Projects to Enhance Arizona's Environment: An Examination of their Functions, Water Requirements and Public Benefits*

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Sharon B. Megdal, Ph.D.
Kelly Mott Lacroix and Andrew Schwarz
Water Resources Research Center
University of Arizona, Tucson AZ

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Source: Arizona Water Protection Fund

Introduction[1]

In Arizona, many once lush riparian areas have been lost. This decline has not gone unnoticed, and in the past decade a growing number of efforts have been undertaken to restore, maintain or create new riparian and wetland areas. The number of riparian restoration projects nationwide has also increased, growing exponentially in the last decade.[2] Along side this explosion of restoration projects, the interest of the scientific community and the public at large has also grown significantly.[3] Scientists have conducted many studies examining various aspects of environmental enhancement projects. Considerable research and debate have surrounded defining and measuring restoration areas[4,5] and the value of "created" habitat. Other research has focused on identifying the common elements of restoration projects, such as the work by Bernhart, et al. who are compiling a comprehensive database of restoration efforts throughout the United States.

In this report, we provide complementary information to these studies in the form of a descriptive look at 30 environmental enhancement projects throughout the State of Arizona. The report examines the more subjective aspects of environmental enhancement projects. At the outset of the project we sought to answer a series of questions: Who are the key players in the implementation of environmental enhancement projects and what factors drive the project's undertaking? What are the benefits of these projects? How are these projects using scarce water resources? Do they have legal claim to these water sources? And how long will supplementary water be required? Along with answers to these questions, we sought lessons learned both through the specific projects and from the wider lens of the 30 projects taken as a whole.

Though the study can not be considered exhaustive, important observations are drawn from the projects we surveyed. The projects highlighted in this study are only a sample of the many environmental enhancement efforts underway in Arizona. In this study we wanted a diverse selection of projects; therefore, project selection was based, in part, on choosing projects with varied sponsors, locations, and intentions.

A unique aspect of this study is that it combines a descriptive project summaries with objective surveys to describe the project. The surveys created categories for each area we were interested in examining. For example, project drivers were summarized into categories such as

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[1] The authors of this study would like to thank Jennifer Jones, former research assistant at the WRRC and Magdalena Escobeda, WRRC NASA intern. We would also like to extend a special thanks to all of the project contacts and to the staff at the Water Protection Fund for their time spent responding to our surveys, answering our questions and attending stakeholder meetings. This report would not have been possible with out the funding and project support provided by the Phoenix office of the Bureau of Reclamation.

[2] Berhardt, E.S., et al. (2005). Synthesizing U.S. River Restoration Efforts. Science. Vol 308, 636

[3] Ibid. p. 6 (supporting online material).

[4] Westman, WE. (1991) Ecological restoration projects: Measuring their performance. Environmental Protection [ENVIRON. PROT.]. Vol. 13, no. 3, 207-215.

[5] David J. Schaeffer, Edwin E. Herricks and Harold W. Kerster. (1988). Ecosystem health: Measuring ecosystem health. Environmental Management, Volume 12, Number 4, 445 – 455.

flood control and public use and enjoyment. We filled in each survey based on information gathered for the project summaries and sent the survey to the project sponsors to accept or change our characterizations of their project. In the end, the project summaries provide detailed descriptions of the projects, while the surveys provide more objective information. Taken together, these two sources of information provide a more complete picture of the diverse ways in which environmental enhancement projects are pursuing their goals.

Background

The thirty projects examined here come from four of the seven ecoregions in Arizona as defined by the United States Environmental Protection Agency. An ecoregion denotes an area within which ecosystems (and the type, quality, and quantity of environmental resources) are generally similar.[6] Figure 1 shows the ecoregions throughout Arizona. The ecoregions represented in this study are Sonoran Basin and Range (81), Madrean Archipelago (79), Arizona/New Mexico Mountains (23) and Arizona/ New Mexico Plateau (22).

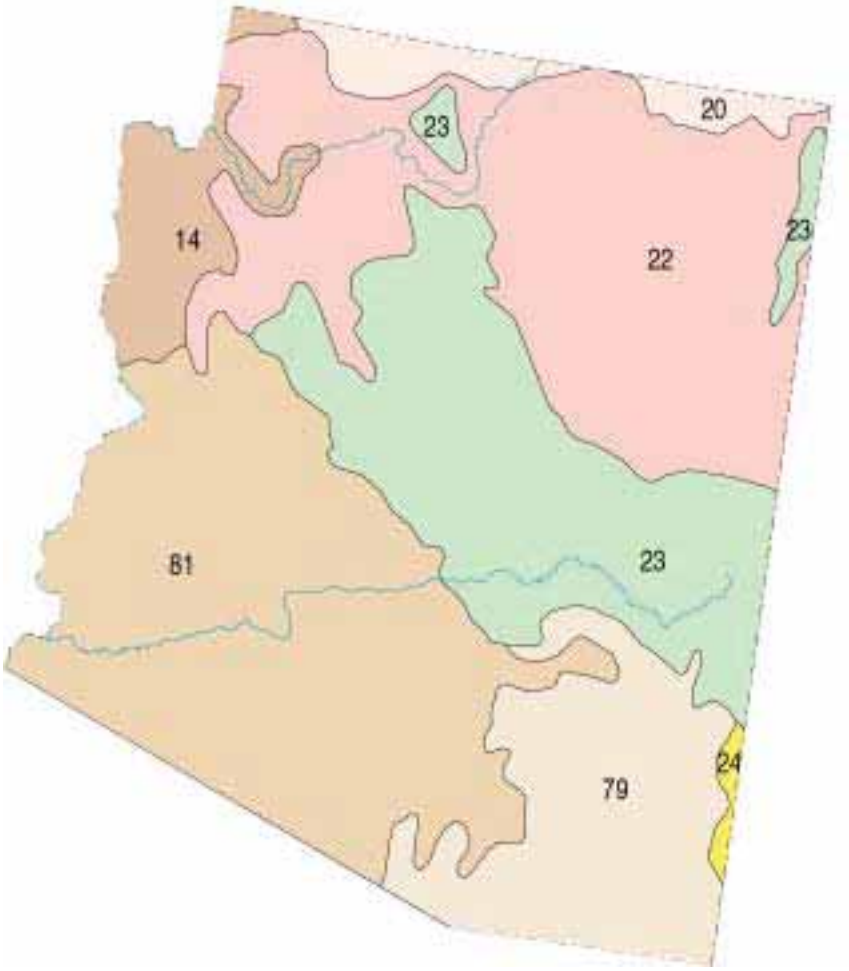

Figure 1. Type III ecoregions in Arizona. Source USEPA

The Sonoran Basin and Range ecoregion contains scattered low mountains and desert lowlands. Water is generally scarce in this area and palo verde-cactus shrub and giant saguaro cactus dominate. Average rainfall in the Sonoran ecoregion is 4-12 inches per year. Principal rivers through this area are the Salt River, Gila River, Verde River and the Colorado River.

The Madrean Archipelago, also known as the Sky Islands, is a region of basins and ranges with medium to high elevation, typically 3,300 to 5,000 feet. Native vegetation in the region is mostly grama-tobosa shrubsteppe in the basins and oak-juniper woodlands on the ranges, except at higher elevations where ponderosa pine dominates. The region has significance as both a barrier and bridge between two major mountain ranges of North America,

[6] U.S. Environmental Protection Agency, National Health and Environmental Effects Laboratory. Level Three Ecoregions of the Conterminous United States. Retrieved August 17th, 2005, EPA Website http://www.epa.gov/wed/pages/ ecoregions/level_iii.htm#Ecoregions.

the Rocky Mountains and the Sierra Madre Occidental. The principal rivers through this area are the San Pedro River and parts of the Santa Cruz River.

The Arizona/New Mexico Mountains are characterized by their lower elevations and vegetation typical of drier, warmer environments. Forests of spruce and Douglas fir are only found in a few high elevation parts of this region. Chaparral is common on the lower elevations, piñon-juniper and oak woodlands are found on lower and middle elevations, and the higher elevations are mostly covered with open to dense ponderosa pine forests. The principal river systems in this area are the Little Colorado River and the Gila River.

The final eco-region represented, the Arizona/New Mexico Plateau, represents a large transitional region between the semiarid grasslands and low elevation plateaus in the east, the drier scrublands and woodland covered high elevation plateaus in the north, and the lower, hotter, less vegetated Mojave Basin and Range in the west and Chihuahuan Deserts in the south. Elevation in the region varies from a few meters on plains and mesa tops to well over 900 feet along plateau side slopes. The principal rivers through this area are the Colorado River and the Little Colorado River.[7]

None of the projects studied would have happened without funding. There are many funding mechanisms used in the projects surveyed, however, only programs that have funded more than one of the projects will be discussed here. The sources of funding are the Arizona Water Protection Fund, Arizona Department of Environmental Quality-Water Quality Grant Program, Arizona Game and Fish Department-Heritage Fund Grant, Army Corps of Engineers, and the Bureau of Reclamation.

Arizona Water Protection Fund is a state grant program that provides money to groups interested in maintaining, enhancing, and restoring river and riparian resources in Arizona. Applications for the grant program must be for capital projects, contain administrative costs less than 5% of funding requested, demonstrate legal and physical access and authority to manage restored area, provide documentation that water for project is legally and physically available, and demonstrate that vital partnerships (funding etc.) have been committed at the time of the application. The funds are awarded according to authorization in Arizona Revised Statutes and administered through the Arizona Department of Water Resources by the Arizona Water Protection Fund Commission.

The Water Quality Improvement Grant Program, administered by the Arizona Department of Environmental Quality, provides funding to improve water quality by controlling non-point source pollution. Applicants must improve or protect water quality by controlling non-point source pollution, have an on-the-ground implementation component, and provide for at least 40 percent of the project costs as non-federal match.

The Heritage Fund Program through Arizona Game and Fish sets aside $20 million each year for parks, trails, natural areas, historic preservation, and a full range of wildlife conservation activities. Eligible applicants include the federal government or any federal department or agency, Indian tribe, all departments, agencies, boards and commissions of this state, counties, school districts, cities, towns, all municipal corporations, and any other political subdivisions of Arizona.

Projects funded by the United States Army Corps of Engineers in this study are funded

[7] Ibid.

through their General Investigations (GI) efforts and Section 1135 or 206 of the Water Resources Development Act of 1986.[8] Under General Investigation, the Corps is authorized to participate in individually authorized programs, with the federal investment depending on the nature of the program and the amount appropriated by Congress. Projects funded under Section 1135 do so pursuant to 1135(b) of the Water Resources Development Act of 1986, which provides authority for the Corps to "investigate, study, modify, and construct projects for the restoration of fish and wildlife habitats where degradation is attributable to water resource projects previously constructed by the Corps."[9]

Projects funded by the United States Bureau of Reclamation in this study are funded through the Wetlands Development Program, Title III of the Colorado River Basin Project Act and the Title 28 program. The Wetlands Development Program provides funding for design and implementation of wetland enhancement projects aimed at improving water quality, wildlife habitat, recreation and aesthetic benefits. The Title 28 program permits the BOR to participate in cost sharing agreements to fund development, rehabilitation, and expansion of recreation and fish and wildlife areas and facilities on Reclamation project lands. Federal contributions must be matched at a minimum of 50/50 with non-Federal partner funds. For fish and wildlife projects the program allows for 75/25 cost sharing agreements. Multi-year funding agreements are possible under this program. [10]

Projects included in this study are shown in Table 1 and located in Figure 2.

Table 1. Projects included in the study

Little Colorado River Basin Projects			
1	EC Bar Ranch	2	Little Colorado River Enhancement Demonstration Project
Lower Colorado River Basin Projects			
3	Ahakhav Tribal Preserve	4	Yuma West Wetlands
5	Yuma East Wetlands		
Salt River Basin Projects			
6	Rio Salado Oeste	7	Tres Rios
8	Rio Salado Phoenix	9	Va Shly 'ay Akimel
10	Rio Salado Tempe		
San Pedro River Basin Projects			
11	Bingham Cienega	12	San Pedro Three Links Farm
13	Las Cienegas National Conservation Area	14	San Pedro Preserve
Santa Cruz River Basin Projects			
15	Agua Caliente Spring	16	San Xavier Indian Reservation Riparian Restoration
17	Ed Pastor Kino Environmental Restoration	18	Santa Fe Ranch Riparian Restoration

[8] Only one project in this study was funded under Section 206, Agua Caliente Spring. Agua Caliente Spring did not move beyond the planning stage.

[9] U.S. Army Corps of Engineers. 2004. Project Modifications for the Improvement of the Environment. Washington: U.S. Army Corps of Engineers. Available at: http://www.nab.usace.army.mil/whatwedo/civwks/CAP/1135.pdf.

[10] Tuel, Darlene (Bureau of Reclamation, Water Resources Planner).2005, November. Study correspondence with author (Andrew Schwarz).

19	El Rio Antiguo	20	North Simpson Riparian Recovery
21	Esperanza Ranch	22	Sweetwater Wetlands
23	Marana High Plains Effluent Recharge Project	24	Tres Rios del Norte
25	Paseo de las Iglesias	26	Accidental Restoration in Pima County
27	Rillito River Restoration (Swan Wetlands)		
Upper Colorado River Basin Project			
28	Grand Canyon Tamarisk Management		
Verde River Watershed Projects			
29	Fossil Creek Restoration	30	Verde River Headwaters Restoration

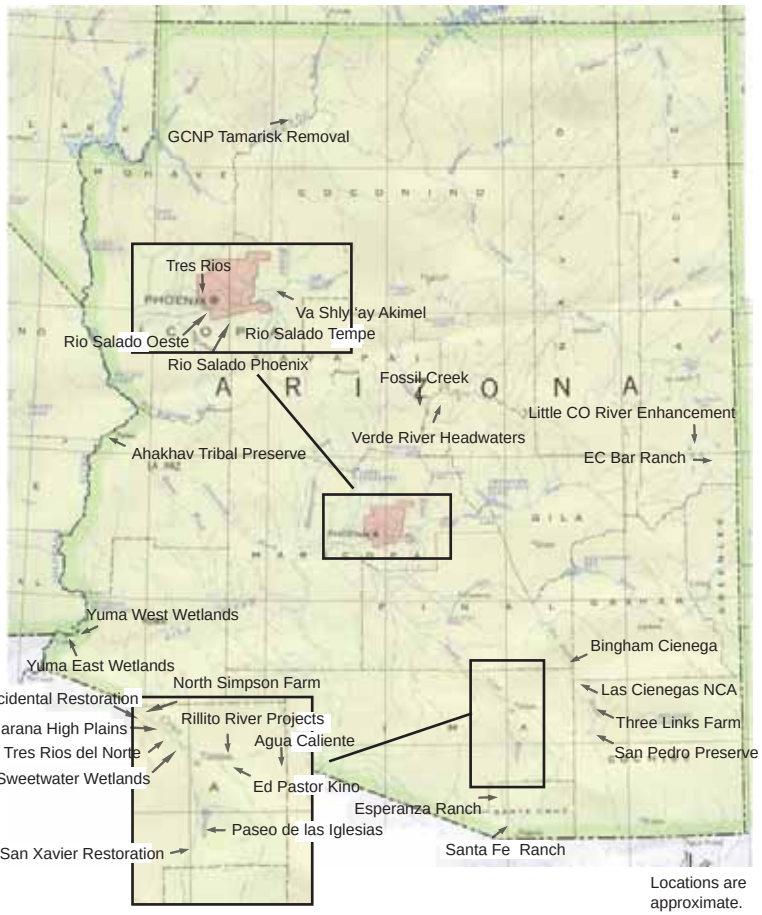

Figure 2. Project locations

Methodology

To select the projects for this study, we identified and invited over 100 people from various interest groups and backgrounds to come to two stakeholder meetings. At these meetings, a short

introduction to the study and an overview of the types of projects targeted for inclusions were provided. The meetings were held in October 2004 in Phoenix and Tucson. About 35 people attended the meetings. Project suggestions were also solicited from the Arizona Water Projection Fund. Over fifty projects were recommended from the various stakeholders. The thirty projects included in this study were evaluated and selected in order to provide a diverse study based on the following criteria:

- Geographic location
- Type of sponsors: private, state, federal (e.g., U.S. Army Corps of Engineers, City of Phoenix)
- Intent of project: wetlands, water quality, wildlife habitat etc.
- Unique element(s) in project
- Ease and availability of information on the project
- Current project phase (a preference was given to completed or nearly completed projects so that lessons learned were likely to be available).

This study builds upon a previous study focused on the environmental enhancement efforts of the U.S. Army Corps of Engineers.[11] Information gathered from the Corps of Engineers study was modified to fit the format of this study and all projects included in the Corps of Engineers study are also included in this study. Once the additional projects were selected, we compiled and analyzed written information such as environmental assessments, grant applications, management procedures, newspaper articles and websites. When possible, we also conducted an interview with the project sponsor and/or site visit. The information from these sources was then synthesized into a standardized project summary, which included information on the project's location, sponsors, history, phases, planning objectives, recommended or implemented plan, monitoring and maintenance, funding and cost, water requirements, land ownership, public outreach, drivers, and challenges/lessons learned.

Preliminary findings were drawn from these summaries and a draft report was circulated to all of the project contacts and other interested parties. Two stakeholder meetings were held in November 2005 to present the initial findings and receive feedback.

Following these meetings, in response to comments from stakeholders, a survey was developed to collect information regarding each of the subject areas of interest in the study. A copy of the survey can be found in Appendix A. A survey and the draft version of the project summary for each project were sent to each of the project contacts. The goal of this exercise was to double check the facts in the summary and give contacts an opportunity to comment on the draft summary. The surveys also provided a more standardized tool for analyzing the data. A database was compiled using the survey data and a list of summary findings was extracted from the database. The project summaries served as background and supporting information for the surveys and documented the details that make each project unique.

Summary Findings

Although every project has a unique story, there were aspects of the projects that can be

[11] Megdal, S.B. 2005. Environmental Restoration Projects in Arizona: The Army Corps Approach.

categorized and examined as a whole in order to create an overall picture of these 30 enhancement projects. The following section provides a summary of the projects' drivers, sponsorship, benefits, water requirements and lessons learned. Relationships among these categories are also discussed.

Drivers

The first question we wanted to answer in this study was what were the specific "drivers" that led the projects to be undertaken? Drivers are defined as the specific reason or force that initiated the project and/or moved the project forward. Drivers differ from other project benefits in an important way. Benefits may be realized from a specific, often ancillary element of a project whereas drivers are the reason the project exists in the first place. For example, public use benefits are derived from a trail constructed around a wetland created to maintain storm water detention and flood protection. The distinction is made between the elements that were integral to the project's conception and implementation and benefits that are complimentary but not integral to the project. The Ed Pastor Kino Environmental Restoration Project is a good example of this distinction. Conceived and funded by the Army Corps of Engineers under section 1135, the project involved redesigning the park area to provide additional storm water detention benefits and wildlife habitat. Trails were added to the project to capture additional benefits but were not a driver to the project's implementation; the project was actually driven by habitat restoration and storm water detention enhancement. Driving forces are an important aspect of the implementation of environmental enhancement projects; separating them from other benefits highlights the most important elements in how a project comes into existence. Benefits should not, however, be seen as after thoughts or superfluous additions to projects in order to make them more attractive. Many of the beneficial elements became part of the projects early in the design phase and were always considered important features.

Most of the projects cited multiple drivers, with an average of three drivers per project. Figure 3 shows a list of drives cited by the projects and the number of projects that cited them. Appendix A lists each project individually and shows the drivers cited by each project. One of the most interesting observations that can be made from a review of the projects is the diversity of the drivers. Nineteen different drivers were cited for the 30 different projects, highlighting a wide range of reasons these projects were undertaken.

Habitat value was the most common driver with 25 projects citing it. The remaining five projects listed habitat as a benefit but not one of the primary reasons the project was undertaken. Two projects listed habitat value as the only driver for the project (Rillito River Park/Swan Wetlands and El Rio Antiguo).

While habitat was by far the most common driver, there were several others that cut across multiple projects. Inclusion in a general or regional restoration plan was cited as a driver for nine projects. For the purpose of this study, general or regional restoration plans were defined as planning initiatives involving more than one project that attempt to meet common or related objectives. The Sonoran Desert Conservation Plan (SDCP) is one such regional planning initiative, integrating natural, historical, and cultural resource planning with urban planning. The Paseo de las Iglesias project is in part driven by its contribution and consistency with the SDCP. Paseo de las Igesias is also part of a three project proposal, including El Rio Medio and Tres Rios del Norte, along the Santa Cruz River that would improve environmental conditions along the river

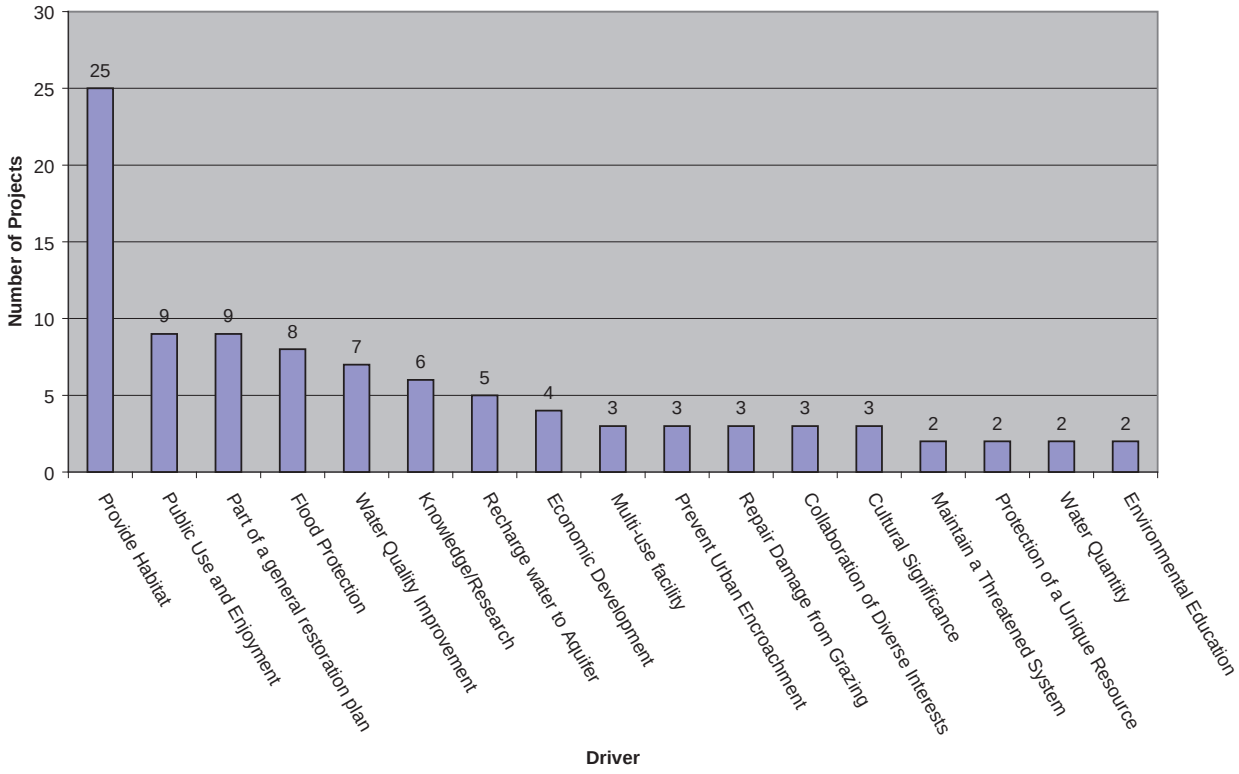

Figure 3. Project Drivers

continuously from the Tohono O'Odham Nation, San Xavier District to Marana. The San Pedro-Three Links Farm project is also part of a larger Nature Conservancy initiative to protect instream flows in the San Pedro River. The Nature Conservancy (TNC) has been systematically identifying properties that have groundwater pumping rights and a hydrological connection to the river, and acquiring the lands to retire the groundwater withdrawals.

Another driver for nine projects was public use and enjoyment. This driver typically involved providing recreational opportunities, including picnic facilities and hiking trails. Interestingly, only one of the projects that cited public use and enjoyment as a driver, the Fossil Creek Dam Removal and Riparian Restoration, was outside of a metropolitan area.

These two drivers, consistency with a general restoration plan and public use and enjoyment, seem to point to two important trends. Increased urbanization throughout Arizona has increased the demand for environmental recreation opportunities. This has become an important force behind many of the projects throughout the state of Arizona, but particularly in the largest urban areas (Metro Phoenix, Tucson, and Yuma). The high proportion of projects citing consistency with a larger general enhancement plan may indicate that project sponsors are taking a more systematic approach to project selection and design. Several of the projects that were part of general restoration plans involved protecting multiple reaches or long stretches of rivers. Dave Harris of The Nature Conservancy reinforced the importance of this approach saying "until the entire reach of the river is protected, all of the rehabilitated area is vulnerable, changes in upstream groundwater or surface

water use may undo the progress made down stream."[12]

Water quality and flood control were also important drivers, with seven and eight projects citing them, respectively. Interestingly, only one of the projects that cited water quality as a driver, EC Bar Ranch, had performed pre and post project Total Maximum Daily Load (TMDL) or Proper Functioning Condition (PFC) reports, two widely accepted methods of quantifying water quality and stream health. Not surprisingly, flood control benefits were distinctly associated with flood control districts (Pima County Regional Flood Control District and Maricopa County Flood Control District) and cities (Tucson, Phoenix, and Tempe). Four of those projects were partnerships between a flood control district and a city, indicating that agencies and organizations that have similar objectives are likely to team up on projects, perhaps to increase support and funding opportunities.

Six of the projects cited the advancement of knowledge as a driving force in the implementation of their projects. This typically involved studying new types of invasive species eradication, revegetation methods, or overall restoration principles and procedures. For example, the Verde Headwaters restoration project emphasized the importance of learning about the ecosystem as well as using the restoration project as a research tool for Northern Arizona University students. In other cases, advancement of knowledge applied to other areas of interest, such as decision making amongst diverse interests. The fact that a fourth of the projects indicated advancement of knowledge as a driver demonstrates that many sponsors still feel that there is much to learn about restoration efforts and the best way to implement them. Improving the overall body of knowledge available to restoration professionals can improve the success rate of projects and possibly improve their cost effectiveness.

The next most common driver was aquifer recharge. The five projects in this category can be distinguished into two groups. The first group included projects that were constructed as recharge facilities (Sweetwater Wetlands and Marana High Plains Recharge Facility)[13] and the second group included projects seeking to increase or protect natural aquifer recharge through a variety of methods. In the case of the Tres Rios project an effluent stream will be diverted through the project area where a wetland will be constructed to help improve the quality of the water before it is allowed to recharge into the ground. The Las Cienegas Preserve, on the other hand, was in part driven forward because it serves as a crucial area of recharge for the aquifers that flow under the Tucson area. Urban encroachment would have significantly damaged the area's ability to function in this manner, therefore, protecting the area in its natural state was an important driver for the project.

