed Granite Trails	1.00 EA	143,232	14,323	12,604	17,016	930	188,106	188105.85
14. 30.010 Other Recreation Features								
14. 30.010. 1 Paved Trail amenities, curb	1.00 EA	10,000	1,000	880	1,188	65	13,133	13132.95
14. 30.010. 2 Comfort Stations	3.00 EA	300,000	30,000	26,400	35,640	1,949	393,989	131329.51
14. 30.010. 3 Rest Stops	5.00 EA	15,000	1,500	1,320	1,782	97	19,699	3939.89
14. 30.010. 4 Concrete Benches	21.00 EA	14,909	1,491	1,312	1,771	97	19,580	932.36
14. 30.010. 5 Signage	21.00 EA	585	59	51	70	4	769	36.60
TOTAL Other Recreation Features	1.00 EA	340,494	34,049	29,963	40,451	2,212	447,169	447168.94
TOTAL RECREATION FEATURES	1.00 EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
TOTAL RECREATION	1.00 EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
30 PLANNING, ENGINEERING, DESIGN								
30.009 Construction	1.00 EA	5,120,000	0	0	0	0	5,120,000	5120000
30.014 Recreation	1.00 EA	95,285	0	0	0	0	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00 EA	5,215,285	0	0	0	0	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT								
31.009 Construction (Restoration)	1.00 EA	5,980,000	0	0	0	0	5,980,000	5980000
31.014 Recreation	1.00 EA	63,879	0	0	0	0	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00 EA	6,043,879	0	0	0	0	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00 EA	74,052,757	3,659,359	3,220,236	4,347,319	237,678	85,517,349	85517349
ESCALATION							4,953,123	
SUBTOTAL							90,470,472	
CONTINGENCY							7,118,185	
TOTAL INCL OWNER COSTS							97,588,657	

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	26,200,000	0	0	0	0	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)									
09. 01 IRRIGATION PLANTING									
09. 01.001 Historic Floodplain									
09. 01.001. 1 Fencing for Erosion Control	656.00	ACR	152,278	15,228	13,400	18,091	989	199,985	304.86
09. 01.001. 2 Clearing & Grubbing, Debris	328.00	ACR	473,723	47,372	41,688	56,278	3,077	622,138	1896.76
09. 01.001. 3 Site Preparation									
09. 01.001. 3.01 Ripping, discing to prepare	590.00	ACR	7,369	737	648	875	48	9,678	16.40
09. 01.001. 3.02 Regrade to req'd slopes, flatten	295.00	ACR	1,421	142	125	169	9	1,867	6.33
09. 01.001. 3.03 Regrade Surface, scraper-grader	1445500	CY	24,160	2,416	2,126	2,870	157	31,729	0.02
TOTAL Site Preparation	1.00	EA	32,950	3,295	2,900	3,915	214	43,274	43273.73
09. 01.001. 4 Excavation	176990.00	CY	341,414	34,141	30,044	40,560	2,218	448,377	2.53
09. 01.001. 5 Compaction (tractor wheel, one	3561940	LF	421,465	42,146	37,089	50,070	2,737	553,508	0.16
09. 01.001. 6 Trenching for Water Supply Pipes	17050.00	CY	22,424	2,242	1,973	2,664	146	29,450	1.73
09. 01.001. 7 Pipe bedding, crushed stone	13110.00	CY	651,765	65,176	57,355	77,430	4,233	855,960	65.29
09. 01.001. 8 Install gated 12" PVC pipe for	114720.00	LF	773,155	77,316	68,038	91,851	5,022	1,015,381	8.85
09. 01.001. 9 Install "U" outlet tubes with	5940.00	EA	56,469	5,647	4,969	6,709	367	74,161	12.48
09. 01.001.!0 Backfill pipe trench, side cast	4590.00	CY	1,789	179	157	213	12	2,350	0.51
09. 01.001.!1 Planting & Seeding									
09. 01.001.!1.01 Mulching, hay, 1" deep, power	558.00	ACR	498,695	49,870	43,885	59,245	3,239	654,934	1173.72
09. 01.001.!1.02 Crimping, Tilling topsoil,	558.00	ACR	88,745	8,874	7,810	10,543	576	116,548	208.87
09. 01.001.!1.03 Seeding, athletic fld mix,	623.00	ACR	1,887,502	188,750	166,100	224,235	12,259	2,478,847	3978.89
09. 01.001.!1.04 Place Coarse Woody debris/rocks	558.00	ACR	421,341	42,134	37,078	50,055	2,737	553,345	991.66
09. 01.001.!1.05 Plant Mesquite/Shrub mix using	250729.00	EA	3,760,935	376,094	330,962	446,799	24,428	4,939,217	19.70
TOTAL Planting & Seeding	558.00	ACR	6,657,218	665,722	585,835	790,878	43,239	8,742,892	15668.27
TOTAL Historic Floodplain	1.00	EA	9,584,651	958,465	843,449	1,138,657	62,253	12,587,475	12587475
09. 01.005 Graded Slope									
09. 01.005. 1 Fencing for Erosion Control	102.00	ACR	60,045	6,005	5,284	7,133	390	78,857	773.11
09. 01.005. 2 Clearing & Grubbing, debris	51.00	ACR	36,829	3,683	3,241	4,375	239	48,367	948.38
09. 01.005. 3 Excavation, strl, mach excav.	1213390	CY	641,883	64,188	56,486	76,256	4,169	842,982	0.69
09. 01.005. 4 Excavation, steep slopes, 5:1									
09. 01.005. 4.01 Hauling, no loading, 16.5 cy	1213390	CY	2,690,328	269,033	236,749	319,611	17,474	3,533,195	2.91
09. 01.005. 4.02 Fill, spread dumped material,	1213390	CY	472,979	47,298	41,622	56,190	3,072	621,162	0.51

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 01.005. 4.03	Compaction, sheepfoot/wobbly	1213390	CY	356,979	35,698	31,414	42,409	2,319	468,819	0.39
	TOTAL Excavation, steep slopes, 5:1	1213390	CY	3,520,287	352,029	309,785	418,210	22,865	4,623,176	3.81
09. 01.005. 5	Fine grading to 20% slope,	110.00	ACR	243,040	24,304	21,387	28,873	1,579	319,183	2901.66
09. 01.005. 6	Header Pipe Laying									
09. 01.005. 6.01	Excavate header trench, 12" dep.	2540.00	CY	1,279	128	113	152	8	1,680	0.66
09. 01.005. 6.02	Header Trench bedding, 3/4"	1020.00	CY	23,017	2,302	2,025	2,734	149	30,227	29.63
09. 01.005. 6.03	Install medium diam. PVC Header	7620.00	LF	97,512	9,751	8,581	11,584	633	128,063	16.81
09. 01.005. 6.04	Backfill trench, FE loader,	1020.00	CY	1,675	168	147	199	11	2,200	2.16
09. 01.005. 6.05	Hauling, surplus cut mat'l,	1530.00	CY	5,734	573	505	681	37	7,531	4.92
	TOTAL Header Pipe Laying	7620.00	LF	129,218	12,922	11,371	15,351	839	169,701	22.27
09. 01.005. 7	8" PVC Leach Pipe Laying									
09. 01.005. 7.01	Excavate trench, 12" depth by	99020.00	CY	49,866	4,987	4,388	5,924	324	65,489	0.66
09. 01.005. 7.02	Install low perm geotextile in	148700.00	SY	161,548	16,155	14,216	19,192	1,049	212,160	1.43
09. 01.005. 7.03	Install 8" PVC leach pipe for	445590.00	LF	1,947,006	194,701	171,336	231,304	12,646	2,556,993	5.74
09. 01.005. 7.04	Install leach pipe filter "sock"	445590.00	LF	717,400	71,740	63,131	85,227	4,660	942,158	2.11
09. 01.005. 7.05	Install pipe fittings as needed			27,000	2,700	2,376	3,208	175	35,459	
09. 01.005. 7.06	Backfill trench, FE loader, whl	93380.00	CY	153,367	15,337	13,496	18,220	996	201,417	2.16
09. 01.005. 7.07	Hauling, surplus cut matl, no	5790.00	CY	21,701	2,170	1,910	2,578	141	28,500	4.92
	TOTAL 8" PVC Leach Pipe Laying	445590.00	LF	3,077,888	307,789	270,854	365,653	19,991	4,042,175	9.07
09. 01.005. 8	Planting & Seeding									
09. 01.005. 8.01	Mulch, hay, 1" deep, power	102.00	ACR	91,159	9,116	8,022	10,830	592	119,719	1173.72
09. 01.005. 8.02	Crimping, tilling topsoil	102.00	ACR	16,222	1,622	1,428	1,927	105	21,304	208.87
09. 01.005. 8.03	Seeding, athletic fld mix,	102.00	ACR	309,028	30,903	27,194	36,713	2,007	405,845	3978.87
09. 01.005. 8.04	Place Coarse Woody debris/rocks	102.00	ACR	77,019	7,702	6,778	9,150	500	101,149	991.66
09. 01.005. 8.05	Plant Mesquite/Shrub mix using	45675.00	EA	685,125	68,513	60,291	81,393	4,450	899,771	19.70
	TOTAL Planting & Seeding	102.00	ACR	1,178,554	117,855	103,713	140,012	7,655	1,547,789	15174.40
	TOTAL Graded Slope	1.00	EA	8,887,743	888,774	782,121	1,055,864	57,727	11,672,230	11672230
09. 01.010	Natural Slope									
09. 01.010. 1	Fencing for Erosion Control	18.00	ACR	25,223	2,522	2,220	2,996	164	33,125	1840.29
09. 01.010. 2	Clearing and Grubbing, debris	13.00	ACR	9,388	939	826	1,115	61	12,329	948.38
09. 01.010. 3	Header Trenching									
09. 01.010. 3.01	Excavate header trench, 12" dep.	86.00	CY	43	4	4	5	0	57	0.66

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 01.010. 3.02 Header Trench bedding, 3/4"	35.00 CY	790	79	70	94	5	1,037	29.63
09. 01.010. 3.03 Install med. diam. PVC Header	1520.00 LF	19,451	1,945	1,712	2,311	126	25,545	16.81
09. 01.010. 3.04 Backfill trench, FE loader,	35.00 CY	57	6	5	7	0	75	2.16
09. 01.010. 3.05 Hauling, surplus cut matl, no	52.00 CY	195	19	17	23	1	256	4.92
TOTAL Header Trenching	1520.00 LF	20,537	2,054	1,807	2,440	133	26,971	17.74
09. 01.010. 4 8" PVC Leach Pipe Laying								
09. 01.010. 4.01 Excavate trench, 12" depth by	16780.00 CY	8,450	845	744	1,004	55	11,098	0.66
09. 01.010. 4.02 Install low perm geotextile in	25200.00 SY	27,377	2,738	2,409	3,252	178	35,954	1.43
09. 01.010. 4.03 Install 8" PVC leach pipe for	75510.00 LF	329,941	32,994	29,035	39,197	2,143	433,310	5.74
09. 01.010. 4.04 Install leach pipe filter "sock"	75510.00 LF	121,571	12,157	10,698	14,443	790	159,659	2.11
09. 01.010. 4.05 Install pipe fittings as needed		20,000	2,000	1,760	2,376	130	26,266	
09. 01.010. 4.06 Backfill trench, FE loader, whl	15830.00 CY	25,999	2,600	2,288	3,089	169	34,145	2.16
09. 01.010. 4.07 Hauling, surplus cut matl, no	990.00 CY	3,711	371	327	441	24	4,873	4.92
TOTAL 8" PVC Leach Pipe Laying	75510.00 LF	537,049	53,705	47,260	63,801	3,488	705,304	9.34
09. 01.010. 5 Planting & Seeding								
09. 01.010. 5.01 Mulch, hay, 1" deep, power	18.00 ACR	16,087	1,609	1,416	1,911	104	21,127	1173.72
09. 01.010. 5.02 Crimping, tilling topsoil	18.00 ACR	2,863	286	252	340	19	3,760	208.87
09. 01.010. 5.03 Seeding, athletic fld mix,	18.00 ACR	54,534	5,453	4,799	6,479	354	71,620	3978.87
09. 01.010. 5.04 Place Coarse Woody debris/rocks	18.00 ACR	13,592	1,359	1,196	1,615	88	17,850	991.66
09. 01.010. 5.05 Plant Mesquite/Shrub mix using	7740.00 EA	116,100	11,610	10,217	13,793	754	152,474	19.70
TOTAL Planting & Seeding	18.00 ACR	203,176	20,318	17,879	24,137	1,320	266,830	14823.87
TOTAL Natural Slope	1.00 EA	795,373	79,537	69,993	94,490	5,166	1,044,559	1044559
09. 01.015 Second Bench								
09. 01.015. 1 Fencing for Erosion Control	124.00 ACR	66,198	6,620	5,825	7,864	430	86,937	701.11
09. 01.015. 2 Clearing and Grubbing, debris	93.00 ACR	67,159	6,716	5,910	7,978	436	88,200	948.38
09. 01.015. 3 Header Trenching								
09. 01.015. 3.01 Excavate header trench, 12" dep.	500.00 CY	252	25	22	30	2	331	0.66
09. 01.015. 3.02 Header Trench bedding, 3/4"	200.00 CY	4,513	451	397	536	29	5,927	29.63
09. 01.015. 3.03 Install med. diam. PVC Header	8080.00 LF	103,399	10,340	9,099	12,284	672	135,793	16.81
09. 01.015. 3.04 Backfill trench, FE loader,	200.00 CY	328	33	29	39	2	431	2.16
09. 01.015. 3.05 Hauling, surplus cut matl, no	300.00 CY	1,124	112	99	134	7	1,477	4.92
TOTAL Header Trenching	8080.00 LF	109,617	10,962	9,646	13,022	712	143,959	17.82
09. 01.015. 4 8" PVC Leach Pipe Laying								

		QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 01.015. 4.01	Excavate trench, 12" depth by	121260.00 CY	61,067	6,107	5,374	7,255	397	80,198	0.66
09. 01.015. 4.03	Install 8" PVC leach pipe for	545686.00 LF	2,384,375	238,437	209,825	283,264	15,487	3,131,388	5.74
09. 01.015. 4.04	Install leach pipe filter "sock"	545680.00 LF	878,545	87,854	77,312	104,371	5,706	1,153,789	2.11
09. 01.015. 4.05	Install pipe fittings as needed		25,000	2,500	2,200	2,970	162	32,832	
09. 01.015. 4.06	Backfill trench, FE loader, whl	114360.00 CY	187,825	18,782	16,529	22,314	1,220	246,669	2.16
09. 01.015. 4.07	Hauling, surplus cut matl, no	7090.00 CY	26,573	2,657	2,338	3,157	173	34,899	4.92
	TOTAL 8" PVC Leach Pipe Laying	545686.00 LF	3,563,384	356,338	313,578	423,330	23,144	4,679,775	8.58
09. 01.015. 5	Planting & Seeding								
09. 01.015. 5.01	Mulch, hay, 1" deep, power	125.00 ACR	111,715	11,171	9,831	13,272	726	146,715	1173.72
09. 01.015. 5.02	Crimping, tilling topsoil	125.00 ACR	19,880	1,988	1,749	2,362	129	26,108	208.87
09. 01.015. 5.03	Seeding, athletic fld mix,	125.00 ACR	378,711	37,871	33,327	44,991	2,460	497,359	3978.87
09. 01.015. 5.04	Place Coarse Woody debris/rocks	125.00 ACR	95,226	9,523	8,380	11,313	619	125,060	1000.48
09. 01.015. 5.05	Plant Mesquite/Shrub mix using	55935.00 EA	839,025	83,903	73,834	99,676	5,450	1,101,887	19.70
	TOTAL Planting & Seeding	125.00 ACR	1,444,557	144,456	127,121	171,613	9,383	1,897,130	15177.04
	TOTAL Second Bench	1.00 EA	5,250,915	525,091	462,081	623,809	34,105	6,896,001	6896001
09. 01.020	First Bench								
09. 01.020. 1	Excavate pipe trench, 18" depth	1.00 LF	1	0	0	0	0	1	0.85
	TOTAL Excavate pipe trench, 18" depth	1.00 LF	1	0	0	0	0	1	0.85
09. 01.020. 2	Pipe Laying								
09. 01.020. 2.01	Install small diam pressure pipe	31000.00 LF	116,975	11,698	10,294	13,897	760	153,623	4.96
09. 01.020. 2.02	Install small diam pipe fittings	3100.00 EA	127,968	12,797	11,261	15,203	831	168,060	54.21
09. 01.020. 2.03	Install long reach (150') sprin-	190.00 LF	22,320	2,232	1,964	2,652	145	29,312	154.28
09. 01.020. 2.04	Install pipe thrust blocks at	238.00 EA	11,900	1,190	1,047	1,414	77	15,628	65.66
	TOTAL Pipe Laying	31000.00 LF	279,163	27,916	24,566	33,165	1,813	366,624	11.83
09. 01.020. 3	Backfill pipe trench, compact	31000.00 LF	50,914	5,091	4,480	6,049	331	66,866	2.16
09. 01.020. 4	Install control valves for sprin	90.00 EA	3,960	396	349	470	26	5,201	57.79
09. 01.020. 5	Install Programmable Logic	1.00 EA	500,000	50,000	44,000	59,400	3,248	656,648	656647.54
09. 01.020. 6	Rough grade & scarify subsoil	89.00 ACR	159,167	15,917	14,007	18,909	1,034	209,033	2348.69
09. 01.020. 7	Planting & seeding								
09. 01.020. 7.01	Mulch, hay, 1" deep, power	89.00 ACR	79,541	7,954	7,000	9,449	517	104,461	1173.72
09. 01.020. 7.02	Crimping, tilling topsoil	89.00 ACR	14,155	1,415	1,246	1,682	92	18,589	208.87
09. 01.020. 7.03	Seeding, athletic fld mix,	89.00 ACR	269,642	26,964	23,728	32,033	1,751	354,119	3978.87
09. 01.020. 7.04	Place Coarse Woody debris/rocks	89.00 ACR	23,625	2,363	2,079	2,807	153	31,027	348.62

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 01.020. 7.05 Plant Mesquite/Shrub mix using	55935.00 EA	839,025	83,903	73,834	99,676	5,450	1,101,887	19.70
TOTAL Planting & seeding	89.00 ACR	1,225,988	122,599	107,887	145,647	7,963	1,610,084	18090.83
TOTAL First Bench	1.00 EA	2,219,194	221,919	195,289	263,640	14,414	2,914,456	2914456
TOTAL IRRIGATION PLANTING	1.00 EA	26,737,876	2,673,788	2,352,933	3,176,460	173,664	35,114,721	35114721
09. 05 BASINS PLANTING								
09. 05.001 Tributary Infiltration Basins								
09. 05.001. 1 Fencing for Erosion Control	18.00 ACR	25,223	2,522	2,220	2,996	164	33,125	1840.29
09. 05.001. 2 Clearing and Grubbing, debris	13.00 ACR	9,388	939	826	1,115	61	12,329	948.38
09. 05.001. 3 Excavate, mach exc., sand & grav								
09. 05.001. 3.01 Stockpile useable cut matl,	830.00 CY	851	85	75	101	6	1,118	1.35
09. 05.001. 3.02 Hauling, surplus cut matl, no	2490.00 CY	9,333	933	821	1,109	61	12,256	4.92
09. 05.001. 3.03 Fill, spread cut matl at dump	2490.00 CY	2,208	221	194	262	14	2,900	1.16
09. 05.001. 3.04 Compaction at dump site, hl rlr,	2490.00 CY	733	73	64	87	5	962	0.39
09. 05.001. 3.05 Compact Basin subgrade, existing	86160.00 SY	192,413	19,241	16,932	22,859	1,250	252,694	2.93
TOTAL Excavate, mach exc., sand & grav	8300.00 CY	205,537	20,554	18,087	24,418	1,335	269,930	32.52
09. 05.001. 4 Backfilling								
09. 05.001. 4.01 Fill, bottom layer, clean sand,	840.00 CY	14,910	1,491	1,312	1,771	97	19,581	23.31
09. 05.001. 4.02 Fill, middle layer, No. 57 blue-	840.00 CY	840	84	74	100	5	1,103	1.31
09. 05.001. 4.03 Fill, middle layer, No. 2 gravel	840.00 CY	21,000	2,100	1,848	2,495	136	27,579	32.83
09. 05.001. 4.04 Fill, top layer, mix of native	840.00 CY	25,200	2,520	2,218	2,994	164	33,095	39.40
TOTAL Backfilling	3360.00 CY	61,950	6,195	5,452	7,360	402	81,359	24.21
09. 05.001. 5 Planting & Seeding								
09. 05.001. 5.01 Mulch, hay, 1" deep, power	18.00 ACR	16,087	1,609	1,416	1,911	104	21,127	1173.72
09. 05.001. 5.02 Crimping, tilling topsoil	18.00 ACR	2,863	286	252	340	19	3,760	208.87
09. 05.001. 5.03 Seeding, athletic fld mix,	18.00 ACR	54,534	5,453	4,799	6,479	354	71,620	3978.87
09. 05.001. 5.04 Plant Mesquite/Shrub mix using	3204.00 EA	48,060	4,806	4,229	5,710	312	63,117	19.70
TOTAL Planting & Seeding	18.00 ACR	121,544	12,154	10,696	14,439	789	159,623	8867.95
TOTAL Tributary Infiltration Basins	1.00 EA	423,641	42,364	37,280	50,329	2,752	556,366	556366.16
09. 05.005 Grade Control Infiltration Basin								

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 05.005. 1 Fencing for Erosion Control	6.00 ACR	14,556	1,456	1,281	1,729	95	19,116	3185.95
09. 05.005. 2 Clearing and Grubbing, debris	5.00 ACR	3,611	361	318	429	23	4,742	948.38
09. 05.005. 3 Excavating, mach exc, sand & gr								
09. 05.005. 3.01 Stockpile useable cut mat'l	280.00 CY	287	29	25	34	2	377	1.35
09. 05.005. 3.02 Hauling, surplus cut mat'l, no	840.00 CY	3,148	315	277	374	20	4,135	4.92
09. 05.005. 3.03 Fill, spread cut mat'l at dump	840.00 CY	745	74	66	88	5	978	1.16
TOTAL Excavating, mach exc, sand & gr	1120.00 CY	4,180	418	368	497	27	5,490	4.90
09. 05.005. 4 Compaction at dump site, hl rlr	840.00 CY	247	25	22	29	2	325	0.39
09. 05.005. 5 Compact basin subgrade, existing	29040.00 CY	64,852	6,485	5,707	7,704	421	85,170	2.93
09. 05.005. 6 Backfilling	1160.00 CY	21,390	2,139	1,882	2,541	139	28,092	24.22
09. 05.005. 7 Planting & Seeding								
09. 05.005. 7.01 Mulch, hay, 1" deep, power	6.00 ACR	5,362	536	472	637	35	7,042	1173.72
09. 05.005. 7.02 Crimping, tilling topsoil	6.00 ACR	954	95	84	113	6	1,253	208.87
09. 05.005. 7.03 Seeding, athletic fld mix,	6.00 ACR	18,178	1,818	1,600	2,160	118	23,873	3978.87
TOTAL Planting & Seeding	6.00 ACR	24,495	2,449	2,156	2,910	159	32,169	5361.46
TOTAL Grade Control Infiltration Basin	1.00 EA	133,331	13,333	11,733	15,840	866	175,103	175102.74
TOTAL BASINS PLANTING	1.00 EA	556,972	55,697	49,014	66,168	3,618	731,469	731468.90
09. 10 HARDENED BANKS								
09. 10.001 Hardened Slopes								
09. 10.001. 1 Fencing for Erosion Control	3.50 ACR	11,109	1,111	978	1,320	72	14,589	4168.37
09. 10.001. 2 Clearing and Grubbing, debris	0.90 ACR	650	65	57	77	4	854	948.38
09. 10.001. 3 Excavating, prepare slope &								
09. 10.001. 3.01 Stockpile subgrade cut matl for	28200.00 CY	28,911	2,891	2,544	3,435	188	37,968	1.35
09. 10.001. 3.02 Hauling, no loading, 16.5 cy	18800.00 CY	41,683	4,168	3,668	4,952	271	54,743	2.91
TOTAL Excavating, prepare slope &	47000.00 CY	70,594	7,059	6,212	8,387	459	92,711	1.97
09. 10.001. 4 Fill, spread dumped mat'l, by								
09. 10.001. 4.01 Compaction, sheepfoot/wobbly	18800.00 CY	5,531	553	487	657	36	7,264	0.39
09. 10.001. 4.02 Fine grade to 1:1 slope, for	14900.00 SY	6,802	680	599	808	44	8,933	0.60
TOTAL Fill, spread dumped mat'l, by	18800.00 CY	12,333	1,233	1,085	1,465	80	16,197	0.86
09. 10.001. 5 Soil Cement application,	61100.00 CY	2,382,900	238,290	209,695	283,089	15,477	3,129,451	51.22

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 10.001. 6 Backfill and Compaction								
09. 10.001. 6.01 Backfill subgrade with cut matl	28200.00 CY	46,316	4,632	4,076	5,502	301	60,826	2.16
09. 10.001. 6.02 Compaction, sheepfoot/wobbly whl	28200.00 CY	8,296	830	730	986	54	10,896	0.39
TOTAL Backfill and Compaction	28200.00 CY	54,612	5,461	4,806	6,488	355	71,722	2.54
TOTAL Hardened Slopes	1.00 EA	2,532,198	253,220	222,833	300,825	16,447	3,325,523	3325523
TOTAL HARDENED BANKS	1.00 EA	2,532,198	253,220	222,833	300,825	16,447	3,325,523	3325523
09. 15 PIPING								
09. 15.001 Irrigation Piping								
09. 15.001. 1 Trenching for Delivery Pipe								
09. 15.001. 1.01 Delivery pipe trench bedding,	1260.00 CY	62,641	6,264	5,512	7,442	407	82,266	65.29
09. 15.001. 1.02 Delivery piping, large dia. say	10440.00 LF	206,616	20,662	18,182	24,546	1,342	271,348	25.99
09. 15.001. 1.03 Backfill delivery pipe trench,	1260.00 CY	21,658	2,166	1,906	2,573	141	28,443	22.57
09. 15.001. 1.04 Hauling, Delivery pipe surplus	1880.00 CY	4,168	417	367	495	27	5,474	2.91
TOTAL Trenching for Delivery Pipe	3130.00 CY	295,083	29,508	25,967	35,056	1,917	387,531	123.81
09. 15.001. 2 Trenching for Main Pipe								
09. 15.001. 2.01 Main pipe trench bedding,	8400.00 CY	417,607	41,761	36,749	49,612	2,712	548,441	65.29
09. 15.001. 2.02 Main piping, large dia. say	69970.00 LF	1,384,762	138,476	121,859	164,510	8,994	1,818,601	25.99
09. 15.001. 2.03 Backfill Main pipe trench,	8400.00 CY	144,386	14,439	12,706	17,153	938	189,621	22.57
09. 15.001. 2.04 Hauling, Main pipe surplus	12600.00 CY	27,937	2,794	2,458	3,319	181	36,689	2.91
TOTAL Trenching for Main Pipe	21000.00 CY	1,974,692	197,469	173,773	234,593	12,826	2,593,353	123.49
09. 15.001. 3 Trenching for Sub-main Pipe								
09. 15.001. 3.01 Sub-main pipe trench bedding,	3370.00 CY	167,540	16,754	14,744	19,904	1,088	220,029	65.29
09. 15.001. 3.02 Sub-main piping, large dia. say	28010.00 LF	288,074	28,807	25,351	34,223	1,871	378,327	13.51
09. 15.001. 3.03 Backfill Sub-main pipe trench,	3370.00 CY	57,926	5,793	5,098	6,882	376	76,074	22.57
09. 15.001. 3.04 Hauling, Sub-main pipe surplus	5050.00 CY	11,197	1,120	985	1,330	73	14,705	2.91
TOTAL Trenching for Sub-main Pipe	8420.00 CY	524,737	52,474	46,177	62,339	3,408	689,135	81.85
09. 15.001. 4 Trenching for Culvert CMP								
09. 15.001. 4.01 Culvert trench bedding,	4200.00 CY	208,803	20,880	18,375	24,806	1,356	274,221	65.29
09. 15.001. 4.02 Install 24" dia. CMP Culvert for	23600.00 LF	449,438	44,944	39,551	53,393	2,919	590,245	25.01
09. 15.001. 4.03 Backfill trench, FE Loader,	4200.00 CY	72,193	7,219	6,353	8,577	469	94,811	22.57

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 15.001. 4.04 Hauling, Sub-main pipe surplus	6300.00 CY	13,968	1,397	1,229	1,659	91	18,345	2.91
TOTAL Trenching for Culvert CMP	10500.00 CY	744,403	74,440	65,507	88,435	4,835	977,621	93.11
TOTAL Irrigation Piping	1.00 EA	3,538,916	353,892	311,425	420,423	22,986	4,647,640	4647640
TOTAL PIPING	1.00 EA	3,538,916	353,892	311,425	420,423	22,986	4,647,640	4647640
09. 20 ROADS & BRIDGES								
09. 20.001 Compacted Earth Maintenance Road								
09. 20.001. 1 Clearing & Grubbing, debris	8.30 ACR	5,994	599	527	712	39	7,872	948.38
TOTAL Clearing & Grubbing, debris	8.30 ACR	5,994	599	527	712	39	7,872	948.38
09. 20.001. 2 Site Preparation								
09. 20.001. 2.01 Ripping, discing to prepare	8.30 ACR	104	10	9	12	1	136	16.40
09. 20.001. 2.02 Regrade, flatten, balance cut	2020.00 CY	973	97	86	116	6	1,278	0.63
09. 20.001. 2.03 Compaction, riding, sheepfoot/	40260.00 SY	11,844	1,184	1,042	1,407	77	15,555	0.39
TOTAL Site Preparation	8.30 ACR	12,921	1,292	1,137	1,535	84	16,970	2044.53
TOTAL Compacted Earth Maintenance Road	8.30 ACR	18,915	1,892	1,665	2,247	123	24,841	2992.91
09. 20.002 Paved Maintenance Roads								
09. 20.002. 1 Clearing & Grubbing, debris	9.00 ACR	6,499	650	572	772	42	8,535	948.38
TOTAL Clearing & Grubbing, debris	9.00 ACR	6,499	650	572	772	42	8,535	948.38
09. 20.002. 2 Site Preparation								
09. 20.002. 2.01 Ripping, discing to prepare	18.00 ACR	225	22	20	27	1	295	16.40
09. 20.002. 2.02 Regrade, flatten, balance cut	21880.00 CY	10,542	1,054	928	1,252	68	13,844	0.63
09. 20.002. 2.03 Compaction, riding, sheepfoot/	86820.00 SY	25,542	2,554	2,248	3,034	166	33,545	0.39
09. 20.002. 2.04 Asphalt Concrete Paving,	781310.00 SF	1,012,457	101,246	89,096	120,280	6,576	1,329,654	1.70
TOTAL Site Preparation	18.00 ACR	1,048,766	104,877	92,291	124,593	6,812	1,377,339	76518.83
TOTAL Paved Maintenance Roads	18.00 ACR	1,055,265	105,527	92,863	125,365	6,854	1,385,874	76993.02
09. 20.003 Gravel Maintenance Road								

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 20.003. 1 Clearing & Grubbing, debris	4.10	ACR	2,961	296	261	352	19	3,888	948.38
TOTAL Clearing & Grubbing, debris	4.10	ACR	2,961	296	261	352	19	3,888	948.38
09. 20.003. 2 Site Preparation									
09. 20.003. 2.01 Ripping, discing to prepare	8.20	ACR	102	10	9	12	1	135	16.40
09. 20.003. 2.02 Regrade, flatten, balance cut	1980.00	CY	954	95	84	113	6	1,253	0.63
09. 20.003. 2.03 Compaction, riding, sheepfoot/	39530.00	SY	11,630	1,163	1,023	1,382	76	15,273	0.39
09. 20.003. 2.04 Gravel course, crushed 3/4"	39530.00	SY	133,987	13,399	11,791	15,918	870	175,964	4.45
TOTAL Site Preparation	8.20	ACR	146,673	14,667	12,907	17,425	953	192,625	23490.85
TOTAL Gravel Maintenance Road	8.20	ACR	149,634	14,963	13,168	17,776	972	196,513	23965.04
09. 20.005 Bridges									
09. 20.005. 1 Fencing for Erosion Control	9.00	ACR	17,831	1,783	1,569	2,118	116	23,418	2601.96
09. 20.005. 2 Clearing and Grubbing, debris	7.00	ACR	5,055	505	445	601	33	6,639	948.38
09. 20.005. 3 Excavating, structural, sand/									
09. 20.005. 3.01 Hauling, no loading, 16.5 cy	3366.00	CY	7,463	746	657	887	48	9,801	2.91
09. 20.005. 3.02 Fill, spread dumped matl, by	3366.00	CY	1,774	177	156	211	12	2,329	0.69
09. 20.005. 3.03 Compaction, sheepfoot/wobbly	3060.00	CY	900	90	79	107	6	1,182	0.39
TOTAL Excavating, structural, sand/	3060.00	CY	10,137	1,014	892	1,204	66	13,313	4.35
09. 20.005. 4 Cast in Place reinforced concret	3060.00	CY	383,516	38,352	33,749	45,562	2,491	503,669	164.60
09. 20.005. 5 Finished grading, tie in, stabl.	9.00	ACR	30,592	3,059	2,692	3,634	199	40,177	4464.06
09. 20.005. 6 Prefab Bridges									
09. 20.005. 6.01 Prefab Bridges (9 ea)			602,589	60,259	53,028	71,588	3,914	791,377	
09. 20.005. 6.02 Unloading and Erection	8090.00	SF	86,053	8,605	7,573	10,223	559	113,013	13.97
TOTAL Prefab Bridges	9.00	EA	688,642	68,864	60,601	81,811	4,473	904,390	100487.83
TOTAL Bridges	1.00	EA	1,135,773	113,577	99,948	134,930	7,377	1,491,605	1491605
TOTAL ROADS & BRIDGES	1.00	EA	2,359,587	235,959	207,644	280,319	15,326	3,098,834	3098834
09. 25 LET DOWN STRUCTURES									
09. 25.001 Let Down Structures									
09. 25.001. 1 Fencing for Erosion Control	2.50	ACR	9,400	940	827	1,117	61	12,345	4937.91
09. 25.001. 2 Clearing & Grubbing, debris	1.90	ACR	1,372	137	121	163	9	1,802	948.38

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
09. 25.001. 3 Prep (excav) slope to receive	500.00 CY	750	75	66	89	5	985	1.97
09. 25.001. 4 30" Pipe Laying								
09. 25.001. 4.01 Install pipe bedding, gravel,	150.00 CY	7,457	746	656	886	48	9,794	65.29
09. 25.001. 4.02 Install 30" dia CMP, 200 lf per	1000.00 LF	40,094	4,009	3,528	4,763	260	52,655	52.66
09. 25.001. 4.03 Install wingwall deflectors on	10.00 EA	30,000	3,000	2,640	3,564	195	39,399	3939.89
TOTAL 30" Pipe Laying	1000.00 LF	77,551	7,755	6,825	9,213	504	101,848	101.85
09. 25.001. 5 Backfilling & Compaction								
09. 25.001. 5.01 Hauling, no loading, 16.5 cy	30000.00 CY	66,516	6,652	5,853	7,902	432	87,355	2.91
09. 25.001. 5.02 Fill, spread dumped matl, by	30000.00 CY	19,500	1,950	1,716	2,317	127	25,609	0.85
09. 25.001. 5.03 Compaction, sheepfoot/wobbly	30000.00 CY	8,826	883	777	1,049	57	11,591	0.39
09. 25.001. 5.04 Fine grade filled area, for	2.50 ACR	5,445	545	479	647	35	7,151	2860.36
TOTAL Backfilling & Compaction	30000.00 CY	100,287	10,029	8,825	11,914	651	131,706	4.39
09. 25.001. 6 Planting and Seeding								
09. 25.001. 6.01 Mulching, hay, 1" deep, power	2.10 ACR	1,877	188	165	223	12	2,465	1173.72
09. 25.001. 6.02 Crimping, tilling topsoil	2.10 ACR	334	33	29	40	2	439	208.87
09. 25.001. 6.03 Seeding, athletic fld mix,	2.40 ACR	7,271	727	640	864	47	9,549	3978.87
09. 25.001. 6.04 Place Coarse Woody debris/rocks	2.10 ACR	1,586	159	140	188	10	2,082	991.66
09. 25.001. 6.05 Plant Mesquite/Shrub mix using	1125.00 EA	16,875	1,688	1,485	2,005	110	22,162	19.70
TOTAL Planting and Seeding	2.10 ACR	27,943	2,794	2,459	3,320	181	36,697	17474.79
TOTAL Let Down Structures	1.00 EA	217,303	21,730	19,123	25,816	1,411	285,383	285382.98
TOTAL LET DOWN STRUCTURES	1.00 EA	217,303	21,730	19,123	25,816	1,411	285,383	285382.98
TOTAL CONSTRUCTION (RESTORATION)	1.00 EA	35,942,852	3,594,285	3,162,971	4,270,011	233,451	47,203,570	47203570
14 RECREATION								
14. 30 RECREATION FEATURES								
14. 30.001 Parking Areas								
14. 30.001. 1 Fencing for Erosion Control	1.80 ACR	7,976	798	702	948	52	10,474	5819.09
14. 30.001. 2 Clearing & Grubbing, debris	1.80 ACR	1,372	137	121	163	9	1,802	1001.07
14. 30.001. 3 Site Preparation								
14. 30.001. 3.01 Ripping, discing to prepare	1.80 ACR	22	2	2	3	0	30	16.40
14. 30.001. 3.02 Regrade to req'd slopes, flatten	1.80 ACR	9	1	1	1	0	11	6.33

** PROJECT INDIRECT SUMMARY - Assm Cat **

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
14. 30.001. 3.03 Regrade surface, scraper-grader,	4410.00 CY	9,587	959	844	1,139	62	12,590	2.85
14. 30.001. 3.04 Compaction, riding, sheepfoot	8810.00 SY	2,592	259	228	308	17	3,404	0.39
14. 30.001. 3.05 Fine grade, grade subgrade for	8810.00 SY	4,731	473	416	562	31	6,214	0.71
TOTAL Site Preparation	1.80 ACR	16,941	1,694	1,491	2,013	110	22,249	12360.60
14. 30.001. 4 Asphalt Paving, 6" stone base,	79280.00 SF	129,226	12,923	11,372	15,352	839	169,712	2.14
14. 30.001. 5 Lines on pavement, parking stall		1,500	150	132	178	10	1,970	
14. 30.001. 6 Parking Lot Amenities, lighting,		10,000	1,000	880	1,188	65	13,133	
TOTAL Parking Areas	1.80 ACR	167,016	16,702	14,697	19,841	1,085	219,341	121855.91
14. 30.005 Decomposed Granite Trails								
14. 30.005. 1 Clearing & Grubbing, debris	2.00 ACR	1,444	144	127	172	9	1,897	948.38
TOTAL Clearing & Grubbing, debris	2.00 ACR	1,444	144	127	172	9	1,897	948.38
14. 30.005. 2 Site Preparation								
14. 30.005. 2.01 Ripping, discing to prepare	2.00 ACR	25	2	2	3	0	33	16.40
14. 30.005. 2.02 Regrade, flatten, balance cut	1540.00 CY	742	74	65	88	5	974	0.63
14. 30.005. 2.03 Compaction, riding, sheepfoot/	30640.00 SY	9,014	901	793	1,071	59	11,838	0.39
TOTAL Site Preparation	2.00 ACR	9,781	978	861	1,162	64	12,846	6422.83
14. 30.005. 3 Decomposed Granite course,								
14. 30.005. 3.01 Material and Delivery	3830.00 TON	114,900	11,490	10,111	13,650	746	150,898	39.40
14. 30.005. 3.02 Spread and Compaction	3830.00 TON	7,106	711	625	844	46	9,333	2.44
TOTAL Decomposed Granite course,	275740.00 SF	122,006	12,201	10,737	14,494	792	160,230	0.58
14. 30.005. 4 Trail amenities, ADA ramps, sign		10,000	1,000	880	1,188	65	13,133	
TOTAL Decomposed Granite Trails	1.00 EA	143,232	14,323	12,604	17,016	930	188,106	188105.85
14. 30.010 Other Recreation Features								
14. 30.010. 1 Paved Trail amenities, curb	1.00 EA	10,000	1,000	880	1,188	65	13,133	13132.95
14. 30.010. 2 Comfort Stations	3.00 EA	300,000	30,000	26,400	35,640	1,949	393,989	131329.51
14. 30.010. 3 Rest Stops	5.00 EA	15,000	1,500	1,320	1,782	97	19,699	3939.89
14. 30.010. 4 Concrete Benches	21.00 EA	14,909	1,491	1,312	1,771	97	19,580	932.36
14. 30.010. 5 Signage	21.00 EA	585	59	51	70	4	769	36.60
TOTAL Other Recreation Features	1.00 EA	340,494	34,049	29,963	40,451	2,212	447,169	447168.94

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
TOTAL RECREATION FEATURES	1.00	EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
TOTAL RECREATION	1.00	EA	650,741	65,074	57,265	77,308	4,227	854,615	854615.43
30 PLANNING, ENGINEERING, DESIGN									
30.009 Construction	1.00	EA	5,120,000	0	0	0	0	5,120,000	5120000
30.014 Recreation	1.00	EA	95,285	0	0	0	0	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	5,215,285	0	0	0	0	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT									
31.009 Construction (Restoration)	1.00	EA	5,980,000	0	0	0	0	5,980,000	5980000
31.014 Recreation	1.00	EA	63,879	0	0	0	0	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	6,043,879	0	0	0	0	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	74,052,757	3,659,359	3,220,236	4,347,319	237,678	85,517,349	85517349
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

** PROJECT DIRECT SUMMARY - Scope **

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	0	0	0	0	26,200,000	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)	1.00	EA	343,303	10546426	4813116	12682559	7,900,751	35,942,852	35942852
14 RECREATION	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
30 PLANNING, ENGINEERING, DESIGN	1.00	EA	0	0	0	0	5,215,285	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT	1.00	EA	0	0	0	0	6,043,879	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	344,214	10582793	4845615	12803035	45,821,315	74,052,757	74052757
OVERHEAD								3,659,359	
SUBTOTAL								77,712,116	
HOME OFC								3,220,236	
SUBTOTAL								80,932,352	
PROFIT								4,347,319	
SUBTOTAL								85,279,671	
BOND								237,678	
TOTAL INCL INDIRECTS								85,517,349	
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

** PROJECT DIRECT SUMMARY - Facility **

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	0	0	0	0	26,200,000	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)									
09. 01 IRRIGATION PLANTING	1.00	EA	287,141	8210895	3807079	7083380	7,636,522	26,737,876	26737876
09. 05 BASINS PLANTING	1.00	EA	14,082	317,937	18,040	89,594	131,400	556,972	556972.24
09. 10 HARDENED BANKS	1.00	EA	2,422	801,347	686,566	1044285	0	2,532,198	2532198
09. 15 PIPING	1.00	EA	26,572	804,650	75,147	2659119	0	3,538,916	3538916
09. 20 ROADS & BRIDGES	1.00	EA	11,176	362,784	171,054	1765490	60,259	2,359,587	2359587
09. 25 LET DOWN STRUCTURES	1.00	EA	1,910	48,812	55,230	40,691	72,570	217,303	217303.02
TOTAL CONSTRUCTIDN (RESTORATION)	1.00	EA	343,303	10546426	4813116	12682559	7,900,751	35,942,852	35942852
14 RECREATION									
14. 30 RECREATION FEATURES	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
TOTAL RECREATION	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
30 PLANNING, ENGINEERING, DESIGN									
30.009 Construction	1.00	EA	0	0	0	0	5,120,000	5,120,000	5120000
30.014 Recreation	1.00	EA	0	0	0	0	95,285	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	0	0	0	0	5,215,285	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT									
31.009 Construction (Restoration)	1.00	EA	0	0	0	0	5,980,000	5,980,000	5980000
31.014 Recreation	1.00	EA	0	0	0	0	63,879	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	0	0	0	0	6,043,879	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	344,214	10582793	4845615	12803035	45,821,315	74,052,757	74052757
OVERHEAD								3,659,359	
SUBTOTAL								77,712,116	
HOME OFC								3,220,236	
SUBTOTAL								80,932,352	
PROFIT								4,347,319	
SUBTOTAL								85,279,671	
BOND								237,678	
TOTAL INCL INDIRECTS								85,517,349	
ESCALATION								4,953,123	

** PROJECT DIRECT SUMMARY - Facility **

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	0	0	0	0	26,200,000	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)									
09. 01 IRRIGATION PLANTING									
09. 01.001 Historic Floodplain	1.00	EA	87,267	2225592	658,160	2802300	3,898,599	9,584,651	9584651
09. 01.005 Graded Slope	1.00	EA	115,227	3384867	2817665	1688173	997,038	8,887,743	8887743
09. 01.010 Natural Slope	1.00	EA	9,473	298,169	27,076	301,170	168,957	795,373	795372.60
09. 01.015 Second Bench	1.00	EA	62,207	1936987	176,205	1916720	1,221,003	5,250,915	5250915
09. 01.020 First Bench	1.00	EA	12,967	365,280	127,972	375,017	1,350,925	2,219,194	2219194
TOTAL IRRIGATION PLANTING	1.00	EA	287,141	8210895	3807079	7083380	7,636,522	26,737,876	26737876
09. 05 BASINS PLANTING									
09. 05.001 Tributary Infiltration Basins	1.00	EA	10,426	235,402	13,352	64,878	110,010	423,641	423641.40
09. 05.005 Grade Control Infiltration Basin	1.00	EA	3,656	82,535	4,689	24,717	21,390	133,331	133330.84
TOTAL BASINS PLANTING	1.00	EA	14,082	317,937	18,040	89,594	131,400	556,972	556972.24
09. 10 HARDENED BANKS									
09. 10.001 Hardened Slopes	1.00	EA	2,422	801,347	686,566	1044285	0	2,532,198	2532198
TOTAL HARDENED BANKS	1.00	EA	2,422	801,347	686,566	1044285	0	2,532,198	2532198
09. 15 PIPING									
09. 15.001 Irrigation Piping	1.00	EA	26,572	804,650	75,147	2659119	0	3,538,916	3538916
TOTAL PIPING	1.00	EA	26,572	804,650	75,147	2659119	0	3,538,916	3538916
09. 20 ROADS & BRIDGES									
09. 20.001 Compacted Earth Maintenance Road	8.30	ACR	331	9,353	9,562	0	0	18,915	2278.93
09. 20.002 Paved Maintenance Roads	18.00	ACR	3,615	119,850	86,291	849,124	0	1,055,265	58625.84
09. 20.003 Gravel Maintenance Road	8.20	ACR	706	20,773	26,083	102,778	0	149,634	18248.03
09. 20.005 Bridges	1.00	EA	6,524	212,807	49,119	813,588	60,259	1,135,773	1135773
TOTAL ROADS & BRIDGES	1.00	EA	11,176	362,784	171,054	1765490	60,259	2,359,587	2359587
09. 25 LET DOWN STRUCTURES									
09. 25.001 Let Down Structures	1.00	EA	1,910	48,812	55,230	40,691	72,570	217,303	217303.02

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL LET DOWN STRUCTURES	1.00	EA	1,910	48,812	55,230	40,691	72,570	217,303	217303.02
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	343,303	10546426	4813116	12682559	7,900,751	35,942,852	35942852
14 RECREATION									
14. 30 RECREATION FEATURES									
14. 30.001 Parking Areas	1.80	ACR	474	24,444	23,998	107,074	11,500	167,016	92786.39
14. 30.005 Decomposed Granite Trails	1.00	EA	343	9,831	8,501	0	124,900	143,232	143231.98
14. 30.010 Other Recreation Features	1.00	EA	95	2,091	0	13,402	325,000	340,494	340493.88
TOTAL RECREATION FEATURES	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
TOTAL RECREATION	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
30 PLANNING, ENGINEERING, DESIGN									
30.009 Construction	1.00	EA	0	0	0	0	5,120,000	5,120,000	5120000
30.014 Recreation	1.00	EA	0	0	0	0	95,285	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	0	0	0	0	5,215,285	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT									
31.009 Construction (Restoration)	1.00	EA	0	0	0	0	5,980,000	5,980,000	5980000
31.014 Recreation	1.00	EA	0	0	0	0	63,879	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	0	0	0	0	6,043,879	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	344,214	10582793	4845615	12803035	45,821,315	74,052,757	74052757
OVERHEAD								3,659,359	
SUBTOTAL								77,712,116	
HOME OFC								3,220,236	
SUBTOTAL								80,932,352	
PROFIT								4,347,319	
SUBTOTAL								85,279,671	
BOND								237,678	
TOTAL INCL INDIRECTS								85,517,349	
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL INCL OWNER COSTS								97,588,657	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	0	0	0	0	26,200,000	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)									
09. 01 IRRIGATION PLANTING									
09. 01.001 Historic Floodplain									
09. 01.001. 1 Fencing for Erosion Control	656.00	ACR	3,421	75,723	0	76,555	0	152,278	232.13
09. 01.001. 2 Clearing & Grubbing, Debris	328.00	ACR	9,338	271,648	202,076	0	0	473,723	1444.28
09. 01.001. 3 Site Preparation	1.00	EA	346	10,505	22,445	0	0	32,950	32950.50
09. 01.001. 4 Excavation	176990.00	CY	6,850	205,185	136,229	0	0	341,414	1.93
09. 01.001. 5 Compaction (tractor wheel, one	3561940	LF	6,918	206,632	214,833	0	0	421,465	0.12
09. 01.001. 6 Trenching for Water Supply Pipes	17050.00	CY	355	11,265	11,159	0	0	22,424	1.32
09. 01.001. 7 Pipe bedding, crushed stone	13110.00	CY	1,210	30,281	6,100	615,383	0	651,765	49.72
09. 01.001. 8 Install gated 12" PVC pipe for	114720.00	LF	9,178	306,245	0	329,246	137,664	773,155	6.74
09. 01.001. 9 Install "U" outlet tubes with	5940.00	EA	1,667	55,638	0	832	0	56,469	9.51
09. 01.001.10 Backfill pipe trench, side cast	4590.00	CY	24	725	1,064	0	0	1,789	0.39
09. 01.001.11 Planting & Seeding	558.00	ACR	47,960	1051746	64,254	1780284	3,760,935	6,657,218	11930.50
TOTAL Historic Floodplain	1.00	EA	87,267	2225592	658,160	2802300	3,898,599	9,584,651	9584651
09. 01.005 Graded Slope									
09. 01.005. 1 Fencing for Erosion Control	102.00	ACR	1,349	29,859	0	30,187	0	60,045	588.68
09. 01.005. 2 Clearing & Grubbing, debris	51.00	ACR	726	21,119	15,710	0	0	36,829	722.14
09. 01.005. 3 Excavation, strl, mach excav.	1213390	CY	9,464	300,071	341,812	0	0	641,883	0.53
09. 01.005. 4 Excavation, steep slopes, 5:1	1213390	CY	47,201	1296750	2223537	0	0	3,520,287	2.90
09. 01.005. 5 Fine grading to 20% slope,	110.00	ACR	5,324	149,044	93,995	0	0	243,040	2209.45
09. 01.005. 6 Header Pipe Laying	7620.00	LF	984	31,922	8,890	88,405	0	129,218	16.96
09. 01.005. 7 8" PVC Leach Pipe Laying	445590.00	LF	41,929	1375303	121,975	1268697	311,913	3,077,888	6.91
09. 01.005. 8 Planting & Seeding	102.00	ACR	8,249	180,799	11,745	300,884	685,125	1,178,554	11554.45
TOTAL Graded Slope	1.00	EA	115,227	3384867	2817665	1688173	997,038	8,887,743	8887743
09. 01.010 Natural Slope									
09. 01.010. 1 Fencing for Erosion Control	18.00	ACR	567	12,543	0	12,680	0	25,223	1401.27
09. 01.010. 2 Clearing and Grubbing, debris	13.00	ACR	185	5,383	4,005	0	0	9,388	722.14
09. 01.010. 3 Header Trenching	1520.00	LF	160	5,294	304	14,939	0	20,537	13.51
09. 01.010. 4 8" PVC Leach Pipe Laying	75510.00	LF	7,106	243,044	20,696	220,453	52,857	537,049	7.11
09. 01.010. 5 Planting & Seeding	18.00	ACR	1,456	31,906	2,073	53,097	116,100	203,176	11287.54
TOTAL Natural Slope	1.00	EA	9,473	298,169	27,076	301,170	168,957	795,373	795372.60
09. 01.015 Second Bench									
09. 01.015. 1 Fencing for Erosion Control	124.00	ACR	1,487	32,918	0	33,280	0	66,198	533.85

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.015. 2 Clearing and Grubbing, debris	93.00	ACR	1,324	38,511	28,648	0	0	67,159	722.14
09. 01.015. 3 Header Trenching	8080.00	LF	852	28,236	1,744	79,637	0	109,617	13.57
09. 01.015. 4 8" PVC Leach Pipe Laying	545686.00	LF	48,435	1615754	131,420	1434233	381,978	3,563,384	6.53
09. 01.015. 5 Planting & Seeding	125.00	ACR	10,109	221,568	14,394	369,571	839,025	1,444,557	11556.46
TOTAL Second Bench	1.00	EA	62,207	1936987	176,205	1916720	1,221,003	5,250,915	5250915
09. 01.020 First Bench									
09. 01.020. 1 Excavate pipe trench, 18" depth	1.00	LF	0	1	0	0	0	1	0.65
09. 01.020. 2 Pipe Laying	31000.00	LF	4,741	157,025	0	110,239	11,900	279,163	9.01
09. 01.020. 3 Backfill pipe trench, compact	31000.00	LF	930	27,854	23,061	0	0	50,914	1.64
09. 01.020. 4 Install control valves for sprin	90.00	EA	80	1,868	0	2,093	0	3,960	44.00
09. 01.020. 5 Install Programmable Logic	1.00	EA	0	0	0	0	500,000	500,000	500000.00
09. 01.020. 6 Rough grade & scarify subsoil	89.00	ACR	2,154	64,504	94,663	0	0	159,167	1788.39
09. 01.020. 7 Planting & seeding	89.00	ACR	5,062	114,029	10,248	262,686	839,025	1,225,988	13775.15
TOTAL First Bench	1.00	EA	12,967	365,280	127,972	375,017	1,350,925	2,219,194	2219194
TOTAL IRRIGATION PLANTING	1.00	EA	287,141	8210895	3807079	7083380	7,636,522	26,737,876	26737876
09. 05 BASINS PLANTING									
09. 05.001 Tributary Infiltration Basins									
09. 05.001. 1 Fencing for Erosion Control	18.00	ACR	567	12,543	0	12,680	0	25,223	1401.27
09. 05.001. 2 Clearing and Grubbing, debris	13.00	ACR	185	5,383	4,005	0	0	9,388	722.14
09. 05.001. 3 Excavate, mach exc., sand & grav	8300.00	CY	8,794	197,362	8,174	0	0	205,537	24.76
09. 05.001. 4 Backfilling	3360.00	CY	0	0	0	0	61,950	61,950	18.44
09. 05.001. 5 Planting & Seeding	18.00	ACR	880	20,114	1,173	52,197	48,060	121,544	6752.45
TOTAL Tributary Infiltration Basins	1.00	EA	10,426	235,402	13,352	64,878	110,010	423,641	423641.40
09. 05.005 Grade Control Infiltration Basin									
09. 05.005. 1 Fencing for Erosion Control	6.00	ACR	327	7,238	0	7,318	0	14,556	2425.92
09. 05.005. 2 Clearing and Grubbing, debris	5.00	ACR	71	2,070	1,540	0	0	3,611	722.14
09. 05.005. 3 Excavating, mach exc, sand & gr	1120.00	CY	56	1,554	2,627	0	0	4,180	3.73
09. 05.005. 4 Compaction at dump site, hl rlr	840.00	CY	4	116	131	0	0	247	0.29
09. 05.005. 5 Compact basin subgrade, existing	29040.00	CY	2,904	64,852	0	0	0	64,852	2.23
09. 05.005. 6 Backfilling	1160.00	CY	0	0	0	0	21,390	21,390	18.44
09. 05.005. 7 Planting & Seeding	6.00	ACR	293	6,705	391	17,399	0	24,495	4082.45
TOTAL Grade Control Infiltration Basin	1.00	EA	3,656	82,535	4,689	24,717	21,390	133,331	133330.84
TOTAL BASINS PLANTING	1.00	EA	14,082	317,937	18,040	89,594	131,400	556,972	556972.24