Ten other drivers were cited by the project contacts as important reasons for their implementation. These other drivers, with the number of projects citing them in parentheses, are the following: economic redevelopment (4), cultural significance (3), collaboration of diverse interests (3), repair damage from grazing (3), prevent urban encroachment (3), multi-use facilities (3), environmental education (2), increase water quantity (2), protect unique water resources (2), and maintain threatened systems (2). The diversity of drivers is striking considering the limited geographical area (Arizona) and relatively compressed time frame (last 10 years) over which the

[12] Harris, David (TNC- Director of Land and Water Protection). (2006, January) Interview with author -Andrew Schwarz.

[13] Recharge facilities as applied to the two projects in this study refer to constructed spreading basins to take a renewable source of water and allow it to percolate into the aquifer below the surface.

projects were carried out.

Many of the projects in this study evolved between conception and implementation. For example, the Little Colorado River Enhancement Demonstration Project found it necessary to change many of their restoration techniques after high river flows in the winter and spring of 2004-2005 damaged or destroyed much of the restoration work that had previously been done. On the whole, however, the projects remained focused on the original purposes and intent for which they were conceived, maintaining the same drivers throughout the process.

There are several ways to group drivers into larger related groups. One of the most useful ways was to separate those drivers that are more human focused from those that are more non-human focused. Appendix C shows a spider diagram of the 17 drivers separated into these two categories. Two of the drivers, part of a general restoration plan and multi-use facility, embody elements of both. The two major categories were broken down further into major issues. Human focused drivers were divided into education, water issues, quality of life issues and collaboration of diverse interests. Quality of life issues included drivers that dealt with economic, cultural, and social aspects that pertain to the fulfillment and enjoyment derived by humans from their surroundings. Non-human focused drivers included water, land use, and habitat issues. It is important to note that all of these drivers have connections to both human and non-human benefits. The distinction is made as a way to look at the human versus non-human values that move environmental enhancement projects forward.[14]

Interestingly, a total of 44 non-human focused and 40 human focused drivers were cited, indicating that projects in the study were driven forward by a values balanced between human and non-human benefits. Another finding is that water issues appear on both sides of the diagram. Non-human focused water issues include quantity, quality and uniqueness of the resource, while the human focused water issues include flood control and recharge. Perhaps it isn't surprising that water crosses over between human and non-human focused drivers, as water is equally essential to humans and wildlife. As a group, water related drivers were indicated by 22 projects, second only to the 27 projects that cited habitat issues.

Sponsorship

Sponsorship was defined as the group or groups that primarily implemented or supervised the enhancement project. As with drivers and benefits, there is a subtle but important difference between sponsorship and funding. In many cases the projects were funded by grants from agencies that, other than approving the grant application, had little influence on the actual design of the project. The Arizona Water Protection Fund (AWPF), was a very important funding agency, endowing 12 of the projects with funds. The AWPF, however, was not listed as a primary sponsor on any of the projects. While AWPF has a broad mandate to provide a source of funds for

[14] Some of these classifications are certainly subject to debate. We believe, however, that the ways in which these elements are employed by the projects justify their classification in this way. For instance, recharge of water to aquifers was classified as human focused, and while there are undeniable benefits that accrue to non-human populations from recharge, in this context most recharge was done to accumulate groundwater recharge credits that could be recovered for later use by humans. Water quantity improvements were classified as non-human focused because most of the additional water was left instream to be used by plants and animals. Knowledge and research was classified as human focused because the improvements in understanding accrue to humans, even though the fruits of that increased understanding may accrue to non-human populations.

projects that maintain, enhance or restore rivers and streams and associated riparian habitats,[15] the AWPF is an administrative agency that does not implement projects. The United States Army Corps of Engineers have the rare combination of both funding mechanisms and the human resources for implementation making them an important sponsor for multiple projects in the study.

The projects highlighted in this study are sponsored wholly or in part by city and county agencies, Native American tribes, non-governmental organizations (NGO), private landowners, federal and state agencies, and universities. A range of projects that had been sponsored by various diverse entities was intentionally selected to elicit information about how the goals reflect the objectives of the sponsoring group. Figure 4 shows a pie chart depicting project sponsorship in the study. (The total number of projects in the graph exceeds 30 because several projects had multiple sponsors.)

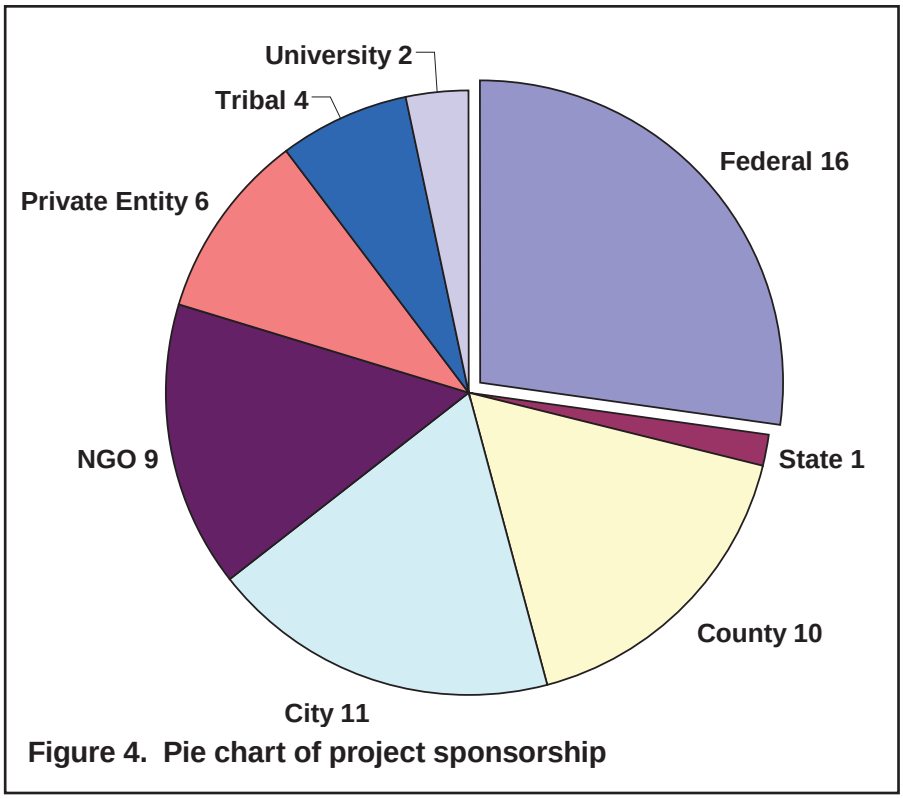

Figure 4. Pie chart of project sponsorship

Project sponsorship was found to be an important factor in the design and implementation of the projects. One factor that was influenced by project sponsorship was the project's size. Projects in this study varied from very large to quite small. Size could be measured in several different ways: acreage, river or stream miles enhanced and cost. Size in acreage of the projects studied varied from less than 20 acres to over 5,600 acres. The largest project studied was the Tres Rios project in the Phoenix area. About half of the projects fell within the range of 100 to 600 acres. It must be noted, that some of the projects that included very large tracts of land did not always involve revegetation or active enhancement on the entire parcel. Areas included in the project, even if they were not actively enhanced, provided open space protection, buffer zones and other benefits to the project. All of the projects had some connection to riparian habitat. Many, but not all, of the projects directly abutted a water course and a length of stream or river was enhanced as a result of the project. Other projects provided wetland or cienega habitat that was not measured in stream miles. Projects that did directly abut water courses ranged in size from less than a quarter of a mile to 19 miles of water course in the case of Tres Rios del Norte in Pima county. Finally, the projects can be

[15] ARS 45-2101.

measure by their costs of implementation. The projects in this study varied in cost from $210,000 to almost $300 million. The projects also had large variations in operating costs including costs for purchasing water. Operation and maintenance budgets were as large as $9.7 million per year. So many variables are involved in distinguishing one project from another that a direct side by side comparison of costs, size, and benefits would be nearly impossible.

The project design is also influenced by project sponsors because most of the project sponsors have a constituency or mandate that directs their activities. City governments provide services to their citizens which often include providing amenities to improve the quality of life in the city. The county flood control districts in this study are charged with minimizing flood damage and some times also take on other related issues.[16,17] Federal agencies, such as the Army Corps of Engineers, have a broad mission to provide engineering services and capabilities to the public.[18] As part of the 1986 Water Resources Development Act, the Army Corps of Engineers was authorized to participate in environmental restoration and remediation projects as authorized by congress or in an effort to repair damage done by previous Corps projects.[19]

Federal agencies sponsored the largest number of projects (16). The U.S. Army Corps of Engineers sponsored 11 of the projects.[20] The National Park Service, National Forest Service, Bureau of Reclamation, and Bureau of Land Management also sponsored projects.

County and city agencies were the next largest sponsors, leading 11 and 10 projects, respectively. In all 11 projects sponsored by county agencies, the agency was the county flood control district (Pima County Regional or Maricopa County). All of these projects took place in the major metropolitan areas of Tucson and Phoenix.

Non-governmental organizations and/or non-profit groups sponsored nine of the projects. An interesting aspect of these projects was that they usually listed several drivers. The San Pedro Preserve and San Pedro Three Links Farm projects, both sponsored by The Nature Conservancy, had four and three different drivers respectively. The Little Colorado River Enhancement Project, sponsored by Apache Natural Resources Conservation District (NRCD) and Upper Little Colorado Watershed Partnership had four different drivers. The Grand Canyon Tamarisk removal project, sponsored by The Grand Canyon National Park Foundation, Wildlands Council and the National Park Service, had four different drivers. This may reflect the need for non-governmental organizations to incorporate multiple objectives into their projects in order to pursue diverse funding sources and broad support from their constituencies. Appendix B shows a complete list of the projects and drivers for the study sample.

The Yuma East project was very interesting in this respect. It was sponsored by the City of Yuma, the Yuma Crossing National Heritage Area (a federally funded commission), and the Quechen Indian Nation. This diverse group of sponsors, as well as a diverse set of

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[16] http://www.fcd.maricopa.gov/District/Default.asp. Retrieved March 3, 2006.

[17] http://rfcd.pima.gov/. Retrieved March 3, 2006.

[18] http://www.usace.army.mil/missions/index.html#Water%20Resources. Retrieved March 3, 2006.

[19] U.S. Army Corps of Engineers. 2004. Project Modifications for the Improvement of the Environment. Washington: U.S. Army Corps of Engineers. Available at: http://www.nab.usace.army.mil/whatwedo/civwks/CAP/1135.pdf.

[20] This number may be artificially skewed due to the inclusion of 11 projects in the study from the previous environmental enhancement study focused on the efforts of the Army Corps of Engineers.

concerns from neighboring property owners and stakeholders, resulted in this project having nine different drivers, almost twice the number of any other project. According to Kevin Eatherly, project manager for the Yuma Department of Public Works, "The East Wetlands is a highly unusual project; because it would have never gotten off the ground had we not listened and responded to all the landowners and stakeholders. Thus, the consensus has created a wide variety of key factors."[21] Each of the stakeholder groups felt strongly about a particular issue and was able to advocate for specific elements to be included in the project. The process resulted in a diverse project that met the needs of the community.

Certain drivers were only associated with specific sponsoring agencies, indicating objectives that are unique to that agency. For example, The Nature Conservancy cited "protection of a threatened system" as a main driver to both their San Pedro River projects, a driver that was not cited by any other project. The driver is a direct reflection of their mission to preserve and protect land and waters for the life that depends upon them. City governments function to provide service and support local economies. The study results show that the driver of economic development was associated predominately with city government sponsored projects in metropolitan areas. Not surprisingly, the driver of flood control was almost exclusively associated with city governments and flood control districts. All four of the projects sponsored by tribal governments had cultural benefits associated with them, and three of the four stated that the cultural elements were primary drivers to the project. In the case of the San Xavier Restoration, the project was initiated to restore a stretch of the Santa Cruz River so that members of the tribe would have a place to walk, mediate and reflect. During the design of the project, tribal elders were consulted in an effort to acquire information about what the area looked like decades ago during their youth. NGOs, such as the Tucson Audubon Society and The Nature Conservancy, appear to shape their restoration efforts more around creating habitat for the intrinsic value of habitat and often restrict public access or prohibit public access all together.

Six of the projects were sponsored by private entities. These projects can be broken down into two groups. The first group includes four projects that involved private consultants who helped public groups undertake the restoration work. In these cases, the consultants were usually intimately involved with the planning and implementation of the work. Mark Briggs of Briggs Restoration, Inc. who helped the San Xavier District implement the San Xavier project states: "We (Briggs Inc.) were hired to help the district select the most appropriate site (we did an analysis that prioritized five potential sites based on a variety of ecological and sociopolitical considerations). Once the site was selected, we did the project design jointly with the District, and then the implementation, monitoring, and evaluation. It was and still continues to be a solid partnership that is a true team effort."[22] The other group includes projects where the private entity actually funded and spearheaded the restoration. The EC Bar Ranch, the private property of Jim Crosswhite, is perhaps one of the most unique projects in the study group. Mr. Crosswhite has pursued funding from nearly every state and federal agency that provides funding for environmental restoration and has followed the guidance of the NRCS, ADEQ, US FWS and others. Mr. Crosswhite has spent tens of thousands of his own dollars in his restoration efforts, and asserts that although no universally accepted definition of a restored riparian area

[21] Eatherly, Keven (City of Yuma, Department of Public Works). 2006, February. E-mail correspondence with author (Andrew Schwarz).

[22] Briggs, Mark (Briggs Restoration, Inc.). 2006, January. Study correspondence with author (Andrew Schwarz).

exists, his property meets more of the acceptable criteria then any other area in the State.

The final category of sponsors in the study was universities. Only two of the projects in the study were sponsored by universities, both by Northern Arizona University. Not surprisingly, both projects were driven by knowledge and research advancement.

Benefits

Although the drivers were the key elements behind each project's undertaking, all of the enhancement efforts incorporated other elements that provided additional benefits. For this study, benefits are defined broadly and do not necessarily have to accrue to human populations. A total of sixteen different benefits were attributed to the projects. These benefits accrue to different human and non-human populations. Appendix C contains a complete list of the projects and the benefits cited by each project.

Figure 5 shows all of the diffent benefits cited by the projects and the number of projects that cited them. All 30 projects cited more than one benefit, with most having between four and six benefits. Not surprisingly, all 30 cited habitat value as a benefit of the project. The problem arises, however, in the definition of "habitat value." There are several measures of habitat value but no universally accepted metric, making the definition of habitat value a contentious issue.[23] Further, although many of the projects continued to monitor wildlife characteristics, the projects rarely conduct a comprehensive review of the project's success. In this study we

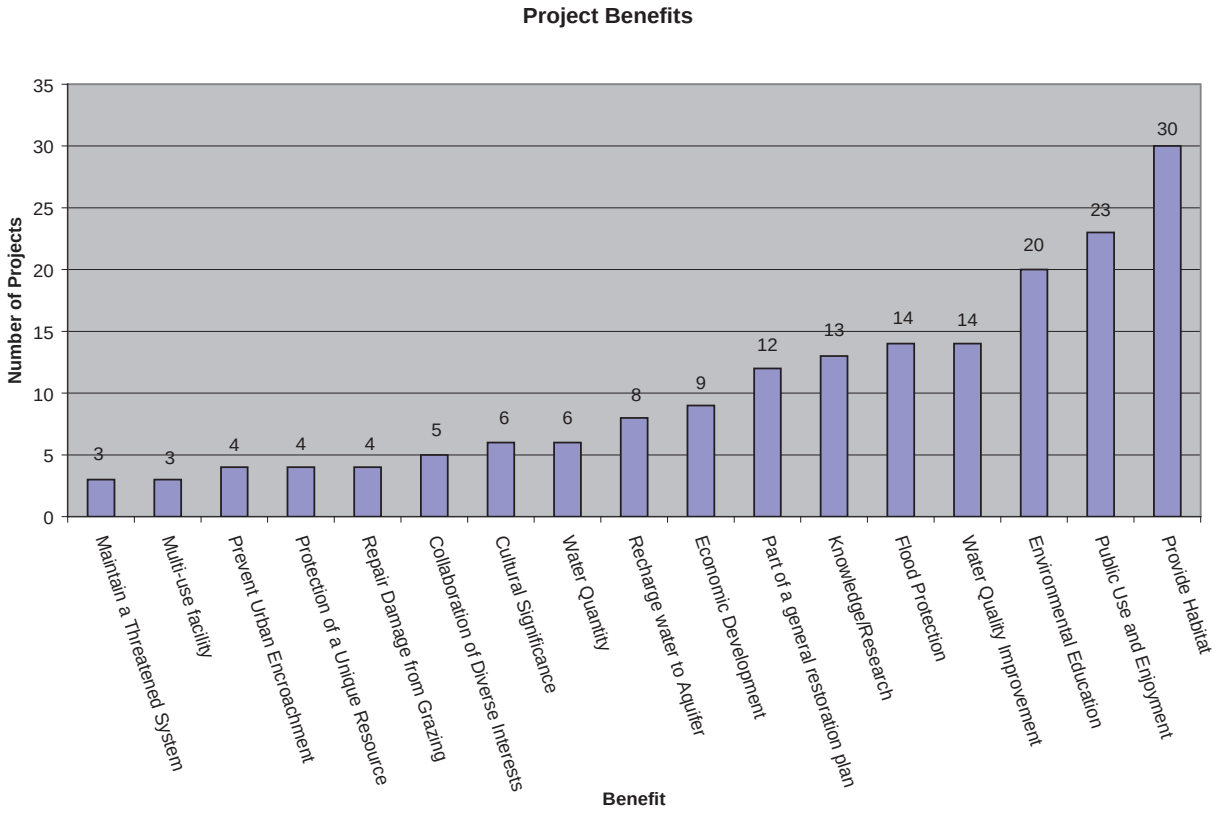

Figure 5. Project Benefits

[23] Hall, L., Krausman, P., and Morrison, M. (1997). The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25:173-182.

have not attempted to apply any metric to the value of habitat and no requirements were set in order for a project to achieve this benefit.

While all 30 projects captured a habitat value benefit, the next three most often cited benefits were directed predominantly at human populations [public use (23), environmental education (20), and flood protection (14)]. Taken as a whole, project drivers tended to be very balanced between human focused (40) and non-human focused drivers (44), whereas for benefits the totals were skewed toward human focused benefits (98-65). Appendix C shows a spider diagram of how the benefits and drivers were divided between those that were human focused and those that were non-human focused.

The benefit of public use and enjoyment was most commonly expressed through parks and trails that were open to the public with few restrictions on access. Two of the 23 projects, the Audubon Society projects at the North Simpson site and Esperanza Ranch, allow public access but with strict restrictions, including the need for visitors to make advanced reservations to visit and be supervised while on the property.

Projects with public use benefits were frequently coupled with environmental education benefits. Eighteen of the 23 projects included an education component. For example, the Ahakhav Tribal Preserve in its first year took over 300 youths canoeing on the river and backwaters and hosted environmental education programs at the Colorado River Indian Tribes Head Start Program and a local junior high school. Of the projects that indicated environment education as a benefit, however, most realized it through interpretive signs on the property. Two additional projects, EC Bar Ranch and Santa Fe Ranch, achieved education benefits without allowing public access to their sites. The Santa Fe Ranch project used a unique method for environmental education. They partnered with local elementary and high schools to develop a riparian ecosystem teacher's guide and tree nursery management activities with students.

Interestingly, of the 20 projects that listed environmental education as a benefit only two of them cited it as a driver for the project. This was by far the largest discrepancy between a characteristic that could be a driver and/or a benefit. This suggests that the project sponsors included environmental education elements in the projects as a way to increase the value of the project to the community and perhaps garner increased support. But few projects were actually conceived as a way to provide environmental education. Figure 6 shows the relationship between project benefits and project drivers.

Knowledge and research benefits were cited by 13 of the projects. Knowledge and research benefits improve the overall understanding of environmental enhancement processes and procedures, but are directed toward the academic community and restoration professionals as opposed to environmental education which is directed at the general public. Knowledge and research benefits were captured by projects that improved the body of knowledge of enhancement techniques, processes and strategies and made their findings available to the wider public.

Knowledge and research values were most frequently cited as benefits in the projects sponsored by NGOs; seven of the nine projects sponsored by them cited this benefit. This is understandable since many of the NGOs implement several projects every year and could improve their ability to carry out their mission by improving their methods and overall knowledge.

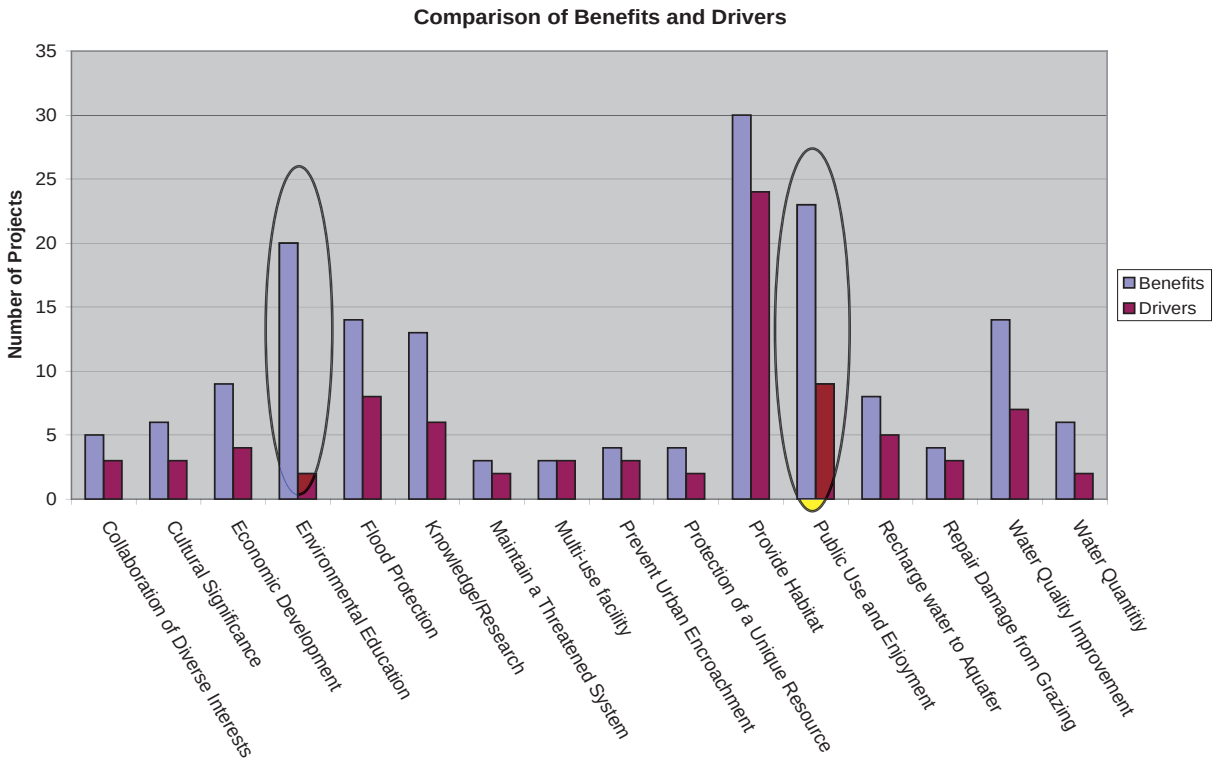

Figure 6. Comparison of benefits and drivers

Improved flood protection also proved to be an important benefit of projects in the study, with 14 projects indicating it as a benefit. Again, we saw an affinity toward a specific benefit by a certain sponsor. Eight of the 10 projects sponsored by cities cited flood control as a benefit. Not surprisingly, 10 of the 11 projects sponsored by county and regional flood control districts also included this benefit. The only county flood control project that did not was the Rillito River Riparian Area (Swan Wetlands), which receives storm water and puts it to beneficial use by creating a wetland, but, does not provide additional flood protection for the area. The U.S. Army Corps of Engineers co-sponsored a great many of these projects, again showing the connection between the mandate of a sponsoring agency and the benefits that are derived from their projects.

Water quality is one of the most significant issues with impaired riparian systems, and 14 projects cited water quality improvements as a benefit, and seven projects listed it as a driver. Unlike habitat value, water quality can be quantitatively measured through techniques such as Total Maximum Daily Load (TMDL). The TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards.[24] Water quality standards are set by federal, state and tribal agencies and may depend on the intended use of the water body i.e., drinking, swimming or aquatic life. Even with this quantitative and accepted measurement for water quality, only one of the projects reviewed in our study, EC Bar Ranch, referenced an TMDL report. This is quite striking and perhaps shows something about the rigor of applications and criteria for funding environmental enhancement projects.

Seven other benefits were noted in our project survey including: cultural significance (6), water quantity (6), collaboration of diverse interests (5), protection of a unique water resource

[24] www.epa.gov/owow/TMDL/intro.html. Retrieved March 3, 2006.

(4), repair damage from grazing (4), prevention of urban encroachment (4), maintenance of a threatened system (3), and multi-use facility(3)[25]. As with drivers, the diversity of benefits derived from the projects is remarkable.

Water use

Riparian areas throughout the state depend on water to maintain their habitat characteristics. There are, however, many competing demands for water in Arizona. Examining how these 30 projects use this limited resource was an important aspect of the project. Our examination of water use in environmental restoration focused on a few pertinent questions. Are environmental projects in the state dependent on un-protected instream flows? Are they surviving without the artificial importation of water? Have they purchased water rights or water supplies such as effluent from those willing to sell them? And what is the range of prices that projects have paid to secure water for the projects.

In order to analyze the information on water use, the projects were classified in one of three ways: 1) project does not require supplemental irrigation; 2) project requires only temporary supplemental irrigation (1-3 years); and 3) project requires long-term supplemental irrigation. The projects that did require some type of supplemental irrigation were then defined by the water supplies they were using to meet their requirements and whether contracts were in place to guarantee the supply of that water. Appendix D contains a flow chart showing each of the classifications, the water sources and the projects that used those water sources.

Six of the projects surveyed did not require any supplemental irrigation water. It is worthwhile to note that most of these projects are located along a natural river channel or ephemeral river supplemented with effluent flow. So, while these projects do not remove any water from the stream channel for irrigation, much of the character and value of the projects is dependent on instream flows. In the case of the Esperanza Ranch project, for example, this is especially critical since the project is oriented around an ephemeral effluent flow that is not guaranteed by contract. In the Grand Canyon at the Grand Canyon Tamarisk removal project, the situation is quite different. This project focused on removing tamarisk and other invasive species along the river corridor. The invasive species consume more water than native species and have a deleterious effect on the character of the river channel. Removing the invasive species was estimated to conserve almost nine acre feet of water per acre of tamarisk removed, thus leaving more water in the stream channel after completion of the project.