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 10 HARDENED BANKS									
09. 10.001 Hardened Slopes									
09. 10.001. 1 Fencing for Erosion Control	3.50	ACR	250	5,524	0	5,585	0	11,109	3173.98
09. 10.001. 2 Clearing and Grubbing, debris	0.90	ACR	13	373	277	0	0	650	722.14
09. 10.001. 3 Excavating, prepare slope &	47000.00	CY	930	26,236	44,358	0	0	70,594	1.50
09. 10.001. 4 Fill, spread dumped mat'l, by	18800.00	CY	243	6,773	5,560	0	0	12,333	0.66
09. 10.001. 5 Soil Cement application,	61100.00	CY	0	733,200	611,000	1038700	0	2,382,900	39.00
09. 10.001. 6 Backfill and Compaction	28200.00	CY	987	29,241	25,372	0	0	54,612	1.94
TOTAL Hardened Slopes	1.00	EA	2,422	801,347	686,566	1044285	0	2,532,198	2532198
TOTAL HARDENED BANKS	1.00	EA	2,422	801,347	686,566	1044285	0	2,532,198	2532198
09. 15 PIPING									
09. 15.001 Irrigation Piping									
09. 15.001. 1 Trenching for Delivery Pipe	3130.00	CY	2,006	65,488	4,289	225,306	0	295,083	94.28
09. 15.001. 2 Trenching for Main Pipe	21000.00	CY	13,436	438,762	28,691	1507239	0	1,974,692	94.03
09. 15.001. 3 Trenching for Sub-main Pipe	8420.00	CY	3,957	128,164	11,504	385,070	0	524,737	62.32
09. 15.001. 4 Trenching for Culvert CMP	10500.00	CY	7,174	172,236	30,663	541,504	0	744,403	70.90
TOTAL Irrigation Piping	1.00	EA	26,572	804,650	75,147	2659119	0	3,538,916	3538916
TOTAL PIPING	1.00	EA	26,572	804,650	75,147	2659119	0	3,538,916	3538916
09. 20 ROADS & BRIDGES									
09. 20.001 Compacted Earth Maintenance Road									
09. 20.001. 1 Clearing & Grubbing, debris	8.30	ACR	118	3,437	2,557	0	0	5,994	722.14
09. 20.001. 2 Site Preparation	8.30	ACR	213	5,916	7,005	0	0	12,921	1556.79
TOTAL Compacted Earth Maintenance Road	8.30	ACR	331	9,353	9,562	0	0	18,915	2278.93
09. 20.002 Paved Maintenance Roads									
09. 20.002. 1 Clearing & Grubbing, debris	9.00	ACR	128	3,727	2,772	0	0	6,499	722.14
09. 20.002. 2 Site Preparation	18.00	ACR	3,487	116,123	83,518	849,124	0	1,048,766	58264.77
TOTAL Paved Maintenance Roads	18.00	ACR	3,615	119,850	86,291	849,124	0	1,055,265	58625.84
09. 20.003 Gravel Maintenance Road									
09. 20.003. 1 Clearing & Grubbing, debris	4.10	ACR	58	1,698	1,263	0	0	2,961	722.14

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 20.003. 2	Site Preparation	8.20	ACR	648	19,075	24,820	102,778	0	146,673	17886.96
	TOTAL Gravel Maintenance Road	8.20	ACR	706	20,773	26,083	102,778	0	149,634	18248.03
09. 20.005	Bridges									
09. 20.005. 1	Fencing for Erosion Control	9.00	ACR	401	8,867	0	8,964	0	17,831	1981.25
09. 20.005. 2	Clearing and Grubbing, debris	7.00	ACR	100	2,899	2,156	0	0	5,055	722.14
09. 20.005. 3	Excavating, structural, sand/	3060.00	CY	148	4,123	6,014	0	0	10,137	3.31
09. 20.005. 4	Cast in Place reinforced concret	3060.00	CY	3,587	121,222	0	262,294	0	383,516	125.33
09. 20.005. 5	Finished grading, tie in, stabl.	9.00	ACR	671	18,761	11,831	0	0	30,592	3399.13
09. 20.005. 6	Prefab Bridges	9.00	EA	1,618	56,936	29,117	542,330	60,259	688,642	76515.81
	TOTAL Bridges	1.00	EA	6,524	212,807	49,119	813,588	60,259	1,135,773	1135773
	TOTAL ROADS & BRIDGES	1.00	EA	11,176	362,784	171,054	1765490	60,259	2,359,587	2359587
09. 25	LET DOWN STRUCTURES									
09. 25.001	Let Down Structures									
09. 25.001. 1	Fencing for Erosion Control	2.50	ACR	211	4,674	0	4,726	0	9,400	3759.94
09. 25.001. 2	Clearing & Grubbing, debris	1.90	ACR	27	787	585	0	0	1,372	722.14
09. 25.001. 3	Prep (excav) slope to receive	500.00	CY	0	0	0	0	750	750	1.50
09. 25.001. 4	30" Pipe Laying	1000.00	LF	481	12,019	6,381	29,151	30,000	77,551	77.55
09. 25.001. 5	Backfilling & Compaction	30000.00	CY	1,008	27,321	48,021	0	24,945	100,287	3.34
09. 25.001. 6	Planting and Seeding	2.10	ACR	183	4,012	242	6,814	16,875	27,943	13306.06
	TOTAL Let Down Structures	1.00	EA	1,910	48,812	55,230	40,691	72,570	217,303	217303.02
	TOTAL LET DOWN STRUCTURES	1.00	EA	1,910	48,812	55,230	40,691	72,570	217,303	217303.02
	TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	343,303	10546426	4813116	12682559	7,900,751	35,942,852	35942852
14	RECREATION									
14. 30	RECREATION FEATURES									
14. 30.001	Parking Areas									
14. 30.001. 1	Fencing for Erosion Control	1.80	ACR	179	3,966	0	4,010	0	7,976	4430.91
14. 30.001. 2	Clearing & Grubbing, debris	1.80	ACR	27	787	585	0	0	1,372	762.26
14. 30.001. 3	Site Preparation	1.80	ACR	268	7,799	9,142	0	0	16,941	9411.90
14. 30.001. 4	Asphalt Paving, 6" stone base,	79280.00	SF	0	11,892	14,270	103,064	0	129,226	1.63
14. 30.001. 5	Lines on pavement, parking stall			0	0	0	0	1,500	1,500	
14. 30.001. 6	Parking Lot Amenities, lighting,			0	0	0	0	10,000	10,000	
	TOTAL Parking Areas	1.80	ACR	474	24,444	23,998	107,074	11,500	167,016	92786.39

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. 30.005 Decomposed Granite Trails									
14. 30.005. 1 Clearing & Grubbing, debris	2.00	ACR	28	828	616	0	0	1,444	722.14
14. 30.005. 2 Site Preparation	2.00	ACR	161	4,481	5,300	0	0	9,781	4890.62
14. 30.005. 3 Decomposed Granite course,	275740.00	SF	153	4,522	2,584	0	114,900	122,006	0.44
14. 30.005. 4 Trail amenities, ADA ramps, sign			0	0	0	0	10,000	10,000	
TOTAL Decomposed Granite Trails	1.00	EA	343	9,831	8,501	0	124,900	143,232	143231.98
14. 30.010 Other Recreation Features									
14. 30.010. 1 Paved Trail amenities, curb	1.00	EA	0	0	0	0	10,000	10,000	10000.00
14. 30.010. 2 Comfort Stations	3.00	EA	0	0	0	0	300,000	300,000	100000.00
14. 30.010. 3 Rest Stops	5.00	EA	0	0	0	0	15,000	15,000	3000.00
14. 30.010. 4 Concrete Benches	21.00	EA	84	1,859	0	13,050	0	14,909	709.94
14. 30.010. 5 Signage	21.00	EA	11	232	0	353	0	585	27.87
TOTAL Other Recreation Features	1.00	EA	95	2,091	0	13,402	325,000	340,494	340493.88
TOTAL RECREATION FEATURES	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
TOTAL RECREATION	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
30 PLANNING, ENGINEERING, DESIGN									
30.009 Construction	1.00	EA	0	0	0	0	5,120,000	5,120,000	5120000
30.014 Recreation	1.00	EA	0	0	0	0	95,285	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	0	0	0	0	5,215,285	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT									
31.009 Construction (Restoration)	1.00	EA	0	0	0	0	5,980,000	5,980,000	5980000
31.014 Recreation	1.00	EA	0	0	0	0	63,879	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	0	0	0	0	6,043,879	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	344,214	10582793	4845615	12803035	45,821,315	74,052,757	74052757
OVERHEAD								3,659,359	
SUBTOTAL								77,712,116	
HOME OFC								3,220,236	
SUBTOTAL								80,932,352	
PROFIT								4,347,319	
SUBTOTAL								85,279,671	

** PROJECT DIRECT SUMMARY - Subsystm **

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
BOND								237,678	
TOTAL INCL INDIRECTS								85,517,349	
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LANDS AND DAMAGES (REAL ESTATE)	1.00	EA	0	0	0	0	26,200,000	26,200,000	26200000
09 CONSTRUCTION (RESTORATION)									
09. 01 IRRIGATION PLANTING									
09. 01.001 Historic Floodplain									
09. 01.001. 1 Fencing for Erosion Control	656.00	ACR	3,421	75,723	0	76,555	0	152,278	232.13
09. 01.001. 2 Clearing & Grubbing, Debris	328.00	ACR	9,338	271,648	202,076	0	0	473,723	1444.28
09. 01.001. 3 Site Preparation									
09. 01.001. 3.01 Ripping, discing to prepare	590.00	ACR	100	2,987	4,383	0	0	7,369	12.49
09. 01.001. 3.02 Regrade to req'd slopes, flatten	295.00	ACR	15	442	980	0	0	1,421	4.82
09. 01.001. 3.03 Regrade Surface, scraper-grader	1445500	CY	231	7,077	17,083	0	0	24,160	0.02
TOTAL Site Preparation	1.00	EA	346	10,505	22,445	0	0	32,950	32950.50
09. 01.001. 4 Excavation	176990.00	CY	6,850	205,185	136,229	0	0	341,414	1.93
09. 01.001. 5 Compaction (tractor wheel, one	3561940	LF	6,918	206,632	214,833	0	0	421,465	0.12
09. 01.001. 6 Trenching for Water Supply Pipes	17050.00	CY	355	11,265	11,159	0	0	22,424	1.32
09. 01.001. 7 Pipe bedding, crushed stone	13110.00	CY	1,210	30,281	6,100	615,383	0	651,765	49.72
09. 01.001. 8 Install gated 12" PVC pipe for	114720.00	LF	9,178	306,245	0	329,246	137,664	773,155	6.74
09. 01.001. 9 Install "U" outlet tubes with	5940.00	EA	1,667	55,638	0	832	0	56,469	9.51
09. 01.001.10 Backfill pipe trench, side cast	4590.00	CY	24	725	1,064	0	0	1,789	0.39
09. 01.001.11 Planting & Seeding									
09. 01.001.11.01 Mulching, hay, 1" deep, power	558.00	ACR	734	16,833	16,363	465,500	0	498,695	893.72
09. 01.001.11.02 Crimping, Tilling topsoil,	558.00	ACR	2,232	68,754	19,991	0	0	88,745	159.04
09. 01.001.11.03 Seeding, athletic fld mix,	623.00	ACR	27,138	600,618	0	1286884	0	1,887,502	3029.70
09. 01.001.11.04 Place Coarse Woody debris/rocks	558.00	ACR	17,856	365,541	27,900	27,900	0	421,341	755.09
09. 01.001.11.05 Plant Mesquite/Shrub mix using	250729.00	EA	0	0	0	0	3,760,935	3,760,935	15.00
TOTAL Planting & Seeding	558.00	ACR	47,960	1051746	64,254	1780284	3,760,935	6,657,218	11930.50
TOTAL Historic Floodplain	1.00	EA	87,267	2225592	658,160	2802300	3,898,599	9,584,651	9584651
09. 01.005 Graded Slope									
09. 01.005. 1 Fencing for Erosion Control	102.00	ACR	1,349	29,859	0	30,187	0	60,045	588.68
09. 01.005. 2 Clearing & Grubbing, debris	51.00	ACR	726	21,119	15,710	0	0	36,829	722.14
09. 01.005. 3 Excavation, strl, mach excav.	1213390	CY	9,464	300,071	341,812	0	0	641,883	0.53
09. 01.005. 4 Excavation, steep slopes, 5:1									
09. 01.005. 4.01 Hauling, no loading, 16.5 cy	1213390	CY	34,703	937,101	1753227	0	0	2,690,328	2.22
09. 01.005. 4.02 Fill, spread dumped material,	1213390	CY	6,431	191,716	281,264	0	0	472,979	0.39

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.005. 4.03	Compaction, sheepfoot/wobbly	1213390	CY	6,067	167,933	189,046	0	0	356,979	0.29
	TOTAL Excavation, steep slopes, 5:1	1213390	CY	47,201	1296750	2223537	0	0	3,520,287	2.90
09. 01.005. 5	Fine grading to 20% slope,	110.00	ACR	5,324	149,044	93,995	0	0	243,040	2209.45
09. 01.005. 6	Header Pipe Laying									
09. 01.005. 6.01	Excavate header trench, 12" dep.	2540.00	CY	21	664	615	0	0	1,279	0.50
09. 01.005. 6.02	Header Trench bedding, 3/4"	1020.00	CY	94	2,846	3,850	16,320	0	23,017	22.57
09. 01.005. 6.03	Install medium diam. PVC Header	7620.00	LF	762	25,427	0	72,085	0	97,512	12.80
09. 01.005. 6.04	Backfill trench, FE loader,	1020.00	CY	31	916	759	0	0	1,675	1.64
09. 01.005. 6.05	Hauling, surplus cut mat'l,	1530.00	CY	77	2,068	3,666	0	0	5,734	3.75
	TOTAL Header Pipe Laying	7620.00	LF	984	31,922	8,890	88,405	0	129,218	16.96
09. 01.005. 7	8" PVC Leach Pipe Laying									
09. 01.005. 7.01	Excavate trench, 12" depth by	99020.00	CY	812	25,894	23,973	0	0	49,866	0.50
09. 01.005. 7.02	Install low perm geotextile in	148700.00	SY	2,379	56,179	14,662	90,707	0	161,548	1.09
09. 01.005. 7.03	Install 8" PVC leach pipe for	445590.00	LF	35,647	1189503	0	623,826	133,677	1,947,006	4.37
09. 01.005. 7.04	Install leach pipe filter "sock"	445590.00	LF	0	0	0	539,164	178,236	717,400	1.61
09. 01.005. 7.05	Install pipe fittings as needed			0	12,000	0	15,000	0	27,000	
09. 01.005. 7.06	Backfill trench, FE loader, whl	93380.00	CY	2,801	83,902	69,465	0	0	153,367	1.64
09. 01.005. 7.07	Hauling, surplus cut matl, no	5790.00	CY	290	7,826	13,875	0	0	21,701	3.75
	TOTAL 8" PVC Leach Pipe Laying	445590.00	LF	41,929	1375303	121,975	1268697	311,913	3,077,888	6.91
09. 01.005. 8	Planting & Seeding									
09. 01.005. 8.01	Mulch, hay, 1" deep, power	102.00	ACR	134	3,077	2,991	85,091	0	91,159	893.72
09. 01.005. 8.02	Crimping, tilling topsoil	102.00	ACR	408	12,568	3,654	0	0	16,222	159.04
09. 01.005. 8.03	Seeding, athletic fld mix,	102.00	ACR	4,443	98,335	0	210,693	0	309,028	3029.69
09. 01.005. 8.04	Place Coarse Woody debris/rocks	102.00	ACR	3,264	66,819	5,100	5,100	0	77,019	755.09
09. 01.005. 8.05	Plant Mesquite/Shrub mix using	45675.00	EA	0	0	0	0	685,125	685,125	15.00
	TOTAL Planting & Seeding	102.00	ACR	8,249	180,799	11,745	300,884	685,125	1,178,554	11554.45
	TOTAL Graded Slope	1.00	EA	115,227	3384867	2817665	1688173	997,038	8,887,743	8887743
09. 01.010	Natural Slope									
09. 01.010. 1	Fencing for Erosion Control	18.00	ACR	567	12,543	0	12,680	0	25,223	1401.27
09. 01.010. 2	Clearing and Grubbing, debris	13.00	ACR	185	5,383	4,005	0	0	9,388	722.14
09. 01.010. 3	Header Trenching									
09. 01.010. 3.01	Excavate header trench, 12" dep.	86.00	CY	1	22	21	0	0	43	0.50

		QUANTITY UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.010. 3.02	Header Trench bedding, 3/4"	35.00 CY	3	98	132	560	0	790	22.57
09. 01.010. 3.03	Install med. diam. PVC Header	1520.00 LF	152	5,072	0	14,379	0	19,451	12.80
09. 01.010. 3.04	Backfill trench, FE loader,	35.00 CY	1	31	26	0	0	57	1.64
09. 01.010. 3.05	Hauling, surplus cut matl, no	52.00 CY	3	70	125	0	0	195	3.75
	TOTAL Header Trenching	1520.00 LF	160	5,294	304	14,939	0	20,537	13.51
09. 01.010. 4	8" PVC Leach Pipe Laying								
09. 01.010. 4.01	Excavate trench, 12" depth by	16780.00 CY	138	4,388	4,062	0	0	8,450	0.50
09. 01.010. 4.02	Install low perm geotextile in	25200.00 SY	403	9,521	2,485	15,372	0	27,377	1.09
09. 01.010. 4.03	Install 8" PVC leach pipe for	75510.00 LF	6,041	201,574	0	105,714	22,653	329,941	4.37
09. 01.010. 4.04	Install leach pipe filter "sock"	75510.00 LF	0	0	0	91,367	30,204	121,571	1.61
09. 01.010. 4.05	Install pipe fittings as needed		0	12,000	0	8,000	0	20,000	
09. 01.010. 4.06	Backfill trench, FE loader, whl	15830.00 CY	475	14,223	11,776	0	0	25,999	1.64
09. 01.010. 4.07	Hauling, surplus cut matl, no	990.00 CY	50	1,338	2,372	0	0	3,711	3.75
	TOTAL 8" PVC Leach Pipe Laying	75510.00 LF	7,106	243,044	20,696	220,453	52,857	537,049	7.11
09. 01.010. 5	Planting & Seeding								
09. 01.010. 5.01	Mulch, hay, 1" deep, power	18.00 ACR	24	543	528	15,016	0	16,087	893.72
09. 01.010. 5.02	Crimping, tilling topsoil	18.00 ACR	72	2,218	645	0	0	2,863	159.04
09. 01.010. 5.03	Seeding, athletic fld mix,	18.00 ACR	784	17,353	0	37,181	0	54,534	3029.69
09. 01.010. 5.04	Place Coarse Woody debris/rocks	18.00 ACR	576	11,792	900	900	0	13,592	755.09
09. 01.010. 5.05	Plant Mesquite/Shrub mix using	7740.00 EA	0	0	0	0	116,100	116,100	15.00
	TOTAL Planting & Seeding	18.00 ACR	1,456	31,906	2,073	53,097	116,100	203,176	11287.54
	TOTAL Natural Slope	1.00 EA	9,473	298,169	27,076	301,170	168,957	795,373	795372.60
09. 01.015	Second Bench								
09. 01.015. 1	Fencing for Erosion Control	124.00 ACR	1,487	32,918	0	33,280	0	66,198	533.85
09. 01.015. 2	Clearing and Grubbing, debris	93.00 ACR	1,324	38,511	28,648	0	0	67,159	722.14
09. 01.015. 3	Header Trenching								
09. 01.015. 3.01	Excavate header trench, 12" dep.	500.00 CY	4	131	121	0	0	252	0.50
09. 01.015. 3.02	Header Trench bedding, 3/4"	200.00 CY	18	558	755	3,200	0	4,513	22.57
09. 01.015. 3.03	Install med. diam. PVC Header	8080.00 LF	808	26,962	0	76,437	0	103,399	12.80
09. 01.015. 3.04	Backfill trench, FE loader,	200.00 CY	6	180	149	0	0	328	1.64
09. 01.015. 3.05	Hauling, surplus cut matl, no	300.00 CY	15	405	719	0	0	1,124	3.75
	TOTAL Header Trenching	8080.00 LF	852	28,236	1,744	79,637	0	109,617	13.57
09. 01.015. 4	8" PVC Leach Pipe Laying								

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.015. 4.01	Excavate trench, 12" depth by	121260.00	CY	994	31,709	29,357	0	0	61,067	0.50
09. 01.015. 4.03	Install 8" PVC leach pipe for	545686.00	LF	43,655	1456709	0	763,960	163,706	2,384,375	4.37
09. 01.015. 4.04	Install leach pipe filter "sock"	545680.00	LF	0	0	0	660,273	218,272	878,545	1.61
09. 01.015. 4.05	Install pipe fittings as needed			0	15,000	0	10,000	0	25,000	
09. 01.015. 4.06	Backfill trench, FE loader, whl	114360.00	CY	3,431	102,752	85,072	0	0	187,825	1.64
09. 01.015. 4.07	Hauling, surplus cut matl, no	7090.00	CY	355	9,583	16,990	0	0	26,573	3.75
	TOTAL 8" PVC Leach Pipe Laying	545686.00	LF	48,435	1615754	131,420	1434233	381,978	3,563,384	6.53
09. 01.015. 5	Planting & Seeding									
09. 01.015. 5.01	Mulch, hay, 1" deep, power	125.00	ACR	164	3,771	3,666	104,279	0	111,715	893.72
09. 01.015. 5.02	Crimping, tilling topsoil	125.00	ACR	500	15,402	4,478	0	0	19,880	159.04
09. 01.015. 5.03	Seeding, athletic fld mix,	125.00	ACR	5,445	120,509	0	258,202	0	378,711	3029.69
09. 01.015. 5.04	Place Coarse Woody debris/rocks	125.00	ACR	4,000	81,886	6,250	7,090	0	95,226	761.81
09. 01.015. 5.05	Plant Mesquite/Shrub mix using	55935.00	EA	0	0	0	0	839,025	839,025	15.00
	TOTAL Planting & Seeding	125.00	ACR	10,109	221,568	14,394	369,571	839,025	1,444,557	11556.46
	TOTAL Second Bench	1.00	EA	62,207	1936987	176,205	1916720	1,221,003	5,250,915	5250915
09. 01.020	First Bench									
09. 01.020. 1	Excavate pipe trench, 18" depth	1.00	LF	0	1	0	0	0	1	0.65
	TOTAL Excavate pipe trench, 18" depth	1.00	LF	0	1	0	0	0	1	0.65
09. 01.020. 2	Pipe Laying									
09. 01.020. 2.01	Install small diam pressure pipe	31000.00	LF	1,907	63,655	0	53,320	0	116,975	3.77
09. 01.020. 2.02	Install small diam pipe fittings	3100.00	EA	2,713	90,530	0	37,438	0	127,968	41.28
09. 01.020. 2.03	Install long reach (150') sprin-	190.00	LF	122	2,839	0	19,481	0	22,320	117.47
09. 01.020. 2.04	Install pipe thrust blocks at	238.00	EA	0	0	0	0	11,900	11,900	50.00
	TOTAL Pipe Laying	31000.00	LF	4,741	157,025	0	110,239	11,900	279,163	9.01
09. 01.020. 3	Backfill pipe trench, compact	31000.00	LF	930	27,854	23,061	0	0	50,914	1.64
09. 01.020. 4	Install control valves for sprin	90.00	EA	80	1,868	0	2,093	0	3,960	44.00
09. 01.020. 5	Install Programmable Logic	1.00	EA	0	0	0	0	500,000	500,000	500000.00
09. 01.020. 6	Rough grade & scarify subsoil	89.00	ACR	2,154	64,504	94,663	0	0	159,167	1788.39
09. 01.020. 7	Planting & seeding									
09. 01.020. 7.01	Mulch, hay, 1" deep, power	89.00	ACR	117	2,685	2,610	74,246	0	79,541	893.72
09. 01.020. 7.02	Crimping, tilling topsoil	89.00	ACR	356	10,966	3,189	0	0	14,155	159.04
09. 01.020. 7.03	Seeding, athletic fld mix,	89.00	ACR	3,877	85,802	0	183,840	0	269,642	3029.69
09. 01.020. 7.04	Place Coarse Woody debris/rocks	89.00	ACR	712	14,576	4,450	4,600	0	23,625	265.45

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 01.020. 7.05 Plant Mesquite/Shrub mix using	55935.00	EA	0	0	0	0	839,025	839,025	15.00
TOTAL Planting & seeding	89.00	ACR	5,062	114,029	10,248	262,686	839,025	1,225,988	13775.15
TOTAL First Bench	1.00	EA	12,967	365,280	127,972	375,017	1,350,925	2,219,194	2219194
TOTAL IRRIGATION PLANTING	1.00	EA	287,141	8210895	3807079	7083380	7,636,522	26,737,876	26737876
09. 05 BASINS PLANTING									
09. 05.001 Tributary Infiltration Basins									
09. 05.001. 1 Fencing for Erosion Control	18.00	ACR	567	12,543	0	12,680	0	25,223	1401.27
09. 05.001. 2 Clearing and Grubbing, debris	13.00	ACR	185	5,383	4,005	0	0	9,388	722.14
09. 05.001. 3 Excavate, mach exc., sand & grav									
09. 05.001. 3.01 Stockpile useable cut matl,	830.00	CY	12	345	506	0	0	851	1.03
09. 05.001. 3.02 Hauling, surplus cut matl, no	2490.00	CY	125	3,365	5,967	0	0	9,333	3.75
09. 05.001. 3.03 Fill, spread cut matl at dump	2490.00	CY	30	895	1,313	0	0	2,208	0.89
09. 05.001. 3.04 Compaction at dump site, hl rlr,	2490.00	CY	12	345	388	0	0	733	0.29
09. 05.001. 3.05 Compact Basin subgrade, existing	86160.00	SY	8,616	192,413	0	0	0	192,413	2.23
TOTAL Excavate, mach exc., sand & grav	8300.00	CY	8,794	197,362	8,174	0	0	205,537	24.76
09. 05.001. 4 Backfilling									
09. 05.001. 4.01 Fill, bottom layer, clean sand,	840.00	CY	0	0	0	0	14,910	14,910	17.75
09. 05.001. 4.02 Fill, middle layer, No. 57 blue-	840.00	CY	0	0	0	0	840	840	1.00
09. 05.001. 4.03 Fill, middle layer, No. 2 gravel	840.00	CY	0	0	0	0	21,000	21,000	25.00
09. 05.001. 4.04 Fill, top layer, mix of native	840.00	CY	0	0	0	0	25,200	25,200	30.00
TOTAL Backfilling	3360.00	CY	0	0	0	0	61,950	61,950	18.44
09. 05.001. 5 Planting & Seeding									
09. 05.001. 5.01 Mulch, hay, 1" deep, power	18.00	ACR	24	543	528	15,016	0	16,087	893.72
09. 05.001. 5.02 Crimping, tilling topsoil	18.00	ACR	72	2,218	645	0	0	2,863	159.04
09. 05.001. 5.03 Seeding, athletic fld mix,	18.00	ACR	784	17,353	0	37,181	0	54,534	3029.69
09. 05.001. 5.04 Plant Mesquite/Shrub mix using	3204.00	EA	0	0	0	0	48,060	48,060	15.00
TOTAL Planting & Seeding	18.00	ACR	880	20,114	1,173	52,197	48,060	121,544	6752.45
TOTAL Tributary Infiltration Basins	1.00	EA	10,426	235,402	13,352	64,878	110,010	423,641	423641.40
09. 05.005 Grade Control Infiltration Basin									