Nine of the 30 projects required only temporary supplemental irrigation. In these projects, irrigation is employed to support revegetation efforts through the critical first three years. After the initial establishment of the vegetation, the vegetation is expected to survive without any supplemental water. Like the first category, there are projects that rely on water sources that are not firm for some of the character and value of the project, but do not rely on these sources for irrigation.

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[25] A multi-use facility was classified as a facility that provided a number of functions for the community including (public use, education, recharge, water quality improvement, etc.). These facilities were counted for each of the individual benefits that they provided and additionally counted as a multi-use benefit because of the synergy benefit that is provided by providing multiple benefits in one space.

At the North Simpson site for example, the Tucson Audubon Society will eventually turn off ground water irrigation systems and leave the meso-riparian revegetation to adapt and compete on its own. Hypo-riparian vegetation will continue to be dependant on effluent flows from wastewater treatment plants in Tucson. If the flows were diverted to another use, the character of the riparian corridor would change significantly but the upland meso-riparian habitat would most likely continue to persist. While this may sound like a tenuous guarantee that the habitat will survive, project sponsors point to the natural ephemerality of riparian corridors in the desert and the value of putting a waste stream to productive use. Ann Phillips, project manager for the site notes that "the North Simpson Site may change character over time due to changes in the volume of effluent releases, impacts of large floods, prolonged drought, or other major impacts. With the exception of changes in effluent flows, these changes are to be expected in all riparian areas. Regardless of how changes might alter habitat in the future, the site right now is serving as habitat for numerous birds and other wildlife. Regardless of how the effluent flows might change over time, the site is now and will continue to be important meso/xeroriparian habitat because of the periodical flood flows that pass through the site".[26] Her point is that in some cases the here and now value of the habitat is sufficient to justify the expense of the project, even if some of the benefits of the project may be lost in the future due to changes in effluent flows. In addition, taking advantage of a waste stream to create hydroriparian habitat that otherwise would not have been present has an significant value.

Another project that will use supplemental irrigation is the Yuma East project. This project will use earthwork to reconfigure open water areas and the eradication of invasive species. Initially, the sponsors will remove water from the river to support revegetation efforts, but the design estimates show that once irrigation ceases, the project will actually leave more water in the Colorado River.

Half of the projects studied required only short-term or no irrigation, the other 15 projects required long-term inputs of water. In the arid climate of Arizona, where populations are expanding all over the state, competition for water supplies gets tighter every day. So how have these projects managed to secure long term water supplies? Many of the projects take advantage of multiple sources of water and can supplement their supplies with storm water or rainwater when available. Other projects provide benefits that augment water supplies by recharging large quantities of water. And others use unique supplies that are not of sufficient quality to be used for other purposes.

Seven of the 15 projects rely on effluent flows. Effluent is a waste product produced after municipal sewage has been treated to a level that is acceptable for re-release to the environment. For years this water was discharged into streambeds and allowed to mix with other surface water or percolate into the ground. Today, the demand for effluent has grown because it is increasingly used for irrigation of turf facilities and municipal landscaping. The seven projects in the study that use effluent employ it in several different ways.

One example is a restoration that was unintentional. A discharge of wastewater in Pima County has created a rich pocket of riparian habitat where volunteer species have colonized the area. The discharge is a result of the waste water treatment plant having no other use for the water and thus discharging it to the stream channel. A number of incidental benefits have emanated from the addition of water to an otherwise dry area. Much of the water eventually seeps in to the

[26] Phillips, Ann (Tucson Audubon Society). 2005, December. Site visit to North Simpson Project (Andrew Schwarz).

aquifer as the water percolates into the ground. The pocket area also provides habitat for birds and other wildlife and has started to attract bird watchers. The project doesn't have a sponsor or any drivers; it isn't really even a "project" per se. It does, however, show that restoration projects need not necessarily be complex pre-planned exercises in order to provide both human and habitat benefits.

In contrast, three of the seven projects that use effluent were intentionally designed to take advantage of effluent flows. The Marana High Plains Recharge Project, Sweetwater Wetlands and Tres Rios on the Salt River near Phoenix were designed to improve the quality of effluent flows and/or recharge them to underground aquifers. All three facilities use the effluent flows to support vegetated areas, a wetland that improves the quality of the water while providing habitat in the case of Sweetwater and Tres Rios and a riparian corridor in the case of the Marana High Plain Recharge project. The effluent streams flow through the riparian habitat and then into large spreading basins to be recharged into the ground. In these projects the water supply is an available waste stream and one of the key benefits: recharge, actually augments water supplies instead of competing with other consumers. The Sweetwater Wetlands project is different from the other two projects in that the water that is recharged into the ground is recovered a short time later to be delivered through the Tucson reclaimed water system. The process of recharge and recovery further improves the quality of the water producing a valuable water supply that can be used for irrigation purposes. The other four projects use effluent to varying degrees as it flows through the project site as an instream flow or piped in tertiary treated reclaimed water for irrigation purposes.

The second most common source of water for the projects studied was storm water. Five of the projects employed storm water as a source of irrigation water. Only three of these projects actually had agreements or contracts in place guaranteeing the delivery of the water during storm events. All five of these projects had at least one other source of water whose delivery was more dependable and predictable.

Four of the projects used groundwater, all of which had contracts for its use. One of these projects, Rio Salado Phoenix, used a groundwater supply under the site that had been contaminated by urban runoff from Phoenix. The water had very little alternative economic value because the cost of treatment that would have been required for municipal use. The project was able to take advantage of the water by treating it to acceptable standards for irrigation and putting it to use.

Of the projects that require long-term irrigation, two use surface water, San Xavier and Yuma West, and a third project Va Shly ay Akimel is planning on using surface water. The San Xavier project was the first project to employ their Central Arizona Project (CAP) water allotment for environmental restoration and laid the groundwork for nearly 50,000 acre-ft of CAP water to be used on the reservation for restoration projects over the next several years. Va Shly ay Akimel project planners also intend to use CAP water to provide irrigation for the project. The Yuma West project uses main-stem Colorado River water from the City of Yuma's entitlement. The Yuma West experience is unique and the long-term water requirements are actually disconnected from the major habitat values of the project. In this project the long-term irrigation requirements are for the upper parkland area which is turf grass. The lower terrace, which contains the revegetated riparian species and most of the habitat value of the project, did not require irrigation beyond the initial establishment period.

An interesting characteristic of the 15 projects that required long-term supplemental inputs

of water was that they were focused exclusively in the main population centers of Arizona, Phoenix Metro, Tucson and Yuma. The 15 projects that do not require long-term inputs of water are scattered through out the state in every eco-region studied.

Projects in the study that required supplemental inputs of water varied widely as to the quantity of water that was required. Some projects required as little as a few hundred acre feet of supplemental water per year while other projects required tens of thousands of acre feet per year. For example, the Rio Salado-Phoenix project will use about 6 million gallons of groundwater per day. Many of the projects paid only costs for pumping groundwater while others projects such as the Rillito River (Swan Wetlands) paid in excess of two hundred dollars per acre foot of water. An in depth analysis of the quantities and costs of water for the projects is not provided here. The significant differences in water sources, availability, and use make it impossible to do an accurate side-by-side analysis. Information about the water use and costs for each project can be found in the project summaries in Part II of this report.

Three of the 15 projects that had long-term irrigation requirements were still in the planning stage and had not finalized the source of water that would be used. As this study was a snapshot of the projects in Arizona we were not able to make any observations about how water source issues affect the eventual implementation or cancellation of projects.

Lessons Learned Summary

Through the process of studying these 30 projects, much has been learned regarding the development of environmental enhancement projects. We categorize the most salient lessons learned as the six peas (P's) in the pond: preparation, persistence, partnerships, progress, pests, and post-construction. These six P's represent six broad categories of advice compiled from a combination of our observations, as well as comments from the project contacts.

Preparation: environmental enhancement projects are complex and dynamic. Many of the projects experienced difficulties due to foreseen and unforeseen obstacles. In some cases pre-construction planning or terrestrial information, such as surveying, was insufficient in some respect and led to large cost increases. Environmental enhancement projects change the character of the landscape in some cases creating undesirable situations such as increasing grass fire danger or attracting homeless people. Many of the projects faced significant regulatory permitting processes and some dealt with complications related to establishing conservation easements. The Rio Salado project, for example, had to obtain nearly 100 federal, state, county and city permits for various aspects of the project. These processes tended to be long and sometimes costly, draining resources and energy. Project teams that devoted significant consideration toward planning and presaging these issues were often able to implement their projects more smoothly and were able to more closely adhere to their project schedules. One example of where more pre-planning would have been helpful was the Bingham Cienega project. In this project, the restoration team, by their own admission, did not consider all of the costs associated with the irrigation lines, which resulted in unexpected expenditures. As a result they recommend that a rigorous cost analysis be conducted prior to project implementation. Had they done this analysis they would have seen, for example, that it was cheaper to drill a well adjacent to the fields rather than depending on the existing well at the house site and irrigation lines from that well. In some cases, especially where the project

Figure 7. The 6 P's in the pond

involved many unknowns, a smaller scale pilot project was conducted. These pilot projects elicited valuable information about the challenges and solutions that could be used in implementing a full scale project.

Persistence: adversity is common and flexibility is a key to success. Many of the projects surmounted huge obstacles or even failed completely on their way to implementation. For example, the Rio Salado Project was first conceived in the late 1960s by James Elmore, the founding dean of Arizona State University's School of Architecture. Elmore's plan evolved over two decades to include 28 miles of lakes throughout the Maricopa metropolitan area and carried a price tag of $2.5 billion. When the City of Phoenix took this plan to the voters in 1987, it was overwhelmingly defeated. Today's Rio Salado Habitat Restoration Project is considerably scaled down, encompassing 5 miles of river and has been endorsed by Phoenix residents. [27] Projects in this study also evolved from their original designs due to outside forces such as adjacent land owners, stakeholders or funding agencies. Projects needed to navigate this process without compromising the goals of the project. EC Bar sponsor, Jim Crosswhite, recommends identifying one focus from which all activities stem. A successful strategy for manipulating this process was assigning one specific person to spearhead fundraising or supervise critical aspects of the project.

Partnerships: different groups bring different strengths. Partnerships were not just about funding. In several instances project partnerships allowed one sponsor to focus on restoration efforts while another sponsor provided heavy equipment, water tanks and wells or police monitoring to keep unauthorized users off of the property. Projects that had multi-disciplinary teams were able to foresee and deal with a wider range of issues. Some projects brought together very diverse interests and agencies. When these partnerships were able to find common ground, they tended to be very successful. Partnerships also included joining together multiple enhancement efforts to pursue common goals. These types of partnerships can sometimes capture synergies between multiple projects. Environmental enhancement projects often become more valuable when their benefits are combined with other projects to provide a more comprehensive improvement. In many cases, partnerships involved cost sharing agreements. Funding from the Bureau of Reclamation and Arizona Department of Environmental Quality used by projects in this study required a percentage

[27] De Semple, Daniel. (2006) Phoenix Rises. Civil Engineering. Vol. 76 Issue 2, p 42-47

of matching funds to be provided by the sponsor. Funding from the Arizona Water Protection Fund requires that monitoring and maintenance of the projects be continued indefinitely into the future. The Fund does not allow their grant money to be put to this use, thus sponsors had to identify other funding sources to cover these costs.

Progress: measuring success of an environmental enhancement project is difficult and sometimes contentious. Quantitative measurement techniques are not widely used by these projects despite the common use of them by state and federal agencies. Most funding agencies do not require reporting of pre-project or post-project reports for water quality (Total Maximum Daily Load measurements) or overall riparian health (Proper Functioning Condition). Our research did not indicate that any widely used quantitative standards or requirements exist for measuring the success of projects. Retrospective evaluations of any kind were also rare.

Pests: many projects faced problems from invasive species, mosquitoes and unwanted wildlife. In many cases the presence of water in areas where there had previously not been water attracted mosquitoes and unwanted wildlife such as beavers and elk. The Verde Headwaters project, for example, found it necessary to construct elk fences around large portions of the site. In places where elk were allowed problems arose from not only the elk grazing but also the elk disturbing the nets placed on the ground to prevent erosion. In other cases invasive species that had been present on the land for years proved nearly impossible to remove. When invasive species on the property could be controlled problems often arose from adjacent properties which provided seed sources for re-colonization. Many projects stressed long time horizons for dealing with invasive species, allowing multiple seasons to continuously deplete seed banks in the soil.

Post-Construction: Monitoring and maintenance are extremely important factors in gauging and achieving success, but are difficult to fund. In many cases the post restoration or enhancement monitoring is arguably the most important aspect of the project. Monitoring post-dam removal in Fossil Creek restoration project, for example, will reveal how this unique travertine system restores itself. Funding for this monitoring has, however, been difficult to find. The Arizona Water Projection Fund requires that its grantees commit to monitoring of the project site after completion but do not allow their funds to be allocated to monitoring. Maintenance considerations are especially important in projects with continued irrigation needs. Several projects experienced irrigation system failures that in some cases caused large die offs of vegetation.

Conclusions

This report details the many benefits that environmental enhancement projects provide to humans and wildlife. Although some projects in this study were designed to use no or minimal surface water diversions, most projects require water to maintain their character. Allocation of scarce water resources is increasingly a concern across Arizona.

Recognizing the link between public awareness of the value of environmental enhancement projects and their future, we suggest two more P's, the Process and the Public. These two P's are not independent. In order to gather the support of the public for the required resource investments, the process should include public outreach and involvement during all phases of the project. Engaging the public early in the process, during project conceptualization, allows citizens to comment on possible design elements and management goals. Using volunteer labor during construction can increase public ownership of the project and foster a deeper understanding of the ecology and appreciation of the value of these projects. And continuing to involve the public after completion by using the site for educational and recreational events can increase the value of the project and

promote the site's use.

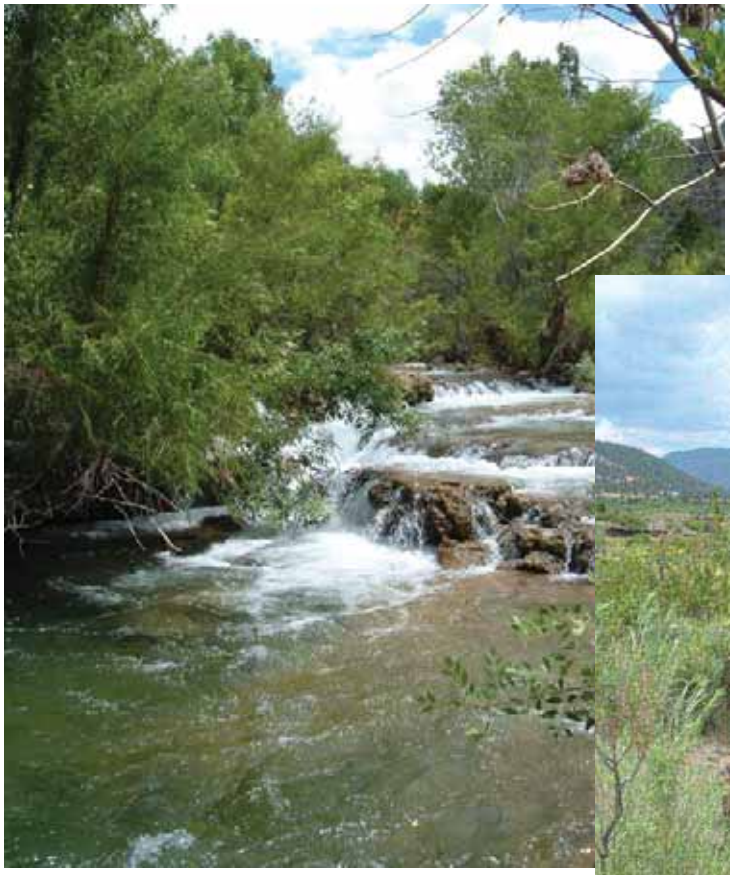
Environmental enhancement projects can be expensive, both in terms of water and funding. Through incorporating the public early and often, agencies can ensure public understanding. Public knowledge is important because of the many competing interests for limited financial and natural resources. Better public appreciation of the need for and value of such projects may result in increased support for environmental enhancement projects, especially those with long-term water resource requirements and significant other public investment.

The Process is important not only for its ability to incorporate the public and engender support but, also in how the projects are managed. Another overarching concept that can be taken from these 30 environmental enhancement projects is adaptive management. Most project sponsors described flexibility, experimentation, communication and evaluation as keys to project success. In the face of water and financial uncertainty, adaptive management strategies can give project teams the tools to adjust to changing conditions and limitations.

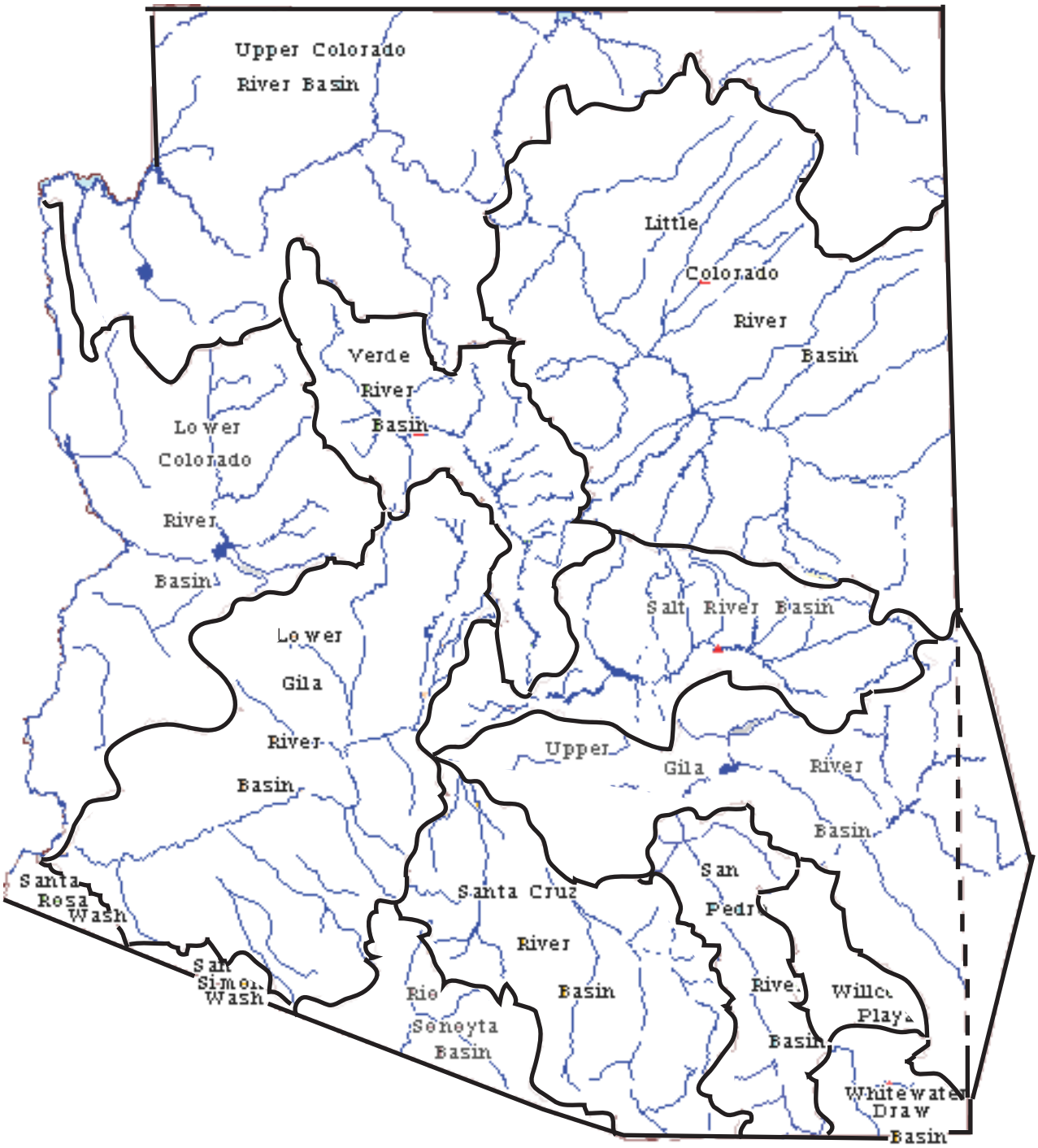
Finally, the Process and the Public come together for another important consideration in environmental enhancement projects. Given the rapid growth throughout Arizona, the focus on water resource utilization can overlook the water needs of the environment. Although the environment is recognized as a water using sector[28], this sector's "demand" for water is often not recognized in municipal water planning or provided equal footing in water rights allocations. The three largest urban areas in Arizona, Maricopa, Pima and Yuma counties, all have multiple, large-scale environmental enhancement projects underway. These projects currently use water that the municipalities do not want or can't use economically at this time, e.g., effluent and contaminated groundwater. In the future, however, scarcity of supply may lead municipalities to look to these sources of water to provide for their populations. Public outreach and education and a better understanding of environmental enhancement projects could assist the process of considering environmental water needs in our overall planning for growth in the future.

[28] Anderson, Mark T., and Woosley, Lloyd H., Jr., 2005, Water availability for the Western United States--Key scientific challenges: U.S. Geological Survey Circular 1261, 85 p.

Section II.
Project Summaries

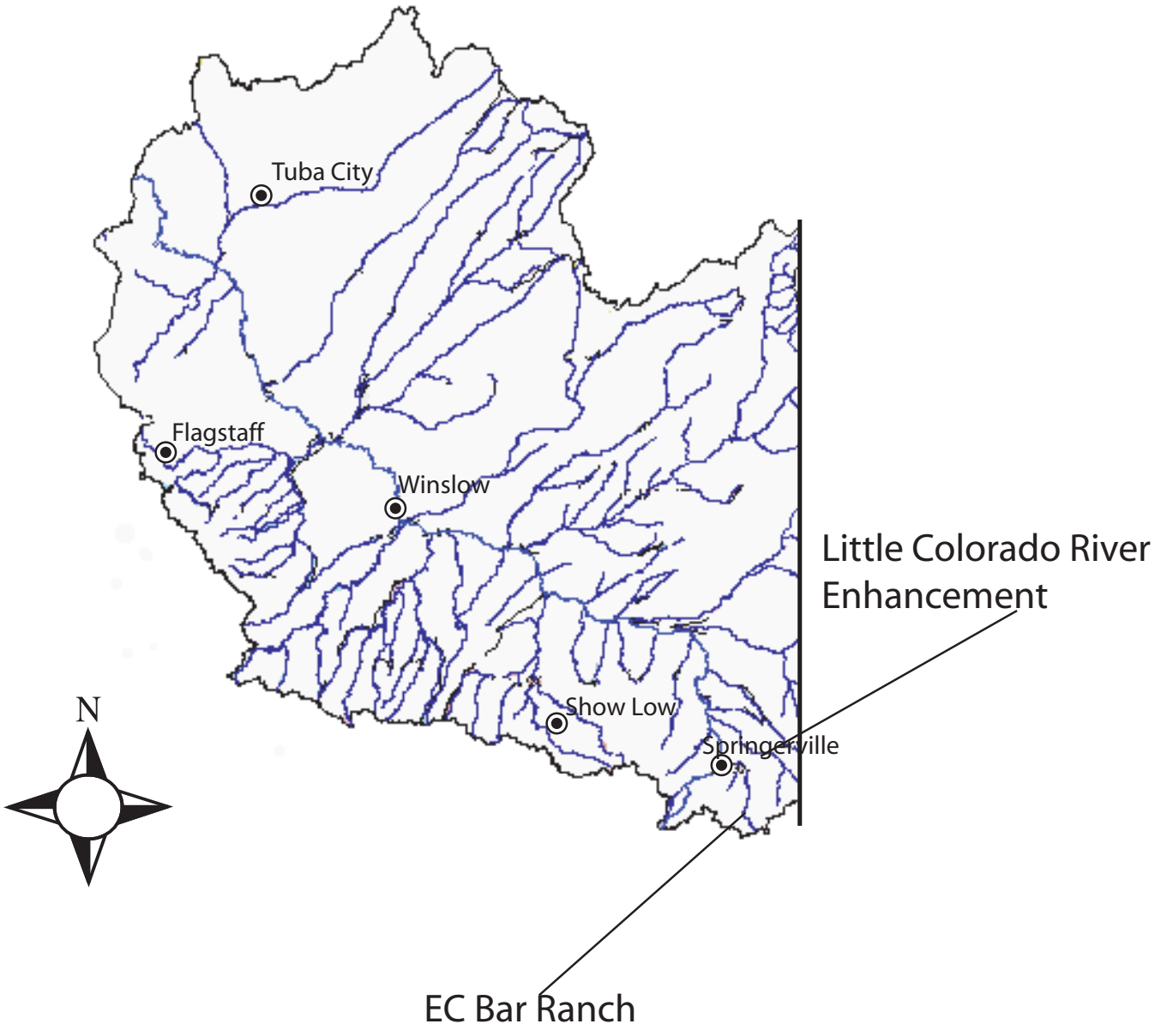


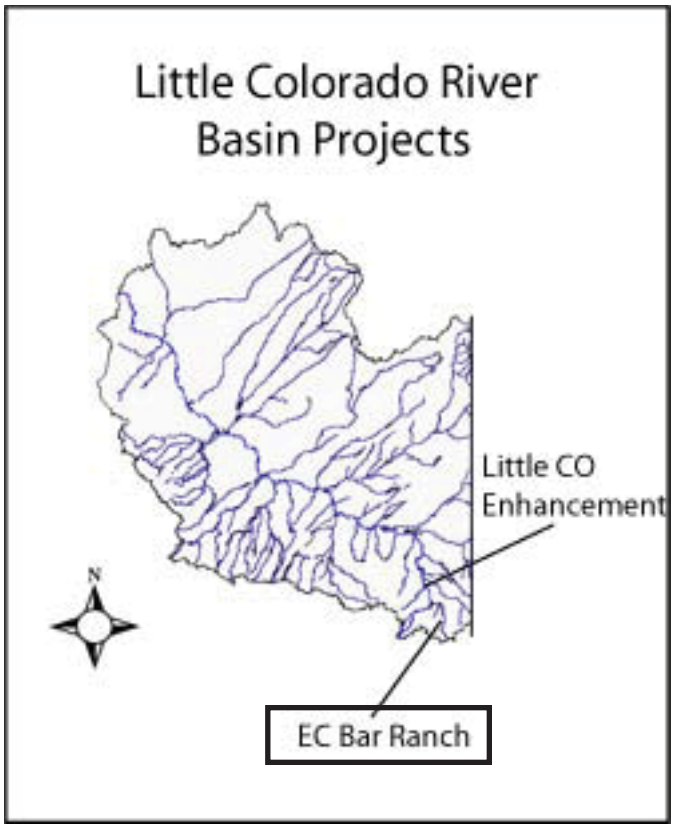
Arizona River Basins



Source: Arizona Cooperative Extension
http://ag.arizona.edu/watershed/

Little Colorado River Basin Projects





EC Bar Ranch Riparian Restoration

Primary Information Source: 2005 grant applications for water quality improvement, livestock and crop conservation as well as personal interviews conducted with landowner (Jim Crosswhite) June, 2005. Interview information updated January 2006.

Location and Size: EC Bar Ranch is located at an elevation of 7,500 feet in the White Mountains of eastern Arizona about 15 miles south of Springerville in Apache County. The Ranch is a 400 acre property that includes almost 3 miles of Nutrioso Creek.

Principal Sponsor: Jim Crosswhite, private landowner.

Other Sponsors: Environmental Protection Agency – Region 9, U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), Arizona Department of Environmental Quality (ADEQ), Arizona Game & Fish Department (AGFD), U.S. Fish & Wildlife Service (FWS), Arizona Department of Water Resources Arizona Water Protection Fund (AWPF), and U.S. Department of Agriculture, Apache-Sitgreaves National Forest.

History: The EC Bar Ranch was originally homesteaded in about 1882. Jim Crosswhite purchased the Ranch in 1996. The area had been grazed since the late 1800's and the three mile central portion of Nutrioso Creek that runs through the EC Bar Ranch was severely degraded. At the time of sale, in 1996, the riparian zone of Nutrioso Creek was classified as "nonfunctional" under the Bureau of Land Management (BLM) Proper Functioning Condition (PFC) national rating system. Invasive rabbitbrush vegetation dominated upland pastures, forcing livestock into the riparian area, which caused the degradation. In addition, the ADEQ had designated 27 miles of Nutrioso Creek as "impaired" due to a high level of suspended sediment or turbidity.[1] In the words of Mr. Crosswhite "When I purchased the EC Bar Ranch in 1996, I had no false hopes for the land and the riparian areas because the productive value and functionality had obviously been slowly destroyed over many years of over-grazing and lack of maintenance. Fortunately, I turned to the Natural Resources Conservation Service (NRCS) early on. This decision changed my way of thinking from consuming resources to conserving natural resources to create a sustainable ranching operation. Over the last nine years, I have worked with many state and federal agency programs and staffers, all of whom have shown a passion for improving the land, including soil quality, water quality and wildlife habitat. From their example, I have developed my own passion for implementing restoration practices,

[1] Bowman, Shad N. (2000) Nutrioso Creek TMDL for Turbidity. Phoenix: Arizona Department of Environmental Quality

maintaining those practices, and protecting them over the long term."[2]

Planning Objectives: Early on, Mr. Crosswhite developed the goal: "To implement practices that demonstrate how the integration of conservation and sustainable agricultural practices can improve ranching economics, soil and water quality, and wildlife habitat while meeting public policy objectives."

Mr. Crosswhite has pursued these goals by implementing a wide range of Best Management Practices (BMPs). BMPs employed at the EC Bar Ranch include those recommended by: ADEQ (Nutrioso Creek TMDL for Turbidity - 2000), AGFD (Nutrioso Creek Fish Management Report - 2001) and FWS (Little Colorado River Spinedace Recovery Plan - 1998).

Phases: In order to implement agency recommendations, Mr. Crosswhite has followed a three phase process toward restoration: 1) install fencing, 2) restore riparian stream banks, and 3) improve irrigation systems. The project began in 1998 with matching funds from the Arizona State Land Department Stewardship Incentive Program (SIP) to build fencing that create riparian pastures to allow dormant season livestock grazing. Also in 1998, matching funds from NRCS Environmental Quality Incentive Program (EQIP) were used to address a number of conservation concerns, including brush management, cross fencing, and stream-grade control structures.

In 2000 ADEQ completed a TMDL[3] report on Nutrioso Creek and found that it was "impaired" due to high sediment. A series of 319(h) water quality improvement grants were awarded to address these water quality concerns on the EC Bar Ranch as well as other downstream properties, including the U.S. Forest Service Land, where turbidity exceeded water quality standards.

Current Phase: At the end of 2005, all recommendations in the TMDL report, the Fish Management Report, Lower Colorado Spinedace Recovery Plan, and the NRCS Conservation Plans, had been implemented. The five-year time table set out in the TMDL report to implement water quality improvement practices and a 50 ton per year sediment load reduction had been met.

Recommended or Implemented Plan: Overall, Mr. Crosswhite follows a general plan on his property of restore, monitor, and preserve. There are over 17 different management plans and reports for the Ranch that cover identification of problems, restoration, monitoring, and practice management. Specific management plans recommended by the NRCS and other experts that have been adopted in recent years include: Pasture and Hayland Management Plan, Irrigation Water Management Plan, Nutrient Management Plan, Pest Management Plan, Wetland Wildlife Management Plan, Wildlife Upland Management Plan, and Riparian Restoration Implementation Plan. In his restoration efforts, Mr. Crosswhite has primarily focused on improving water quality because he believes it is the key factor in habitat and soil quality degradation.

Examples of Best Management Practices employed on the EC Bar Ranch include: exclusion of cattle and elk from the riparian area during the growing season so emergent plants can grow without disturbances; installation of stream-grade stabilization structures to help protect the at risk banks during high flow events and raise the water table; installation of off-channel water wells and drinkers for livestock and wildlife to permanently eliminate the need for large ungulates to enter the stream for daily watering; revegetation of the riparian corridor with willow plantings and grass

[2] Crosswhite, Jim. (2005) Livestock and Crop Conservation Grant Program FY 2005 Grant Program Application Package

[3] TMDL (Total Maximum Daily Load) is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards.

seeds using the NRCS Critical Area Planting method; and improvements to the irrigation system to save up to 100 million gallons of water that had previously been lost in earth ditches due to seepage and evaporation.[4]

Monitoring/Management: Monitoring on the Ranch began with photo monitoring at four sites in 1998 by the NRCS. As practices were implemented through grant programs, monitoring expanded to include riparian and upland pasture vegetation, wildlife such as birds and elk, and water quality. In addition to state and federal agencies monitoring water quality and wildlife, expert consultants specializing in geomorphology, erosion control, vegetation, soil quality, and livestock forage production have performed monitoring studies and observations. Mr. Crosswhite has used this monitoring data to set management priorities and adjust planning activities. In recent years a variety of management plans recommended by the NRCS have been implemented, as well, as a riparian restoration plan. Some monitoring is over a short term, one or two years, while other monitoring, such as in the Safe Harbor Agreement, will be carried out for 50 years.

Funding and Cost: Almost $2 million has been invested in conservation projects on the EC Bar Ranch, including over 50% in matching funding by Mr. Crosswhite. Grant funding has been awarded by: (1) AZ Department of Agriculture Landowner Crop Conservation Grant Program (LCCGP), (2) AZ State Land Department Stewardship Incentive Program, (3) USDA NRCS Environmental Quality Incentive Program (EQIP); (4) Arizona Water Protection Fund (AWPF); (5) Arizona Department of Environmental Quality/ Environmental Protection Agency Region 9; (6) Arizona Game and Fish Department Cooperative Stewardship Agreement, Landowner Incentive Program (LIP); (7) Heritage Fund; (8) U.S. Fish and Wildlife Service Partners for Fish and Wildlife; and (9) Western Region Sustainable Agriculture Research and Education (WSARE) Farmer/Rancher Grant.

Land Ownership: Private

Water: Nutrioso Creek is a 27 mile long tributary of the Little Colorado River. Less than 20% of the riparian areas in the Upper Little Colorado River Watershed are rated in Proper Functioning Condition (PFC).[5]

Jim Crosswhite has diversion and storage rights to water in Nutrioso Creek which he uses for management of conservation projects as well as crop and pastureland production. Groundwater is also used to supplement surface water when needed. Following an NRCS Irrigation Water Management Plan, he utilizes a sprinkler system to irrigate about 60 acres of upland pastures and a portion of riparian pastures between April 15 and September 15. Through irrigation system improvements, up to 100 million gallons of water previously lost each year due to seepage and

[4] The Critical Area Planting Method involves planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas.

[5] Properly Functioning Condition is defined by the Bureau of Land Management as: "Riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality; filter sediment, capture bed load, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize stream banks against cutting action; develop diverse ponding, and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity. The functioning condition of riparian-wetland areas is a result of interaction among geology, soil, water, and vegetation". USDI- BLM, Proper Functioning Condition Work Group. 1998. Process for Assessing Proper Functioning Condition, Riparian Area Management. Technical Reference 1737-9.

evaporation in earthen ditches has been eliminated. Much of the "lost" water has remained in Nutrioso Creek as surface flows. During extended periods of extreme drought when the creek can dry up above and below the EC Bar Ranch, supplemental water may be used to maintain vegetation in the riparian corridor and support native fish populations, including the Lower Colorado Spinedace which is listed as a threatened species.

Pubic Outreach: Since 1999, Mr. Crosswhite has hosted over 400 people at the EC Bar Ranch to observe and discuss conservation practices. Visitors have included former-Governor Jane Hull, state legislators, agency staff, farmers, and ranchers. He has made numerous public presentations to hundreds of people, including the 2005 Ecosystem Restoration Conference hosted by University of Arizona. Over 20 newspaper and magazine articles have been written, a television film produced, and a short film made for the ADEQ to use at grant workshops. An extensive slide presentation has been used by the EPA for several years describing how the Nutrioso Creek TMDL was created and has evolved. Broader outreach has been conducted via the internet at the EC Bar Ranch website, www.ecbarranch.com, which has had over 20,000 visitors.

Challenges/Lessons Learned: Mr. Crosswhite believes that the key to successful restoration is to have a focus from which all other restoration activities come, in his case the focus was protecting native fish and their habitat through water quality, soil quality, and habitat improvement practices while creating a sustainable and compatible ranching operation. All of his efforts on the Ranch have revolved around collaboration with state and federal agencies with support from private consultants. A challenge that Mr. Crosswhite has encountered has been to coordinate grant applications, funding sources, practice implementation, and on-going ranching operations. Another challenge is to protect conservation projects over the long term through the development of a conservation easement with a qualified organization, a process that takes many years of persistent effort.

Perhaps, the most important lesson learned so far is that restoration alone will not solve the problems. The restoration must have a successful outcome and be sustainable over the long term, generally through collaboration with many others, including state and federal agencies. An on-going challenge encountered at the EC Bar Ranch, as well as across the Southwest, is the control and eradication of invasive noxious weeds, such as Muskthistle. Mr. Crosswhite spends considerable time and money to keep the invasive species populations under control on his property, however, there is no way to ensure that neighbors or even county officials (highway maintenance especially) do the same. Mr. Crosswhite has even begun to voluntarily eradicate invasive species on neighboring properties and along the road that abuts his property in an effort to control their spread on his own property.[6]

Through Mr. Crosswhite's efforts and support from state and federal agencies, the outcome from conservation projects on the EC Bar Ranch in 2005 has produced substantial and positive results:

1. Installation of about 50,000 feet of livestock and elk fencing has allowed rotational grazing under a Livestock Management Plan recommended by the NRCS.
2. Installation of conveyance pipes and off-channel water wells to support a sprinkler irrigation system have eliminated earth ditches and loss of water. Irrigation Water and Nutrient Management Plans recommended by the NRCS have been adopted. Forage production in irrigated pastures has increased from 300 lbs. /acre in 1996 to 4,000 lbs. /acre in 2005.
3. Riparian vegetation and eroding stream banks have been restored to meet water quality

[6] Crosswhite, Jim. (2005) June 8. Personal Interview with Author (Mott Lacroix).

and habitat improvement recommendations by state and federal agencies. Wetland and Upland Wildlife Management Plans have been adopted.

4. In 2003, Mr. Crosswhite completed the first Safe Harbor Agreement between a private landowner and FWS in Arizona. This voluntary agreement provides protections while encouraging threatened and endangered species habitat improvements. See link http://www.fws.gov/arizonaes/Safe_Harbor.htm.
5. The majority of the three mile riparian area on the Ranch rated as "non-functional" in 1996 was recently rated in Proper Functioning Condition. For details see the PFC Survey (10-05) at the Monitoring Report link http://ecbarranch.com/monitoring/PFC/pfc.htm.
6. Native fish populations, including the Lower Colorado spinedace, have declined over the last few years in Nutrioso Creek due to drought. The largest population now lives on the EC Bar Ranch where BMPs have been implemented. See Fish Survey (5-05) at link http://ecbarranch.com/agfd/AGFDNutriosoCreekFish5-16-05/Fish5-16-05.htm.
7. In 2005, Mr. Crosswhite completed the implementation of all water quality improvement practices in the ADEQ *TMDL Report*. and he completed all wildlife habitat improvement recommendations in the AGFD *Fish Management Report*. This action distinguishes the EC Bar Ranch as having the first and only riparian area in the State of Arizona "restored" to standards described in reports by state and federal agencies.

Drivers: Restoring water quality and habitat in a riparian ecosystem with a history of overgrazing.

Restored native grasses and flowers, irrigation piping also shown.
EC Bar Ranch

Jim Crosswhite at an Elk Fence
EC Bar Ranch

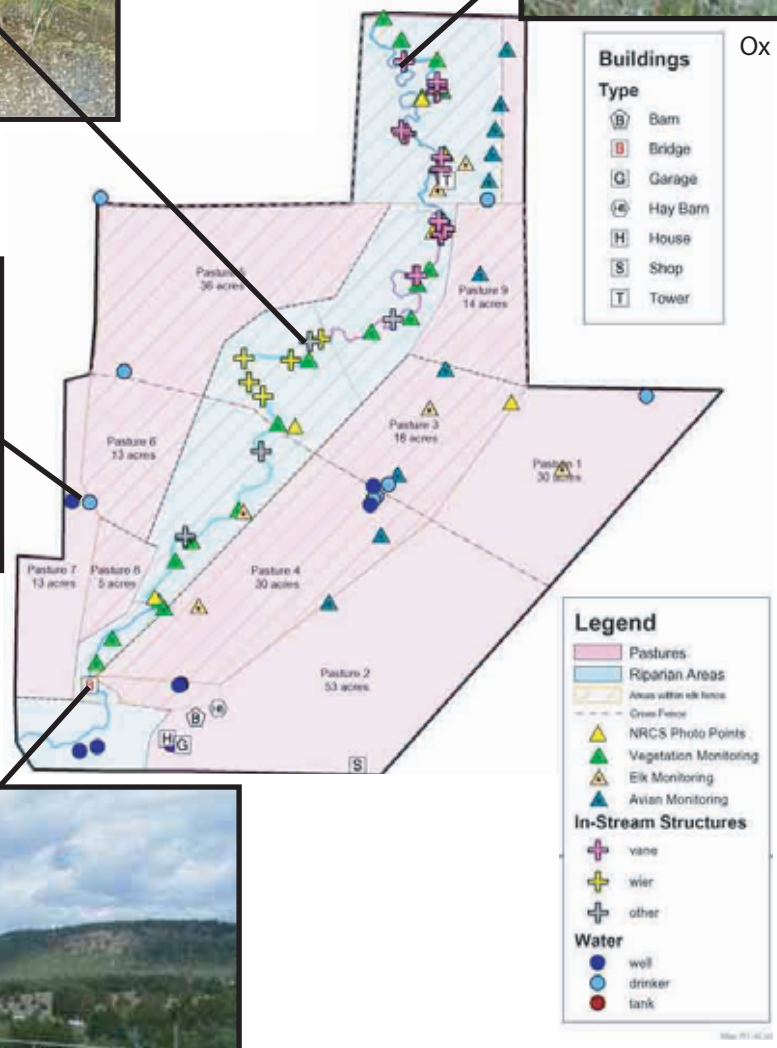
Nutrioso Creek
EC Bar Ranch

Invasive Species Control: Non-native rabbit brush on left of the fence and restored native grasses on right.
EC Bar Ranch

Hay bale bank stablization

Ox bow vane

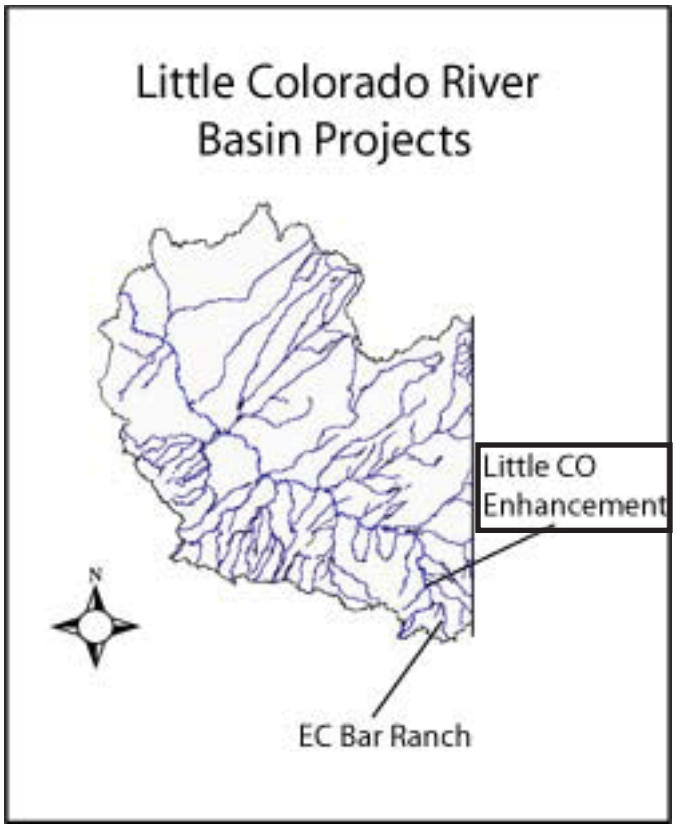
Livestock/wildlife drinker



Livestock bridge

Jim Crosswhite has employed fifteen different conservation practices on his ranch. This page shows a few from reaches 1 - 4 on the EC Bar Ranch.

Photos by Kelly Mott Lacroix



Little Colorado River Enhancement Demonstration Project

Primary Information Source: 1999 grant application to Arizona Water Protection Fund.

Location and Size: Project is located in the Round Valley area 1.5 miles northwest of downtown Springerville off of Highway 60 in Apache County. Project is approximately 85 acres and encompasses approximately one mile of the Little Colorado River.

Primary Sponsor(s): Apache Natural Resources Conservation District (NRCD) and Upper Little Colorado Watershed Partnership (Partnership).

Other Sponsors: Arizona Department of Game and Fish, College of Engineering and Technology at Northern Arizona University (NAU), Gary and Cheryl Enders, Arizona Department of Water Resources (ADWR), and Arizona Water Protection Fund (AWPF).

History: In the past the Little Colorado River through Round Valley was a low gradient, highly sinuous perennial stream that dispersed flood flows over broad floodplains. Over the past century, the river's flow has been changed by agricultural use, water diversions, upstream regulation of flow and channel straightening. The area historically supported native emergent species such as sedges and rushes and woody vegetation such as narrow leaf cottonwoods, elderberry, and wild rose. Today, the channel through Round Valley is incised to the point that it has very little connection to its historic floodplain and is therefore unstable and prone to vertical and/or lateral erosion, especially during high flow events.[7] In response to growing concern about the Little Colorado River, the towns of Springerville and Eager and the Round Valley Water Users Association initiated the Upper Little Colorado Watershed Forum in October 1998. The goal of the forum was to develop a comprehensive water plan for the Upper Little Colorado River Watershed. This project contributes to the objectives of the Upper Little Colorado River Watershed plan.

Planning Objectives: The stated goal of this project is: "To demonstrate that the stability threshold of a stream reach can be improved using methods based on hydrogeomorphic principals and that this can have a beneficial effect on the riparian vegetation in former wet meadows adjacent to the stream channel." The specific objectives are to increase the stability of the stream channel while preserving natural stream processes, to enhance the native riparian vegetation; and to assist in educating other landowners and natural resource managers about techniques for stream and riparian restoration as well as use the area as an outdoor classroom to supplement the Apache

7 Apache Natural Resource Conservation District. (1999) Application to Arizona Water Protection Fund for the Little Colorado River Enhancement Demonstration Project. Springerville: Apache NRCD.

NRCDs Education Center's existing curriculum on biology, aquatic and riparian systems, and domestic livestock and wildlife interactions.[8]

Current Phase: Monitoring and maintenance. Active contract with AWPF scheduled to terminate December 31, 2006.

Phases: Prior to AWPF grant Partnership received a grant from Arizona Department of Water Resources Watershed Partnership Grant program to create a comprehensive watershed assessment and inventory which was completed by the College of Engineering and Technology at NAU. The phases of this project were as follows: create an Upper Little Colorado River concept plan (Jan 2001); assess site conditions (Nov 2000); create a final design plan which includes a topographic survey of project reach, assessment of hydrology and site characteristics, channel cross sections and bank fill measurements and a cursory evaluation for plan species and location for use in revegetation efforts (Feb 2001); develop monitoring plans; conduct primary construction and initial revegetation (Feb 2001); complete final construction and revegetation (grantee evaluate channel construction in 2003 and made modification to the channel as necessary based on evaluation, Dec. 2003); and conduct monitoring and maintenance of the site as well as public outreach (Aug. 2001 – present).

Recommended or Implemented Plan: The project contains 21 reaches labeled A – U. Examples of restoration in these reaches include: bank sloping, terrace lowering, toe rock installation, willow fascine,[9] willow bundles, willow pole plantings, brush revetment,[10],willow mattress,[11] hydroseed on terraced slopes, erosion control fabric, vertical bundles, and a compost sock.[12] In each reach different techniques were used based on the channel morphology. These techniques were monitored after year one and revised and/or repaired according to their effectiveness.

Monitoring/Management: "The objective for revegetation monitoring is to determine the survival rate and vigor of the transplanted plants. To accomplish this we will document the density and species composition on the banks immediately after planting and evaluate it again the following spring to determine whether it is adequate for protecting stream banks. Areas of erosion or geomorphic change will also be noted." Photographic monitoring will also be used to qualitatively document success of channel restoration and riparian restoration. [13] Under the agreement with the AWPF, the sponsors have committed to maintain and improve the site for at least 20 years.

Funding and Cost: $348,628 in funds from Arizona Water Protection Fund.

Land Ownership: Arizona Game and Fish Department. (At project initiation the land was owned privately, however, it was sold to Arizona Game and Fish for habitat preservation purposes in 2003.)

Water: The Little Colorado Demonstration project will not use surface or groundwater to supplement new plantings. Water rights along this area of the Little Colorado River are part of the Norville decree, as such, there are no documents showing the appropriation of water rights. The

[8] Ibid.

[9] A fascine is a cylindrical bundle of sticks bound together for use in the construction of earthworks and dams.

[10] A revetment is a masonry facing used to support an embankment.

[11] A willow mattress is an area that is planted with willows attached to stakes about four feet apart and then laid with willow and brush between the stakes.

[12] Natural Channel Design. (2004) Final "As Built" Report: Upper Little Colorado River Riparian Enhancement Demonstration Project. Flagstaff: Natural Channel Design.

[13] Supra note 7

Enders, the original owners of the land describes the disposition of their water rights in the pasture in a letter that was part of the project application to the AWPF.[14]

This project was predominantly managed by Tom Moody of Natural Channel Designs in Flagstaff, Arizona with coordination from Dr. Wilbert Odem at the beginning of the project. It implements a natural channel approach to river restoration which is based on locating and identifying the "stable geomorphic dimensions of the channel and then incorporating them into a design to meet specified objectives." A natural channel approach uses a variety of structural and non-structural practices such as rock weirs, rock vanes, engineered stream bank morphology, and revegetation.[15]

Pubic Outreach: To date, three workshops have been completed as part of the public outreach aspect required under the AWPF grant. The first workshop was held in Springerville, Arizona in November 2001 and was attended by 33 participants representing local landowners, tribes, and state and federal agencies. The purpose of this first workshop was to acquaint local landowners and other technical representatives from tribes and resource management agencies with bioengineering practices that will be incorporated into the Little Colorado River Enhancement Demonstration Project.[16] A second workshop was conducted in November 2003 in Springerville which focused on techniques for stream-bank stabilization and bioengineering. A third workshop was conducted in March 2005 in Parker, Arizona titled "Restoring Riparian Habitats: removing exotic species; restoring native species; stream bank stabilization." This workshop was held in conjunction with the Arizona Riparian Council.

Challenges/Lessons Learned: High flows in the winter and spring of 2004-2005 undermined many of the treatments installed. Although this was discouraging to the restoration team, the intention of the project was to see what worked and what did not, so the failure of some of the techniques has been taken as a positive aspect. During monitoring, the restoration team noted that vegetation was very slow to establish on steep banks. They also noticed that protection along the toe of the bank was critical to prevent erosion, but techniques that they used were not always effective. Willow fascines used as toe protection have largely failed in this project. Brush revetments were, on the whole, more effective. The project team also found that willow bundles and trenches were much more effective than individual willow poles in terms of overall survivorship of the plantings.[17]

Drivers: This project was implemented as part of a watershed plan. The main driver was to use hydro-geomorphic principles to stabilize a degraded stream bank. The project was designed as a study area to determine which techniques work best in specific conditions. The project results will be used to improve the overall knowledge of stream restoration techniques and to demonstrate those techniques to other restoration practitioners.

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[14] Ibid

[15] Ibid.

[16] Apache Natural Resources Conservation District. 2001. November 30, 2001 Quarterly Report for Grant No. 99-092 Springerville: Apache Natural Resources Conservation District.