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 05.005. 1 Fencing for Erosion Control	6.00	ACR	327	7,238	0	7,318	0	14,556	2425.92
09. 05.005. 2 Clearing and Grubbing, debris	5.00	ACR	71	2,070	1,540	0	0	3,611	722.14
09. 05.005. 3 Excavating, mach exc, sand & gr									
09. 05.005. 3.01 Stockpile useable cut mat'l	280.00	CY	4	116	171	0	0	287	1.03
09. 05.005. 3.02 Hauling, surplus cut mat'l, no	840.00	CY	42	1,135	2,013	0	0	3,148	3.75
09. 05.005. 3.03 Fill, spread cut mat'l at dump	840.00	CY	10	302	443	0	0	745	0.89
TOTAL Excavating, mach exc, sand & gr	1120.00	CY	56	1,554	2,627	0	0	4,180	3.73
09. 05.005. 4 Compaction at dump site, hl rlr	840.00	CY	4	116	131	0	0	247	0.29
09. 05.005. 5 Compact basin subgrade, existing	29040.00	CY	2,904	64,852	0	0	0	64,852	2.23
09. 05.005. 6 Backfilling	1160.00	CY	0	0	0	0	21,390	21,390	18.44
09. 05.005. 7 Planting & Seeding									
09. 05.005. 7.01 Mulch, hay, 1" deep, power	6.00	ACR	8	181	176	5,005	0	5,362	893.72
09. 05.005. 7.02 Crimping, tilling topsoil	6.00	ACR	24	739	215	0	0	954	159.04
09. 05.005. 7.03 Seeding, athletic fld mix,	6.00	ACR	261	5,784	0	12,394	0	18,178	3029.69
TOTAL Planting & Seeding	6.00	ACR	293	6,705	391	17,399	0	24,495	4082.45
TOTAL Grade Control Infiltration Basin	1.00	EA	3,656	82,535	4,689	24,717	21,390	133,331	133330.84
TOTAL BASINS PLANTING	1.00	EA	14,082	317,937	18,040	89,594	131,400	556,972	556972.24
09. 10 HARDENED BANKS									
09. 10.001 Hardened Slopes									
09. 10.001. 1 Fencing for Erosion Control	3.50	ACR	250	5,524	0	5,585	0	11,109	3173.98
09. 10.001. 2 Clearing and Grubbing, debris	0.90	ACR	13	373	277	0	0	650	722.14
09. 10.001. 3 Excavating, prepare slope &									
09. 10.001. 3.01 Stockpile subgrade cut matl for	28200.00	CY	392	11,717	17,194	0	0	28,911	1.03
09. 10.001. 3.02 Hauling, no loading, 16.5 cy	18800.00	CY	538	14,519	27,164	0	0	41,683	2.22
TOTAL Excavating, prepare slope &	47000.00	CY	930	26,236	44,358	0	0	70,594	1.50
09. 10.001. 4 Fill, spread dumped mat'l, by									
09. 10.001. 4.01 Compaction, sheepfoot/wobbly	18800.00	CY	94	2,602	2,929	0	0	5,531	0.29
09. 10.001. 4.02 Fine grade to 1:1 slope, for	14900.00	SY	149	4,171	2,631	0	0	6,802	0.46
TOTAL Fill, spread dumped mat'l, by	18800.00	CY	243	6,773	5,560	0	0	12,333	0.66
09. 10.001. 5 Soil Cement application,	61100.00	CY	0	733,200	611,000	1038700	0	2,382,900	39.00

	QUANTITY UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 10.001. 6 Backfill and Compaction								
09. 10.001. 6.01 Backfill subgrade with cut matl	28200.00 CY	846	25,338	20,978	0	0	46,316	1.64
09. 10.001. 6.02 Compaction, sheepfoot/wobbly whl	28200.00 CY	141	3,903	4,394	0	0	8,296	0.29
TOTAL Backfill and Compaction	28200.00 CY	987	29,241	25,372	0	0	54,612	1.94
TOTAL Hardened Slopes	1.00 EA	2,422	801,347	686,566	1044285	0	2,532,198	2532198
TOTAL HARDENED BANKS	1.00 EA	2,422	801,347	686,566	1044285	0	2,532,198	2532198
09. 15 PIPING								
09. 15.001 Irrigation Piping								
09. 15.001. 1 Trenching for Delivery Pipe								
09. 15.001. 1.01 Delivery pipe trench bedding,	1260.00 CY	116	2,910	586	59,144	0	62,641	49.72
09. 15.001. 1.02 Delivery piping, large dia. say	10440.00 LF	1,796	59,934	0	146,682	0	206,616	19.79
09. 15.001. 1.03 Backfill delivery pipe trench,	1260.00 CY	40	1,192	987	19,480	0	21,658	17.19
09. 15.001. 1.04 Hauling, Delivery pipe surplus	1880.00 CY	54	1,452	2,716	0	0	4,168	2.22
TOTAL Trenching for Delivery Pipe	3130.00 CY	2,006	65,488	4,289	225,306	0	295,083	94.28
09. 15.001. 2 Trenching for Main Pipe								
09. 15.001. 2.01 Main pipe trench bedding,	8400.00 CY	775	19,402	3,909	394,296	0	417,607	49.72
09. 15.001. 2.02 Main piping, large dia. say	69970.00 LF	12,035	401,684	0	983,079	0	1,384,762	19.79
09. 15.001. 2.03 Backfill Main pipe trench,	8400.00 CY	265	7,945	6,577	129,864	0	144,386	17.19
09. 15.001. 2.04 Hauling, Main pipe surplus	12600.00 CY	360	9,731	18,206	0	0	27,937	2.22
TOTAL Trenching for Main Pipe	21000.00 CY	13,436	438,762	28,691	1507239	0	1,974,692	94.03
09. 15.001. 3 Trenching for Sub-main Pipe								
09. 15.001. 3.01 Sub-main pipe trench bedding,	3370.00 CY	311	7,784	1,568	158,188	0	167,540	49.72
09. 15.001. 3.02 Sub-main piping, large dia. say	28010.00 LF	3,395	113,292	0	174,782	0	288,074	10.28
09. 15.001. 3.03 Backfill Sub-main pipe trench,	3370.00 CY	106	3,187	2,639	52,100	0	57,926	17.19
09. 15.001. 3.04 Hauling, Sub-main pipe surplus	5050.00 CY	144	3,900	7,297	0	0	11,197	2.22
TOTAL Trenching for Sub-main Pipe	8420.00 CY	3,957	128,164	11,504	385,070	0	524,737	62.32
09. 15.001. 4 Trenching for Culvert CMP								
09. 15.001. 4.01 Culvert trench bedding,	4200.00 CY	388	9,701	1,954	197,148	0	208,803	49.72
09. 15.001. 4.02 Install 24" dia. CMP Culvert for	23600.00 LF	6,473	153,697	16,317	279,424	0	449,438	19.04
09. 15.001. 4.03 Backfill trench, FE Loader,	4200.00 CY	133	3,972	3,289	64,932	0	72,193	17.19

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	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 15.001. 4.04 Hauling, Sub-main pipe surplus	6300.00	CY	180	4,865	9,103	0	0	13,968	2.22
TOTAL Trenching for Culvert CMP	10500.00	CY	7,174	172,236	30,663	541,504	0	744,403	70.90
TOTAL Irrigation Piping	1.00	EA	26,572	804,650	75,147	2659119	0	3,538,916	3538916
TOTAL PIPING	1.00	EA	26,572	804,650	75,147	2659119	0	3,538,916	3538916
09. 20 ROADS & BRIDGES									
09. 20.001 Compacted Earth Maintenance Road									
09. 20.001. 1 Clearing & Grubbing, debris	8.30	ACR	118	3,437	2,557	0	0	5,994	722.14
TOTAL Clearing & Grubbing, debris	8.30	ACR	118	3,437	2,557	0	0	5,994	722.14
09. 20.001. 2 Site Preparation									
09. 20.001. 2.01 Ripping, discing to prepare	8.30	ACR	1	42	62	0	0	104	12.49
09. 20.001. 2.02 Regrade, flatten, balance cut	2020.00	CY	10	302	671	0	0	973	0.48
09. 20.001. 2.03 Compaction, riding, sheepfoot/	40260.00	SY	201	5,572	6,273	0	0	11,844	0.29
TOTAL Site Preparation	8.30	ACR	213	5,916	7,005	0	0	12,921	1556.79
TOTAL Compacted Earth Maintenance Road	8.30	ACR	331	9,353	9,562	0	0	18,915	2278.93
09. 20.002 Paved Maintenance Roads									
09. 20.002. 1 Clearing & Grubbing, debris	9.00	ACR	128	3,727	2,772	0	0	6,499	722.14
TOTAL Clearing & Grubbing, debris	9.00	ACR	128	3,727	2,772	0	0	6,499	722.14
09. 20.002. 2 Site Preparation									
09. 20.002. 2.01 Ripping, discing to prepare	18.00	ACR	3	91	134	0	0	225	12.49
09. 20.002. 2.02 Regrade, flatten, balance cut	21880.00	CY	109	3,275	7,266	0	0	10,542	0.48
09. 20.002. 2.03 Compaction, riding, sheepfoot/	86820.00	SY	434	12,016	13,527	0	0	25,542	0.29
09. 20.002. 2.04 Asphalt Concrete Paving,	781310.00	SF	2,940	100,741	62,592	849,124	0	1,012,457	1.30
TOTAL Site Preparation	18.00	ACR	3,487	116,123	83,518	849,124	0	1,048,766	58264.77
TOTAL Paved Maintenance Roads	18.00	ACR	3,615	119,850	86,291	849,124	0	1,055,265	58625.84
09. 20.003 Gravel Maintenance Road									

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 20.003. 1 Clearing & Grubbing, debris	4.10	ACR	58	1,698	1,263	0	0	2,961	722.14
TOTAL Clearing & Grubbing, debris	4.10	ACR	58	1,698	1,263	0	0	2,961	722.14
09. 20.003. 2 Site Preparation									
09. 20.003. 2.01 Ripping, discing to prepare	8.20	ACR	1	42	61	0	0	102	12.49
09. 20.003. 2.02 Regrade, flatten, balance cut	1980.00	CY	10	296	658	0	0	954	0.48
09. 20.003. 2.03 Compaction, riding, sheepfoot/	39530.00	SY	198	5,471	6,159	0	0	11,630	0.29
09. 20.003. 2.04 Gravel course, crushed 3/4"	39530.00	SY	439	13,266	17,943	102,778	0	133,987	3.39
TOTAL Site Preparation	8.20	ACR	648	19,075	24,820	102,778	0	146,673	17886.96
TOTAL Gravel Maintenance Road	8.20	ACR	706	20,773	26,083	102,778	0	149,634	18248.03
09. 20.005 Bridges									
09. 20.005. 1 Fencing for Erosion Control	9.00	ACR	401	8,867	0	8,964	0	17,831	1981.25
09. 20.005. 2 Clearing and Grubbing, debris	7.00	ACR	100	2,899	2,156	0	0	5,055	722.14
09. 20.005. 3 Excavating, structural, sand/									
09. 20.005. 3.01 Hauling, no loading, 16.5 cy	3366.00	CY	96	2,600	4,864	0	0	7,463	2.22
09. 20.005. 3.02 Fill, spread dumped matl, by	3366.00	CY	37	1,100	674	0	0	1,774	0.53
09. 20.005. 3.03 Compaction, sheepfoot/wobbly	3060.00	CY	15	424	477	0	0	900	0.29
TOTAL Excavating, structural, sand/	3060.00	CY	148	4,123	6,014	0	0	10,137	3.31
09. 20.005. 4 Cast in Place reinforced concret	3060.00	CY	3,587	121,222	0	262,294	0	383,516	125.33
09. 20.005. 5 Finished grading, tie in, stabl.	9.00	ACR	671	18,761	11,831	0	0	30,592	3399.13
09. 20.005. 6 Prefab Bridges									
09. 20.005. 6.01 Prefab Bridges (9 ea)			0	0	0	542,330	60,259	602,589	
09. 20.005. 6.02 Unloading and Erection	8090.00	SF	1,618	56,936	29,117	0	0	86,053	10.64
TOTAL Prefab Bridges	9.00	EA	1,618	56,936	29,117	542,330	60,259	688,642	76515.81
TOTAL Bridges	1.00	EA	6,524	212,807	49,119	813,588	60,259	1,135,773	1135773
TOTAL ROADS & BRIDGES	1.00	EA	11,176	362,784	171,054	1765490	60,259	2,359,587	2359587
09. 25 LET DOWN STRUCTURES									
09. 25.001 Let Down Structures									
09. 25.001. 1 Fencing for Erosion Control	2.50	ACR	211	4,674	0	4,726	0	9,400	3759.94
09. 25.001. 2 Clearing & Grubbing, debris	1.90	ACR	27	787	585	0	0	1,372	722.14

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. 25.001. 3 Prep (excav) slope to receive	500.00	CY	0	0	0	0	750	750	1.50
09. 25.001. 4 30" Pipe Laying									
09. 25.001. 4.01 Install pipe bedding, gravel,	150.00	CY	14	346	70	7,041	0	7,457	49.72
09. 25.001. 4.02 Install 30" dia CMP, 200 lf per	1000.00	LF	467	11,672	6,312	22,110	0	40,094	40.09
09. 25.001. 4.03 Install wingwall deflectors on	10.00	EA	0	0	0	0	30,000	30,000	3000.00
TOTAL 30" Pipe Laying	1000.00	LF	481	12,019	6,381	29,151	30,000	77,551	77.55
09. 25.001. 5 Backfilling & Compaction									
09. 25.001. 5.01 Hauling, no loading, 16.5 cy	30000.00	CY	858	23,169	43,347	0	0	66,516	2.22
09. 25.001. 5.02 Fill, spread dumped matl, by	30000.00	CY	0	0	0	0	19,500	19,500	0.65
09. 25.001. 5.03 Compaction, sheepfoot/wobbly	30000.00	CY	150	4,152	4,674	0	0	8,826	0.29
09. 25.001. 5.04 Fine grade filled area, for	2.50	ACR	0	0	0	0	5,445	5,445	2178.00
TOTAL Backfilling & Compaction	30000.00	CY	1,008	27,321	48,021	0	24,945	100,287	3.34
09. 25.001. 6 Planting and Seeding									
09. 25.001. 6.01 Mulching, hay, 1" deep, power	2.10	ACR	3	63	62	1,752	0	1,877	893.72
09. 25.001. 6.02 Crimping, tilling topsoil	2.10	ACR	8	259	75	0	0	334	159.04
09. 25.001. 6.03 Seeding, athletic fld mix,	2.40	ACR	105	2,314	0	4,957	0	7,271	3029.69
09. 25.001. 6.04 Place Coarse Woody debris/rocks	2.10	ACR	67	1,376	105	105	0	1,586	755.09
09. 25.001. 6.05 Plant Mesquite/Shrub mix using	1125.00	EA	0	0	0	0	16,875	16,875	15.00
TOTAL Planting and Seeding	2.10	ACR	183	4,012	242	6,814	16,875	27,943	13306.06
TOTAL Let Down Structures	1.00	EA	1,910	48,812	55,230	40,691	72,570	217,303	217303.02
TOTAL LET DOWN STRUCTURES	1.00	EA	1,910	48,812	55,230	40,691	72,570	217,303	217303.02
TOTAL CONSTRUCTION (RESTORATION)	1.00	EA	343,303	10546426	4813116	12682559	7,900,751	35,942,852	35942852
14 RECREATION									
14. 30 RECREATION FEATURES									
14. 30.001 Parking Areas									
14. 30.001. 1 Fencing for Erosion Control	1.80	ACR	179	3,966	0	4,010	0	7,976	4430.91
14. 30.001. 2 Clearing & Grubbing, debris	1.80	ACR	27	787	585	0	0	1,372	762.26
14. 30.001. 3 Site Preparation									
14. 30.001. 3.01 Ripping, discing to prepare	1.80	ACR	0	9	13	0	0	22	12.49
14. 30.001. 3.02 Regrade to req'd slopes, flatten	1.80	ACR	0	3	6	0	0	9	4.82

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. 30.001. 3.03 Regrade surface, scraper-grader,	4410.00	CY	120	3,666	5,920	0	0	9,587	2.17
14. 30.001. 3.04 Compaction, riding, sheepfoot	8810.00	SY	44	1,219	1,373	0	0	2,592	0.29
14. 30.001. 3.05 Fine grade, grade subgrade for	8810.00	SY	104	2,902	1,830	0	0	4,731	0.54
TOTAL Site Preparation	1.80	ACR	268	7,799	9,142	0	0	16,941	9411.90
14. 30.001. 4 Asphalt Paving, 6" stone base,	79280.00	SF	0	11,892	14,270	103,064	0	129,226	1.63
14. 30.001. 5 Lines on pavement, parking stall			0	0	0	0	1,500	1,500	
14. 30.001. 6 Parking Lot Amenities, lighting,			0	0	0	0	10,000	10,000	
TOTAL Parking Areas	1.80	ACR	474	24,444	23,998	107,074	11,500	167,016	92786.39
14. 30.005 Decomposed Granite Trails									
14. 30.005. 1 Clearing & Grubbing, debris	2.00	ACR	28	828	616	0	0	1,444	722.14
TOTAL Clearing & Grubbing, debris	2.00	ACR	28	828	616	0	0	1,444	722.14
14. 30.005. 2 Site Preparation									
14. 30.005. 2.01 Ripping, discing to prepare	2.00	ACR	0	10	15	0	0	25	12.49
14. 30.005. 2.02 Regrade, flatten, balance cut	1540.00	CY	8	231	511	0	0	742	0.48
14. 30.005. 2.03 Compaction, riding, sheepfoot/	30640.00	SY	153	4,241	4,774	0	0	9,014	0.29
TOTAL Site Preparation	2.00	ACR	161	4,481	5,300	0	0	9,781	4890.62
14. 30.005. 3 Decomposed Granite course,									
14. 30.005. 3.01 Material and Delivery	3830.00	TON	0	0	0	0	114,900	114,900	30.00
14. 30.005. 3.02 Spread and Compaction	3830.00	TON	153	4,522	2,584	0	0	7,106	1.86
TOTAL Decomposed Granite course,	275740.00	SF	153	4,522	2,584	0	114,900	122,006	0.44
14. 30.005. 4 Trail amenities, ADA ramps, sign			0	0	0	0	10,000	10,000	
TOTAL Decomposed Granite Trails	1.00	EA	343	9,831	8,501	0	124,900	143,232	143231.98
14. 30.010 Other Recreation Features									
14. 30.010. 1 Paved Trail amenities, curb	1.00	EA	0	0	0	0	10,000	10,000	10000.00
14. 30.010. 2 Comfort Stations	3.00	EA	0	0	0	0	300,000	300,000	100000.00
14. 30.010. 3 Rest Stops	5.00	EA	0	0	0	0	15,000	15,000	3000.00
14. 30.010. 4 Concrete Benches	21.00	EA	84	1,859	0	13,050	0	14,909	709.94
14. 30.010. 5 Signage	21.00	EA	11	232	0	353	0	585	27.87
TOTAL Other Recreation Features	1.00	EA	95	2,091	0	13,402	325,000	340,494	340493.88

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL RECREATION FEATURES	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
TOTAL RECREATION	1.00	EA	912	36,367	32,498	120,476	461,400	650,741	650741.37
30 PLANNING, ENGINEERING, DESIGN									
30.009 Construction	1.00	EA	0	0	0	0	5,120,000	5,120,000	5120000
30.014 Recreation	1.00	EA	0	0	0	0	95,285	95,285	95285.00
TOTAL PLANNING, ENGINEERING, DESIGN	1.00	EA	0	0	0	0	5,215,285	5,215,285	5215285
31 CONSTRUCTION MANAGEMENT									
31.009 Construction (Restoration)	1.00	EA	0	0	0	0	5,980,000	5,980,000	5980000
31.014 Recreation	1.00	EA	0	0	0	0	63,879	63,879	63879.00
TOTAL CONSTRUCTION MANAGEMENT	1.00	EA	0	0	0	0	6,043,879	6,043,879	6043879
TOTAL Paseo de las Iglesias Feas Study	1.00	EA	344,214	10582793	4845615	12803035	45,821,315	74,052,757	74052757
OVERHEAD								3,659,359	
SUBTOTAL								77,712,116	
HOME OFC								3,220,236	
SUBTOTAL								80,932,352	
PROFIT								4,347,319	
SUBTOTAL								85,279,671	
BOND								237,678	
TOTAL INCL INDIRECTS								85,517,349	
ESCALATION								4,953,123	
SUBTOTAL								90,470,472	
CONTINGENCY								7,118,185	
TOTAL INCL OWNER COSTS								97,588,657	

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	ACARC2	5 carpnters		PROD =	100%			CREW HOURS =	148
MIL	B-CARPNTERF	Carpenters	1.00 HR	34.07	1.00	34.07			34.07
MIL	B-CARPNTERL	Carpenters	4.00 HR	33.07	4.00	132.30			132.30
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00 HR	22.13	1.00	22.13			22.13
	TOTAL				6.00	188.50	0.00	0.00	188.50
	ALABCLAB1	1 laborer		PROD =	100%			CREW HOURS =	42848
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00 HR	22.13	1.00	22.13			22.13
	TOTAL				1.00	22.13	0.00	0.00	22.13
	ALABCLAB2	2 laborers		PROD =	100%			CREW HOURS =	4422
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00 HR	22.13	2.00	44.26			44.26
	TOTAL				2.00	44.26	0.00	0.00	44.26
	CLABB13	5 laborers + 1 crane, hydr, trk mtd, 60 ton		PROD =	100%			CREW HOURS =	67
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	23.13	1.00	23.13			23.13
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00 HR	22.13	4.00	88.53			88.53
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00 HR	35.19	1.00	35.19			35.19
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00 HR	28.24	1.00	28.24			28.24
GEN	C80Z2280 E	CRANE, HYD, TRUCK MTD, 65T	1.00 HR	94.68			1.00	94.68	94.68
	TOTAL				7.00	175.09	1.00	94.68	269.76
	CLABB14	5 laborers + 1 loader, BH, wheel, 0.80 CY FE bkt		PROD =	100%			CREW HOURS =	1079
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	23.13	1.00	23.13			23.13
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00 HR	22.13	4.00	88.53			88.53
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00 HR	30.80	1.00	30.80			30.80
GEN	L50Z4640 E	LOADER/BCK-HOE,WH, 0.80CY(0.6M3	1.00 HR	15.12			1.00	15.12	15.12
	TOTAL				6.00	142.46	1.00	15.12	157.59
	CODBB53	1 eqoprlt + 1 trencher, chain, 35" D, 8" W		PROD =	100%			CREW HOURS =	0
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00 HR	30.80	1.00	30.80			30.80
GEN	T30Z6720 E	TRENCHER, CHAIN, 16"W, 48"DP	1.00 HR	5.73			1.00	5.73	5.73
	TOTAL				1.00	30.80	1.00	5.73	36.54
	CODEB12B	1 eqoprcrn + 1 hydr excavator, crawler, 1.50 CY		PROD =	100%			CREW HOURS =	990
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00 HR	35.19	1.00	35.19			35.19
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00 HR	28.24	1.00	28.24			28.24
GEN	H25Z3185 E	HYD EXCV, CRAWLER, 55,000LBS,	1.00 HR	58.72			1.00	58.72	58.72
	TOTAL				2.00	63.43	1.00	58.72	122.14

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	CODEB12C	1 eqoprcrn + 1 hydr excavator, crawler, 2.00 CY			PROD =	100%			CREW HOURS =	4731
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	35.19	1.00	35.19			35.19
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	28.24	1.00	28.24			28.24
GEN	H25Z3190 E	HYD EXCV, CRAWLER, 70,000LBS,	1.00	HR	72.24			1.00	72.24	72.24
	TOTAL					2.00	63.43	1.00	72.24	135.67
	CODFB10N	1 eqoprmed + 1 loader, F/E, crawler, 1.50 CY			PROD =	100%			CREW HOURS =	6043
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	22.13	0.50	11.07			11.07
GEN	L35Z4240 E	LOADER, F/E, CRWLR, 1.50CY	1.00	HR	37.19			1.00	37.19	37.19
	TOTAL					1.50	44.92	1.00	37.19	82.12
	CODLB6	1 eqoprlt + 1 loader, BH, wheel,0.80 CY F/E bkt			PROD =	100%			CREW HOURS =	938
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	22.13	2.00	44.26			44.26
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00	HR	30.80	1.00	30.80			30.80
GEN	L50Z4640 E	LOADER/BCK-HOE,WH, 0.80CY(0.6M3	1.00	HR	15.12			1.00	15.12	15.12
	TOTAL					3.00	75.07	1.00	15.12	90.19
	CODSB33D	1 eqoprmed + 1 scraper, self propelled, 14-20 CY			PROD =	100%			CREW HOURS =	128
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.30	HR	33.86	1.30	44.01			44.01
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	22.13	0.50	11.07			11.07
GEN	S20Z5970 E	SCRAPER, SP, 14-20CY (11-15M3)	1.00	HR	103.06			1.00	103.06	103.06
GEN	T15Z6600 E	DOZER, CRAWLER, 341-440HP	0.30	HR	99.64			0.30	29.89	29.89
	TOTAL					1.80	55.08	1.30	132.96	188.04
	CODSB33F	1 eqoprmed + 1 scraper, elev, 11 CY			PROD =	100%			CREW HOURS =	67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.30	HR	33.86	1.30	44.01			44.01
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	22.13	0.50	11.07			11.07
GEN	S10Z5920 E	SCRAPER, SP,ELEV, 11CY (8.4M3)	1.00	HR	59.05			1.00	59.05	59.05
GEN	T15Z6600 E	DOZER, CRAWLER, 341-440HP	0.30	HR	99.64			0.30	29.89	29.89
	TOTAL					1.80	55.08	1.30	88.94	144.02
	CODTB10B	1 eqoprmed + 1 dozer, crawler, 181-250 HP			PROD =	100%			CREW HOURS =	4652
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	22.13	0.50	11.07			11.07
GEN	T15Z6520 E	DOZER, CRAWLER, 181-250HP	1.00	HR	65.93			1.00	65.93	65.93
	TOTAL					1.50	44.92	1.00	65.93	110.85
	CODTB10L	1 eqoprmed + 1 dozer, crawler, 76-100 HP			PROD =	100%			CREW HOURS =	24
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	22.13	0.50	11.07			11.07
GEN	T15Z6440 E	DOZER, CRAWLER, 76-100HP	1.00	HR	27.53			1.00	27.53	27.53
	TOTAL					1.50	44.92	1.00	27.53	72.45