[17] Correspondence via e-mail between Tom Moody and Rodney Held. June 29, 2005

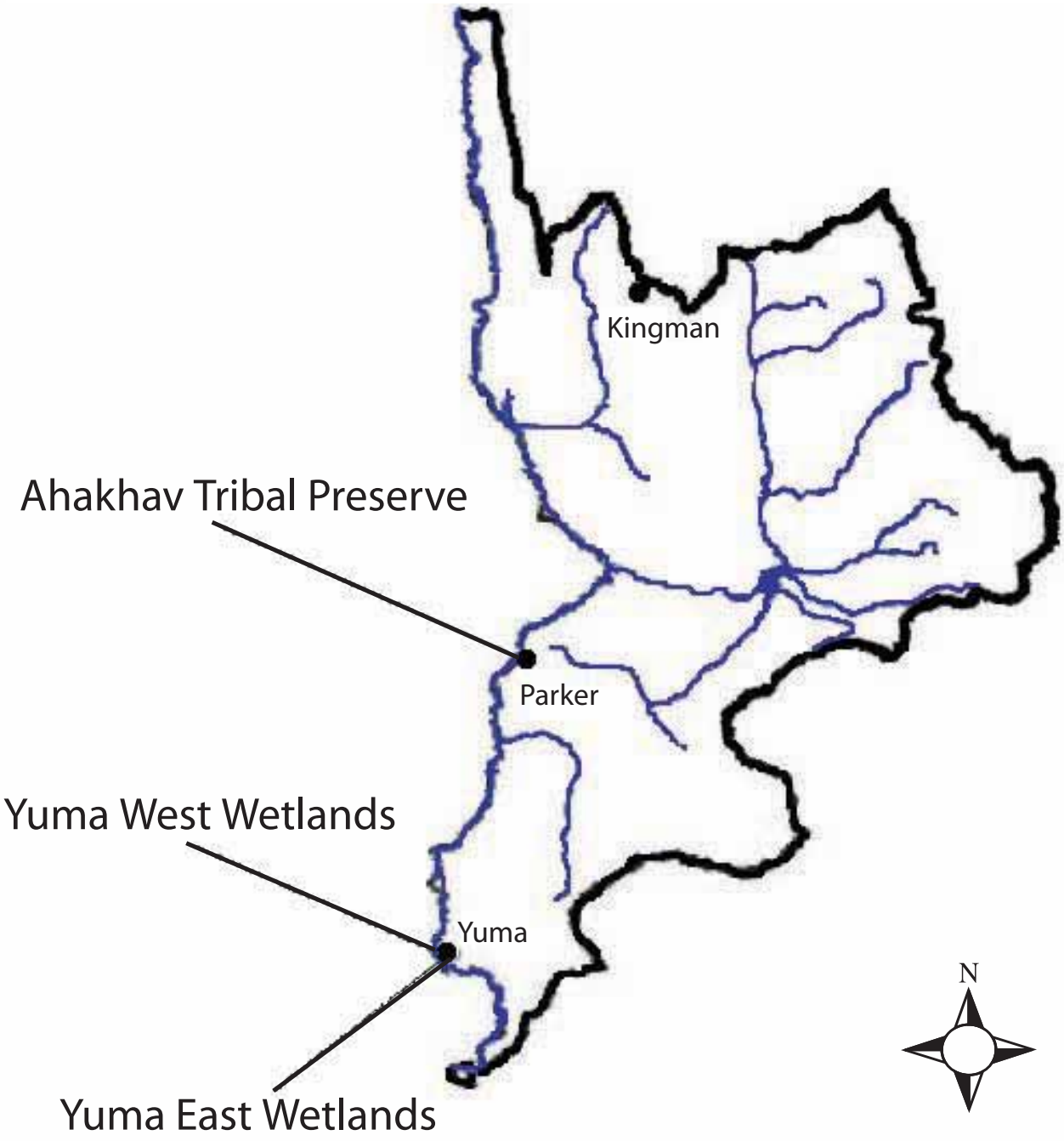
Construction
LIttle Colorado River Enhancement
Demonstration Project

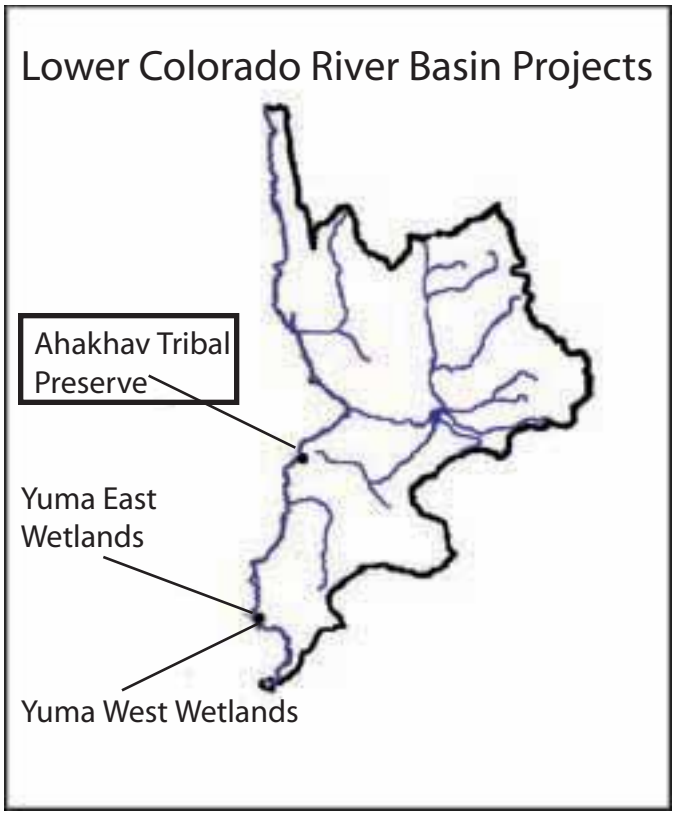
Bank stabalizaiton
Litte Colorado River Enhancement
Demonstration Project

Little Colorado River running through site
Litte Colorado River Enhancement Demonstration
Project

All photos courtesy of Arizona Water
Protection Fund

Lower Colorado River Basin Projects





‘Ahakhav Tribal Preserve

Primary Information Source: 1996 and 1997 Arizona Water Protection Fund grant applications and 1996 Final Draft Report on ‘Ahakhav Tribal Preserve.

Location and size: The project is located on the Colorado River near Parker, Arizona, in La Paz County. The Preserve consists of 1,042 acres in and around Deer Island (738.5 acres) and ‘Ahakhav Backwater (303.5 acres). Between the two projects implemented to date, ‘Ahakhav Preserve and Deer Island, there have been 285 acres of riparian restoration and 228,547 cubic yards of dredging. The length of river through the project is 1.5 miles.

Primary Sponsor(s): Colorado River Indian Tribes (CRIT).

Other Sponsors: Bureau of Reclamation (BOR) and Arizona Water Protection Fund (AWPF).

History: Historically the Colorado River Valley floodplain supported 450,000 acres of riparian vegetation composed mostly of cottonwoods, willows, and mesquite. Currently only 110,000 acres remain. Of these 110,000 acres, 45,000 acres are salt cedar, 20,000 acres are mesquite and mesquite-salt cedar mix, and only 6,000 acres contain cottonwoods and willows.

The ‘Ahakhav area is a perfect example of the decline of Colorado River Valley floodplain. It historically supported large cottonwood and mesquite bosques and a wide variety of birds and land animals. Today, however, as a result of upstream dam construction, water channelization projects and the introduction of exotic plants, most of the cottonwood and mesquite that once flourished are gone. Without sufficient flow from the main channel and the natural scouring action of historic floods, the backwater channels are being filled with sediment. Areas that were once shallow wetlands are drying up and becoming upland riparian areas covered with exotic and invasive salt cedar. The consequence of all of these changes is a lack of habitat for bird and other riparian species.

Planning Objectives: “The purpose of this project is to dredge historic river channels, revegetate native riparian vegetation, and monitor both of these actions for optimum successful restoration of the habitat along the lower Colorado River in the ‘Ahakhav Tribal Preserve.”[18] One of the principal motives for this project was to “learn from the restoration effort and develop a template for environmental restoration in other areas along the lower Colorado River.”[19] The goals for

[18] CRIT Education Department. (1996) Application to Arizona Water Protection Fund for the ‘Ahakhav Tribal Preserve.. Parker: Colorado River Indian Tribes.

[19] Ecosystem Management International, Inc. Annual Report ‘Ahakhav Native Habitat Restoration Project. Flagstaff, AZ March 10, 1998. Flagstaff: Ecosystem Management International.

the restoration of the Preserve are as follows: restore open areas of the backwater; revegetate with native species; improve and expand habitat for the diverse wildlife species along the lower Colorado River; maintain restoration of the Preserve; and strengthen public understanding and respect for the ecology and cultural history of the 'Ahakhav area.[20] The objectives for the Deer Island project were to: establish a stand of native vegetation, including cottonwood, willow, and mesquite; institute monitoring programs to determine success of revegetation efforts; and use revegetated areas for environmental education, low-impact recreation, and Native arts.[21]

Current Phase: Monitoring and maintenance, contract complete with AWPF.

Phases: Prior to the AWPF grant, the Tribe had already revegetated 25 acres, established a native plant nursery, and built interpretive trails using volunteer hours. Twenty dumpsters worth of trash were also cleaned up by the community. The first AWPF project, 'Ahakhav Preserve, included the following phases: pre-dredge activities (June 1997 - September 1997); pre-revegetation bird census (December 1997 – March 1998); revegetation of two 50-acre sites (first site: June 1997 – December 1997; and second site: June 1998 - September 1998); conduct dredging operations and stabilize dredge material relocation sites (September 1998 – September 1999); construction of water control structures (June 1998 – September 1999); construction of fish habitat structures (September 1998 – June 1999); post-dredging activities (December 1998 – September 2000); and two post-vegetation bird censuses (June 1999 and September 1999). The Deer Island revegetation project began in 1998 and included: an avian census; native species revegetation of 75 acres (May 1998 – January 2000); and revegetation site maintenance (April 1999 - January 2000).

Recommended or Implemented Plan: The first year of the project was used to establish a baseline of scientific information that would be used to evaluate the changes brought about by restoration efforts. In the first year, the restoration team also attempted to accurately characterize the existing topography as well as design appropriate restoration criteria.[22] Once this was complete, revegetation began on the first of two 50-acre sites. Both 50-acre sites of the Preserve and the 75 acres of the Deer Island project were revegetated with predominantly cottonwood, screw bean mesquite, and willow.

The next step of the project was to dredge the backwater. This was completed in two stages. A Terramodel computer program aided creation of the design and was used to perform earthwork calculations.[23] Once the first part of the backwater was dredged, fish habitat structures were constructed out of scrap mesquite and salt cedar wood from the revegetation sites. The completion of the backwater dredging made way for post-dredging hydrographic mapping and sediment analysis. The dredge material relocation sites were replanted with willows. In the end, the backwater area dredged did not reflect the design, however, the flow through it is significant and has resulted in a large increase in wetland area that can be flooded by holding water in the backwater.[24] Once all

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[20] Phillips, Fred, Adam Perillo, Sonia Mullenix. (1998) 'Ahakhav Tribal Preserve: Final Draft Report. Parker: Colorado River Indian Tribes. p. 37

[21] CRIT Education Department. (1997) Application to Arizona Water Protection Fund for the 'Ahakhav Tribal Preserve – Deer Island Revegetation. Parker: Colorado River Indian Tribes.

[22] Ecosystem Management International. (1998) Annual Report: 'Ahakhav Native Habitat Restoration Project. Flagstaff: EMI, Inc.

[23] Shepard-Wesnitzer, Inc. Post-Dredge Summary Report for Ahakhav Backwater. Flagstaff: Shephard-Wesnitzer, Inc.

[24] CRIT Education Department. (1999) Ahakhav Tribal Preserve Habitat Restoration Project, Quarterly Report Sept. 30, 1999 sec. 2.0. Parker: Colorado River Indian Tribes.

revegetation and dredging were complete, biological monitoring and topographical surveys were conducted.

Monitoring/Management: All components of the project included a monitoring aspect. For example, for revegetation operations monitoring began immediately after planting and continued throughout the project. Vegetation monitoring consisted of measuring each tree from base to top of the tallest up-stretched leaf through the first season and recording this information in a database. When growth was less than expected, immediate steps were taken, usually in the form of changing the rate or duration of irrigation.[25] Prior to revegetation on the two sites, ten bird censuses were conducted to establish pre-revegetation population levels. After vegetation had been planted, three censuses were conducted each month. Birds were the only animals censused in this restoration effort because they are excellent indicators of environmental health and they are easy to monitor in the field.[26]

Funding and Cost: For this project the CRIT donated over $410,000 in in-kind and cash contributions.[27] Additional funding for the project came from the Bureau of Reclamation- Upper Colorado Region ($45,000); Arizona Game and Fish – Heritage Grant ($36,298); Bureau of Reclamation- Lower Colorado Region – Matching Funds ($380,861); and two AWPF grants ($931,477 and $1,988,000).[28] In 1999 the contract with AWPF was amended to add an additional $200,000 for dredging due to technical difficulties encountered. At this time, the Bureau of Reclamation also committed another $670,000 in order to complete dredging activities.

Land Ownership: Colorado River Indian Tribes.

Water: Deer Island Backwater originally consisted of approximately 290 surface acres of water, 355 acres of riparian habitat, and 105 acres of wetland. Flooding and succession had eliminated 78% of the water surface area in the lake and wetlands. [29] All plantings received supplemental irrigation for their first year. For both restoration sites, ‘Ahakhav and Deer Island, new plantings received eight gallons per day for five days over a course of 18 weeks. Care was taken to not plant cottonwoods or willows in areas where the permanent water source was greater than eight feet below the surface.[30] The main water implication from this restoration project was related to dredging the areas to recreate the backwater habitat. Restoration work was focused on having enough flow of water in backwaters to maintain desired dissolved oxygen levels in order to sustain aquatic life.[31] Prior to restoration, an evaluation of the seasonal changes in the water quality in the study area and main stem of the lower Colorado River were conducted.[32]

The sponsors found that “water loss by evaporation at the Deer Island Backwater and the ‘Ahakhav Backwaters under present physical and biological conditions is considerably less than it was in the

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[25] CRIT Education Department. (1997) Ahakhav Tribal Preserve Habitat Restoration Project, 2nd quarterly report August 1997. Parker: CRIT Education Department.
[26] Supra note 18
[27] Ibid.
[28] Ibid.
[29] Supra note 20
[30] ‘Ahakhav will have at least 6,000 trees on each 50 acre plot and Deer Island will have about 160 per acre or 12,000 trees. CRIT Education Department. (1997). Application to Arizona Water Protection Fund for Ahakhav Tribal Preserve – Deer Island project. Parker: CRIT Education Department.
[31] CRIT Education Department (1997) Ahakhav Tribal Preserve Habitat Restoration Project, Quarterly report March 4, 1998
[32] Supra note 19

early 1960s because there is less water surface area. However, restoring these backwaters to their 1960s physical size and similar biological condition will not cause a net increase in consumptive use of water according to the Supreme Court Decree in Arizona v. California."

Pubic Outreach: The project has included the community in both cleaning up the area prior to restoration and building trails after restoration was complete. In the first year, they took over 300 youths canoeing on the river and backwaters and hosted environmental education programs at the CRIT Head Start Program and Lew Wallace Junior High School.[33] They also conducted summer camps. The Preserve Educator regularly visits schools to teach about local wildlife or add lessons to the currently prescribed curriculum. The Preserve staff also conducted teacher in-service training which included tours of the Preserve, and student activities.

Challenges/Lessons Learned: In October 1998, the Bureau of Reclamation withdrew from the project because of budgetary constraints. At that point only 50% of the dredging was complete. The size and characteristics of the dredged material caused equipment failures which delayed the timeline and greatly increased expense. A sediment analysis had been prepared prior to project initiation and had been used by the Bureau of Reclamation to determining equipment requirements. That analysis was later found to be inaccurate and incomplete. Further investigation revealed that the samples were taken utilizing push tubes that only reached 2 feet below the surface despite a dredging design that called for a 10- to 12-foot excavation depth. Ultimately in January of 1999, CRIT, Reclamation, and AWPF came to a new agreement that restarted the project and allowed it to be completed.

Another challenge encountered was that some of the channel locations had to be modified from the original design due to rock outcroppings. On future projects, the restoration team recommends the use of real-time survey control over traditional tape and stake methods to minimize deviations from the design.

Challenges also occurred with erosion of culverts, which lead CRIT to recommend that consultant's contracts include performance criteria that stipulate how remedial repairs will be conducted if culverts and other features are found to be structurally deficient after initial use. [34]

Additional challenges also complicated the project, including lack of information regarding the effects of restoration projects in the Lower Colorado River Basin. Project planners had few resources for looking at previous projects in the basin to determine what strategies had been successfully employed and what gains had been made. The project also struggled with excessive reproduction of exotic plant species and insufficient reproduction of native plant species.

To date, the project has had many successes, including stimulating interest in restoration activities on other properties in the area. The 'Ahakhav Tribal preserve nursery now sells over 50,000 trees annually to restoration projects on the Colorado River.[35]

The project is also one the Lower Colorado River Multi-Species Conservation Plan (MSCP) models. The BOR uses the 'Ahakahv Tribal Preserve as a base for many of it's experimental revegetation programs as part of the MSCP. Over 200 acres of additional

[33] CRIT Education Department. (1997) Ahakhav Tribal Preserve Habitat Restoration Project, 2nd quarterly report June 4, 1997. Parker: CRIT Education Department.

[34] Environmental Management International, Inc. (2000) Final Report: Post Restoration Activities Stage VIII 'Ahakhav Preserve Backwater Restoration Project. Durango: EMI, Inc. pp 40-45.

[35] Phillips, Fred. (2006) January. Review comments of draft report of this study.

revegetation adjacent to the preserve has been funded through BOR and the MSCP. These areas, formally agricultural fields, are now forests of cottonwood, willow, mesquite and other riparian plant species that are anticipated to attract willow flycatcher and yellow billed cuckoo.[36]

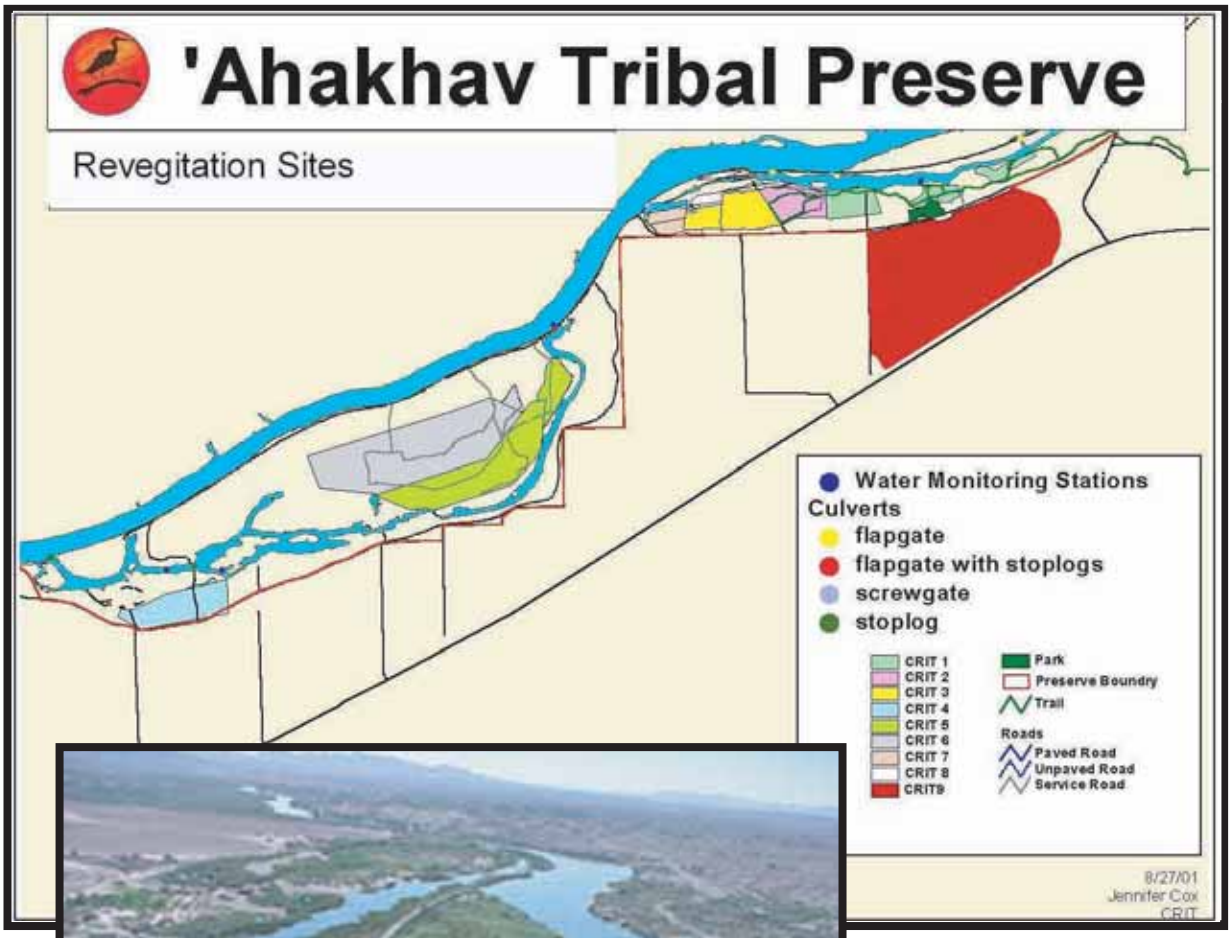
Drivers: Restoration of a culturally significant area that had damaged riparian and wetland habitat, insufficient water flow through wetlands, and lack of aquatic and terrestrial critical habitat for several endangered species such as the Yuma clapper rail.

[36] Ibid.

'Ahakav Backwater

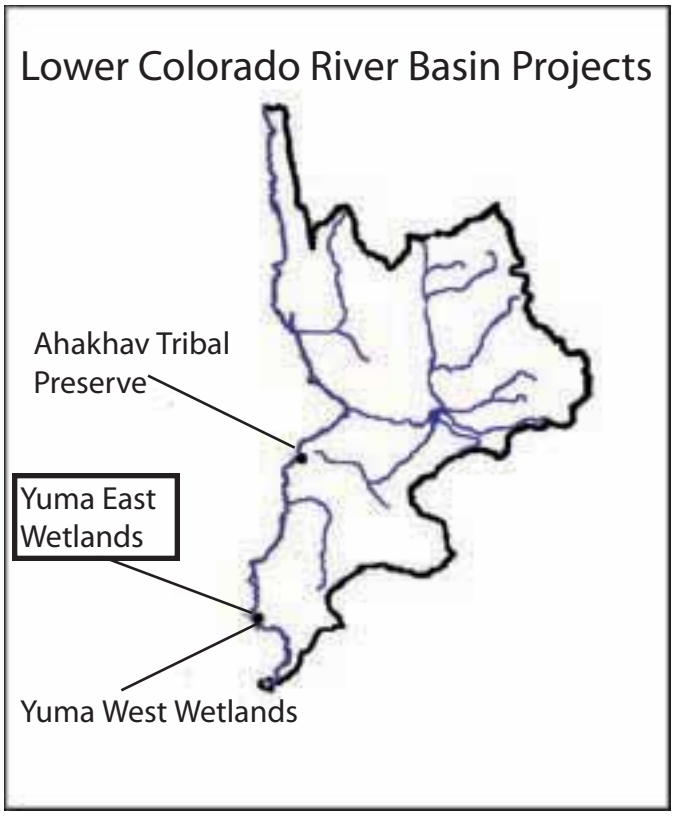
1997, Mesquite bosque planting

2001, Mesquite bosque



Aerial view of the preserve

All photos courtesy of
'Ahakhav Tribal Preserve



Yuma East Wetlands

Primary Information Source: 2004 grant application to Arizona Water Protection Fund, 2004 Yuma Area Office of Bureau of Reclamation Environmental Assessment for Yuma East Wetlands Project, and 2001 Yuma East Wetland Restoration Plan.

Location and Size: The project area is along the Colorado River floodplain between river miles 29.0 and 34.0, bounded to the west by the Ocean-to-Ocean Bridge and to the west by the Gila and Colorado River confluence in the city of Yuma. The project encompasses 1,418 acres.[37] The restoration area includes 1,100 acres of riparian habitat, 148 acres of open water, 98 acres of marshland, and 20 acres of agriculture. To date 101 acres have received funding for restoration activities.[38]

Primary Sponsor(s): Yuma Crossing National Heritage Area, Quechan Indian Nation, and City of Yuma.

Other Sponsors: U.S. Army Corps of Engineers (USACE), Bureau of Reclamation (BOR), and Arizona Water Protection Fund (AWPF).

History: The Yuma East Wetlands (YEW) area has been home to the Quechan Indian Tribe for centuries. The Quechans depended on the river and its riparian area for all aspects of their livelihood. Their way of life, as well as the character of the Colorado River, began to slowly change in the 18th century with the exploration and then settling of the area by the Spaniards. The most drastic changes to the ecosystem came, however, in the 20th century and the era of large scale dams on the river. The combination of dams, agriculture and the introduction of exotic species such as tamarisk has radically altered the Yuma East Wetlands system. Today exotic plants and agriculture have replaced most of the once abundant mesquite bosques and cottonwood/willow gallery forests. Backwaters and beaches have in some places disappeared entirely and in others are deteriorating. In less than a century the area has been transformed from a wild, meandering river to a confined, impaired ecosystem.[39] In addition to vegetation and river flow changes, the project area also had at its inception at least 20 illegal dumpsites and between 10-15 transient encampments. [40]

Planning Objectives: According to the Environmental Assessment for the project "[t]he Yuma East Wetlands Restoration project aims to restore native riparian, wetland, and aquatic habitats

[37] Yuma Area Office, U.S. Bureau of Reclamation. (2004) Environmental Assessment: Yuma East Wetlands Restoration and Enhancement Project. Yuma: U.S. Bureau of Reclamation

[38] Quechan Indian Nation. (2004) Application to Arizona Water Protection Fund Quechan Indian Nation Yuma East Wetlands Restoration Project, Phase I. Yuma: Quechan Indian Nation.

[39] Phillips Consulting. (2001) Yuma East Wetlands Restoration Plan: Final Draft Concept Plan. Flagstaff: Phillips Consulting.

[40] Ibid.

along the lower Colorado River. This will be accomplished through; restoring water flow in degraded wetland and aquatic habitats, riparian re-vegetation activities, and conversion of existing non-native habitat to native cottonwood/willow habitat."[41]

Specific goals for the project are broken down into three areas: channel stabilization and wetland enhancement; revegetation; and cultural preservation, environmental education and low-impact recreation. Examples of channel stabilization and wetland enhancement goals are: enhance the natural river channel dynamics; manipulate sediment loads to decrease river maintenance requirements, while maximizing wildlife benefit and protecting existing valuable habitat; excavate historic channels to improve water quality and flow in the existing wetlands and improve hydrology and enhance wetlands and backwaters utilizing new and existing water control structures.

The revegetation goals include: enhance and manage existing native riparian vegetation; establish stands of native vegetation, including cottonwood, willow and mesquite, in areas currently of low wildlife habitat value; remove exotic plant species on the existing riverbank and revegetate this lower terrace with cottonwood, willow and native wetland plants; and design vegetation stands to minimize threat from wildfire.

Examples of cultural preservation goals are: establish Yuma East Wetlands interpretive/cultural center and nature park for community members; improve safety and aesthetic value by cleaning up illegal dumping sites in the project area; relocate homeless Yuma East Wetland residents in a respectful and helpful manner; involve the Quechan and Yuma communities in the restoration operations; and provide cultural, educational and economic opportunities for the Yuma and Quechan communities. [42]

Current Phase: The first 25 acres have been restored, and dredging of the river channel will begin in September 2005.[43]

Phases: The project will take place in three phases. Phase one included revegetation of a 25 acre pilot plot in the Ocean-to-Ocean Bridge area, the conversion of 13.7 acres of agricultural lands to cottonwood/willow habitat, and the beginning of channel restoration activities. Phase two will focus on channel restoration, including the continued restoration of 254.4 acres of marsh channels. Phase three completes the project by revegetating an additional 636 acres of land as well as developing the Yuma and Quechan Nature Parks. It is anticipated that phase three will be complete in 2010.[44]

Recommended or Implemented Plan: "The YEW is a 5-10 year phased implementation program that will include the following project features: creation of a 6-acre YEW park through riparian revegetation; conversion of existing non-native dominated habitat to native cottonwood/willow habitat; restoration of natural channel configuration resulting in restoration of water flow in degraded wetland and aquatic habitats (dredging/excavation activities); conversion of 77.5 acres of agricultural land to native riparian trees and shrubs; and sequential replacement of the remaining 1,318.5 acres of non-native saltcedar and giant cane habitats with native riparian trees and shrubs."[45]

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[41] Ibid. p. 78

[42] Supra note 39

[43] Volkmann, Michelle. 2005. "Trading spaces: Transformation of Yuma's East Wetlands from dumping area into environmental treasure beginning to take shape." Yuma Daily Sun, June 11.

[44] Phillips Consulting. 2003. Yuma East Restoration Project Biological Evaluation. Flagstaff: Phillips Consulting.

[45] Supra note 37. p. 2

Monitoring/Management: Monitoring of the site will include a post-construction topographic survey which will verify the total excavated quantities and serve as base for the long-term monitoring effort. It is anticipated that long-term monitoring activities will focus on determining the minimum maintenance schedule necessary to keep wetland inlet and outlet structures functional. The Yuma East Wetlands will also be monitored for aquatic and wetland ecosystem effectiveness which will begin within one month after the construction crew has completed their efforts.[46] Revegetation monitoring will include observation of plant species-specific percent survival and growth rates, determination of species survivability based on variation in depth to water table and salinity, and calculation of foliage volume and density.[47] After the first year of post-construction monitoring, a workshop will be held to develop a long-term plan for the aquatic and wetland monitoring and maintenance of the restoration site.[48]

Funding and Cost: Total estimated project cost for ten years is $9,920,953. Funding received to date: from AWPF (04 grant) $277,033, from EPA $60,000, City of Yuma $80,000, from AWPF (05 grant) $263,803, $15,000 from Quechan Nation, and $1,721,448 from BOR.

Land Ownership: Quechan Indian Tribe, U.S. Bureau of Land Management, Arizona State Land Department, City of Yuma and numerous private parties.[49]

Water: In order to assess the water needs for the Yuma East Wetlands restoration project, an analysis was conducted that examined the following elements: the amount of open water; the amount of water proposed to be used through revegetation, excavation, and channelization; the amount of water subject to evaporation and loss; a comparison of the proposed surface area waters to those originally identified in 1965; the current water entitlements and consumptive use amounts of the various landowners and stakeholders; and the potential return flow credits from the Main Outlet Drain Extension (MODE) canal,[50] City of Yuma filtered decant water, and/or future effluent discharge.

The results of the consumptive use analysis indicate that the restoration project will not increase the water use above current levels. Total consumptive use of water at the Yuma East Wetlands site prior to restoration was estimated at 6362.4 acre-feet per year. Estimates of consumption after restoration is complete, were initially expected to be 6275.2 acre-feet, or 87 acre-feet less than without restoration,[51] however, more recent estimates using the Bureau of Reclamation‘s table for water consumption by plant species have but the consumptive savings at 870 acre-feet per year.[52] The reduction of overall water consumption on the site is a result of changes in evaporative losses due to structural changes in channelization and open water elements as well as replacement of non-native vegetation with native vegetation.

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[46] Supra note 39

[47] Ibid.

[48] Ibid.

[49] Private property owners have been contacted, and all have indicated their initial support for the project. Supportive, private landowners in Phase 1, have been willing to discuss selling property within the project area or executing title transfer options, which might include quid pro quo considerations for other parcels, waiver of fees, or gifting of the land for tax benefits.

[50] The MODE canal is part of the Yuma Desalination Plant and is currently used to transport return flow agricultural water to Mexico.

[51] Supra note 39

[52] Eatherly, Kevin (City of Yuma, Department of Public Works). (2006) February. Review comments of draft report of this study.

Surface water diverted from the Colorado River, apportioned through the city's water right, will be used to irrigate revegetated areas during the first three seasons after planting. Filter backwash water from the city's water treatment plant will also be added to the system. The backwash water will be added to one of the backwater channels to supplement natural water in the channel but is not required to sustain any of the features of the project.

Pubic Outreach: "The goal of YEW public outreach is to educate the public on the Yuma East Wetlands Restoration Plan and generate increased citizen participation. Public outreach will primarily target local service clubs and organizations, church groups, civic groups, student councils and other environmental organizations. Additionally, considerable efforts will be made to cross over cultural barriers, reaching all ethnic groups in Yuma area."[53]

Challenges/Lessons Learned: Flexibility is a key element to the success of the project. No matter how detailed and well constructed the plan is, the ability to adapt to changing situations, while keeping the main goals of the project in focus, is required to see the project through all stages of development.

Project sponsors note that communication is a key to prevent fear of the unknown or past failures from killing the project. Involving the community is the key to long-term vitality and creates ownership of the project. Also respecting your stakeholders' needs and cultural differences is essential in identifying common goals and objectives, opportunities, and constraints. Impacts on adjacent landowners must also be taken into consideration and handled with the utmost care. According to Kevin Eatherly at the City of Yuma, "[Adjacent landowners] can become your best project proponents or your worst enemy".[54]

Drivers: Prior to restoration, the site was used as a dump and was a haven for illegal activities. The project is motivated by a desire to clean up and restore the natural and cultural beauty of the area. Yuma East Wetlands is a part of the City of Yuma's Yuma Crossing National Heritage Area project, which seeks to revitalize the waterfront area and "attract visitors, investment, and economic opportunity to Yuma to improve the quality of life for its residents."[55] The project sponsors also report that knowledge and research were drivers to the project.

[53] Supra note 39

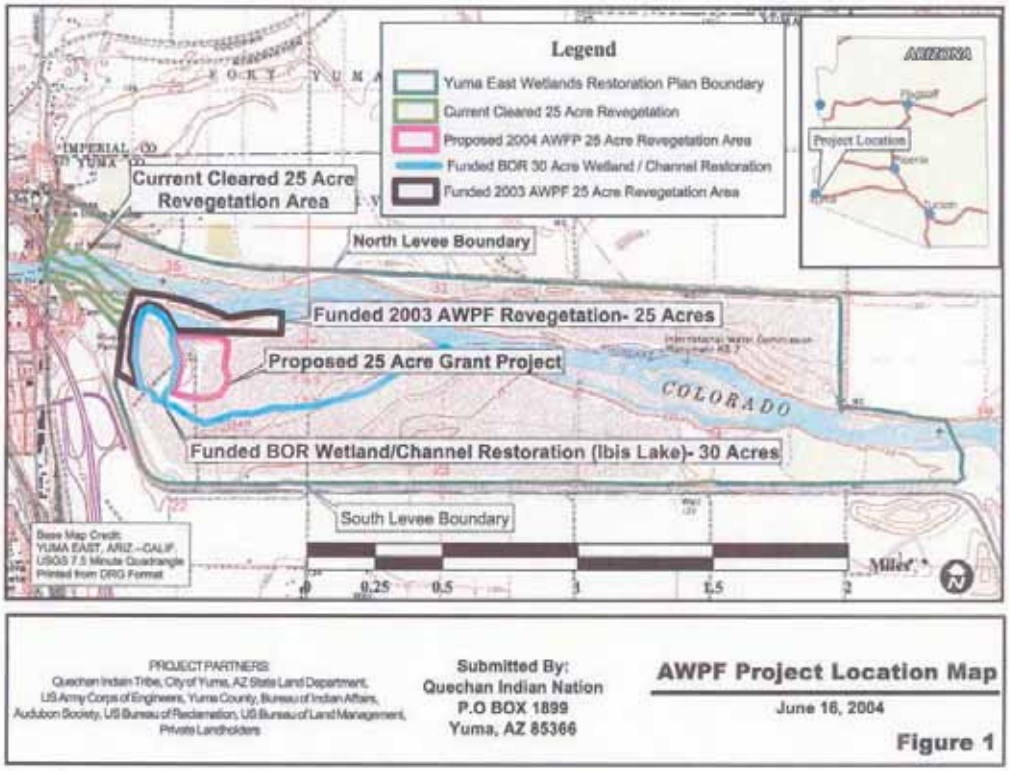
[54] Supra note 52

[55] Yuma Crossing Heritage Area. 2005. Goals of the Yuma Crossing Heritage Area. http://www.yuma heritage.com/ourproject.html

Areal view of project area
Yuma East Weslands

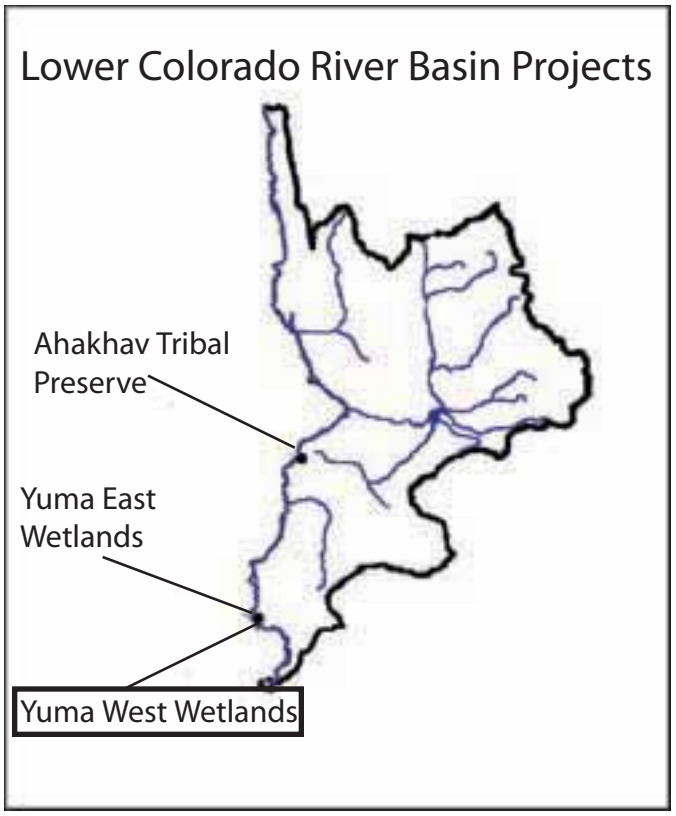
Existing cattail and bulrush habitat near Ibis Lake
Yuma West Wetlands

Prior to restoration the area was used by transients and as an illegal trash dump
Yuma West Wetlands



Map of project site
Yuma East Westlands

Photos courtesy of AWPF



Yuma West Wetlands

Primary Information Source: 2001 City of Yuma: West Wetlands Report 1999-2000 and 1999 Bureau of Reclamation, Yuma Area Office of Environmental Assessment.

Location and Size: North from Colorado Street to the Colorado River and between 12th and 23rd Avenues. The site is 110 acres with 35 acres of riparian restoration.

Primary Sponsor(s): City of Yuma.

Other Sponsors: Bureau of Reclamation.

History: Over the past century, the Colorado River has been dammed and diverted for agricultural, municipal, and industrial purposes. This project is part of a larger effort by the city of Yuma to reclaim the riverfront area. At around the turn of the 20th century, the city began to use this area as a landfill, a practice that continued until 1971. In 1998, the United States Environmental Protection Agency conducted a Brownfields Program Screening Site Inspection of the former landfill. This inspection revealed that the site could be released for use without any other remedial action other than a covering of new, clean fill.[56] The riverfront portion of the site was separated from neighboring residential areas by the Main Outlet Drain Extension (MODE, salinity canal), the Yuma Valley Levee, two maintenance roads, a railroad line, and a maintenance road leading to the gauge station on the river. The lower portion of this site had been overrun by invasive species and was subject to frequent flooding. In 1996 a fire caused by the extensive human encampment of the area burned native and non-native vegetation and caused the demise of much of the remaining native vegetation in the area. According to the Yuma West Wetlands sponsors, "[t]he 1996 fire was a wake-up call to the community that the resource along the river would continue to be lost and a hazard to local residents unless action could be taken to reclaim this section of the river."[57]

Planning Objectives: "The primary objective of the Yuma West Wetlands Revegetation Project is to establish and protect 35 acres of long-term, self-sustaining, native cottonwood and willow riparian habitat along the 100-year floodplain of the Colorado River."[58] The riparian corridor will serve as habitat for the willow fly catcher, an endangered species, and other native wildlife.

Current Phase: Revegetation of the lower terrace is complete. Phase one of the park construction is complete, including the boat ramp and irrigation infrastructure. Paving of the loop road around the park is also complete.

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[56] US Bureau of Reclamation-Yuma Area Office. (1999) Environmental Assessment Cooperative Agreement with the City of Yuma, Arizona for the Yuma West Wetlands Project. Yuma: Bureau of Reclamation.

[57] City of Yuma. (2001) West Wetlands Report 1999-2000. Yuma: West Wetlands. p. 9.

[58] Fred Phillips Consulting. (2004) Yuma West Wetlands 2004 Plant Monitoring Report. Flagstaff: Fred Phillips Consulting. p. 1

Phases: This project included improvements to both the upper and lower terraces along the river. The lower terrace improvements included: constructing a boat launch, re-vegetation with cottonwood and willow, construction of three snags (roosting spots) for ospreys and eagles, and construction of a handicapped-accessible walkway. Upper terrace improvements included clearing and re-vegetation of the area. On one-third of the upper terrace Sonoran desert species will be planted in higher densities as part of a hummingbird sanctuary. An access road, parking area, and handicapped accessible trail with restrooms and observation deck will also be built in the higher density restoration area of the upper terrace. Two trails will traverse the upper terrace to provide additional recreational opportunities to visitors.

Recommended or Implemented Plan: The restoration site is divided into two terraces, one close to the river and the other on the higher ground to the south of the river. Restoration activities in the river terrace included removal of non-native species and revegetation and reforestation with native species. Before developing the upland terrace of the site in the area that was a landfill, a geo-technical analysis was conducted so that the development plan could be shaped to avoid the need to dig up and remove large parts of the landfill.[59] The upper terrace, approximately 110 acres, will consist of irrigated turf grass for use as a park. The park will contain an interactive playground that has been donated by a local businessman.

Monitoring/Management: Prior to restoration, numerous analyses of the site were conducted to determine both baseline conditions and the areas best suited for revegetation. To monitor the site, photo monitoring stations were established, and Global Positioning System (GPS) and Geographic Information System (GIS) methods were used to develop and analyze species survival data. Six photo monitoring stations were established, and panoramic pictures were taken at monthly intervals throughout the growing season. The monthly monitoring began once revegetation was completed. As of the 2004 growing season, data has been collected from 22 transects located throughout 20 of the 35 acres.[60]

Funding and Cost: Funding for this project was put into place with several agreements between the Bureau of Reclamation and the City of Yuma through Title 28 and Wetlands Programs. Total BOR funding was $2,325,000.

An additional $1,000,000 in funding came from: Local State and Regional Parks $570,000; State Lake Improvement Fund $350,000; Heritage Trails $95,000; Arizona Game and Fish $25,000; Environmental Protection Agency, Border Area Wetlands Revegetation and Reforestation $25,000; BOR Title 28 MODE Enhancement $95,000; National Park Service Heritage Area Designation; and Bureau of Land Management $50,000. Local contributions include $25,000 from Caballeros de Yuma, $8,500 from Desert Verde Nursery, $10,000 from Riverfront Nursery, and $1000 from a Wal-Mart Mini-Grant.[61] A local businessman has also donated $100,000 for the construction of an interactive playground in the park.[62]

Land Ownership: Federal (BOR) and City of Yuma.

Water: The upper terrace component of the project will be irrigated park land. The area will require irrigation indefinitely which will be supplied by surface water from the Colorado River.

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[59] Ibid.

[60] Ibid.

[61] Supra note 57

[62] Eatherly, Kevin (City of Yuma, Department of Public Works). 2006, February. Review comments of draft report of this study.

The city holds a priority water right for Colorado River water and has allocated a portion of that right to the project. The lower terrace will consist of a 45 acre wetland which will require supplemental irrigation for only the first 3 years as vegetation is established.

The upper terrace component of the project will be constructed over a retired landfill. Water may also be needed to surcharge the landfill to insure that subsidence will not occur.

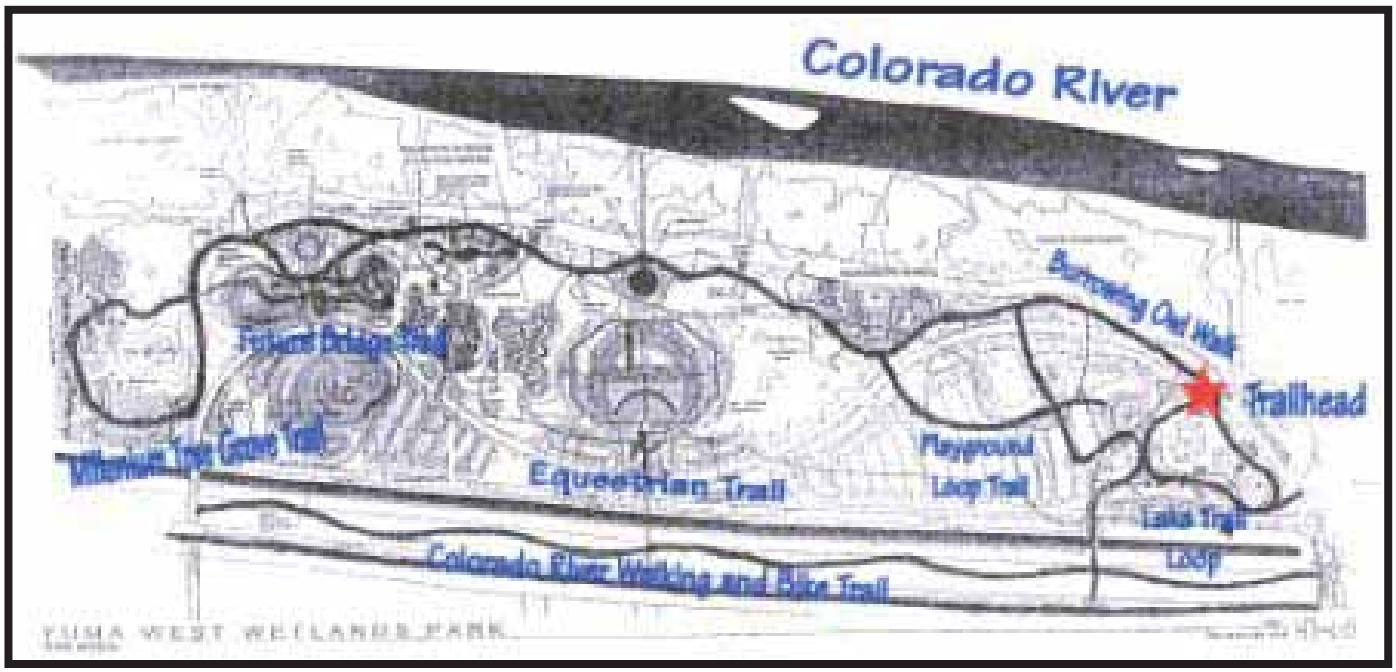
Pubic Outreach: Many actions for the West Wetlands are spearheaded by the Riverfront Task Force, a community-based group formed early in the planning process. This group organized the first site cleanup in 1997 that used 250 volunteers. Additional cleanup efforts were conducted in 1998 and 1999. Public outreach was conducted in 1999 to determine what park improvements were most needed. One citizen involvement picnic had over 200 people in attendance. Through these public outreach sessions, the Riverfront Task Force found that people wanted a park that would feature both active and passive uses and the park has since been designed to reflect this.[63]

Challenges/Lessons Learned: **"**It is very difficult to work in and around a closed landfill and ensure that it is not reopened." Complete understanding of the vertical and horizontal limits of the landfill are imperative to working in such close proximity to a hazard. In addition, the team must fully understand what constitutes "reopening" of the landfill and what remediation must occur in this situation. With complete information, the design of the project can be tailored to minimize the risks of interaction with hazardous or costly situations. Construction of elements on top of the landfill may need to be built in phases to evaluate how the landfill is reacting to the disturbance.[64]

Another important lesson from Yuma West Wetlands is the importance of involving the community in both the planning and construction process. The project sponsors suggest a good way to involve the public is through volunteer tree planting and trail construction. Doing so will create greater initial support for the project as well as momentum to keep the project moving.[65]

Drivers: This project is driven by the City of Yuma's need for recreation and aesthetic amenities with in the city, and the city's long-term goal of providing orderly growth and economic development. According to Kevin Eatherly at the City of Yuma, "It will change the look and feel of Yuma and be the catalyst for Yuma's redevelopment as an ecotourism destination."[66] The project site also contains BOR owned infrastructure in need of repair, facilitating some funding of the project.

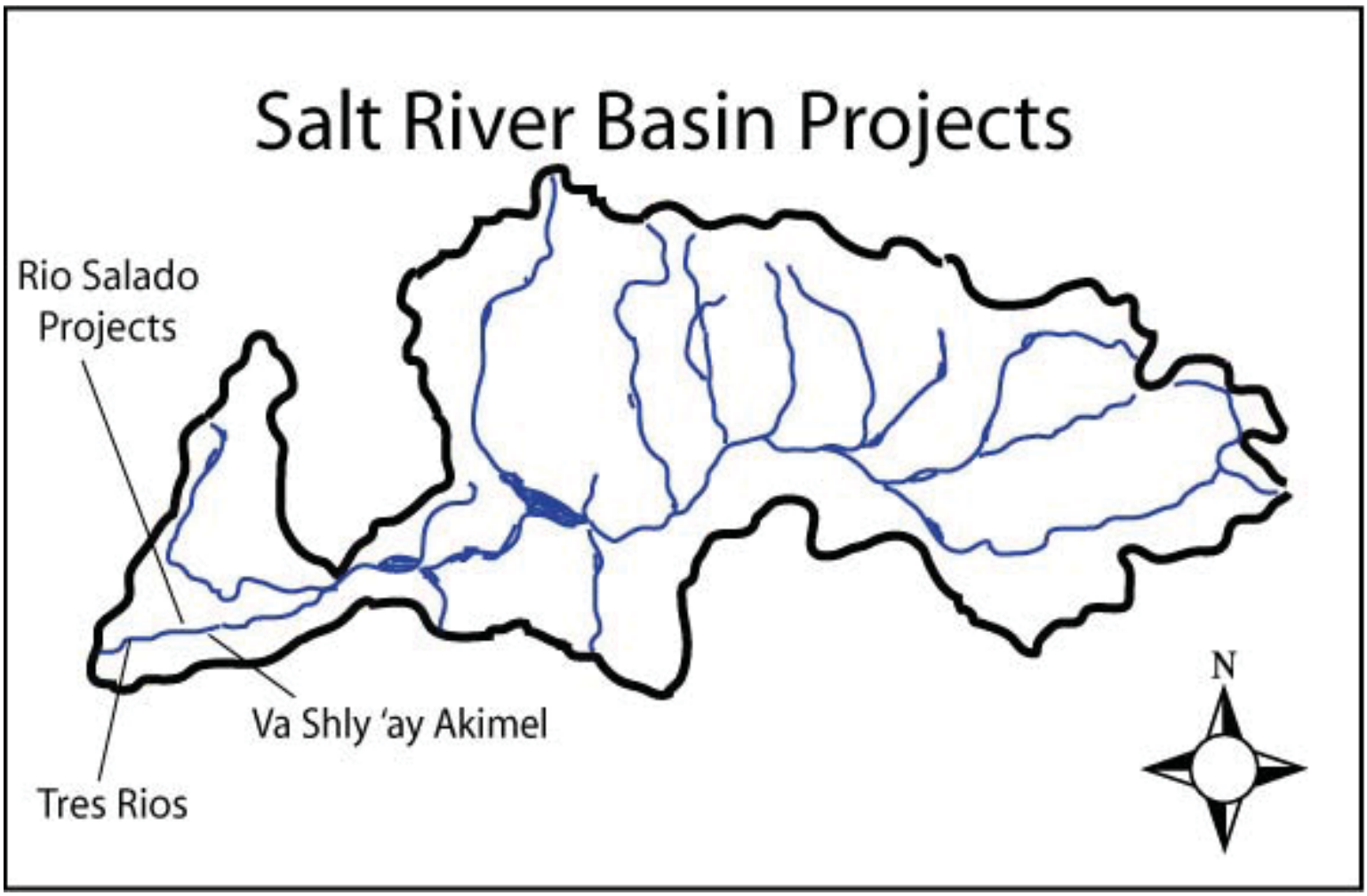
[63] Supra note 57
[64] Supra note 62
[65] Ibid.
[66] Supra note 57



Project site map
Yuma West Wetlands

Volunteer workers
Yuma West Wetlands

Photos courtesy of Yuma Parks and Recreation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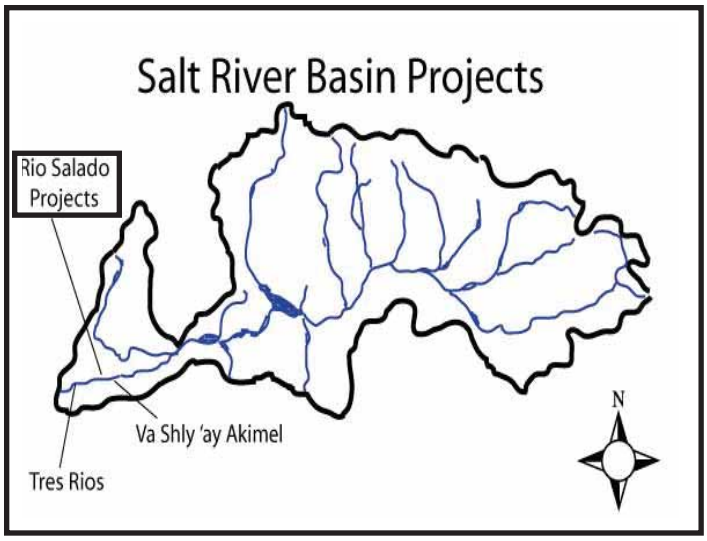

Rio Salado Oeste

Primary Information Source: Draft Interim 2004 US Army Corps of Engineers Feasibility Study and Environmental Impact Statement.

Location and Size: Salt River, Maricopa County, Phoenix; 19th Ave. west to 83rd Ave. The project encompasses eight miles.