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	CODTB10M	1 eqoprmed + 1 dozer, crawler, 341-440 HP			PROD = 100%			CREW HOURS =	101
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00 HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50 HR	22.13	0.50	11.07			11.07
GEN	T15Z6600 E	DOZER, CRAWLER, 341-440HP	1.00 HR	99.64			1.00	99.64	99.64
	TOTAL				1.50	44.92	1.00	99.64	144.57
	CODTB10W	1 eqoprmed + 1 dozer, crawler, 101-135 HP			PROD = 100%			CREW HOURS =	4567
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00 HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50 HR	22.13	0.50	11.07			11.07
GEN	T15Z6480 E	DOZER, CRAWLER, 101-135HP	1.00 HR	29.83			1.00	29.83	29.83
	TOTAL				1.50	44.92	1.00	29.83	74.75
	CODTB11R	1 eqoprmed + 1 dozer, crawler, 181-250 HP			PROD = 100%			CREW HOURS =	1436
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00 HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50 HR	22.13	0.50	11.07			11.07
GEN	T15Z6520 E	DOZER, CRAWLER, 181-250HP	1.00 HR	65.93			1.00	65.93	65.93
	TOTAL				1.50	44.92	1.00	65.93	110.85
	COEIB34B	1 trkdvrhv + 1 truck, dump, 16-23.5 CY			PROD = 100%			CREW HOURS =	954
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00 HR	27.03	1.00	27.03			27.03
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00 HR	45.79			1.00	45.79	45.79
GEN	T40Z6860 E	REAR DUMP BODY, 16-23.5CY (12.2	1.00 HR	2.14			1.00	2.14	2.14
	TOTAL				1.00	27.03	2.00	47.93	74.96
	COFCB10F	1 eqoprmed + 1 roller, vib, tandem, S/P, 12 ton			PROD = 100%			CREW HOURS =	4504
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00 HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50 HR	22.13	0.50	11.07			11.07
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00 HR	46.53			1.00	46.53	46.53
	TOTAL				1.50	44.92	1.00	46.53	91.46
	COFCB32F	1 eqoprmed + 1 truck, water, off-hwg, 6,000 gal			PROD = 100%			CREW HOURS =	2505
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00 HR	22.13	1.00	22.13			22.13
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00 HR	33.86	1.00	33.86			33.86
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00 HR	27.03	1.00	27.03			27.03
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00 HR	19.65			1.00	19.65	19.65
GEN	T60Z7920 E	TRUCK, OFF-HWY, WATER, 6000GAL	1.00 HR	73.85			1.00	73.85	73.85
	TOTAL				3.00	83.02	2.00	93.49	176.51
	COFGB11L	1 eqoprmed + 1 grader, motor, artic, 28,770 lbs			PROD = 100%			CREW HOURS =	3123
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00 HR	33.86	1.00	33.86			33.86
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00 HR	22.13	1.00	22.13			22.13
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00 HR	35.31			1.00	35.31	35.31
	TOTAL				2.00	55.99	1.00	35.31	91.30

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	COFGB12K	1 eqoprcrn + 1 hydr excav, trk mtd, 6x4, .75 CY				PROD = 100%			CREW HOURS =	178
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	35.19	1.00	35.19			35.19
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	28.24	1.00	28.24			28.24
GEN	H30Z3760 E	HYD EXCAV, TRUCK MTD, 0.750CY	1.00	HR	62.84			1.00	62.84	62.84
	TOTAL					2.00	63.43	1.00	62.84	126.26
	COFGB36C	3 eqoprmed + 1 dozer, crawler, 251-340 HP				PROD = 100%			CREW HOURS =	111
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	23.13	1.00	23.13			23.13
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	33.86	3.00	101.57			101.57
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	27.03	1.00	27.03			27.03
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
GEN	T15Z6570 E	DOZER, CRAWLER, 300-340HP	1.00	HR	83.26			1.00	83.26	83.26
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
GEN	T60Z7910 E	TRUCK, OFF-HWY, WATER, 5000GAL	1.00	HR	40.14			1.00	40.14	40.14
	TOTAL					5.00	151.74	4.00	205.24	356.98
	COKCB25	8 laborers + 1 asph finisher, w/screed, 10' wide				PROD = 100%			CREW HOURS =	163
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	23.13	1.00	23.13			23.13
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00	HR	22.13	7.00	154.92			154.92
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	33.86	3.00	101.57			101.57
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00	HR	74.74			1.00	74.74	74.74
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00	HR	19.65			1.00	19.65	19.65
	TOTAL					11.00	279.63	3.00	140.92	420.54
	COKCB25B	8 laborers + 1 roller,vib,tandem,S/P,12Ton,84"w				PROD = 100%			CREW HOURS =	95
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	23.13	1.00	23.13			23.13
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00	HR	22.13	7.00	154.92			154.92
MIL	B-EQOPRMEDL	Equip. Operators, Medium	4.00	HR	33.86	4.00	135.43			135.43
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00	HR	74.74			1.00	74.74	74.74
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	2.00	HR	46.53			2.00	93.07	93.07
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00	HR	19.65			1.00	19.65	19.65
	TOTAL					12.00	313.49	4.00	187.45	500.93
	CTDHB34C	1 trkdvrhv + 1 trailer, dump, 17 CY				PROD = 100%			CREW HOURS =	36897
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	27.03	1.00	27.03			27.03
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00	HR	45.79			1.00	45.79	45.79
GEN	T45Z7080 E	TRAILER, END DUMP, 17CY, 22T	1.00	HR	4.79			1.00	4.79	4.79
	TOTAL					1.00	27.03	2.00	50.57	77.60
	SIWRRODM4	4 rodmen				PROD = 100%			CREW HOURS =	429
MIL	B-RODMAN L	Rodmen, (Reinforcing)	4.00	HR	39.79	4.00	159.17			159.17
	TOTAL					4.00	159.17	0.00	0.00	159.17

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	ULABA2	2 laborers + 1 truck, flatbed, 20,000-25,000 GVW		PROD =	100%			CREW HOURS =	927
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00 HR	22.13	2.00	44.26			44.26
MIL	B-TRKDVRLTL	Truck Drivers, Light	1.00 HR	26.57	1.00	26.57			26.57
GEN	T40Z6960 E	TRK FLATBED, 8'X 12'(2.4MX 3.7M	1.00 HR	0.72			1.00	0.72	0.72
GEN	T50Z7400 E	TRUCK, HWY 25,000 (11,340KG)GVW	1.00 HR	17.77			1.00	17.77	17.77
	TOTAL				3.00	70.84	2.00	18.50	89.33
	ULABB2	5 laborers		PROD =	100%			CREW HOURS =	2304
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	23.13	1.00	23.13			23.13
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00 HR	22.13	4.00	88.53			88.53
	TOTAL				5.00	111.66	0.00	0.00	111.66
	ULABB20A	2 laborers		PROD =	100%			CREW HOURS =	29940
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	23.13	1.00	23.13			23.13
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00 HR	22.13	1.00	22.13			22.13
MIL	B-PLUMBER L	Plumbers	1.00 HR	47.90	1.00	47.90			47.90
MIL	B-PLUMBER A	Plumbers	1.00 HR	40.31	1.00	40.31			40.31
	TOTAL				4.00	133.47	0.00	0.00	133.47
	ULABC8A	4 laborers		PROD =	100%			CREW HOURS =	163
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	23.13	1.00	23.13			23.13
MIL	B-LABORER L	Laborers, (Semi-Skilled)	3.00 HR	22.13	3.00	66.40			66.40
MIL	B-CEMTFINRL	Cement Finishers	2.00 HR	31.59	2.00	63.18			63.18
	TOTAL				6.00	152.71	0.00	0.00	152.71
	UOEHB40A	1 eqoprcrn + 1 crane, mech, crawler, 25 ton		PROD =	100%			CREW HOURS =	3082
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00 HR	35.19	1.00	35.19			35.19
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00 HR	30.80	1.00	30.80			30.80
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00 HR	28.24	1.00	28.24			28.24
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00 HR	22.13	1.00	22.13			22.13
GEN	C85Z2550 E	CRANE, MECH, CRWLR, LIFTING, 25	1.00 HR	53.86			1.00	53.86	53.86
GEN	A15Z0160 E	AIR COMPRESSOR, 600CFM, 100 PS	1.00 HR	32.17			1.00	32.17	32.17
GEN	A20Z0480 E	AIR HOSE,1.5"X 100'L (38MMX 31M	1.00 HR	0.53			1.00	0.53	0.53
	TOTAL				4.00	116.36	3.00	86.56	202.92
	USKCSKWK2	2 skillwkrs		PROD =	100%			CREW HOURS =	101
MIL	B-SKILLWKRL	Skilled Workers	2.00 HR	23.35	2.00	46.69			46.69
	TOTAL				2.00	46.69	0.00	0.00	46.69

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-CARPNTER	Carpenter	20.25	0.0%	37.8%	5.17	0.00	33.07	HR	05/19/05	31.68	742
MIL	B-CEMTFINR	Cement Finisher	20.00	0.0%	27.9%	6.01	0.00	31.59	HR	02/06/04	28.47	326
MIL	B-EQOPRCRN	Equip. Operator, Crane/Shovel	22.22	0.0%	29.2%	6.48	0.00	35.19	HR	05/19/05	32.62	9048
MIL	B-EQOPRLT	Equip. Operator, Light	19.91	0.0%	29.2%	5.08	0.00	30.80	HR	02/06/04	28.51	5099
MIL	B-EQOPRMED	Equip. Operator, Medium	21.19	0.0%	29.2%	6.48	0.00	33.86	HR	05/19/05	30.27	28508
MIL	B-EQOPROIL	Equip. Operator, Oiler	16.84	0.0%	29.2%	6.48	0.00	28.24	HR	05/19/05	24.69	9048
MIL	B-LABORER	Laborer (Semi-Skilled)	13.07	0.0%	37.2%	4.20	0.00	22.13	HR	05/19/05	23.81	155050
MIL	B-PLUMBER	Plumber	28.75	0.0%	32.0%	9.95	0.00	47.90	HR	05/19/05	34.82	59880
MIL	B-RODMAN	Rodman (Reinforcing)	20.91	0.0%	40.8%	10.35	0.00	39.79	HR	02/06/04	36.56	1717
MIL	B-SKILLWKR	Skilled Worker	14.68	0.0%	35.2%	3.50	0.00	23.35	HR	02/06/04	25.96	202
MIL	B-TRKDVRHV	Truck Driver, Heavy	16.33	0.0%	35.1%	4.97	0.00	27.03	HR	05/19/05	24.66	40466
MIL	B-TRKDVRLT	Truck Driver, Light	15.99	0.0%	35.1%	4.97	0.00	26.57	HR	05/19/05	23.25	927
MIL	X-EQOPRHVY	Outside Equip. Operator, Heavy	22.02	0.0%	29.2%	5.08	0.00	33.53	HR	02/06/04	31.93	162
MIL	X-EQOPRLT	Outside Equip. Operator, Light	19.91	0.0%	29.2%	5.08	0.00	30.80	HR	02/06/04	28.22	3672
MIL	X-EQOPRMED	Outside Equip. Operator, Medium	20.99	0.0%	29.2%	5.08	0.00	32.20	HR	02/06/04	30.68	277
MIL	X-EQOPROIL	Outside Equip. Oiler	16.64	0.0%	29.2%	5.08	0.00	26.58	HR	02/06/04	24.82	162
MIL	X-LABORER	Outside Laborer	12.37	0.0%	37.2%	3.50	0.00	20.47	HR	02/06/04	24.50	27441
MIL	X-STRSTEEL	Outside Steel Worker	20.91	0.0%	55.8%	10.35	0.00	42.93	HR	02/06/04	39.01	809
MIL	X-TRKDVRLT	Outside Truck Driver, Light	15.33	0.0%	35.1%	4.67	0.00	25.38	HR	02/06/04	23.49	604

** EQUIPMENT BACKUP **

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
GEN	A15Z0160	AIR COMPRESSOR, 600CFM, 100 PSI	5.36	1.56	13.86	4.87	0.15	0.03	6.35	32.17 HR	3082
GEN	A20Z0480	AIR HOSE,1.5"X 100'L (38MMX 31M)	0.17	0.02					0.34	0.53 HR	3082
GEN	A30Z0640	ASPHALT PAVER, 10.0' (3.1M)W,SP	21.05	5.68	8.08	4.34	1.69	0.30	33.60	74.74 HR	259
EP	C75GV016	CRANE,HYD,S/P,RT,4WD,100T/88'BM,	51.99	17.18	15.41	5.77	4.45	0.78	61.27	156.85 HR	162
GEN	C80Z2280	CRANE, HYD, TRUCK MTD, 65T	28.95	10.65	18.25	5.98	0.92	0.16	29.77	94.68 HR	67
GEN	C85Z2550	CRANE, MECH, CRWLR, LIFTING, 25T	18.83	6.46	6.30	1.55			20.72	53.86 HR	3082
EP	G15CA003	GRADER,MOTOR, ARTIC, CAT 12-H	10.84	4.29	6.86	2.89	0.47	0.08	12.74	38.17 HR	38
GEN	G15Z3080	GRADER, MOTOR, 135 HP (101KW)	9.86	3.91	6.61	2.79	0.47	0.08	11.59	35.31 HR	3234
GEN	H25Z3185	HYD EXCV, CRAWLER, 55,000LBS,	17.96	5.51	8.76	4.10			22.39	58.72 HR	990
GEN	H25Z3190	HYD EXCV, CRAWLER, 70,000LBS,	21.63	6.64	11.58	5.42			26.98	72.24 HR	4731
GEN	H30Z3760	HYD EXCAV, TRUCK MTD, 0.750CY	24.35	5.28	9.29	4.13	0.64	0.11	19.04	62.84 HR	178
GEN	L15Z3880	HYDROMULCHER, 3,000 GAL(11,356L)	9.43	1.04	7.06	2.07			9.45	29.04 HR	604
GEN	L35Z4240	LOADER, F/E, CRWLR, 1.50CY	9.00	1.92	5.12	2.40			18.76	37.19 HR	6043
EP	L50CS006	LDR,BH,WH, 1.25CY FE BKT,	6.04	1.81	4.48	1.78	0.85	0.15	7.99	23.10 HR	162
GEN	L50Z4640	LOADER/BCK-HOE,WH, 0.80CY(0.6M3)	3.76	1.14	3.13	1.24	0.72	0.13	5.00	15.12 HR	2017
EP	R30HY005	ROLLER,STATIC,DD,S/P,10T, 50"W	5.65	1.47	3.91	1.14			6.90	19.08 HR	38
GEN	R30Z5645	ROLLER, STATIC, 9 TIRES, SP,14T	6.05	1.32	4.17	1.22	0.34	0.06	6.49	19.65 HR	2763
GEN	R45Z5580	ROLLER, VIB, SD, SP 13.0T	13.61	2.95	10.54	4.19	0.48	0.08	22.93	54.79 HR	96
GEN	R45Z5690	ROLLER, VIB, DD, SP 12.0T	12.58	2.68	7.27	2.89			21.12	46.53 HR	4968
GEN	S10Z5920	SCRAPER, SP,ELEV, 11CY (8.4M3)	17.33	4.69	9.12	4.48	2.46	0.43	20.54	59.05 HR	67
GEN	S20Z5970	SCRAPER, SP, 14-20CY (11-15M3)	23.87	9.56	28.06	9.19	7.94	1.39	23.04	103.06 HR	128
EP	T10LE001	ROTARY HOE, 80" WIDE ROTERRA	0.52	0.13					0.64	1.29 HR	3672
GEN	T15Z6440	DOZER, CRAWLER, 76-100HP	6.42	1.84	4.55	2.02			12.69	27.53 HR	24
GEN	T15Z6480	DOZER, CRAWLER, 101-135HP	6.88	1.97	5.12	2.28			13.59	29.83 HR	4567
GEN	T15Z6520	DOZER, CRAWLER, 181-250HP	15.87	7.11	13.65	4.79			24.50	65.93 HR	6087
GEN	T15Z6570	DOZER, CRAWLER, 300-340HP	19.61	8.78	18.20	6.39			30.28	83.26 HR	111
GEN	T15Z6600	DOZER, CRAWLER, 341-440HP	22.90	10.26	23.04	8.09			35.36	99.64 HR	160
MAP	T25JD005	TRACTOR,WH,FARM, 40- 59HP, 2X4	2.04	0.42	2.09	0.73	0.27	0.05	2.07	7.67 HR	3672
GEN	T30Z6720	TRENCHER, CHAIN, 16"W, 48"DP	1.13	0.25	1.98	0.69	0.07	0.01	1.60	5.73 HR	0
GEN	T40Z6860	REAR DUMP BODY, 16-23.5CY (12.2-	0.93	0.20					1.01	2.14 HR	954
GEN	T40Z6960	TRK FLATBED, 8'X 12'(2.4MX 3.7M)	0.34	0.07					0.31	0.72 HR	927
GEN	T45Z7080	TRAILER, END DUMP, 17CY, 22T	1.87	0.49			0.52	0.09	1.80	4.79 HR	36897
EP	T50FO009	TRK,HWY, 21,000 GVW, 4X2, 2 AXLE	2.57	0.63	7.08	2.32	0.34	0.06	2.55	15.53 HR	604
EP	T50GM006	TRK,HWY, 8,600GVW,4X2, 3/4T-PKUP	1.83	0.40	4.18	1.47	0.32	0.06	1.96	10.23 HR	38
GEN	T50Z7400	TRUCK, HWY 25,000 (11,340KG)GVW	3.48	0.87	6.88	2.25	0.70	0.12	3.47	17.77 HR	927
GEN	T50Z7420	TRUCK, HWY 45,000 (20,412KG)GVW	10.97	2.40	15.62	5.48	0.97	0.17	10.16	45.79 HR	37851
GEN	T60Z7910	TRUCK, OFF-HWY, WATER, 5000GAL	10.38	3.38	9.12	3.63	1.82	0.32	11.48	40.14 HR	111
GEN	T60Z7920	TRUCK, OFF-HWY, WATER, 6000GAL	18.80	6.13	17.21	6.84	3.45	0.61	20.80	73.85 HR	2505

No errors detected...

* * * END OF ERROR REPORT * * *

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

BACKUP REPORTS — BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX K

PUBLIC INVOLVEMENT

Revised July 2005

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

TABLE OF CONTENTS

ATTACHMENTS

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (the "Corps") is conducting a feasibility study in the Paseo de las Iglesias reach of the Santa Cruz River to identify, define and solve environmental degradation, flooding and related water resource problems. These efforts are proceeding in partnership with the Pima County Flood Control District. Throughout the planning process for this project, public input has been solicited utilizing a variety of avenues including local newspaper articles, public information mailings, and coordination with special-interest groups, public workshops and formal public hearings. This appendix provides details of the public involvement activities completed as of July 2005.

2.0 NOTICE OF INTENT

The Corps and the Pima County Flood Control District (the project's non-Federal sponsor) implemented a public involvement program to obtain input from various groups, organizations, or individuals that represent business, homeowner, educational, environmental, government, neighborhood, and community interests. The program established a mailing list of interested parties. The mailing list was used for the distribution of invitations to public meetings and dissemination of project documents. Announcements for public meetings were also made in local newspapers, including date, time, place, and subject matter.

In April 2001, the Corps prepared a Notice of Intent (NOI) for the Paseo de las Iglesias Ecosystem Restoration EIS (Attachment A). This notice was published in the *Federal Register* (April 6, 2001, Volume 66, Number 67) in compliance with 40 C.F.R. 1508.22. As recommended in 40 C.F.R. 1501.7(b), public scoping meetings also were held for the project.

3.0 PUBLIC SCOPING MEETINGS

The meetings were held on March 30 and 31, 2001 at 450 W. Paseo Redondo in Tucson. An evening meeting was held on March 30 from 5:00 p.m. to 8:00 p.m. and an all day meeting was conducted on March 31 between 8:00 a.m. and 3:00 p.m. Guided site visits were available on April 1, 2001 for all who expressed interest.

Public comments received during the public scoping meeting, have been incorporated into the plan formulation, feasibility, and evaluation process associated with this flood control project. The key issues that were raised during the public scoping process are summarized below. A more detailed summary of the comments may be found in Attachment B.

Process: Many people expressed concern about what process should take place to address the Santa Cruz River. Attendees at the scoping meeting advocated bringing together a diverse group of people (government officials, scientists, citizens, nonprofits, and schools) to address the technical, ecological, political, community, and business issues affecting river restoration.

River Channel and Banks: People expressed a desire to have the river channel restored to a more natural pattern. Specifically, the public advocated removing soil cement banks completely where possible and re-evaluating their use. Other comments addressed allowing a more natural meandering pattern and establishing terraces along the banks vegetated with native plants.

Natural Habitat Restoration: Most respondents expressed a desire to see a restoration of natural habitats along the river. Clean ups and native vegetation plantings were suggested and the need to control invasive plants was noted. People indicated a desire to see vegetation supported by rain, flood, and/or reclaimed water. No one source of water was favored.

River Flow and Water: Comments regarding the use and presence of water in the river varied. Some called for the addition of water in some form (e.g. effluent, Central Arizona Project water and reclaimed water) while others recognized the potential problems in committing substantial volumes of water to restoration. Creation of standing water would have the undesirable consequence of breeding of mosquitoes.

Recreation: People expressed a strong desire to have recreation integrated with restoration. Specific recreation requirements identified included trails, interpretive signage and picnic/resting spots.

Rio Nuevo and Redevelopment: With regard to redevelopment plans and the Rio Nuevo project, people raised concerns about how restoration might be integrated with re-development.

4.0 OTHER PUBLIC INVOLVEMENT EFFORTS

Several meetings have been held during the course of the study to obtain additional public input. In March of 2002 representatives of the Corps, the non-Federal sponsor and local entities met to discuss potential restoration approaches (Attachment C). In April of 2003 representatives of the Corps and the non-Federal sponsor met with representatives of other local government and members of the public to obtain additional input to the plan formulation process (Attachment D). In September of 2003 representatives of the Corps and the non-Federal sponsor met with representatives of other government agencies and members of the public to obtain input regarding potential recreational features of the tentatively selected plan (Attachment E). An additional public workshop was conducted by the non-Federal sponsor on January 22, 2004 to present the tentatively recommended plan to the general public (Attachment F).

5.0 PUBLIC REVIEW OF DRAFT DOCUMENTS

The Draft Feasibility Report and Draft EIS were circulated for public review and comment on October 8, 2004 for a 45-day review period. The review period was initiated by publication of a Notice of Availability (NOA) for the draft EIS in the Federal Register in compliance with 40 C.F.R. 1508.22. Copies of the report were provided to concerned Federal, state, and local agencies as well as being made available to the general public. All comments received and responses to each comment are included in Appendix 14.5 of the Final Environmental Impact Statement.

A final public meeting was conducted on October 26, 2004 to provide further opportunity for public comment. The non-Federal sponsor utilized the services of a Public Relations Firm to disseminate information and conduct final public meeting. A transcript of the final public meeting is included in Appendix 14.5 of the Final Environmental Impact Statement.

ATTACHMENT A
NOTICE OF INTENT

SUMMARY: Development of environmentally sustainable flood protection alternatives for the St. Johns Bayou and New Madrid Floodway basins is the purpose of the proposed reevaluation. A Notice of Availability for the Final Supplemental Environmental Impact Statement (FSEIS) on the St. Johns Bayou and New Madrid Floodway, Missouri, First Phase, Supplement to the 1982 St. Johns Bayou-New Madrid Floodway Final Supplemental Environmental Impact Statement and the Mississippi River and Tributaries Project, Mississippi River Levees and Channel Improvement 1976 Final Environmental Impact Statement was published in the **Federal Register** on September 8, 2000. The FSEIS was distributed to Federal and State agencies and the public. The FSEIS evaluated plans that provide flood protection in the St. Johns Bayou and New Madrid Floodway Basins in southeast Missouri. Substantive comments promulgated by the Department of the Interior, U.S. Environmental Protection Agency (EPA), and the State of Missouri concerning the FSEIS array of alternatives resulted in the Corps of Engineers decision to prepare a revised DSEIS to evaluate alternative levee closure alignments and relevant mitigation options.

FOR FURTHER INFORMATION CONTACT: Mr. Larry Sharpe, telephone (901) 544-3476, CEMVM-PM-P, 167 North Main street, B-202, Memphis, TN 38103-1894. Questions or comments regarding the revised DSEIS (including scoping input) may be directed to Mr. David L. Reece, Chief, Environmental and Economic Analysis Branch, telephone (901) 544-3970, CEMVM-PM-E, or Mr. John Rumancik, telephone (901) 544-3975, CEMVM-PM-E.

SUPPLEMENTARY INFORMATION: The St. Johns Bayou Basin and New Madrid Floodway are located in the Bootheel region of southeast Missouri, and include all or portions of New Madrid, Scott, and Mississippi counties. The basins are adjacent to the Mississippi River, and subject to both backwater and interior headwater flooding. Congress authorized the Mississippi River and Tributaries (MR&T) Project in the Flood Control Act of 1928, to construct the mainline Mississippi River levees. The Birds Point—New Madrid Floodway was a portion of the 1928 Flood Control Act. A levee closure and outlet structure at New Madrid, Missouri, were authorized in the Flood Control Act of 1954 (Pub. L. 780-83), but not constructed. The St. Johns Bayou Basin levee closure, with drainage structure, was authorized in the Flood Control Act of July 24, 1946, and subsequently constructed. An EIS for the MR&T and Channel Improvement was filed with the Council on Environmental Quality on July 2, 1976, which addressed the New Madrid Floodway levee closure. The St. Johns Bayou/New Madrid Floodway Project Final Supplemental Environmental Impact Statement (SEIS) was filed with the EPA on July 23, 1982. The current project was authorized for construction by the Water Resources Development Act of 1986 (Pub. L. 99-662), section 401(a). The authorized project is based on the Report of the Chief of Engineers, dated January 4, 1983, which is part of the Phase I General Design Memorandum (GDM) documents prepared in response to section 101(a) of the Water Resources Development Act of 1976 (Pub. L. 94-587). This revised DSEIS is being prepared to supplement the 1976 MR&T EIS and the 1982 St. Johns Bayou/New Madrid Floodway Project Final SEIS.

1. Proposed Action

The recommended plan of improvement for the First Phase work, as evaluated in the September 2000 FSEIS, includes about 23 miles of channel modification, a 1,000 cfs pumping station for the St. Johns Bayou Basin area, a 1,500 cfs pumping station for the New Madrid Floodway area, and a 1,500 foot closure levee and gravity outlet structure at the southern end of the New Madrid Floodway. The revised DSEIS will address and evaluate the environmental and economic impacts of alternative levee closure locations, develop and discuss the locations of potential compensatory mitigation sites, and further address concerns from Federal and State resource agencies.

2. Alternatives

Several flood reduction alternatives, including mitigation, were evaluated in the previous EIS(s). In addition to the recommended plan, the September 2000 FSEIS included a reevaluation of the 1986 authorized plan for flood protection and NO Action alternative. The revised DSEIS will analyze other alternative levee closure alignments and options inside the New Madrid Floodway. Each alternative levee closure alignment would result in different amounts of cropland and wooded land available for periodic Mississippi River backwater flooding to provide fishery spawning and rearing habitats.