Primary Sponsor(s): United States Army Corps of Engineers (USACE) and City of Phoenix.

History: Prior to urbanization and agricultural development in the Phoenix metropolitan area the Salt River, a major tributary to the Gila River was a perennial stream fed by snowmelt from mountains in eastern Arizona. The first major changes to the River system came in the early 20th century with dams constructed as part of the Salt River Project. These changes were exacerbated by sand and gravel mining operations and other activities along the river. Over time diversions from the river increased and eventually the River's perennial flows in the river ceased, causing the groundwater table to drop. As a result of these changes to the River system the natural riparian habitat declined to the point where only small, isolated pieces of habitat remain. These changes have also allowed saltcedar, an invasive non-native plant species with minimal habitat value, to become established in the region.[67]

Planning Objectives: "Restore native riparian and wetland habitat, and adjacent vegetation communities between 19th Avenue and 83rd Avenues for a period of 50 years; Attract wetland and riparian avian species in the study area; Establish the presence of amphibian species, reptilian species, mammalian species, and avian species in the study area; Suppress undesirable fish and wildlife species; Manage undesirable invasive plant species in the study area; Increase passive recreational and environmental education opportunities for visitors, which are linked to the restoration project in the study area; Reduce flood damages to structures and infrastructure within the 100 and 500 year floodplain between 19th and 83rd Avenues."[68]

Current Phase: Pre F4 - Alternative Review Conference

Phases: Reconnaissance completed September 2000, F3 milestone May 2002.

Recommended or Implemented Plan: Final USACE FS/EIS is anticipated in 2006 /2007.

Monitoring/Maintenance: TBD

Funding and Cost: The project is funded by the USACE General Investigation, Ecosystem Restoration. Costs will be shared between the USACE and the local sponsor. Total cost is unknown

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[67] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Va Shly' ay Akimel Salt River Ecosystem Restoration Feasibility Study, Final Environmental Impact Statement. Phoenix: U.S. Army Corps of Engineers. p. 2-1

[68] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. 2002. Rio Salado Oeste, Salt River Arizona Interim Feasibility Report F3 Milestone-Without Project Conditions. Los Angeles: U.S. Army Corps of Engineers. p. V-4

until a recommended plan is chosen.

Land Ownership: City of Phoenix

Water: Storm water runoff, groundwater, effluent and reclaimed water from 23rd Ave Wastewater Treatment Plant are all possibilities for the eventual delivery of irrigation water to the project.[69] A final decision on water supply will not be made until the project design is finalized and approved.

Public Outreach: Initial public meetings were held in September 2000 with the community. Ongoing progress reports on the study have been presented to the Rio Salado Citizen Advisory Committee.

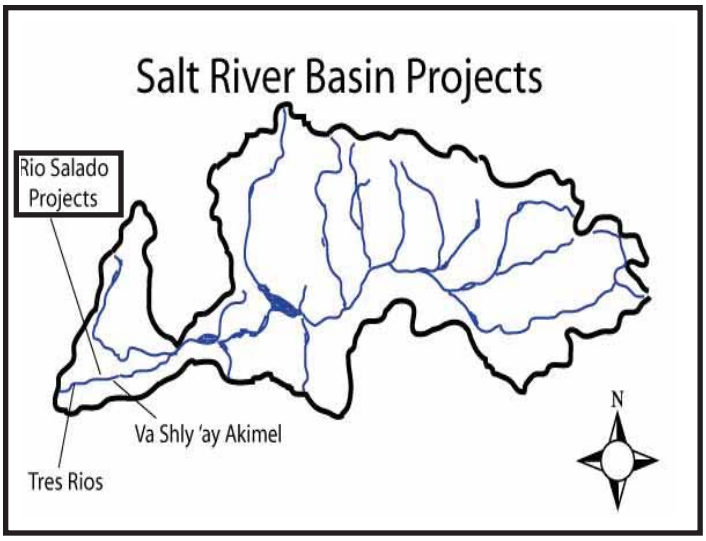
Once the Rio Salado – Phoenix Project is near completion then the City of Phoenix and Community Advisory Committee will direct the public's attention toward Oeste.[70]

Challenges/Lessons Learned: Project is in initial stages, no lessons learned reported to date.

Drivers: Improve habitat value within the Salt River corridor; improve urban landscape by replacing blighted river corridor with restored green space, flood management, environmental education opportunities, recreation, and draw visitors and interest to downtown increasing demand for redevelopment activities.

[69] Ibid.

[70] Williams, Karen. (2004) August. Personal communication with author (Mott Lacroix).



Rio Salado- Phoenix Reach

Primary Information Source: 1998 U.S. Army Corps of Engineers Feasibility Study and Environmental Impact Statement.

Location and Size: Salt River, Maricopa County, Phoenix; I-10 to 19th Avenue. The project encompasses five river miles and 595 acres.

Primary Sponsor(s): United States Army Corps of Engineers (USACE), City of Phoenix, and Flood Control District of Maricopa County

History: See Rio Salado - Oeste summary.

Planning Objectives: "Restore riparian habitat in and around the Salt River within the Cities of Phoenix and Tempe; Create a complete and diverse riparian system...; The restored habitat areas should incorporate a diverse mix of riparian habitat types including mesquite, cottonwood/ willow, wetland march, aquatic strand/scrub, open water, and open edges; Increase environmental education and passive recreation opportunities incidental to the restoration effort."[71] The project also will provide increased flood control and protection to the area. It is also intended to be an attraction to businesses and individuals to bring them into the downtown area as part of a larger downtown revitalization project.

Current Phase: Currently, the last phase of the Phoenix construction is underway. The city of Phoenix celebrated the grand opening of the Project on November 5, 2005.

Phases: Reconnaissance Study completed in 1995 for 33 mile reach of Salt River, Feasibility Report and EIS April 1998. Construction of the low-flow channel began in June of 2000 and continued through 2001. Habitat construction and restoration activities followed completion of the low-flow channel in 2002 and is expected to be completed in 2007.

Recommended or Implemented Plan: The 595-acre project features two gateway plazas that lead to terraces with wetlands and native trees and shrubs. Ten miles of trails have been constructed, and an extensive water system comprised of supply wells and reservoirs is used to water the plants. There is also a 12-acre forest of 1,000 cottonwood trees and 140 acres of mesquite woodlands. Additionally, there are 51 acres of aquatic vegetation in the river channel and 16 acres of wetland marsh.

The Rio Salado Phoenix project was designed to provide maximum possible environmental benefits for wildlife while meeting flood control standards. The city worked closely with the Flood Control District of Maricopa County and the Army Corps of Engineers to design and construct the low-flow channel. 1.7 million cubic yards of sand and gravel were removed from the middle of the riverbed to create the low-flow channel. The channel was then reinforced with a series of guide dikes and concrete structures in the banks to maintain its alignment during the heaviest floods. The

[71] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. 1998. Rio Salado Salt River, Arizona Feasibility Report and Environmental Impact Statement. Los Angeles: U.S. Army Corps of Engineers. p. V-2

low-flow channel is designed to contain flows of up to 12,200 cubic feet per second or nearly 5.5 million gallons of water per minute[72]. Flows in excess of this level will be conveyed through the wider river corridor between the second terrace on each side of the river.

Monitoring/Maintenance: Operated and Managed by Phoenix Parks and Recreation Department. For the first five years of the project, the cost of monitoring and maintenance will be shared between the USACE and the local sponsors. In each of the three habitats: mesquite, cottonwood/willow, and wetland marsh, monitoring will be conducted monthly for the first six months and every other month for another year. The area will be maintained to have no non-natives and 80% survival the first year and 100% survival the second and third years and/or attain 40% cover after five years of planted species. Ninety percent cover is expected after ten years. Surveys of wildlife will also be conducted as a measure of success.[73] After the five year period, monitoring and maintenance will become solely the responsibility of the local sponsors. The City of Phoenix is currently developing an adaptive management and monitoring plan for the future of the site.[74]

Funding and Cost: Securing funding for the Rio Salado Project has taken many years, involved many different agencies and ultimately has been supplied by a number of different funding sources. In 1999, the city succeeded in getting Congress to include the construction authorization for the project in the Water Resources Development Act bill. Construction of the project's flood control elements began in 2000 after an advance credit agreement with the Army Corps of Engineers and an Intergovernmental Agreement with the Flood Control District of Maricopa County. Construction was paid for using county funds.

A number of challenges arose along the way, including securing a letter of concurrence from the Federal Aviation Administration stating that the Project had addressed concerns about wildlife near Sky Harbor International Airport.

Total project funding secured to date totals $100 million: 65% from the Army Corps of Engineers-through General Investigation, Ecosystem Restoration funds, 19% Phoenix Voter-Approved 2001 Capital Improvement Bond Funds and 1999 Phoenix Parks, Preserve Initiative Funds, 14% Flood Control District funds and 2% grants and donations[75]. Annual operation and maintenance of the site is estimated at $1,971,000.

Land Ownership: City of Phoenix

Water: Water for the irrigation of the new riparian habitat will be supplied by five groundwater wells. The estimated average requirement for the project is about six million gallons per day. Because of seasonal variations in demand, and possible periodic disruptions in production from the wells, the actual design capacity of the wells will be 12 million gallons per day. Shallow groundwater will be used from an aquifer that lies close to the surface. This aquifer is not used for urban water supplies because it is contaminated by agricultural and urban pollutants. The water will require some wellhead treatment to meet water quality standards. (The city of Phoenix supplies effluent from the 23rd Avenue wastewater treatment plant to Roosevelt Irrigation District, allowing the District to reduce its use of groundwater. Phoenix receives water supply credits from the Arizona Department of Water Resources for this exchange, which are used to offset pumping

[72] Williams, Karen (City of Phoenix). (2005) January. Review comments on draft report of this study.

[73] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. 1998. *Rio Salado Salt River, Arizona Feasibility Report and Environmental Impact Statement.* Los Angeles: U.S. Army Corps of Engineers. p VI - 13

[74] Supra note 72

[75] Supra note 73

at the Rio Salado supply wells.)[76]

The well water is used to feed three over bank reservoir ponds. Water from the ponds is then released as needed for irrigation via canals or underground pipes. The water is used to feed streams, ponds, wetlands, and other features of the restoration project and to supply high velocity sprinkler heads mounted on poles along the river banks to deliver water to trees and plant areas. A sprinkler system is being used instead of drip or flood irrigation because of the vulnerability of these systems to high flow events in the rivers flood canal.

It is estimated that 60% of the water delivered to the project area will be returned to the aquifer through infiltration and seepage. The remaining 40% will be lost to evaporation and transpiration. The riparian vegetation bordering the river will server to reduce erosion and filter contaminants from storm water drains that outflow into the river.

Public Outreach: According to Karen Williams at the City of Phoenix, "To keep the public informed, the city team produced a newsletter in Spanish and English and worked with the Mayor and Council to appoint a Rio Salado Citizens Advisory Committee. Additionally, the team worked with the City Council to develop a partnership with the National Audubon Society to lease four acres next to the Rio Salado to build an Audubon nature center. This will help to address the science-based education needs of school children and capture the interest of adults in environmental education subjects. Before the grand opening of Rio Salado, the team provided educational programs for 312 middle school students. The program was created through a partnership with Arizona State University and funded by Nina Mason Pulliam Trust. Additionally, the team held 515 public presentations on the project since April 1997, reaching over 18,700 people."[77]

Challenges/Lessons Learned: Karen Williams at the City of Phoenix notes the following challenges and lessons learned. "The River and the adjacent properties had been used for years as dumping grounds for unwanted materials through formal and informal landfills. The city team worked to develop creative ways to construct the project in this environment, using specialized techniques to protect structural facilities, specialized plant pits to protect vegetation, and selecting appropriate irrigation techniques.

The project had to obtain nearly 100 federal, state, county and city permits for various aspects of the project. Workers scooped 138,572 cubic yards of debris and waste from the River and removed 1,185 tons of tires. The city team created an innovative screening and recycling guideline that saved millions of dollars in waste removal to the projects bottom line. It also uniquely uses recycled items in the project as site furnishings and construction materials that are illustrative of the river's history and use, and provides recreational and educational opportunities for visitors."[78]

Drivers: Drivers include: improve habitat value within the Salt River corridor; improve urban landscape by replacing blighted river corridor with restored green space; flood management; environmental education opportunities; recreation; and to draw visitors and interest to downtown which will increase demand for redevelopment activities.

[76] Ibid.
[77] Ibid.
[78] Ibid.

Park walkway
Rio Salado Phoenix

Park Signage
Rio Salado Phoenix

Low flow channel at Central Ave.
Rio Salado Phoenix

Open water area at Central Ave.
Rio Salado Phoenix

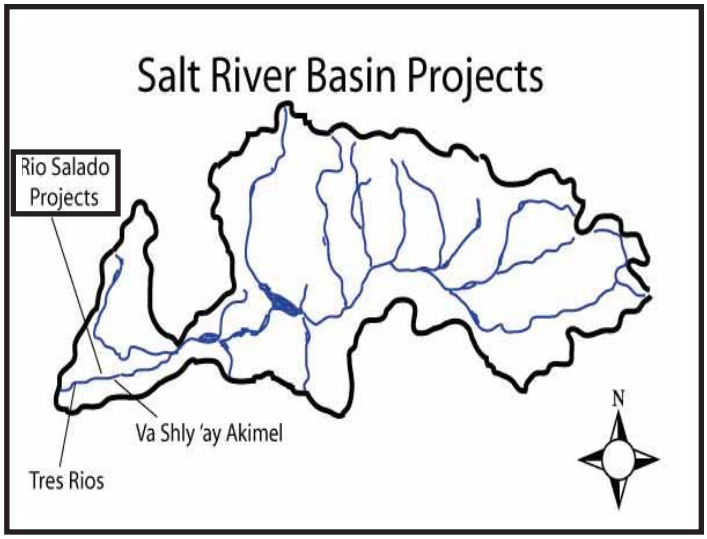
Photos by Kelly Mott Lacroix

Releasing wildlife
Rio Salado Phoenix

Rio Salado Phoenix

RIo Salado grand opening celebration November, 2005
Rio Salado Phoenix

All Photos by Kelly Mott Lacroix



Rio Salado- Tempe Reach

Primary Information Source: 1998 U.S. Army Corps of Engineers Feasibility Study and Environmental Impact Statement.

Location and Size: Salt River, Maricopa County, McClintock to Priest Drive (except Tempe Town Lake in the middle) and McKellips Rd. south to Tempe Town Lake. The project has two phases encompassing a total of 136 acres.

Primary Sponsor(s): United States Army Corps of Engineers (USACE), City of Tempe, and Flood Control District of Maricopa County.

History: Prior to urbanization and agricultural development in the Phoenix metropolitan area the Salt River, a major tributary to the Gila River was a perennial stream fed by snowmelt from mountains in eastern Arizona. The first major changes to the River system came in the early 20th century with dams constructed as part of the Salt River Project. These changes were exacerbated by sand and gravel mining operations and other activities along the river. Over time diversions from the river increased and eventually the River's perennial flows in the river ceased, causing the groundwater table to drop. As a result of these changes to the River system the natural riparian habitat declined to the point where only small, isolated pieces of habitat remain. These changes have also allowed saltcedar, an invasive non-native plant species with minimal habitat value, to become established in the region.[79] In the past, the area encompassed by the Tempe Reach contained abundant mesquite trees and high quality mesquite bosque riparian habitat. Large amounts of erosion and streambed incising have lead to the lowering of the Salt River bed by as much as 30 feet in places.[80]

Planning Objectives: "Restoration of threatened and endangered species habitat; Restoration of the study area to a more natural condition through the installation of plant species that are native to and occurred historically in riparian streams and washes in the region; and increase recreation opportunities."[81]

Current Phase: Phase 1 is currently under construction, phase 2 is in redesign. (High flood flows in the winter of 2005 required that the number of trees be reduces and relocated). Construction of phase 2 is anticipated to begin in March 2006.

Phase: Reconnaissance Study completed in 1994 for 33 mile reach, Feasibility Report and EIS completed April 1998.

Recommended or Implemented Plan: Alternative T5 - mesquite, cottonwood willow, wetland,

[79] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Va Shly' ay Akimel Salt River Ecosystem Restoration Feasibility Study, Final Environmental Impact Statement. Phoenix: U.S. Army Corps of Engineers. p. 2-1

[80] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (1998) Rio Salado Salt River, Arizona Feasibility Report and Environmental Impact Statement. Los Angeles: U.S. Army Corps of Engineers. p. IV-2

[81] Ibid. p. VI-1

strand scrub, and open edge habitat. This alternative was selected because it closely follows the planning objectives. [82]

Monitoring/Maintenance: For the first five years of the project, the cost of monitoring and maintenance will be shared between the USACE and the local sponsors. After this time monitoring and maintenance becomes solely the responsibility of the local sponsors. In each of the three habitats (mesquite, cottonwood/willow, and wetland marsh) monitoring will be conducted monthly for the first six months and every other month for another year. The area will be maintained to have zero non-natives and 80% survival the first year and 100% survival the second and third years and/or attain 40% cover after five years. Ninety percent cover is expected after ten years. Surveys of wildlife will also be conducted as a measure of success.[83]

Funding and Cost: The project is funded by USACE General Investigation, Ecosystem Restoration. Costs will be shared between the USACE and the local sponsors. Total gross investment is $6,171,000 and total annual cost is $684,000, which includes operation and maintenance of approximately $230,000 per year.[84]

Land Ownership: City of Tempe and the Flood Control District of Maricopa County. Restoration activities on Indian Bend Wash were permitted by FCDMC through an intergovernmental Agreement and habitat easement.

Water Source: Proposed source of water is a new irrigation (non-potable) well. Water demand is approximately 1,690 acre-feet per year.[85] The water will be used to provide irrigation water for the establishment of new vegetation and will be used to provide a permanent source of replacement water for the wetland ponds. A contract is in place for the provision of this groundwater. Storm water flowing through Indian Bend wash is also transmitted to the site but there is no contractual agreement that guarantees the provision of this water.

Public Outreach: Typical USACE public outreach process during reconnaissance and feasibility stages. Public access is not permitted within the environmental restoration area; however, public access is provided along the western edge of the site by a multi-use path and observation ramada.

Challenges/Lessons Learned: Because of the project site's close proximity to developed urban areas, several concerns have been raised about possible management problems on the site.

Wetland ponds being a source of mosquito breeding, hydroseeded grasses causing wildfire danger, noxious weeds, homelessness, and vandalism have all been raised as concerns of adjacent businesses, path users, and nearby residents. Adaptive management will be an ongoing challenge for the project as managers address these issues.

Drivers: Improve habitat value for threatened and endangered species, flood management, environmental education opportunities, and recreation.

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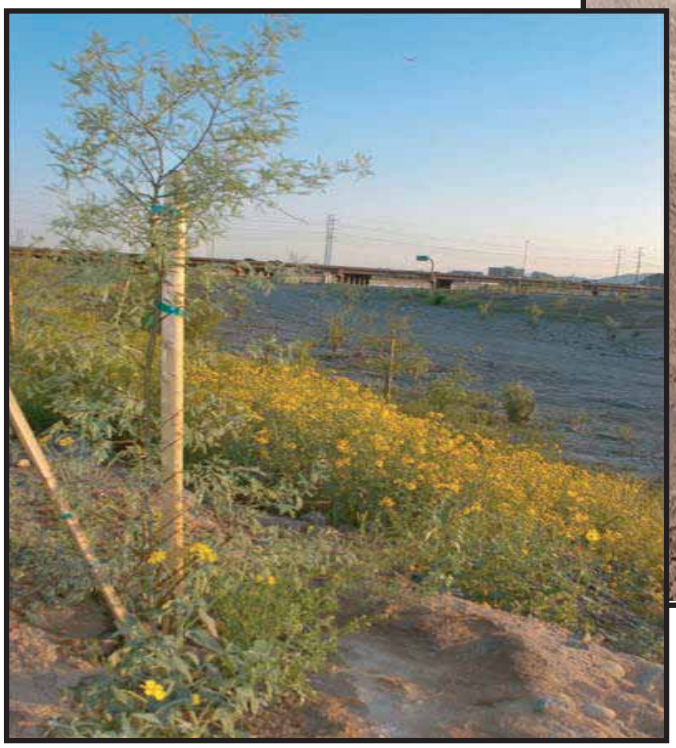
[82] Ibid.
[83] Ibid. VI - 13
[84] Ibid. p. VI-4, Table 6.3
[85] Ibid. p. VI-2

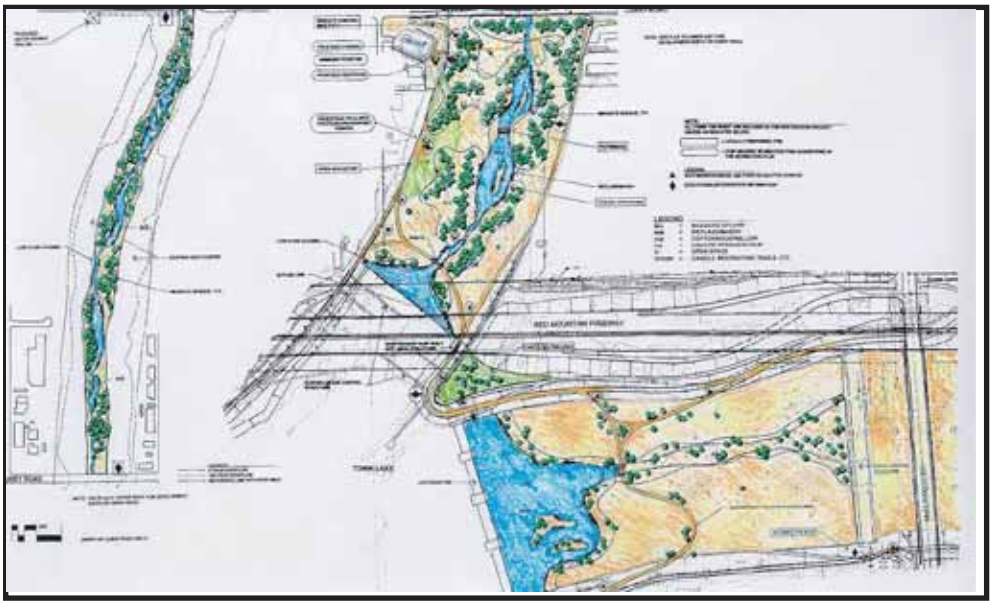
Indian Bend Wash restoration May 2004
Rio Salado Tempe

Indian Bend Wash Construction
Rio Salado Tempe

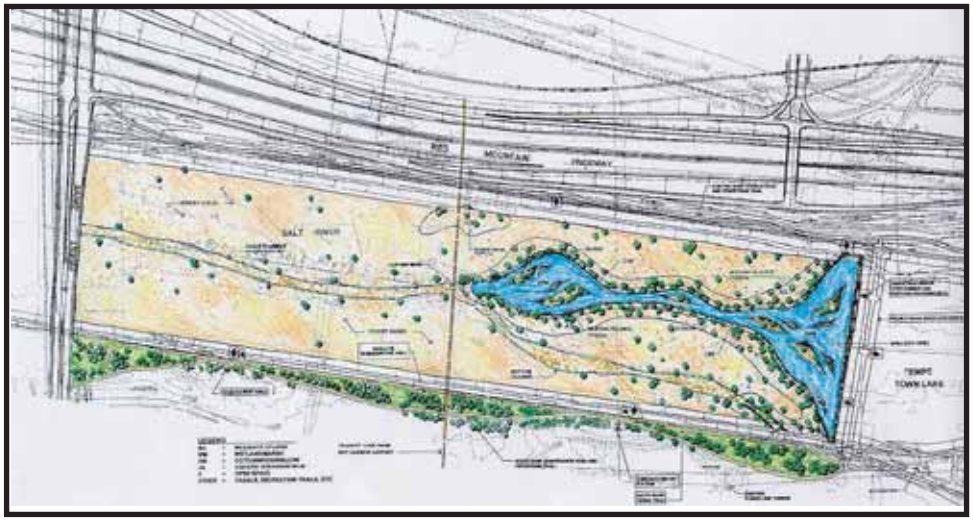


Indian Bend Wash restoration
April 2004
Rio Salado Tempe

Aerial photo with
project area outlined
Rio Salado Tempe

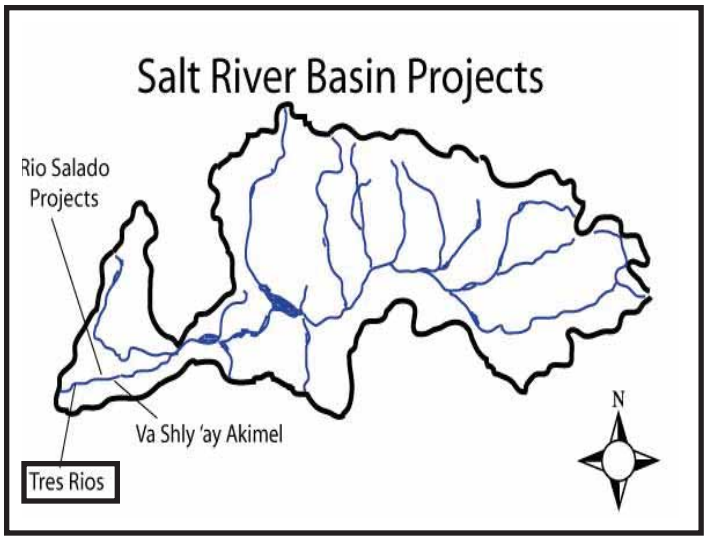


Rio Salado Tempe Upper Reach
Rio Salado Tempe



Rio Salado Tempe Lower Reach
Rio Salado Tempe

Photos and maps courtesy of City of Tempe



Tres Rios

Primary Information Source: 2000 U.S. Army Corps of Engineers Feasibility Study and Environmental Impact Statement.

Location and Size: Salt River and Gila River, Maricopa County. Beginning at 83rd Ave. to the confluence with Agua Fria River. The project study area included 9.2 river miles. The actual restoration project area includes approximately 7 river miles and 5,600 acres.[86]

Primary Sponsor(s): United States Army Corps of Engineers (USACE) and City of Phoenix (Tres Rios Restoration). United States Bureau of Reclamation and City of Phoenix (Tres Rios Demonstration Wetland).

History: In the past, gallery forests of cottonwoods and willows covered hundreds of miles along the lower reaches of the Salt and the Gila Rivers. Before Roosevelt Dam was constructed, the Lower Salt River was a perennial stream with an average annual discharge of approximately 1,250,000 acre-feet. At the confluence of the Gila and the Salt, the "Salt River's clear, streaming waters contrasted with the muddy, sluggish Gila River." The river had backwater and many channel meanders and sand bars that were conducive to riparian growth. Today, the historic perennial and high winter flows no longer exist because of dams upstream and diversions for urban and agricultural use.[87]

Planning Objectives: "Provide sustainable and diverse native riparian habitat in and around the Tres Rios area; Reduce flood damages to the Holly Acres community, surrounding development, and agricultural areas; and Increase environmental education and recreation in the study area."