3. Scoping Process

An intensive public involvement program has been ongoing. There have been additional interagency environmental and project sponsor meetings since the September 2000 FSEIS was produced. Interagency environmental meetings will continue to be held as needed. Significant issues to be addressed in the revised DSEIS will include alternative levee closure locations for the New Madrid Floodway, related impacts, and fish and wildlife mitigation alternatives. This NOI will serve as a request for scoping input. Interested parties are invited to provide comments or concerns to the above address. It is anticipated that the revised DSEIS will be available for public review in the Fall of 2001.

Luz D. Ortiz,

Army Federal Register Liaison Officer.

[FR Doc. 01-8554 Filed 4-5-01; 8:45 am]

BILLING CODE 3710-KS-M

DEPARTMENT OF DEFENSE

Department of the Army, Corps of Engineers

Intent To Prepare a Draft Environmental Impact Statement (DEIS) Pertaining to the Santa Cruz River Where Its Course From the South Enters the City of Tucson, Pima County, AZ

AGENCY: U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: Analyses of foreseeable environmental impacts from potential actions along the Santa Cruz River in the City of Tucson, Pima County, Arizona, will commence. No explicit plans have been advanced as yet, so contents of the Draft EIS remain to be determined during the public scoping process. The portion of the river to be studied extends from about Valencia Road (upstream) to about Congress Road (downstream), a distance of about 6.9 river miles. Pima County has identified within this length of the river needs associated with loss of riparian habitat and the presence of cultural resources. Those needs will guide the formulation of plans for this region, the *Paseo de las Iglesis* (way, or walk of the churches) segment of the Santa Cruz River.

The U.S. Army Corps of Engineers and Pima County, Arizona, will cooperate in conducting this feasibility study.

ADDRESSES: District Engineer, U.S. Army Corps of Engineers, Los Angeles District, ATTN: CESPL-PD-RP, P.O. Box 532711, Los Angeles, California 90053-2325.

FOR FURTHER INFORMATION CONTACT: Mr. John E. Moeur, Environmental

Coordinator, telephone (213) 452–3874, or Mr. John E. Drake, Study Manager, telephone (602) 640–2033. The cooperating entity, Pima County, requests inquiries he made to Ms. Mary Lou Johnson, telephone (520) 740–6444, for any additional information.

SUPPLEMENTARY INFORMATION:

1. Authorization

Feasibility studies for Paseo de las Iglesias were authorized by Section 6 of the Flood Control Act of 1938. The 75th Congress of the United States passed what became Public Law 761. This legislation states, in part: "* * * the Secretary of War [Secretary of the Army since 1947] is hereby authorized and directed to cause preliminary examinations and surveys * * * at the following locations * * * Gila River and tributaries, Arizona, * * *." The Santa Cruz River ouce flowed into the Gila when a wetter climate prevailed in the southwest, and its watershed still joins that of the Gila near Laveen, Arizona.

2. Background

The Santa Cruz River arises in southeastern Arizona, passes southwesterly into Sonora, Mexico, then turns northward again and re-enters the United States at Nogales, Arizona. Since before the late 16th century when the Spanish explored the southwest, the Santa Cruz River never ran continuously all the way to the Gila. Where underlying bedrock along its course forced water to the surface, the Santa Cruz was perennial. Historically, reliable surface flows along the Santa Cruz could be found intermittently between Nogales and Martinez Hill, to the east Mission San Xavier in the southerly parts of what is now metropolitan Tucson. Subsurface flow farther north sustained a riparian community. Downstream of the confluence with the so called West Branch of the Santa Cruz the water table again rose above the surface around Sentinel Hill. Year-round water supplied the needs of Mission San Agustín, built on the west side of the river at the foot of the hill where Tohono O'Odham people kept a village (called *stjukshon* by them), and the *presidio* on the east side of the Santa Cruz. These two historic locations became the origin modern day Tucson.

The Feasibility Studies to be evaluated by this Draft EIS will evaluate: (1) Alternative means of structural stabilization to the river's banks between Valencia Road (upstream) and the site of Mission San Agustín (downstream); (2) opportunities to reclaim lotic properties of the Santa Cruz near downtown Tucson, and elements of the riparian community on its banks; (3) modifications of upland surfaces adjacent to the incised banks to promote growth of appropriate native upland vegetation; (4) designs for recreational facilities which would feature prehistoric elements, historic properties, and biological traits of this portion of the Sauta Cruz; (5) integrate these recreational considerations into the Juan Bautista de Anza National Trail; and (6) the efficacy of recharging subsurface aquifers by means of water released into the river bottom downstream of Valencia Road.

Prehistoric and historic cultural resources are abundant along this stretch of the Santa Cruz. Neither Federally protected species nor critical habitat for listed species have been identified here.

3. Proposed Action

No plan of action has yet been identified.

4. Alternatives

a. *No Action:* No improvement or reinforcement of existing banks or uplands.

b. *Proposed Alternative Plans:* None have been formulated to date.

5. Scoping Process

Participation of all interested Federal, State, and County resource agencies, as well as Native American peoples, groups with environmental interests, and all interested individuals is encouraged. Public involvement will be most beneficial and worthwhile in identifying pertinent environmental issues, offering useful information such as published or unpublished data, direct personal experience or knowledge which inform decision making, assistance in defining the scope of plans which ought to be considered, and recommending suitable mitigation measures warranted by such plans. Those wishing to contrihute information, ideas, alternatives for actions, and so forth can furnish these contributions in writing to the points of contacts indicated above, or hy attending public scoping opportunities.

The scoping period will conclude 30 days after publication of this NOI and simultaneous publication in newspapers circulated in the greater Tucson area.

When plans have been devised and alternatives formulated to embody those plans, potential impacts will be evaluated in the DEIS. These assessments will emphasize at least fourteen categories of resources: Land use, impromptu historic landfills created by dumping trash over the banks, hazardous wastes, physical environment, hydrology, groundwater, biological, archaeological, geological, air quality, noise, transportation, socioeconomic, and safety.

Luz D. Ortiz,
Army Federal Register Liaison Officer.

[FR Doc. 01–8553 Filed 4–5–01; 8:45 am]
BILLING CODE 3710–KF–M

DEPARTMENT OF EDUCATION

[CFDA No.: 84.299B]

Indian Education Discretionary Grant Programs—Professional Development

AGENCY: Department of Education.

ACTION: Notice inviting applications for new awards for fiscal year (FY) 2001.

Purpose of Program: The purposes of this program are to (1) increase the number of qualified Indian individuals in professions that serve Indian people; (2) provide training to qualified Indian individuals to become teachers, administrators, teacher aides, social workers, and ancillary educational personnel; and (3) improve the skills of qualified Indian individuals who serve in the capacities described in (2). Activities may include, but are not limited to, continuing programs, symposia, workshops, conferences, and direct financial support.

Grants for training educational personnel may be for preservice or inservice training. For individuals who are heing trained to enter any field other than education, the training received must be in a program resulting in a graduate degree.

For FY 2001, the competition for new awards is restricted to projects designed to meet the absolute priority described in the PRIORITY section of this application notice.

Eligible Applicants: Eligihle applicants for this program are institutions of higher education, including Indian institutions of higher education; State or local educational agencies, in consortium with institutions of higher education; and Indian tribes or organizations, in consortium with institutions of higher education. An application from a consortium of eligible entities must meet the requirements of 34 CFR 75.127 through 75.129. The written consortium agreement must be submitted with the application. The agreement must be signed or the applicant must submit other evidence that all the members of the consortium agree to the contents of the agreement. Letters of support do not meet the consortium requirements. The

ATTACHMENT B
SUMMARY OF PUBLIC SCOPING MEETING

1.0 PUBLIC INPUT FROM THE PASEO DE LAS IGLESIAS SCOPING MEETINGS EXECUTIVE SUMMARY

Seventy-six people submitted written responses to the question "If I were in charge of the Santa Cruz River, I would..." The open-ended question allowed individuals to select the topic or concern that interested them most. There was a remarkable congruence of opinions about certain topics. The responses have been categorized into the following areas of interest: process, river channel and banks, natural habitat restoration, river flow and water, Rio Nuevo and redevelopment.

Process: Many people responded about what process should take place to address the Santa Cruz River. People advocated bringing together a diverse group of people, including government officials, scientists, citizens, nonprofits, and schools. This group should address various concerns that affect river restoration: technical, ecological, political, community, and business issues. These issues and restoration plans could be addressed through workshops, conferences, and social events.

River Channel and Banks: People commented on restoring the river channel to a more natural pattern. Numerous comments dealt specifically with the soil cement banks, either advocating removing them completely, where possible, or at least re-evaluating their use. Other comments addressed allowing a more natural meandering pattern and vegetating the banks along terraces with native plants.

Natural Habitat Restoration: Most respondents expressed a desire to see a restoration of natural habitats along the river. Clean ups, natural and native vegetation plantings were suggested. People indicated a desire to see vegetation supported by rain, flood, and reclaimed and/or reclaimed water. No one source of water was favored.

River Flow and Water: Comments regarding the use and presence of water in the river varied. Some called for the addition of water in some form – effluent, CAP water, reclaimed water, while others pointed out the connection between the pumping of groundwater and the reduction in river flow.

Rio Nuevo and Redevelopment: With regard to redevelopment plans and the Rio Nuevo project, people put forth many ideas for what they would like to see such as gardens, trails, wildlife corridors, museums, access routes for different modes, and special event centers.

2.0 SPECIFIC COMMENTS

Many people responded about what process should take place to address the Santa Cruz River. People advocated bringing together a diverse group of people, including government officials, scientists, citizens, nonprofits, and schools. This group should address various concerns that affect river restoration: technical, ecological, political, community, and business issues. These issues and restoration plans could be addressed through workshops, conferences, and social events.

People commented on restoring the river channel to a more natural pattern. Nine out of the 15 comments dealt specifically with the soil cement banks, either advocating removing them completely, where possible, or at least re-evaluating their use. Other comments addressed allowing a more natural meandering pattern and vegetating the banks along terraces with native plants.

Many respondents expressed a desire to see a restoration of natural habitats along the river. Clean ups, natural and native vegetation plantings, supported by rain, flood, reclaimed and/or reclaimed water was the predominant message in these comments.

Comments regarding the use and presence of water in the river varied. Some called for the addition of water in some form – effluent, CAP water, reclaimed water, while others pointed out the connection between the pumping of groundwater and the reduction in river flow.

With regard to redevelopment plans and the Rio Nuevo project, people put forth many ideas for what they would like to see such as gardens, trails, wildlife corridors, museums, access routes for different modes, and special event centers.

2.1 Verbatim Responses to "If I were in charge of the Santa Cruz River, I would..."

2.1.1 PROCESS

Create public service announcements to inform the public about ALL ongoing that concern the SCRA's projects. Work with school districts to form workshops and fieldtrips for students. Devise a plan to integrate the SCRA with other businesses that initially do not seem to relate... "opposites attract" (e.g. automotive industry with water conservation).

Make the City and County work together on a watershed-wide flood control, runoff, drainage, restoration plan with a NON-STRUCTURAL focus wherever possible.

First, pull in all issues that have and foreseeable will have an impact on the river and issues the river will create. Bring together all types of people and be ready to hear and open to consider all concerns. Gather a base of technical information and residential desires. E.g. how much water is "sustainable," then what things will increase and what things will reduce this, then how can we balance the desires and the impact they will have with this knowledge.

Convene a workshop, 3 to 4 days, with Ann Riley as the leader, bring together hydrologists, geomorphologists, Corps, bureaucrats, citizens, politicians to design a restoration plan for a reach of the river, in context of the entire watershed.

Bring organizations that are interested in Santa Cruz River restoration (those in this symposium) together to work out a comprehensive plan to make this a "living river."

Show people what the issues are. Explain tensions among various interests. Create "what if" scenarios that give approximate costs of choices. Provide ways for public input/feedback. Allow for different levels of "management" at different points along the river. Make as much of it as self-maintainable as possible.

Make sure that River Keepers were initially involved with River Planners.

Far more complicated than most people realize. Balance ecologically appears to "require" economic as well as political cooperation. All of the diverse groups need to form some sort of coalition to define and prioritize projects then work the projects jointly. Need to activate and involve everyday citizens.

Dare to dream but be totally aware of the technical and ecological challenges of river restoration. Think of creating a river of green, but not necessarily a river of water. Your commitment is wonderful. But we can't go back to where we were.

Appoint Ann Riley and Regenesis as project facilitators; schedule regular river and wash walks and workshops in neighborhoods who choose to participate and co-facilitate, linking the river to its network of people and uplands; hold annual social/cultural events in the river and its uplands; secure adequate funding for this immensely important work, schedule monsoon and winter rain celebrations; start at the top where water is manageable and healing work is easier.

Promote cooperation among the NGOs/citizens who care about the river – the FOSCR, SCRA, Arizona Center for Law, Defenders of Wildlife, etc.

2.1.2 RIVER CHANNEL AND BANKS

NO soil cement where the river has not been already soil cemented, particularly between Ajo Road and 29^{th}.

Remove the concrete (soil concrete) stabilizations and restore natural flow and boundaries, protect what exists upstream in natural watershed areas. Begin with a ceremonial request and acknowledgement to the river spirit by local medicine people.

Consider Ann Riley's vision of terraced channel (as in her slides) and not trapezoidal channel as part of Rio Nuevo Project. Make meanders to fit grade of river.

Refrain from use of sand cement siding.

Go to a more natural channel that is at the proper gradient and is allowed to meander as described by Ann Riley. Get rid of soil cement!

I know the bank stabilization is important, but can't animal paths be included instead of this rock barrier. It is another barrier like I-10.

Remove all the soil cement and enforced areas around the bridges only. If any embankment is done or needed, use riprap embankment.

I would remove as much soil cement as is practical and add not one more inch of soil cement.

Widen the channel as it flows through Rio Nuevo Project. Make two terraces. Widening the channel would better accommodate floods. The raised "terrace" would be planted in cottonwood/willow and irrigated with reclaimed effluent from a pipe along the uppermost terrace.

Restore the land regionally – stop channelization of banks in the Rio and all drainage leading to it. Hold water on the land as has been done in Turkey Creek in the Chiracauas.

Let river meander – stop controlling it in soil cement that encourages inappropriate development along the sides.

Give it more space; soften the bank protection.

Design for catastrophic floods, not "100 year" events.

Re-evaluate use of soil concrete and create meandering, low flow section of river with native vegetation.

Take away the soil cement.

Replace soil cement with vegetated banks and a meandering stream.

Install barriers so that cars, trucks, and other motorized vehicles (ATVs, etc.) would not be able to enter the wash.

2.1.3 NATURAL HABITAT RESTORATION

Help trees grow; hear running water here and there.

Leave it be natural; allow vegetation to grow.

Restore as much of the riparian growth as is practical – re-plant grass, cottonwoods, mesquites on the banks; re-plant cottonwood trees along Cottonwood Lane, a historic irrigation district. Recharge? I'm not sure how effective that would be.

Celebrate for water, air, contact with nature.

Grow as much natural vegetation as possible in as wide and area as possible. Do NOT WASTE the precious water. Vegetation must be diverse. Do not allow any motorized vehicles of any type. Dogs and cats are detrimental to wildlife.

I want the vision of a living river to move this community that it chooses to begin the long work of learning (and relearning) how to inhabit this place in a regenerative way.

I would encourage funds and water allocation, primarily recycled (highest quality treatment) water for habitat enhancement and restoration projects, i.e. wild habitat (not highly developed parks), native species, with a focus on conserving and restoring lost historic riparian habitat along the Santa Cruz.

Work on a holistic plan to incorporate recharge, some instream flow, and enhanced vegetation into Santa Cruz River rehabilitation. We can never return river to the many things it was historically – but we can create something living, something that is appropriate to our landscape and water needs.

I recently visited the Tres Rios Wetland Demonstration Project in Phoenix. I have to say I was stunned that a place like that existed in Phoenix. Over the years, the consortium has effectively created a viable ecosystem. It was incredible... an established beaver population, a resident bobcat, an incredible diversity of native plant communities, and – in the month of March anyway – great egrets, snowy egrets, cormorants, nesting Gambels quail, black necked stilts, whistling ducks. The Santa Cruz River needs ecosystem-based ecological restoration/creation most of all. Tucson needs its lifeblood – the Santa Cruz River. We need the river as a wildlife corridor MOST of all before it's too late for so many species. We need a Santa Cruz River ecosystem with many types of habitat to nurture and sustain ourselves, our city.

Clean the banks, remove the landfills; plant and MAINTAIN native vegetation. Recreate wildlife habitat: self-maintaining, low cost; healthy and self-perpetuating; arranged by nature; managed by nature; natural processes maximize beauty!

Re-vegetate using the natural water – rain, floodwater.

Try to recapture the traditional flavor and usage of the natural environment – farming is not an option – trees, native plants – accessibility to populace for natural and spiritual experience.

Open the nasal passages of every river keeper to the odor of wet dirt, which precedes the rain. That they might remember the river of green before the greed for water. That they might equate the fragile wetness of their own throats to a living river. That they might re-envision our poor plumbing experiment and begin to re-design ditches where crows fly into channels, where pup fish swim, that they learn from the children and for the children how to re-inherit this wetland – that is if they plan to stay.

Try to keep all of the cultural as well as the desert plantation the same. I would not try to turn it into California scenery.

Given need to make beautiful cottonwood forest between 29th/Ajo and Congress, the Rio Nuevo Project must find an up-stream location for a new sewage plant that can feed Rio Nuevo riparian with effluent. Need cost study with 30-year time line for re-use gallonage costs.

Make it become alive again – shady trees on the side, benches, etc.

Restore it and protect it for the future generations and not just in Rio Nuevo, but make it a park for the length of it and for as wide on either side of the river as I could control. I would then restore the water and vegetation as I could afford to.

Replant cottonwoods trees in historic Cottonwood Lane.

Purchase all land that borders the river and preserve that land. Some of the land could go to recreational parks (watered with recharged water) and the remainder/majority of the land would remain natural.

Try to raise money to buy area along the river, which would be used to allow natural flooding, and channel movement – this would help in natural (passive) regeneration of native vegetation.

2.1.4 RIVER FLOW AND WATER

Phase out groundwater pumping rights in areas adjacent to the river to allow groundwater table to recover underneath the channel (where flood flows infiltrate).

Run effluent and other re-use water in the channel.

Create not a living river but the hub of a living watershed. Restore the river as natural and cultural center of Tucson, then facilitate its use as a model for washes and tributaries throughout the rest of the watershed - resources for schools, neighborhood associations, and "friends of" groups to accomplish similar projects in their areas of Tucson.

Do reasonable mosquito management by referring to the University of Arizona entomology department.

Try to increase (or protect current allocation) allocation of effluent for river/riparian restoration.

Fill up the dry river with its water from the Sea of Cortez and use the wastewater from the Roger Road treatment plant to raise bamboo, fish, and blue green algae, to make hydrogen for fuel cells to offset the cost of pumping water to the residents.

Like to see water flowing.

Put water in it and plant BIG trees!
Emphasize the need for "cleaner" regenerated wastewater, the need to conserve water and to prioritize water use. There is no clear program that is preventing further destruction of the water table – this needs to be done first before other programs can be effective.

If I were in charge of the Santa Cruz River and the City of Tucson's water allocation, including effluent, I would use all effluent supplies to recharge into the Santa Cruz, as there seems a strong correlation (which I need to learn more about) between aquifer pumping and the decrease in surface flows. So, put it back (to a degree) where it came from. I like the idea of creating more "natural" streambeds to avoid increasingly expensive flood control measures.

Use CAP water in the Santa Cruz River – make it a river again!

Whiskeys for drinking, water's for fighting. Nothing can be done unless the 50,000 AF from the sewage plants is totally dedicated to instream flows (now it's none!). And another 50,000 AF for riparian projects near the Santa Cruz. That's 100,000 AF for the river please – ensured by law. And maybe some more from the CAP.

Dedicate CAP water to create a Tucson version of San Antonio's Riverwalk (with water in a riverine corridor) and coordinate this with central well field recharge needs.

If I were in charge of the Santa Cruz River, I would do everything possible to bring back the water, in a river form. If a river was not possible, maybe a lake - if they could put water at the lake at Kennedy Park, why not the Santa Cruz River?!!!! Bring back the water!!

I would place two small dividing dams, one located at 22nd and the other near Grant. They would be an overflow type with a water level set at 4 feet. I would also create a recirculation pump system at the near Grant dam, pumping water back to the first dam at 22nd. Being that the river flows in the north direction.

Propose we learn to live on our annual budget of rain and sun.

Create in-stream flow rights for riparian habitat. Depending on effluent flows: keep the effluent in the river, have ADWE allow 100% recharge credits for the channel effluent recharge.

Test effluent/CAP water for hormones/antibiotics.

Add water only if there is leftover reclaimed water after golf courses and other non-essential amenities have been watered with it.

Ensure adequate and effective enforcement of point and nonpoint source pollution into the river.

Make as natural as possible, do not waste the water, reinforce to everyone that water is a precious commodity, keep to minimal cost, do not display CAP water as if were in abundance.

2.1.5 RIO NUEVO AND REDEVELOPMENT

Clean up the litter and ORU trails north of Camino del Cerro and make a natural park in that area.

Contact Barbara Grygutis, Tucson's best public artist who wrote a report on urban art projects for downtown Santa Cruz. Included: 1) elder's hummingbird garden, 2) cactus maze garden with local sculptor, 3) "clock" garden of seasonal blooms, 4) "palo verde" walk-like Washington, DC cherry blossom walk, 5) a "rock garden" with geology story of Santa Cruz in tiles, 6) in channel junk-sculptor's project with viewing location, 7) in channel dance stage.

I would like to get it like the river in San Antonio with boutiques along its banks.

Like to have a lake somewhere as near as possible to the gift shops. Try to keep cottonwood trees, elms, and mesquites and entertainment for children like even a carousel or train for the area for sightseers. Think of the children too!

Design the west branch as a feature of Rio Nuevo.

I'd like to see the Regional Visitor Center feature natural and cultural past, present and future rather than being a big commercial front for Tucson businesses.

Bundrick commented that his experience with managing recreation along Santa Cruz was extremely trying. What management/enforcement will be used with Rio Nuevo recreational activities?

City might be able to sponsor special events along river, a great place to watch July fireworks. Hope the Rio Nuevo project makes good use of what the Santa Cruz has to offer.

Make it a better place to play.

Stop trying to turn it into another San Antonio – some development/amenities, yes! But not just another tourism attraction.

Make recycling facilities convenient and available; have more nature trails/activities than commercial activities; have shuttle or public transportation and limited parking; consent with communities already living there before anything begins at all.

To have it be saved for the future. As parks, trails, multiuse community centers, riparian and animal habitat areas. Industry should be kept away from the riverbanks. Flood control would need to be considered. Redo bridge at Sunset Rd. Idea: nature trails, botanical garden, museum of river history/interpretive center, Indian cultural center. In the short term, just clean up the garbage, provide some trails and restrict some areas for certain activities.

Encourage the Santa Cruz River as a recreation destination through picnic areas, trails, and information plaques.

A wildlife corridor to A Mountain (probably near Mission Gardens); foot and bicycle trails by river expanded; more business opportunities for locally owned businesses; use Rio Nuevo money for river restoration; use historic approach to architecture, i.e. Southwestern, Hispanic, Native American, etc.

Create access to the river.

Make accessible to people – recreation, alternative transportation (Tucson's Central Park, Hyde Park, Bois de Boulogne), works better for our BIG city rather than old-fashioned downtown.

Raise money and community support to restore the Santa Cruz River to the healthiest habitat that it can be today for wildlife and compatible recreation and education: education programs in schools and programs for adults in English and Spanish on both sides of the border; make the Santa Cruz the centerpiece of our community and give it the respect it deserves; clear the trash out of the river bed; make the urban restoration (Rio Nuevo) extend beyond 22nd to Congress to St. Mary's, Speedway and Grant.

Be more mindful of Native American, Hispanic culture – would love to see more Native Americans recognized or tribal recognition, after all, they were here before all of us and what better way to thank and acknowledge them.

Make it a mass transit and bicycle transportation corridor along the river, restoring the river as much as possible to its natural state. Once it is developed that way, it may be used for community centers as well. Plant trees to restore.

Get trash out of the river, extend walking/bike path, plant more trees and tell stories about its life and renewal.

There really needs to be a massive clean-up in and along the river – lets get the junk out!! I'd like to see the bike path complete farther south – from 29th Street to the Mission.

Do not allow a bus barn or bus park and maintenance center in area as pollution will reach under water flow.

Mi opinion serea que si reconstruyeran todo el area del Rio, para que la misma comunidad se beneficiara, pero todo lo natural posible, sin un canal de cementa. (My opinion would be that if they reconstruct the whole river area, that the local community benefits while making it as natural as possible and without a cement canal.)

3.0 DISCUSSION GROUPS BY TOPICS AT LUNCH 128 PARTICIPANTS

3.1 Topic: FLOOD CONTROL

What opportunity do you see to rehabilitate the river? Put habitat in washes where the water is. Moral and legal responsibility to store water upstream rather than speeding it up. Impacting downstream residents. Look at full gamut of flows – annual up to 100 year. Setting aside land to create a wider floodplain. Be creative with remnant natural areas (not bank protected). Don't do standard soil cement. To perhaps channel drainageways into auxiliary treatment plant to apply smaller, sustainable flows to stormwater of effluent into the river.

Where do we go from here? Ask how the river will adjust itself and then adjust rest. Look at watershed management and nonstructural solutions including reducing damageable structures in the way (as in Rio Nuevo). Upstream areas have the most promise for rehabilitation. Erosion areas = deal with bioengineering (like willows) in upstream areas. Noted CONCERN that the B.P. (soil cement) 1:1 sided currently in place downstream of Silverlake, will be done between Silverlake and Ajo. Buy land and let river do its thing. Ensure wildlife habitat co-exist with river – wildlife preservation/enhancement. How is valuable wildlife to be preserved in Rio Nuevo? Forget soil cement or put it in at 5:1 side slopes.

3.2 Topic: INTERGOVERNMENTAL COOPERATION

What opportunity do you see to rehabilitate the river? Have to get all stakeholders in participation including and importantly, citizens.

Where do we go from here? A) Need to include state agencies like AZSLD and citizens along rivers in planning. B) Need to devise water sources. Create Watershed Council that includes Sonora, Santa Cruz County, ambos Nogales, Tucson, Marana, Pima County, Corps. Need paid staff for Council! Need citizens, experts, government, ALL together as equals on Council. 1) Joint funding could come out to create funded position that would be equally funded by all governments (to staff the Council). 2) Will have both CAP and effluent available to put in river. 3) Riparian restoration is one of key elements to the County's Sonoran Desert Conservation Plan.

3.3 Topic: MOSQUITOES

What opportunity do you see to rehabilitate the river? If restored to conditions similar to estimate of original Fort Lowell, will lead to problems of health. Solution: engineering to avoid pockets of still water. Or, be sure to have fish (Gila top minnows and pupfish). Have good capacity but are endangered species. Would have high maintenance requirements.

3.4 Topic: RECHARGE

What opportunity do you see to rehabilitate the river Perching conditions where present would be more favorable sites for restoration projects; would need to conduct historical research using air photos. Could verify with geotechnical methods if budget available. Using permeable bank protection would aid restoration efforts.

Where do we go from here? Standardize data collection (QA/QC)

3.5 Topic: RECREATION – SANTA CRUZ

What opportunity do you see to rehabilitate the river? Underutilization: Need to increase safety – drawing people (non-transients). Make a self-guided historic walk with benches and written info, shade and benches. Picnic areas – eat lunch – ramadas with BBQs.

Where do we go from here? Establish continuity with Rillito-Santa Cruz. Have paths on full length of urban area. Expand adopt-a-wash. More police presence/call boxes (? We didn't all agree). Make riverbed more natural and scenic (even without water).

3.6 Topic: RIO NUEVO

What opportunity do you see to rehabilitate the river? With the Rio Nuevo project concentrated in the heart of downtown on both sides of the river, it will be a crucial part of the Santa Cruz. How that project proceeds will have a major impact on the future of the Santa Cruz, but little time has been spent on how the Santa Cruz will dovetail with the Rio Nuevo project. East side of river appears to be commercial. How do we preserve the west side in the context of its historical context?

Where do we go from here? Citizen groups (Rio Nuevo Citizens Task Force and Neighborhood Associations) have to introduce the importance of the Santa Cruz into their discussions. The beautification of the Santa Cruz is a major theme of Rio Nuevo and ties the whole project together. Don't loose sight of the core of Rio Nuevo is the river. With better engineering, can we remove the cement soil banks, return it to a meandering river again (Riley talk).

3.7 Topic: URBAN RESTORATION

What opportunity do you see to rehabilitate the river? Multiple objectives – recreation, wildlife, beauty, economics. Re-evaluate soil cement.

Where do we go from here? Three-day workshop with Ann Riley as leader/facilitator. Bring together cities, County, Corps, Bureau, citizens to learn the techniques Ann espouses and to pick a reach of the SCR to work up a plan for.

3.8 Topic: VEGETATION, REHABILITATION, REVEGETATION

What opportunity do you see to rehabilitate the river? Attention to upper reaches of watershed and retention of native vegetation will cause less impact to trunk stream. Important to maintain present wash and tributary boundaries. Define river boundaries so you know where to revegetate.

Where do we go from here? Focus on whole watershed. Use only water from natural watershed. More permacultural programs for whole communities. Sing and dance and tell stories together. Learn from the O'odham elders that EVERY living thing is to be respected.

3.9 Topic: VEGETATION AND REGENERATION

What opportunity do you see to rehabilitate the river? 1. Work with forces of nature (tensile strength of trees). Rillito River problems cited. Engineers worked in vacuum. No participation, no landscape architects. Best part is area without soil cement. Erosion already present at St. Phillips. 2. Damaged property can be rehabilitated. Need for invasive plant weeding.

Where do we go from here? Community involvement, networking with neighborhoods and others, adopt a river (clean up party), education – kids educate parent and newcomers need understanding. Need meetings like this one annually.

10. Topic: VEGETATION/REVEGETATION

What opportunity do you see to rehabilitate the river? The opportunity is limited/bounded only by imagination and creativity. We need to start with working with the available water we have now. The will is there – now we are finally addressing what is ecologically appropriate in the Sonoran Desert ecosystem. Need to incorporate more permaculture techniques in water harvesting/planning/design/implementation.

Where do we go from here? More small projects, using a variety of funding sources. More local incentive, involvement, public input. More show-me trips to those making decisions on the development phase; take ecologically successful (working) restoration sites. Hire good people who know how to promote public involvement (Freda is excellent.

3.11 Topic: WATER RESOURCES FOR RIVER RESTORATION

What opportunity do you see to rehabilitate the river? Creative landscaping, not cottonwoods. Opportunistic plantings – eddy's etc. where plants can thrive is more naturalistic. Funding stream is vital. West branch of the river might be more manageable to rehabilitate – near Mission Gardens and convents – in better shape than the main channel.

Where do we go from here? Explore alternative funding to pay for water to these areas (surcharge, impact fees, user fees, taxes). Opportunities for effluent to support riparian vegetation – sources for effluent, i.e. Green Valley. Zoning and [unclear word] use to encourage water harvesting along the river. Explore the region-specific opportunities for landfill mitigation (just as recharge is region-specific). River – acequia system is something that has been very important to people so water could be in them rather than the river itself. Can be intermittent – need not have perennial flow of water. Let Tucson show how to create a river amenity without constant water flows. Water to support vegetation can come from water harvesting. Greater participation in decisions being made that affect the river. Focus on the west branch to showcase a living river.

3.12 Topic: WATER SUPPLY FOR INSTREAM HABITAT

What opportunity do you see to rehabilitate the river? Concept of WWTP upstream of Roger Rd. More remote sites. Localized WWTP at Rio Nuevo. Can Ann Riley's ideas be incorporated here? Aquarium backwash water. Create xeric riparian habitat to use episodic flows when there is uncertainty about effluent supply. Need to balance needs of COT and river recharge (for Indians) for effluent recharge credits and ADWR credit allowance and instream flow rights. Talked about dedicating water to riparian uses as part of SDCP process. Rio Nuevo – reconfigure channel, add bridges, make better connections to river. Mosquito issues/attraction of wildlife to water sources – secondary effects.

3.13. Topic: WILDLIFE

What opportunity do you see to rehabilitate the river? Restore water, vegetation, diverse structure of native vegetation (grasses, shrubs, trees). Consult O'odham, Yaqui about the goals of restoration should be – particular species? Diversity? Habitats? Keeping Rio Nuevo to its original commitments to enhance the river area and restore wildlife. Insist that the restoration be natural and native vegetation.

Where do we go from here? Bring people to the river – cleanups, wildlife counts, educational fieldtrips – develop appreciation for nature. Use restoration of the Santa Cruz proper as model for citizens to see what might be possible for their branches of the SC watershed (e.g. neighborhood washes, etc.). Educate our children to love and respect our Sonoran heritage.

ATTACHMENT C
MEETING MINUTES
MARCH 21, 2002

Paseo de las Iglesias/Santa Cruz River
Summary of Planning Brainstorming Workshop
March 21, 2002

I. Participants

NAME	ADDRESS	PHONE
1. Thomas Helfrich	PCFCD 201 North Stone	740-6350
2. M.J. Dillard	TDOT 201 N. Stone	791-3115 X419
3. John S. Jones	City of Tucson Rio Nuevo	791-5580
4. Eldon Kraft	David Miller Assoc.	818-833-9728
5. Sue Morman	Tetra Tech	623-7980
6. Kevin Eddy	Tetra Tech	623-7980
7. Bob Aston	Pima College Facilities Planning	206-4730
8. Sam Arrowood	Army Corps of Engineers	602-640-2015 X246
9. Barbara Strelke	Tetra Tech	623-7980
10. Julia Fonseca	PCFCD	740-6350
11. Diana Hadley	Santa Cruz River Alliance	622-7301
12. Kathleen Bergmann	Army Corps of Engineers	602-640-2003 X2

Workshop Moderators:
Sam Arrowood, Project Manager for U.S. Army Corps of Engineers [USACE]
Thomas Helfrich, Project Manager for Pima County Flood Control District
Barbara Strelke, Project Manager for Tetra Tech

The following summary documents the major topics of discussion. It is not intended to be a verbatim record of workshop proceedings. It is important to stress that the workshop was a preliminary step in the USACE planning process. It reflects opportunities that are being looked at rather than plans or formal proposals for construction. This brainstorming discussion was a preliminary step that will be followed by many iterations in the planning process. [Clarifications and/or additional information appear in brackets].

II. Project Introduction

Thomas Helfrich
Tom introduced the project and noted that the original study area was expanded beyond the Santa Cruz River Channel to include tributaries and the West Branch of the Santa Cruz. The expanded study area extends from Congress Street south to the Tohono O'odham/San Xavier District and Mission Road east to I-10/I-19.

The project is viewed by Pima County as similar to a Multiple Objective Management Project with the purpose to create a plan that incorporates environmental restoration, recreation, recharge, and flood control measures within the study area environment. Pima County Flood Control District (PCFCD) is the local sponsor of the project and the U.S. Army Corps of Engineers is the federal funding source in a 50-50 partnership.

What we hope to accomplish in today's workshop :

Brainstorming session to identify components of plan alternatives that the Army Corps can analyze for support for future funding and programming. This session offers the opportunity for input by participants who have a variety of backgrounds and interests.

How we plan to accomplish this:

1. Brainstorm design components for the objectives introduced in the Paseo de Iglesias Reconnaissance Study, July 1999, 905b Analysis.
2. Encourage participants to plan water features into the alternatives (if appropriate); consider proposed recreational loop through Indian Reservation into San Xavier Mission area, and the Sonoran Desert Conservation Plan Biological Reserve areas in the study area.

Sam Arrowood

Sam provided background on the Rio Salado and water supply issues. Rio Salado's water source is artificial, pumped, and supplied locally. Sam posed the question to committee members, "Would the City of Tucson pay to pump water into the study area for habitat restoration?"

Corps Scope of Study

- Original goal was to stabilize riverbank using vegetation bank to bank. As the Corps researched the study area, we saw potential for expanding the study into a master planning process that includes opportunities for cultural, recreation, and land acquisition planning. This study is an evolving process.

What the Corps hopes to accomplish in today's workshop:

- Develop 3 to 4 Preliminary Restoration Plan Alternatives that will provide a basis for the Corps to begin to evaluate the environmental resource value and implementation cost of the project components.
- Because of the Corps time frame for project implementation, now is the time to initiate improvements and approvals for improvements because it will be at least 7 years before physical construction would begin.

Barbara Strelke

Barbara noted that the Corps is looking at new ideas for flood control and is thinking holistically. This is a planning process that projects what we want the river/study area to look like in 20 years. This is an opportunity for key resource people who are familiar with the existing conditions along this portion of the Santa Cruz River to brainstorm and provide their vision of how they would like to see the study area restored.

Today's Workshop Goal is to 1) get our creative juices flowing; 2) develop elements or components of plan alternatives; and 3) generate plan alternatives that represent a blending of ideas based on existing conditions and knowledge of future land uses planned for this area in the future.

Land use and habitat mapping shows that today's existing conditions in this study area are

- 60% Urban (Developed residential, commercial, and industrial)
- 18% Undeveloped/fallow/vacant
- The remaining approximately 20% includes mapped habitat areas

Many studies have been done to analyze existing conditions and define objectives for the study area. Participants received excerpts of some of those in information packet:

- *U.S. Army Corps of Engineers Reconnaissance Report*, July 1999, 905b Analysis

- Material from Julia Fonseca: *Santa Cruz River, San Agustín Mission to San Xavier District – Water Resource, Wildlife, and Recreation Concepts*

Today's Approach:

1. Discuss the opportunities and constraints reach by reach, beginning with Congress to 22nd Streets.

2. Evaluate the components noted in the Memo/Agenda of March 14, 2002.

3. Select appropriate components and incorporate them into the alternatives.

III. Rio Nuevo Reach [Congress to 22nd Street]

John Jones, Project Manager for Rio Nuevo

John noted Rio Nuevo means New River of Life -- not as a flowing river, but as the imagery of the river. Rio Nuevo is also a commercial development project that is the first step in revitalizing Downtown Tucson.

What the Rio Nuevo project hopes to achieve:

1. Emphasize – Green in Rio Nuevo Area. Propose a mini-oasis that brings the vegetation and habitat of the River back into the Downtown area.
2. Sustain grasses in the area.
3. Remove soil- cement bank- protection; widen the river and look at bank protection that incorporates design and plants. Look at sculptured, artistic embankments, similar to Larson Company designs.
4. Top of bank – propose upland trees with high canopies to provide shade.
   Over-story Vegetation (Requires ongoing irrigation):
   - Cottonwood
   - Ash
   - Willow

Planning Process:

The section of the property between Clearwater and Congress will be the Cultural Plaza area for Rio Nuevo and will include water features, irrigated landscaping, shaded river walk. The idea in this area is to create a shaded corridor effect.

Water Source

A possible irrigation water source for this area may be to use water from an existing underground culvert that encloses a tributary. City has obtained a 404 Permit in order to implement this.

Remediation of Landfill

Currently underway is a City pilot program for the remediation of landfills so that this land can be developed. The pilot program by AZDEQ will hopefully accelerate the decomposition process. Pilot program has an aquifer protection permit to pipe water into the Nearmont Landfill to aide the decomposition process. This is a method that has been used successfully elsewhere. The Nearmont Landfill is composed of construction debris and organic materials (hide and tallow operations discarded organic waste products). The City hopes to begin remediation on the other landfills in the site area as soon as possible. Final remediation would require removal of solid waste materials. [The landfills in the study area are expected to be remediated prior to Corps involvement in any restoration project].

Other

Rio Nuevo redevelopment plan proposes the reconstruction of the San Agustín Convento site, near Tucson's birthplace. Also, three pedestrian bridges; commercial and residential uses.

Potential Corps involvement in Rio Nuevo?

[Sam Arrowood to John Jones]

1. It would be helpful to the Corps to know how the Rio Nuevo team has evaluated potential river changes and has already eliminated ideas that are not appropriate.
2. Corps is open to any information that can help it determine possible restoration concepts that fit into the Rio Nuevo vision. Corps would evaluate the proposed concepts and attach costs to it. In the case of landfill remediation, the Corps can pursue restoration at remediated sites--can revegetate or build on a remediated landfill.

    Response: Evaluation of landfill usually has constraints and unknowns. It will take a minimum of 2 years to compost out the landfill in this pilot program before it can be determined what is feasible development on the landfill.
3. Corps may look at restoration at remediated landfills as an opportunity.
4. Remediation is an expensive process but if the Corps can show positive tradeoffs then the Corps may be interested in getting involved.

IV. Overview of Corps process [by Sam Arrowood]

The Corps' F3 project milestone explores the end use without placing conditions on the possibilities.

Starting point, 3-22-02

2002 Evaluate existing conditions to make possible project assumptions.

2012 Base year – begin Project Implementation (Base year is ***2002*** plus usually 5-8 or more years).

Corps will need to project what the existing conditions of the project area will be by the base year (2012).

Then the Corps will project 50 years [future conditions]. If nothing is implemented ["without-project conditions"] what will the study area look like in 50 years?

Compare possible changes perceived in 50 years, then develop alternatives according to these perceptions.

Four questions that the Corps needs to address to obtain project approval:

1. Technical feasibility
2. Environmental restoration value
3. Costs
4. Public acceptability

Question/Examples [for Rio Nuevo]

What is the end use within the Santa Cruz study area? A nature park? An urbanized area with high economic/tax base?

What are the landfill reuse options? Cap the landfill and then top it with soil and plant grassland?

What types of projects are applicable for Corps funding?

Water features to celebrate the original spring that became Tucson's first water source.
Damming the 18th Street Wash to create a water feature.
Other controlled water features.

How to achieve water features/restored areas that require about 225 acre-feet of water per year? [brainstorming by participants]

1. [Use reclaimed water from the joint agreement conservation pool between COT and Pima County].
2. Water harvesting, then release into the restored natural areas
3. Stormwater irrigation
4. System of check dams, may need to be replaced approximately every 2 years – cheap labor makes it feasible
5. Low-flow channels
6. Create a weir (permanent or inexpensive) to replace after flooding

Grade Control Structures [comments by USACE and PCFCD]

Corps evaluates costs and opportunities for grade control structures. Inflatable dams may be possible for the Rio Nuevo area reach. Grade control structures may be difficult because river is narrow in this area. Inflatable dam would be designed over grade control structures and would be deflated in a storm event to prevent flooding outside of the channel.

Erosion control/ bank stability [comments by Sam]

Factors to consider:

- Channels & velocity
- How important is it to create a stable system? Is it acceptable if habitat in channel is washed away? Is it feasible to reduce erosion by widening channel?

V. Brainstorming by Participants based on knowledge of existing conditions:

Possible to widen channel south of Mission Lane to 22nd Street.
Clearwater Street and Mission Lane to Congress reach – narrow channel [not possible to widen because of Rio Nuevo master plan land needs]; requires a minimum erosion setback of 100'
Challenges: Protect or rebuild the Congress Street Bridge?
Provide sinuosity in the river channel – Coordinate watering with storm drains and weirs Volunteer vegetation in high water table areas in the channel (willows, tamarisk, Rhus lancea).
Arroyo Chico example of habitat restoration in the Tucson area.
Restore hydraulics to tributaries that drain into the Santa Cruz. (Daylight storm sewers to widen wash channel and provide vegetation.)
A-Mountain landfill restoration would provide a significant wildlife habitat corridor connection between Tumamoc Hill and the Santa Cruz River [and to the Tucson Mountains].
Learn from past mistakes: Vegetation selection is important – in the past did not select the right trees for the given environment. Planted trees were not desert species and required irrigation. Trees died due to lack of water. Need engineered solutions in place as a back up plan to irrigate vegetation when necessary.

VI. General Comments and Projections for Study Area

General

High likelihood for development in the area (use property ownership and zoning information for projections).

Indicate where development will occur.

Based on projections, develop a case for improvements that the Corps can defend. Corps needs to demonstrate importance of restoration value. Generally speaking, the more dire the future outlook, the better the restoration project looks.

Development will occur in areas with soil cement [bank protection] and private land.

What does Tucson value? Down the road, what will be the value of open space? Plan now?

PCFCD has a land acquisition program for vacant properties along the Santa Cruz River and West Branch of the Santa Cruz. Implementation is ongoing.

Determining Opportunities for West Branch of the Santa Cruz from 29th Street to Ajo

- Formulate process for purchasing property.
- What happens if jurisdictions do nothing?
- How will the river continue to degrade?
- Evaluate Corps opportunities.

Empowerment Zone

Rio Nuevo [and the Paseo de las Iglesias] is within the newly created Empowerment Zone. Empowerment Zone creates a development opportunity through tax credits. This promotes development within the Santa Cruz [Paseo de las Iglesias] study area. Industrial [and Park Industrial] zoning in the area provides opportunities and development pressure to establish more Campus Park Industrial developments.

What does Tucson want for the Santa Cruz River Corridor?
It becomes a political decision. Develop or preserve or both?

What will be the existing conditions in 2012?

What is the 50-year projection for the existing conditions of the study area in 2062? Consideration implies that it could be a great opportunity for habitat restoration. The interstate is the eastern edge of the study area. This creates positive reason to develop the area. What is the reality for 2012? 2062? Tucson needs to decide what its vision is for this area. Political support and a plan of development and open space will help the Corps tell a convincing story for project improvements and funding.

VII. Discussion/Brainstorming on Paseo Project Objectives [& Design Solutions]

What are the long-term Objectives?

- Create continuity of habitat?
- Create a wildlife preserve?
- How much open space should be environmentally restored?
- How much urban areas developed?

1. Utilize Transportation Corridors for storm drain system to capture then recharge water for irrigation.

2. Maintain the Rural Character of Cottonwood Lane
   - Cottonwood neighborhood is anxious to preserve the area
   - Currently, land to the south and west of Cottonwood Lane is up for sale
   - Create linkage of the old West Branch of the Santa Cruz and the new West Branch
   - Can propose a trail as part of the habitat component
3. Avoid soil cement for future bank improvements
4. Encourage bio-restoration on steep embankments
5. Lower, widen and design laid back and terraced banks where appropriate
6. Restore wetland
7. Restore habitat for fish and wildlife (maximize acreage)
8. Restore hydraulics of tributaries at entry points along the Santa Cruz River
9. Create an optimal mix of habitats (Minimize disturbance in existing habitat areas)
10. Establish habitat corridors
11. Re-establish tributary integrity

VIII. Focus on Components [Elements] to Create Alternatives [Sam/USACE]
Need a bag of tools. What tools are needed? Use the tools to create opportunities. What tools do we need to evaluate?

For example: what components are required to create a natural, low-flow channel? Define the low flow channel's location, purpose, and then evaluate what is needed to create it.

<u>Possible Tools (Components) for Paseo [Brainstorming List by Participants]</u>

1. Develop Water Sources.
   TARP Remediated water Acquisition and Transfer Type II rights
   CAP TARP Effluent Other groundwater
   Reclaimed Runoff from Indian Reservation

2. Natural Water Sources
   Passive Capture – grading and contouring
   Active Capture – pumping into a basin

3. Low Flow Channel

4. Open Water
   Flowing or standing water, pools
   May be seasonal – benefit for migratory birds

5. Laid Back Banks / Channel Widening (changing bank angle)

6. Terracing

7. Islands/ sand bars /oasis

8. Modify confluence/distribute incoming flows

9. In-channel vegetation

10. Bank vegetation

11. Upland vegetation

(Viable Tools continued)

12. Berms/debris/obstruction removal

13. Soil cement removal [Isn't soil cement an option or tool as well in particular reaches?]

14. Palisades/fence jetties

15. Drop structures/weirs

    - Stabilize Channel
    - Catch Water
    - Semi-permanent

16. Erosion Protection for Restored Areas

17. Elements conducive to wildlife/fish

18. Recreation Components
    Trails
    Viewing area
    4-wheel area [ATV]
    Equestrian area
    Dirt bike area
    Kiosks
    Educational experience/ecology

19. Agricultural Education

20. Cultural Education / Interpretation/Ecological Interpretation

21. Land Acquisition
    - Purchase Land
    - Conservation Easements

IX. Alternatives

Based on brainstorming the application of the above 21 components, three alternatives were developed in a very preliminary fashion during the last half hour of the workshop. They are:

Alternative 1: Water Resources and Riparian Habitat
Alternative 2: Sonoran Grassland and Floodplain Restoration
Alternative 3: Wildlife Corridors through Infrastructure Modifications

Components proposed for **Alternative 1 (Water Resources and Riparian Habitat)** include aspects of nearly all of the 21 components listed in the Workshop Summary. Components #5, #12, #13, #14, and #19 are not specifically illustrated but may be necessary to support the other components as the alternative concept is developed in more detail. Those components or plan features that are most important to implement the Water Resources and Riparian Habitat concept are those that require major water sources. This concept will utilize both developed and natural water sources to restore and sustain high value vegetative communities. Components are listed in the legend in the order of relative importance for the alternative.

Components proposed for **Alternative 2 (Sonoran Grassland and Floodplain Restoration)** include nearly all of the list of 21 components listed in the Workshop Summary, with the possible exception of components #5, #9, and #15. Those components or plan features that are most important to implement the concept of the alternative are illustrated, and listed in the legend in the order of relative importance for the alternative.

Components proposed for **Alternative 3 (Wildlife Corridors through Infrastructure Modifications)** include aspects of nearly all of the 21 components listed in the Workshop Summary. This concept proposes to reestablish habitat connections between the Santa Cruz River and public lands in the Tucson Mountains by removing road barriers, restoring tributary washes, and enlarging culverts for wildlife movement. To support and sustain high quality habitat resources within the Santa Cruz River corridor, water resources will need to be developed and maintained. Those components or plan features that are most important to implement this concept are listed in the legend in the order of relative importance for the alternative.

Participants were invited to take home a map of the study area and generate further ideas.

ATTACHMENT D
MEETING NOTES
APRIL 9, 2003

Meeting Notes (by K. Gavigan)
Wednesday, April 09, 2003, 9:00am – 3:00pm
PCFCD Offices, 201 N. Stone, Tucson, AZ
Conference Room B

Attendees: Tom Helfrich, Pima County
Jennifer Becker, Pima County
Kim Gavigan, USACE Study Manager
Steve Peacock, USACE Environmental Coordinator
Eldon Kraft, DMA
Bill Bissell, DMA
Mike McGarry, DMA
Phil Rosen, UA/West Branch Neighbors
Glenn Hicks, Tucson Parks and Recreation
Jason Bill, Pima Association of Governments
Ries Lindley, City of Tucson
M.J. Dillard, City of Tucson DOT
Mike Martinez, USFWS
John Jones, City of Tucson Rio Nuevo
Diana Freshwater, AZ Open Land Trust

Meeting Purpose:

1) Re-evaluate without project assumptions, goal and objectives; 2) new plan formulation exercise.

Meeting Notes:

Kim Gavigan, Lead Planner for the Corps of Engineers, opened the meeting. After introductions Kim reviewed the study process. The study area was defined and the rationale for the study limits was reviewed: San Xavier District to the South, El Rio Medio study area to the North, I-19 Freeway to the East and Mission Road (to allow inclusion of the two major tributaries) to the West. The ecosystem restoration goal was reviewed and the there were no comments on any of the above items.

The next step was for the group to review the future without project assumptions. While in general agreement, the group raised several issues. First, it was noted that a restoration project consisting of vegetative bank stabilization would be in place on Irvington Wash prior to the first project year (2010). Second, Tom Helfrich indicated that not all the remaining stands of mesquite would necessarily disappear since he (Pima County) was required, pursuant to a 404 permit, to purchase 73.2 acres and manage them as natural floodplain. The purchased land has some mesquite and it is not clear if they will survive. The expected topographic condition of the gravel mine site was questioned and it was decided, based on the lack of a required closeout plan, to assume the current physical condition would be maintained. The group also asked that that Assumption No. 1 be revised to read, "No new large or medium ecosystem restoration projects will be in place prior to the construction of a Federal project." The future without project assumptions regarding Rio Nuevo will be reviewed and adjusted as appropriate.

The group discussed the planning objectives and the only issues raised concerned the possibility of providing incidental benefits in the areas of bank erosion, flood damage reduction and water quality. The City of Tucson expressed particular interest in having bank stabilization included in the restoration on the east bank in the area of Irvington to Drexel. Mr. Helfrich and Ms. Dillard discussed the possibility of the City of Tucson submitting a letter to the County regarding this matter. Mr. Gavigan reviewed the results of the Corps hydraulic analysis using HEC-RAS reporting that it showed no flooding on the main stem, moderate flooding on the New West Branch and substantial flooding on the Old West Branch. It was noted that implementation of flood protection measures on the Old West Branch would not be environmentally sustainable and for that reason would not be investigated. Mr. Gavigan affirmed that all engineering solutions that were consistent with restoration would be evaluated. A number of data needs were identified by Mike McGarry of David Miller & Associates including; a Point of Contact at Pima Community College (Jenny Becker will provide), the 5 year transportation plan (PAG will provide), and the water plan and underground stratigraphy (Tucson City Water will try to provide). A review of the plan formulation ground rules produced no comments and the group took a short break.

After the break the group began a discussion of restoration measures by reviewing the measures included in the Corps' Without Project Condition (F3) Report:

On subject of Natural Water Sources it was suggested that a study by the Yaqui Tribe of storm water capture on Black Wash be reviewed. Recharge upstream of Martinez Hill was also suggested, however a Record of Decision regarding TCE might conflict with this measure.

On the subject of Low Flow Channel the issue of coordinating local bank protection actions was raised again.

The possibility on negative (e.g., groundwater quality) recharge impacts was raised when Open Water was discussed.

The following measures were accepted without comment:

- Laid Back Banks/Channel Widening
- Terracing
- Islands/Sand Bars/Oasis (place clay lenses)
- Modify Confluence/Distribute Incoming Flows
- In Channel, Bank and Floodplain Vegetation

The measure named Berms/Debris/Obstruction Removal was clarified as meaning cleaning up the main stem channel with removal of any constructed obstructions being limited to tributaries, if at all.

It was pointed out that Soil Cement Removal was intended to be confined to the Rio Nuevo area.

Ms. Becker volunteered to provide the study team plans of the Palisades/Fence Jetties. Root wad revetments were suggested as an approach to this measure. Concept drawings will be needed.

The discussion of Drop Structures/Weirs suggested that these measures be aligned with existing or new grade control structures.

It was noted that Erosion Protection for Restored Areas might address City concerns and it was suggested that local environmental interests would view any bank hardening critically.

After considerable discussion it was decided to leave fish in the Elements Conducive to Wildlife/Fish measure. The potential for vector control issues was raised and designs targeting ephemeral aquatic species were suggested. The concept of developing a hierarchy of alternatives based on species habitat demand was put forward.

The group agreed to delete references to off-road vehicles under Recreation Components.

Following the discussion of restoration measures lunch was delivered and the group took a short break before reconvening to eat lunch while listening to a discussion of vision of Rio Nuevo as it pertained to Paseo de las Iglesias.

John Jones described the Rio Nuevo vision of a "river of green" (not necessarily perennial water). A particular emphasis was placed on using reestablishing connectivity between the river and the existing A Mountain preserve. Mr. Jones broke the Rio Nuevo area into three reaches and outlined the following associated features:

Starr Pass to Mission Lane:

- Maintain soil cement on the east bank
- Low flow channel
- Vegetate islands in the river
- Gallery forests on banks
- Remove some soil cement on the west bank to broaden bend
- Landfill (originally a clay extraction operation) remediation is anticipated to be complete in 10 years. Organics removed in one year. Methane gas is a problem now
- Mesquite-Palo Verde forest between A-Mountain and Santa Cruz River.

Mission Lane to Clearwater:

- Reestablish Mission at San Augustine
- Interpret historic/prehistoric agricultural practices
- Gallery forests on banks
- Planting in the channel
- 18th Street Wash water harvesting
- New non-vehicular bridge at Mission Lane

Clearwater to Congress:

- Replace soil cement with sculpted concrete (e.g., fake boulders/rocks)
- Establish culturally significant access to the river
- Add pedestrian bridge (by 2007) from Convention Center
- Add trolley/transit, pedestrian, vehicular bridge (by 2007)
- Gallery forests along banks (100-150 feet wide) using reclaim water
- UofA hydrology lab and Desert Museum satellite office
- Promote agricultural practices of Cienega.
- Replacing existing grade control structure with a weir

Following this presentation the discussion moved on to how best to incorporate restoration measures into distinct alternatives. Mike McGarry led the group in compiling various measures based on the following areas of the ecosystem:

1) <u>Active Channel</u>: bundles, clay liners, aquitards, grade control, seasonal pools, low flow channel, palisades/jetties, increase sinuosity, cottonwood/willow, and perennial flow.
2) <u>Terraces and Banks</u>: tributary deltas, distributary floodplains, soil cement removal, terracing, gallery forest, palisades/jetties, and aquitards upstream of confluences.
3) <u>Historic Overbank Floodplain</u>: gallery forest, water harvesting, blue Palo Verde, Bosque floodplain, distributary floodplain.
4) <u>Old West Branch</u>: fish habitat, New West branch connection, and irrigation.
5) <u>Gravel Pit</u>: wetlands, perennial flow, cottonwood-willow, and water storage.

NOTE: The preceding notes were prepared by Eldon Kraft and Kim Gavigan and are their interpretation and/or understanding of the issues discussed therein. Meeting attendees are asked to advise Mr. Gavigan of any discrepancies and/or omissions.

ATTACHMENT E
MEETING NOTES
SEPTEMBER 24, 2003

Recreation Plan Meeting Notes
Wednesday, September 24, 2003,1:30am – 4:00pm
PCFCD Offices, 201 N. Stone, Tucson, AZ
4th Floor Conference Room

The following notes were prepared by Kim Gavigan, USACE Study Manager and are his interpretation and/or understanding of the issues discussed therein. Meeting attendees are asked to advise Mr. Gavigan of any discrepancies and/or omissions. Thank you.

Attendees: Tom Helfrich, PCFCD Project Manager
Jennifer Becker, PCFCD
Kim Gavigan, USACE Study Manager
Mike Fink, USACE Environmental Coordinator
Glenn Hicks, COT Parks & Rec.
Steve Anderson, COT Parks & Rec.
Lucy Amparano, COT Rio Nuevo
Frank Jesus Reyes, COT-DOT
Shellie Ginn, COT- DOT
J.T. Fey, COT Planning
Peg Weber, COT Parks & Rec.
Richard Corbett, PAG
Roger Anyon, PC Cultural Resources
Linda Mayro, PC Cultural Resources
Doug Potts, PC Nat. Res. And Parks & Rec.
Darrin Brightman, PC Nat. Res. And Parks & Rec.
Michael Ingraldi, AZ Game & Fish
Laurie Averill-Murray, AZ Game & Fish
Mark Holden, Saguaro Nat. Park/National Park Service

Meeting Purpose: Gain insight on recreations plans in the community and discuss applicability to the Paseo de las Iglesias restoration project.

Meeting Notes:

The meeting was opened at 1:40pm with introductions. Mr. Gavigan gave an overview of the Corps' study process, cost-sharing responsibilities, and progress to date on the Paseo study. The study area and alternative formulation process to date were described to the group. The discussion was then opened up to input from the group regarding master plans, trail needs, future development plans, etc.

Mr. Reyes, from City of Tucson, indicated that the City plans on constructing a hard-surfaced trail from the north side of Ajo Way (on the west side of the river) to the east end of Cottonwood Lane. Plans for this trail are at a 90% design stage and have been submitted to the County for review. The trail alignment apparently encroaches down into the Santa Cruz River channel. Construction is scheduled approximately 18 months from now.

The group asked about the Corps policies on participation in recreation features and lands needed for trails. Mr. Gavigan indicated that the Corps policy does not allow for federal cost sharing for lands purchased for a recreation purpose. However, lands needed and acquired for the basic ecosystem project can also be used for recreation development. Recreation lands outside the restoration projects lands become a 100% non-federal cost. Mr. Gavigan emphasized that recreation development at an ecosystem restoration project should be totally ancillary. Recreation facilities may be added to take advantage of the education and recreation potential of the ecosystem project, but the project cannot be specifically formulated for a recreation purpose. The recreation potential may be satisfied only to the extent that recreation does not diminish the ecosystem restoration purpose. Mr. Gavigan also reviewed the 10% Limit Rule an indicated that the 10% limit should not be used as a target. All separable recreation features must be justified through economic analysis in order to be cost-shared.

Mr. Anyon gave a description of the Juan Batista de Anza Historic Trail and emphasized the importance of this route as a "cornerstone" of any recreation plan along the Santa Cruz River. There is an existing Environmental Impact Statement for the de Anza Trail and the National Parks Service has already certified portion of the existing trail from Mission Lane to Irvington Road. The intent is for this to be a multi-purpose, natural surface trail surrounded by pre-settlement vegetation. A 200-foot wide corridor is desired with a minimum width of 50-feet. Mr. Anderson added that the minimum width would be revised soon to 100-feet. Directional signing will also be added at points along Mission Road to direct interested parties to the trail. The San Xavier District of the Tohono O'odham Nation is apparently not supportive (at this time) of showing (on maps) or having the trail through tribal lands. A County bond proposal to fund portions of the trail is being proposed. Mr. Anyon will supply USACE with a proposed trail alignment in hard copy format.

The City of Tucson's' Parks Master Plan identifies the Paseo study reach as a "River Park" with both paved and unpaved trails on both sides of the Santa Cruz River channel. Additional amenities such as rest areas, water fountains, bird watching areas, and public restroom facilities are also identified in the plan.

Mr, Helfrich indicated that maintenance roads, including access ramps would be needed as part of the restoration project. Width of maintenance roads can vary from 12 – 20 feet depending on access requirements and equipment.

Mr. Hicks indicated that a trail connection from the Tucson Diversion Channel (Julian Wash) is need to the Paseo system. The same is true for the wash immediately south of the Pima Community College campus.

Ball fields are being planned for north of Ajo Way, west of Interstate 19.

The Rio Nuevo Project will incorporate numerous amenities including, but not limited to natural resources at the bend/landfill area, trails system, pedestrian bridges over the SCR, trolley bridge over SCR, cultural park, and a U of A facility. Mr. Fey shared a draft (i.e., not for distribution) site plan for the Tucson Origins Cultural Park.

Ms. Mayro indicated that numerous cultural resources and archeological sites exist within the study area. Chances are that some mitigation will be required due to uncertainty of many of these sites. Mr. Gavigan indicated that a programmatic agreement is typically entered into between the Corps and SHPO, with concurrence from sponsor(s) and Native American Tribes.

The meeting was adjourned at approximately 4:00pm.

ATTACHMENT F
MEETING NOTES
JANUARY 22, 2004

Paseo de las Iglesias

Feasibility Study for Santa Cruz River and West Branch Ecosystem Restoration
January 22, 2004 Open House (6:00-8:00 p.m.)

A G E N D A

1. **Welcome and Introductions**
   Freda Johnson, Moderator

2. **Presentation**
   Thomas Helfrich, Water Resources Division,
   Pima County Flood Control District

3. **Question/Answer Session**

4. **Open House**

*****

Paseo de las Iglesias Study Objective

Increase size, health and diversity of native riparian habitat within the historic floodplain. This will be accomplished by enhancing and protecting habitat within the river corridor.

Additional opportunities:

- **Provide passive recreation sites**
- **Establish 'River Park' connectivity**
- **Reduce bank erosion and sedimentation issues**
- **Provide incidental flood reduction benefits**
- **Establish wildlife corridors**
- **Improve surface water quality**
- **Control invasive species**
- **Protect cultural resources**
- **Other community interests**

*****

For more information, contact Jennifer Becker, Program Coordinator, Water Resources Division, Pima County Flood Control District at 740-6350.

Under construction! Paseo de las Iglesias website
http://www.dot.co.pima.az.us/flood/envrest/paseo.htm

Paseo de las Iglesias
Habitat Explanations

Xeroriparian Restoration Approach.

Xeroriparian habitats are associated with streams that flow in response to rainfall (ephemeral streams). Plant species present are similar to those in upland areas, but in greater densities due to the extra water.

Restored mesquite and palo verde trees would provide limited shade to the channel invert and would be bordered by Sonoran desertscrub species. Vegetative stabilization of the riverbanks, and an increase in flood retention and incidental recharge would result. Mostly small trees and shrub-sized vegetation would provide improved habitat for native wildlife and a setting for passive recreation. Irrigation would be needed for vegetation establishment, with planned delivery via water trucks. No irrigation system would be installed. After establishment, only water captured by water harvesting techniques would be used to sustain vegetation. An increase in abundance of ~65 native wildlife species would be expected. Project goals are harmonious with the Sonoran Desert Conservation Plan (SDCP).

Mesoriparian Restoration Approach.

Mesoriparian habitats are associated with areas with shallow groundwater and or intermittent flow. Dense mesquite forest (bosque) is characteristic of this habitat type.

Restored and irrigated mesquite-hackberry bosques would provide shade to the channel invert and would be bordered by mesquite and palo verde woodland and Sonoran desertscrub species. The outcome of this approach is expected to be most similar to the historic vegetation communities in this river reach. Vegetative stabilization of the riverbanks, and an increase in flood retention and incidental recharge would result. Both tree and shrub vegetation would provide improved habitat for native wildlife and a pleasant setting for passive recreation. Permanent irrigation would be needed to accomplish design goals, and an irrigation system would be installed. An increase in abundance of ~80 native wildlife species would be expected. Project goals are harmonious with the SDCP.

Hydro-meso Riparian Restoration Approach.

Hydro-mesoriparian habitats are associated with perennial watercourses where plant species such as cottonwoods and willow are present.

Restored and irrigated cottonwood-willow galleries would shade the intermittently flowing channel and be bordered by both mesquite bosques and Sonoran desertscrub species. Vegetative stabilization of the riverbanks, and an increase in flood retention and incidental recharge would result. Both tree and shrub vegetation would provide improved habitat for native wildlife and a pleasant setting for passive recreation. Permanent and extensive irrigation would be needed to accomplish design goals, and an irrigation system would be installed. Depending on period of stream flow; roughly one-third to two-thirds of all irrigation water would be used to maintain intermittent to perennial flow in the main channel. An increase in abundance of ~95 native wildlife species would be expected. Project goals are harmonious with the SDCP

Paseo de las Iglesias
Open House
Pima Community College Desert Vista Campus
January 22, 2004

Summary of Question and Answer Session

Beryl Baker asked about plans for erosion control. Tom Helfrich of Pima County answered that numerous alternatives are being considered. The Corps Project Manager, Kim Gavigan, added that the Corps environmental restoration feasibility studies evaluate projects for flood control, but not erosion control. He also said that based on the flood risk analysis the Corps is not recommending any soil cement, and that design engineering work will evaluate erosion control options when designing a future project. Freda Johnson noted that a description of the types of erosion control measures could be put on the project website if there was interest.

Connie Harris asked about the location of the 30 acres to be developed near the West Branch. Tom showed the audience the location on the map noting the location is near the bend of the West Branch Diversion Channel located at Irvington and Mission. Another question was asked if the New West Branch Diversion is new. Tom answered that the diversion is the same one built in the 1980s.

Tom Wilson commented that the maps used at the meeting seem outdated. In addition, he said the lack of space adjacent to the river would not allow for future development of trails and other facilities, and he noted that power line runs along the river. Tom Helfrich mentioned that he does not see any conflicts regarding lack of space, and that most photos and maps being used for the study are less than a couple years old. He also noted that the project has and will continue to collaborate with the City of Tucson and others in planning trails and other recreational areas.

A question was asked regarding bank-to-bank flood flows on the Santa Cruz River. The concern was for the preservation of the new vegetation and the riverbanks. The Corps spokesperson answered that the project will be designed to withstand a certain amount of water but there will be funds allocated for maintenance and revegetation.

Kendall Kroesen asked about the water harvesting in the third option (XXX). He also noted that water harvesting could be carried out in the other two options. Staff responded that water harvesting from storm drains could be included in all options. This would occur in the design phase of the project. Mike Fink said that development impacts water flow. The future design work will examine areas where additional water is available to harvest. Kendall also asked if the estimated water usage included harvesting. Staff said it does include capture of local rainfall, but not stormwater run-off harvesting.

Don Kucera asked if pedestrian underpasses at Irvington and Congress (for the DeAnza Trail) would be included in the project. Staff said that at the present time these underpasses are not included but that connectivity of trails will be examined.

Yolanda Herrera asked how the Iglesias project ties in with the work done by the Santa Cruz River Neighborhood Task Force. She also asked if the project has the information from the Task Force. Freda noted that she will give this information from the City of Tucson's Multiple Benefits Water Projects to the Pima County staff.

Teddie Burch asked whether reclaimed water could be used to establish perennial flow in the Santa Cruz. Tom Helfrich commented that the project is identifying water sources and looking at subsequent feasibility and permitting. Sherry Barfield noted that reclaimed water can be a health issue and is generally not used in situations where people may come in contact with it.

A comment was made regarding the lack of bank protection of the river from Silverlake to Ajo. The situation in this area is dangerous because the water speeds up through the other bank protected areas upstream and then erodes the bank from Silverlake to Ajo. Jennifer Becker asked the audience to add comments about soil stabilization to the comment form.

John Titus commented that the xeroriparian option (XXX) might not result in "stunted" trees as stated in the presentation, and that non-irrigated trees would be stronger during droughts if the irrigation water is taken away. He added that true xeriscape has good growth and provides a nice riparian habitat. Jennifer Becker responded that "stunted" may have been a poor word choice, but due to the lack of groundwater available to tree roots and the limited rainfall, un-irrigated trees are not expected to ever reach full maturity height.

Josefina Cardenas said she hopes that the neighbors can count on the County because she does not trust the City. She added that families and neighbors are important as well as acequias (canals). She thinks the riverfront should be preserved.

Don Kucera asked when the project would end. Kim answered that the feasibility study would be completed by the end of the 2003-2004 fiscal year in July. The design phase would take 2-3 years and 2008-2010 would be the soonest construction might begin. Staff added that local and congressional leaders have to work together to make the project happen. Matching funds can be in the form of land, infrastructure, etc.

Beryl Baker asked how the Corps proves to Congress that this project is important. She noted that the presentation and slide show demonstrated what will happen if nothing is done. Staff said that over 95% of the riparian areas in Arizona has been lost. The feasibility documents will have to persuade Congress. Mike Fink also said that the Corps is using new methods to evaluate non-monetary and monetary value of projects.

Teddie Burch commented that she sits on PAGs Transportation Enhancement (TE) Committee. She asked if TE funds could be used on the project. Tom Helfrich noted that TE funds might be able to be used as part of the matching funds. An audience member noted that these funds could be used for trail development providing connectivity to multi-modal opportunities.

Phil Rosen asked how this project will compete in Congress for funding given the increase in local species and how that value may compare to a project along the Mississippi River. Staff stated that the Corps will have to tell the story. It is hard to convince lawmakers in the east that in the early 1900s the desert southwest looked very different than it does today. It is also important to include that the increase of species provides habitat for even more species, and may attract endangered species.

Diana Hadley noted that TIF financing (Tax Increment Financing) could provide matching funds for landfill clean up. She also thinks the Rio Nuevo Project needs to be more river-oriented. Staff said that this project will not conflict with Rio Nuevo. Lucy Amparano noted that the City and Rio Nuevo team are collaborating with many projects, neighborhoods, transportation planners, the Tucson Origins Heritage Park Project, and others. She added that there is still a lot of planning to do.

Yolanda Herrera asked how trees will be protected from washing away. Staff answered that vegetation could be taken out in a big flood. The project will be designed to take into account the need for replacement.

Robin West asked why there is not a 50-foot linear park shown in the project. She also noted that Rio Nuevo Project has a plat with no linear park in order to fill and put buildings up to the river. Tom Helfrich noted that the Paseo de las Iglesias project is within City jurisdiction, but the City is not a sponsor of the project. The recreation elements of this study have not yet been incorporated. Lucy Amparano mentioned that a Master Planner for Rio Nuevo has been hired and will take everything into consideration.

Beryl Baker commented that small species are not often included. She encouraged the project to add up even the smallest species that will inhabit the river area. Mike Fink noted that all species have and will be taken into consideration to show the biggest possible impact.

Paseo de las Iglesias
Feasibility Study for Santa Cruz River and West Branch Ecosystem Restoration
January 22, 2004
Open House Comment Form

Tally of Responses from 20 Returned Comment Forms as of February 9, 2004

1. Do you support ecosystem restoration along the Santa Cruz River and tributaries?

Yes: 19
No: 1

Explain:

- The plants, animals, insects, etc. need it.
- Restoration is necessary and an important goal for our community.
- It's an important community value.
- The Santa Cruz could be a real attraction in Tucson—unique southwestern restored river.
- It is our social responsibility to restore/rehab the river.
- We don't know what we've lost and if a riparian woodland were back we would be so glad!
- Riparian restoration is the most pro-active measure that can be done to preserve and enhance Arizona's wildlife species.
- As long as it is in conjunction with construction of concrete bank protection.
- We've got a unique opportunity to assist mother nature with one of her gems in our Old Pueblo which will benefit our community.
- Reestablish native vegetation and wildlife, reduce or abate degradation and erosion.
- We would like to see more vegetation and water.
- Focus needs to be on increasing wildlife and wildlife viewing opportunities through habitat restoration. The Santa Cruz River is a foundation on which Tucson was built around. From ancient times up to the early 1900s, the river provided essential resources for surrounding communities and defined much of who we are. Today, we have lost most of what the river was and stood for. As a result, generations today do not have the opportunity to appreciate the once great attributes of this once great river. All we have are memories and stories from our elders who were fortunate enough to see the last living days of the Santa Cruz. As a community, we would benefit in many regards from restoring the Santa Cruz. Not only is it a moral prerogative to restore what we have destroyed, but it is a responsibility we share for the benefit of future generations. When children and families can once again picnic along the verdant banks of this great river, we will have mended a deep wound that has festered for much too long.
- The traditional ecosystem has been and is very important to the Native-Americans of this area.
- You have not been realistic on the study.

2. Based on what you learned during the presentation about types of habitat, which type listed below would you prefer to see along the Santa Cruz River. Definitions are on the back of the agenda. Choose the one type you believe would best suit our community.

Xeroriparian:	3
Mesoriparian:	13
Hydro-mesoriparian:	5
No action or status quo:	0
Combination:	3

Explain your response:

- Given limited funding and water availability, mesoriparian appears to make the most sense.
- An appropriately designed mosaic with xeroriparian being the "work horse" plant community that has the best chance of long-term survival.
- Unless water is provided in small portions of the river channel in particular locations riparian vegetation will not survive—better to stay with mesquite, hackberry, palo verde and possibly willow.
- I don't wish to pick one of those options; a mosaic of the above options would be most effective and realistic.
- Water resources are unpredictable! With some irrigation during the seedling/sapling phase mesquites, palo verdes, hackberries, graythorns etc. will thrive when the water is cut off. With a million more people in the area water will be an issue. Plan for a waterless future.
- The need for surface water that would be available to wildlife is imperative. Available surface water with an established mesquite bosque (i.e., hydro-meso) will more closely resemble historic conditions.
- [Mesoriparian] would best enhance the existing native areas. Please include security lighting along the river park.
- [Mesoriparian is the] most prudent and water responsible and sustainable. Best represents the area.
- [Mesoriparian] bank protection along the river.
- [Mesoriparian is] a good compromise between the five extremes and probably more acceptable to general public than the hydro-meso riparian proposal. This would provide shade and shelter in a desert setting.
- I would like to see a more economically modest proposal with some chance of successfully being funded, but one done in such a way that more mesic features could be added or upgraded in future.
- [Mesoriparian] seems to be the balance between the other two options.
- I believe that useful habitat restoration can be done by combining the water allocation envisioned in the mesoriparian option with the water harvesting strategies in the xeroriparian option. The hydroriparian option allocates too

much scarce water for too little return. Techniques such as tributary wash gabions, detention basins behind soil cement, microbasin rainfall catchment, and perched aquifers should all be considered.

- Mesoriparian would be, overall, a more appropriate and fiscally responsible way of restoring the river although historically, Cottonwood-willow gallery forests were present immediately south of Congress St. If a combination of mostly mesoriparian with a small stretch of hydro-mesoriparian could be accomplished, we will succeed in creating a more diverse and enjoyable river.
- Some help is necessary to re-establish and maintain the traditional eco-system now. This is necessary because the water has been diverted by the increased human demands.
- This whole concept is so flawed with this presentation that it is a joke.

3. If a restoration project proceeds, recreational opportunities can be incorporated into the plan. Tell us how important each of these potential recreation activities are to you:

	Very Important	Somewhat Important	Not Important
Trail system for walking:	17	1	1
Trail system for bicycling:	9	5	3
Trail system for bird watching:	17	0	1
Trail system for wildlife viewing:	17	0	1
Picnicking:	4	7	6
Horseback riding:	7	6	4

Other ideas or comments:

- Create wildlife thickets inaccessible to humans for true protection of species.
- Bicycle trails usually involve too much soil cement and reduction of restoration potential.
- Safe pedestrian connectivity with other passive recreation areas.
- Opportunities for public education; i.e. nonprofit groups.
- Education/interpretation.
- Trails that connect Santa Cruz to Tucson Mountain Park.
- The Santa Cruz River has always been used by traditional Native Americans as a roadway or trail, especially during ceremonial times.

4. Are there specific areas you recommend we consider for ecosystem restoration? If so, describe them here and explain briefly why each area is important to you.

- The pit @ south of Valencia, east of river @ sand gravel co. that support willows and cattails.
- All vacant land in the area.
- Enhance vegetation along West Branch

- Pima County land on West Branch - still has existing remnant riparian area
- First of all, why not just arrest degradation of the West Branch? Emphasize restoration at spot locations where water harvesting techniques are appropriate.
- Most restoration projects fail. So use areas where water harvesting is most effective and establish mesquite there. Not EVERYWHERE can be a mesquite bosque…the riparian zone vegetation will vary. Your restoration needs to reflect this.
- Erosion control on Cottonwood Lane
- Please install concrete bank protection between Silverlake and Ajo where there are very dangerous earthen vertical banks.
- South of Irvington – all areas. 29th to Ajo Way. Blank canvas areas with great potential.
- Ecosystem restoration would be wonderful for the area between Valencia Road and Irvington Road. Currently there is nothing there and it looks terribly ugly.
- The west bank between Irvington and Valencia as I have personally worked for many years on extending the river park at this site. It is adjacent to a large neighborhood (Midvale Park). Also, there were approved County bonds (1998?) for this purpose.
- West Branch restoration of hydro-riparian conditions would be most feasible there.
- The land owned by the County between Cottonwood Lane and the Santa Cruz River should be used as an area for re-vegetation.
- I am in favor of habitat restoration to the maximum extent possible. There should be a program that promotes carrying over project restoration techniques to private land and commercial landscaping in the area.
- The area immediately south of Congress down to 29th Street or so, historically the area with the highest level of above surface flow. This area, because of its proximity to downtown and communities, may be most appropriate for significant restoration, although I do not intend to "cherrypick" areas – the entire stretch has ecological, historical and recreational significance.

5. Tell us about any other issues you want us to consider as we proceed with next steps in the Restoration Study.

- Please be sure to read the landscape and restore the vegetation in concordance with that. Riparian tress are very flood tolerant but in a restoration you can't know where the trees would've survived…then after the flood you can see the flood "safe sites". I'd opt for zeroriparian.
- Maintaining connectivity (i.e., habitat connectivity) north and south (upstream and downstream) of the project area. Unlike other Federal projects, incorporate a post monitoring plan and implement the plan so that we can see what works and what does not.
- More water harvesting.
- Concrete bank protection is an absolute must.
- Multi-use trail system should continue on the Santa Cruz along with all the restoration projects.
- Bridge extension for Drexel Road to connect the Midvale Neighborhood area with the South Tucson area. Try harder to generate community involvement. It's necessary to

do door-to-door outreach. Encourage support through neighborhood iglesias (churches). Also, go after support from major entities like Hughes, TAA, Sunnyside School District, Starr Pass, Native American Tribes, Home Depot, Pima CC.

- Purchase the common area (West Branch SC) along Cottonwood Park.
- 1) wetlands area. 2) perennial flow of reclaimed water (in limited area). 3) interpretive trails, kiosks, signage at Valencia and Julian Wash archaeological sites.
- Please check the number of species likely to benefit. 1) a conservative estimate is good but only if the same rigorous standard is equally applied to competing restoration proposals. 2) I suspect a reasonable consideration would indicate that 2-3 times the 95 vertebrates species will actually benefit.
- Please make all information available on the website, including conceptual drawings, plant lists, water harvesting strategies being considered, locations of the 1000 acres available for restoration, details of the three current alternatives, timeline (or at least order and nature) of upcoming events in the project, and comment forms. People who could not go to the meetings need to be able to keep up with the project and comment at various stages. It would be interesting to have a better understanding of how the County and the Corps will come to a final plan recommendation and to what extent it can involve new elements or combinations of elements currently contained in the three alternatives. What is the timetable for continued opportunities for public comment?
- I am interested in the feasibility of using treated effluent for irrigation and above surface flows. While Sweetwater has a long reputation for smelling bad, are there remedies or different procedures for efficiently providing a more sustainable source of water? Using water from the Colorado River or much less our aquifers for this restoration project seems to defeat the purpose of restoration. Storm runoff catchments and slow releases? Other ways of wastewater treatment?
- There is one small mobile home park which has been densely populated for at least thirty years by low-income old Tucson families; this property should be bank protected so that the low-income families can continue to use it and preserve their homes (mobile homes).

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Notes submitted by Julia Fonseca on behalf of various people.

- Prefers reclaimed, not groundwater, Wonders if cottonwoods really feasible. Recognizes equity issue if bank protect5ion is provided one place perhaps it's only fair to protect all, but questions whether it's good for the river.
- Yolanda Herrera tells me that we need to get better notification to neighborhoods along the SC River; e.g. Midvale neighbors weren't here, were they notified? Try e-mail. City doesn't have e-mail notification but they do send newsletters by e-mail so they have some kind of list.
- Kendall Kroesen suggests you put the water harvesting basin images on the website so that others can see them.
- Diana Hadley suggests pockets in the soil cement a la Phil Rosen. I mentioned that there are gaps in fp [floodplain] on Rillito. Either way, it provides areas where veg

gets flooded, but velocities are so low that it doesn't get torn out. I can give you Phil's image to put on your website, just remind me.