Phases: Tres Rios Demonstration Wetland was authorized in 1992 and was constructed in 1995. Reconnaissance for the Tres Rios Restoration was completed April 1, 1997; and the Feasibility Report and Final EIS in April 2000.

Current Phase: The flood control levee is under construction, and environmental features for the rest of the project are at 60% design. Construction of the restoration project is expected to conclude in 2009, depending on yearly congressional appropriations.[88] Monitoring and maintenance continue on the Tres Rios Demonstration Wetland.

Recommended or Implemented Plan: Alternative 3.5 includes: "pump station facility; regulating wetland for treatment plan discharge; the creation of linear, constructed wetlands along the north over bank; a pipeline from the over-bank wetland leading to cottonwood/willow corridors west of El Mirage Road; open water/marsh areas within the channel west of El Mirage Road; south side distribution of dewatering well water and large open water/marsh creation areas; a flood

[86] Alice Brawley-Chesworth. (2006) January. Review comments on draft report of this study.

[87] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. 2000. Tres Rios, Arizona, Feasibility Report. Los Angeles: U.S. Army Corps of Engineers. p. IV- 1-4.

[88] Supra note 86

control levee to protect Holly Acres as well as other surrounding residential commercial, industrial buildings, and farmland."[89]

Monitoring/Maintenance: For the first five years of the project, the cost of monitoring and maintenance will be shared between the USACE and the local sponsors. After this time, monitoring and maintenance becomes solely the responsibility of the local sponsors. In each of the three habitats, cottonwood/willow, wetland marsh and open water, monitoring will be conducted monthly for the first six months and every other month for another year. The area will be maintained to have zero non-natives and 80% survival the first year and 100% survival the second and third years and/or attain 40% cover after five years. Ninety percent cover is expected after ten years. Surveys of wildlife will also be conducted as a measure of success.[90]

Funding and Cost: The project is funded by the USACE General Investigation, Ecosystem Restoration. Costs will be shared between the USACE and the local sponsors. Total first cost is $99,321,000 with a total annual cost of $9,722,100 which includes operation and maintenance which is approximately $2,414,150 per year (includes annual cost of water at $1,221,150).[91] All costs are in 1999 dollars.

Land Ownership: City of Phoenix, Flood Control District of Maricopa County, Arizona Game & Fish Department, and Federal lands.

Water: The main sources of water are the 91st Avenue Wastewater Treatment Plant effluent and existing dewatering wells from within the treatment plant. Water demand is 24,423 acre-feet per year.[92] An agreement exists ensuring the continued flow of effluent to the project site.

Public Outreach: 1995 Tres Rios Steering Committee (includes city, county, state and federal government officials) formed Tres Rios Public Involvement Subcommittee, which helped to facilitate public involvement and dialogue with the Corps (for more info see Feasibility April 2000, VIII-3).

Challenges/Lessons Learned: The Demonstration Project has contributed significantly to the knowledge of wetlands treatment of effluent in the arid southwest. In addition to water quality data, research has also been conducted in mosquito control, non-lethal beaver management, vegetation sustainability, Salt Cedar control, public accessibility, and site security. The main lesson, however, was that a demonstration project is invaluable for large-scale wetlands projects. Much has been learned that will aid in the success of the full-scale project.

The most valuable information emerged from situations that had not originally been research focus areas. Beaver management and mosquito control were two areas of research that evolved out of "emergency situations" on the demonstration project and required additional research and problem solving.

For the full-scale project implementation, one of the main challenges has been increasing land costs in the area. This part of the valley is transitioning to residential development very rapidly. Development pressures have caused the costs of land to increase significantly over what was predicted in the initial studies. In addition, challenges remain in non-native plant control, multi-

[89] Supra note 87
[90] Ibid. VI - 13
[91] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2000) Tres Rios, Arizona, Feasibility Report, Summary. Los Angeles: U.S. Army Corps of Engineers. p. 3
[92] Ibid.

jurisdictional coordination, vector control, and balancing wildlife and human needs. Negotiations continue for full participation of the sovereign Gila River Indian Community.[93]

Drivers: Drivers for this project include: restoration of riparian habitat, flood control, water quality improvement, and pre-treatment of effluent for groundwater recharge.

[93] Supra note 86

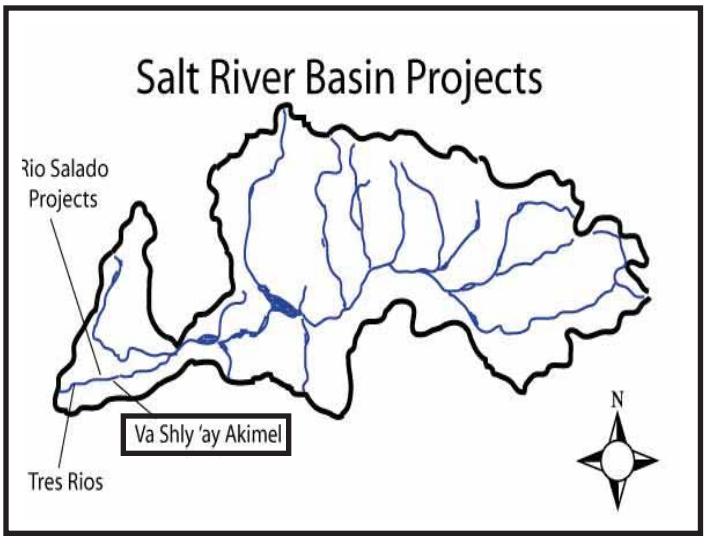
Demonstration Wetland
Tres Rios

Demonstration Wetland
Tres Rios

91st WWTP outfall into Salt River
Tres Rios

Map of project area
Tres Rios

Photos courtesy of City of Phoenix



Va Shly 'ay Akimel

Primary Information Source: 2004 U.S. Army Corps of Engineers Feasibility Study and Environmental Impact Statement.

Location and Size: Salt River, Maricopa County; Granite Reef Dam to Loop 101 Bridge. The study area encompassed a 14 mile reach of the Salt River and 17,435 acres. The final project area will encompass 4,130 acres.

Primary Sponsor: United States Army Corps of Engineers (USACE), City of Mesa, and Salt River Pima-Maricopa Indian Community (SRPMIC).

History: See Rio Salado - Oeste summary.

Planning Objectives: "Restore the riparian ecosystem to the degree that it supports native vegetation and wildlife through the Salt River from immediately downstream of the Granite Reef Dam to the Pima Freeway (SR 101); Establish a functional floodplain in unconstrained river reaches of the study area that is ongoing and mimics the natural processes found in other naturalized riparian corridors in Arizona; Provide passive recreation opportunities for visitors of all ages, abilities, and backgrounds that are in harmony with the SRPMIC's management of its culture and native ecology; Create awareness through ongoing educational opportunities of the significance of the cultural resources relating to the Salt River; Create awareness through ongoing education opportunities of the significance of the Salt River ecosystem; Create awareness through ongoing educational opportunities of the ecological connection between other ongoing riparian restoration projects along the Salt River." [94]

Current Phase: Feasibility study was completed in January 2005 and design agreement negotiations are currently on going.

Phases: Reconnaissance initiated November 2000, Feasibility initiated August 2001, Final EIS submitted September 2004, Feasibility study completed (Chief's Report) January 2005.

Recommended or Implemented Plan: Alternative O is the recommended plan and includes vegetation of large portions of the project area and minimal support for flood control structures. The restoration includes: cottonwood-willow (883.4 acres), mesquite woodlands (379.7 acres), river bottom (225.1 acres), wetlands (200 acres), and Sonoran Desert scrub shrub (23.6 acres).[95]

Monitoring/Maintenance: The USACE and local sponsors created biological goals and objectives for the restoration project. These objectives were used to create habitat value goals using HydroGeoMorphic Assessment of Wetlands (HGM). Performance targets were then established

[94] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Va Shly' ay Akimel Draft Salt River Ecosystem Restoration Study. Los Angeles: U.S. Army Corps of Engineers. p. V-6

[95] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. 2004. Va Shly' ay Akimel Salt River Ecosystem Restoration Feasibility Study, Final Environmental Impact Statement. Phoenix: U.S. Army Corps of Engineers. p. 5-28

for both acreage of desired cover types and the functional capacity index (FCI) of those habitats.[96] During the course of the restoration, data will be collected on survival and health of the restored habits and entered into the HGM model. The model then outputs functional capacity indices for the habitats. For the restoration project to be deemed successful, the results must meet or exceed 80% of the projected results for each of the four Target Years. Should the project fall below the 80% threshold of predicted acreages and/or FCI values, adaptive management strategies will be implemented. Monitoring of insects will also be conducted annually during the Operations and Maintenance period to address concerns regarding disease vector control. The Corps, in cooperation with the local sponsors, will write an annual report at the end of each of the first five years post construction. This report will include a written description of current conditions as well as the results of any HGM runs; flora and fauna surveys conducted; geo-references and maps for the area covered in the report; topographic survey results identifying all significant features (planting sites, on-going mining operations, etc.); and a well documented photographic record including oblique photos from before, during, and after construction.[97]

Funding and Cost: The project is funded by a cost share agreement through the USACE General Investigation, Ecosystem Restoration program. "The ecosystem restoration component of the Tentatively Recommended Plan would require $76,143,600 in construction costs, $19,035,900 in contingency costs, $7,614,400 in Pre-construction Engineering and Design, $761,400 in Engineering during Construction, and $4,949,300 in Supervision and Administration, for a total construction cost of $108,504,600." Operations, Maintenance, Rehabilitation and Repair for the ecosystem restoration component has been estimated at $131,000 per year. Associated costs for water supply are currently estimated at $1,283,000 per year.[98]

Land Ownership: Salt-River Pima Indian Community and City of Mesa

Water: Water for the project comes from seven sources: Salt River Project water leaking from Granite Reef Dam, groundwater from existing and new wells, storm water, irrigation tail water, surface water and groundwater from the SRPMIC, and effluent from the City of Mesa Wastewater Treatment Facility. The construction of a well may require additional diversion structures. "This project will rely primarily on excess surface water from the SRPMIC and effluent from the City of Mesa Wastewater Treatment Facility. Groundwater is considered a secondary source of water." [99] Annual water demand is 17,100 acre-feet.[100]

Public Outreach: A series of six scoping meetings were held with SRPMIC and the City of Mesa between January 24, 2002 and April 1, 2003. The purpose of these meetings was to introduce the project to the public, give individuals and agencies an opportunity to identify issues for consideration in the EIS, and to solicit input on the project. News articles related to the project were also published, and the draft EIS was made available for public review and comment.[101]

Challenges/Lessons Learned: Project is in the early stages. No challenges or lessons learned were provided.

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[96] Functional Capacity Indices are derived from field measurements taken from several different variables.

[97] Supra note 95

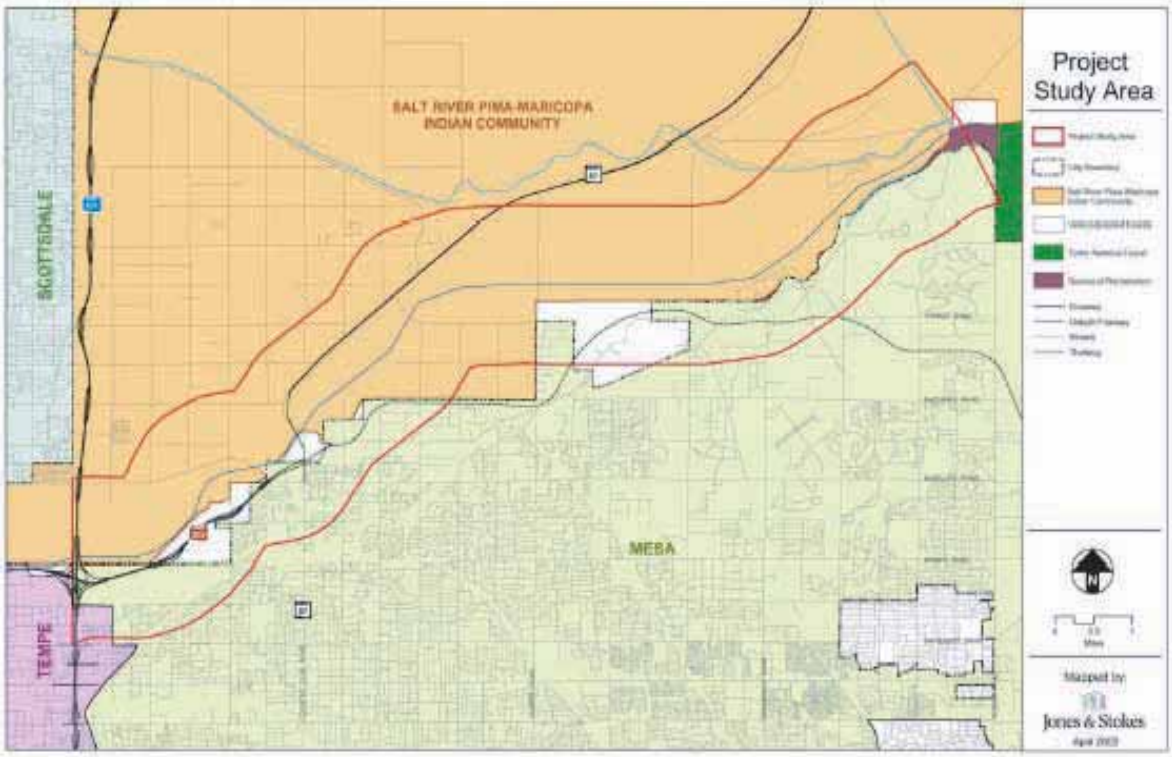
[98] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Va Shly' ay Akimel Draft Salt River Ecosystem Restoration Study. Los Angeles: U.S. Army Corps of Engineers. p. VI-6

[99] Supra note 97

[100] Ibid. Table 54

[101] Ibid. p. 11-2

Drivers: The drivers for this project were to restore a degraded system and connect with other restoration efforts along Salt River.

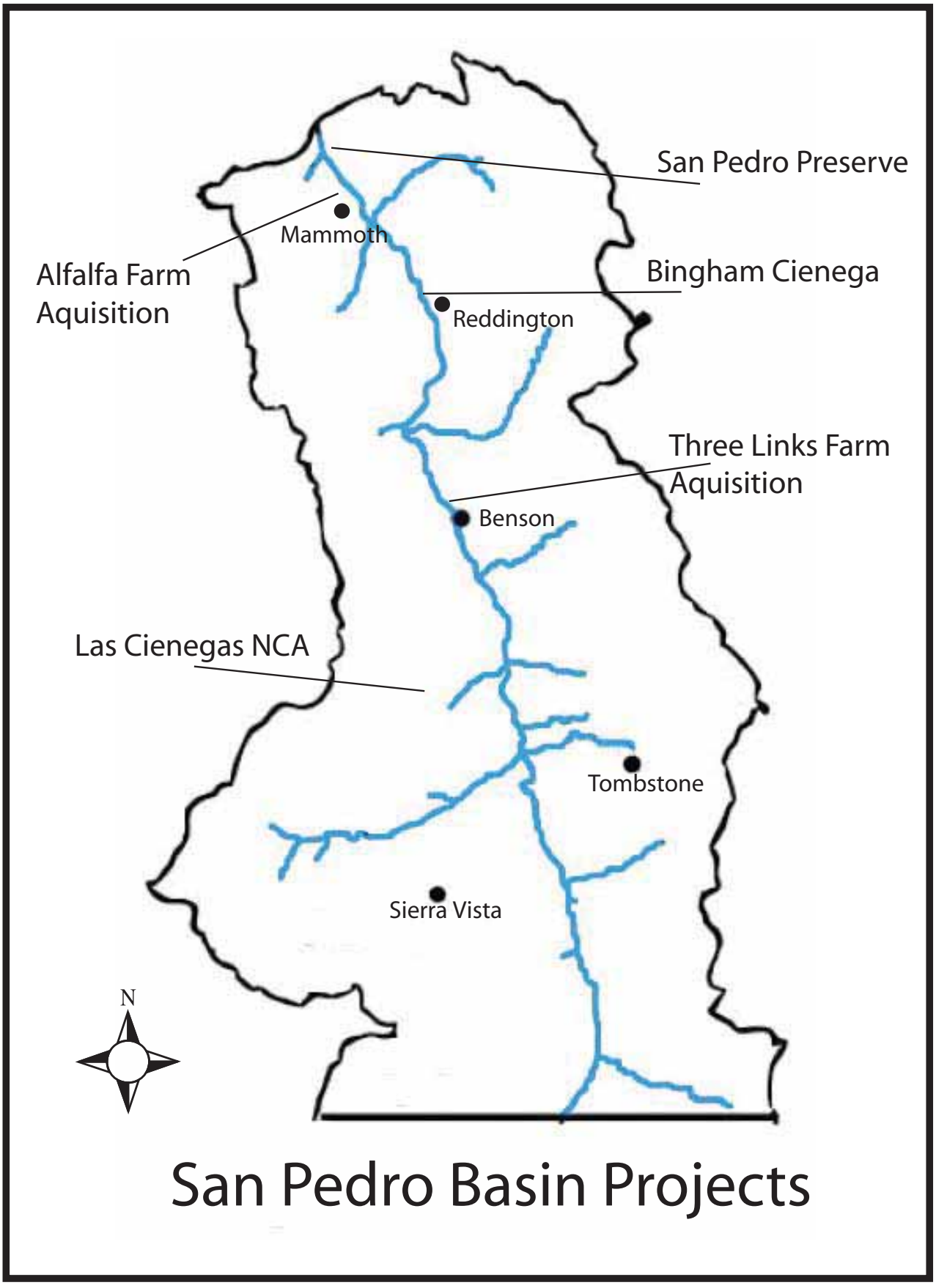


Map of project area
Va Shly 'ay Akimel

Down river of dam
Va Shly 'ay Akimel

Wetland created behind dam
Va Shly 'ay Akimel

Photos courtesy of USACE


San Pedro Preserve
Mammoth
Alfalfa Farm
Aquisition
Bingham Cienega
Reddington
Three Links Farm
Aquisition
Benson
Las Cienegas NCA
Tombstone
Sierra Vista
N
San Pedro Basin Projects

Bingham Cienega Natural Preserve Restoration

Primary Information Source: 2001 Bingham Cienega Restoration: Sonoran Desert Conservation Plan, 2000 Arizona Water Protection Fund progress report, and 2001 Pima Association of Governments Bingham Cienega Source Water Supply Final Progress Report.

Location and Size: Approximately 2000 feet west of the lower San Pedro River and 0.25 mile north of the settlement of Reddington in Pinal County. Bingham Cienega is on the western site of the San Pedro River Valley bounded by the Santa Catalina Mountains and Galiuro Mountains. The Bingham Cienega Natural Preserve occupies 285 acres.

Principal Sponsor(s): The Nature Conservancy (TNC) and Pima County Regional Flood Control District (PCRFCD)

Other Sponsors: Arizona Water Protection Fund (AWPF)

History: The Bingham Cienega was historically used for farming and ranching. The agricultural fields in the area were last cultivated in 1987. In 1989, the Pima County Regional Flood Control District purchased the cienegas along with 285 acres of surrounding land in order to restore natural ecological processes and to prevent floodplain development. In addition to the cienega, the Bingham Cienega Natural Preserve also contains deciduous wooded swamp, mesquite bosque, cottonwood/willow riparian forest, and sacaton grass areas. After Pima County purchased the land, they entered into a 25 year agreement with The Nature Conservancy to manage the preserve.[102] The Bingham Cienega project is part of a series of projects that The Nature Conservancy has implemented to preserve the San Pedro River which is on its list of "Last Great Places."

Planning Objectives: The restoration goals for the Bingham Cienega are to establish a diversity of riparian habitats in former agricultural fields and to plant species where the depth-to-groundwater and soil moisture are sufficient to maintain the plantings once established. Related to the restoration goals, the objectives of the project were to promote long term re-establishment of deciduous riparian woodland, sacaton grassland, and mesquite woodland in the fields and to develop practical techniques for promoting establishment of native plants that either do not require irrigation or that require infrequent irrigation.[103]

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[102] Pima Association of Governments. (2004) Riparian Areas: Restoration and Management in Eastern Pima County. Watershed Forum, December 3, 2003. Based on meeting minutes. p. 10

[103] Pima County Supervisors. 2001. Bingham Cienega Restoration: Sonoran Desert Conservation Plan.

Current Phase: Monitoring and maintenance of the site is ongoing. The initial restoration was completed in 2001.

Phases: Restoration began in 1998 with planting of sacaton seedlings and deciduous tree saplings. Mesquites were planted in 1999 and native grasses in 2001, and cottonwood/ willow poles were planted in 2000/2001.

Recommended or Implemented Plan: "Restoration habitat types were selected based on depth to groundwater. The deciduous riparian woodland planting area was located close to the wetlands where depth to groundwater was approximately three feet. Sacaton grasses were restored in areas with six to nine foot depth to water, and mesquite woodland was planted where depths to water exceeded nine feet." The project emphasized sacaton riparian grasslands restoration because the region has lost so much of this type of habitat over the last century. In three years a total of approximately 62,000 sacaton seedlings were transplanted to the site.

Monitoring/Management: Monitoring and maintenance was conducted throughout the course of the project. Separate monitoring tailored to each different riparian community type (deciduous riparian woodland, sacaton grassland, and mesquite woodland) was conducted. In each area, monitoring activities included hydrologic monitoring, vegetation monitoring on plots and transects, photo point monitoring, and a three-year bird monitoring study.

Funding and Cost: The total project cost was $221,024. Of this amount, $84,679 was funded by the Arizona Water Protection Fund. Other monies for the project came from U.S. Fish and Wildlife Service, Wallace Genetic, University of Arizona, The Nature Conservancy, and Tri-Community as well as in-kind donations from the Pima County Regional Flood Control District.

Land Ownership: Land is owned by Pima County Regional Flood Control District and operated by The Nature Conservancy.

Water: Cienegas are low- to mid- elevation spring-fed wetlands characterized by non-fluctuating shallow surface water.[104] In this project, the type of riparian system restored in each area was determined by the distance to the water table. Only riparian systems that could subsist on naturally present water were established. This strategy reduced the need for long-term watering and helped to ensure long-term viability of the site with minimal human management.

Water for the project, needed for the initial establishment of vegetation, came through an irrigation agreement with adjacent property owners which granted PCRFCD access to their irrigation pump well, canal, and underground pipe. The landowner's original irrigation pump was not functional at the beginning of the project so a new pump, purchased with grant monies, was required.

Pubic Outreach: Public outreach for this project included numerous field trips, about six a year, for the three-year duration of the AWPF grant. The participants included high school and university students, TNC members, other conservation groups, and local residents. Presentations were made at various conferences and the local newsletter, Reddington Resource Review, carried informational articles about the project. [105]

Challenges/Lessons Learned: During the course of this restoration effort, TNC learned that an interdisciplinary team is very important for project planning. In order to ensure the best possible

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[104] Pima Association of Governments. 2001. Bingham Cienega Source Water Study: Final Project Report. Tucson: Pima Association of Governments. p. 4

[105] Supra note 103

result, however, all of the team members needed to understand the project design and their roles in that design. They also found that continuity of the team was very important so that lessons learned in one stage of the project are carried on to the next stage.

One of the challenges that the project faced was ever escalating costs on project elements that were not considered when creating the initial budget. For example, the restoration team did not consider all of the costs associated with the irrigation lines, which resulted in unexpected expenditures. As a result, they recommend that a rigorous cost analysis be conducted prior to project implementation. Had they done this analysis in their project, they would have seen, for example, that it was cheaper to drill a well adjacent to the fields rather than depending on the existing well at the house site and irrigation lines from that well.

Management of non-native vegetation on the site was a significant problem. As a result, the restoration team recommends that weed management be a primary objective of any restoration project where invasive species are a concern. They also recommend that the project timeline be prolonged at least ten years in order to demonstrate success as well as to provide the flexibility to adapt to climactic conditions.[106]

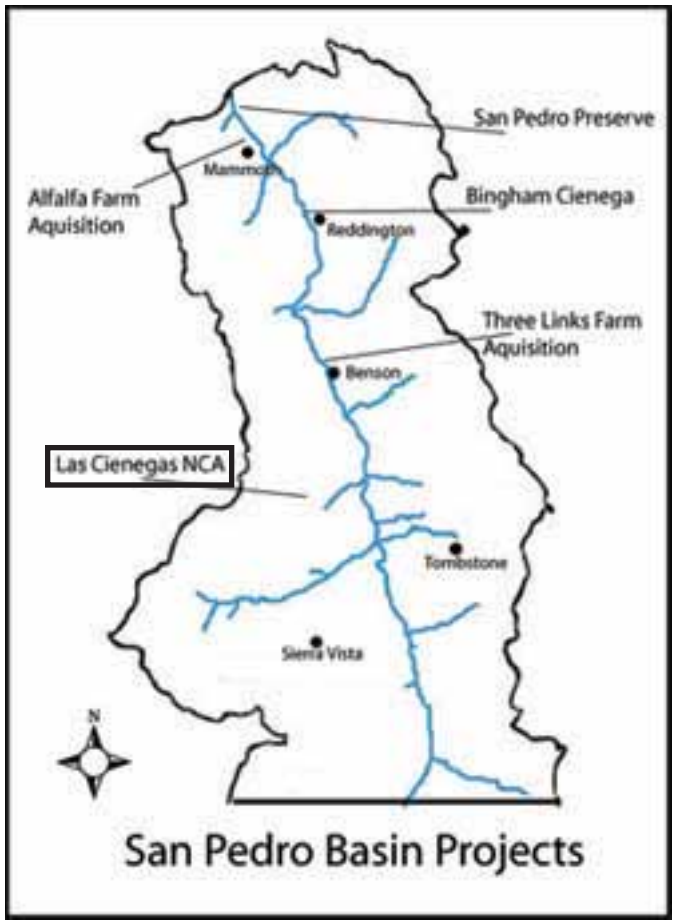
Drivers: Habitat restoration and floodplain protection.

[106] Supra note 102

Restoring farmland 1998
Bingham Cienega

Restored native grassland 2003
Bingham Cienega

Photos courtesy of Pima County
Regional Flood Control District



Las Cienegas National Conservation Area

Primary Information Source: 2002 Bureau of Land Management: Las Cienegas Resource Management Plan and Record of Decision.

Location and size: The Las Cienegas National Conservation Area is located 50 miles outside of Tucson between the Empire and Whetstone mountain ranges in Pima County. Two and one-half miles of creek were restored under an Arizona Water Protection Fund grant. (Much of the Las Cienegas National Conservation Area is also located in the Santa Cruz Basin.)

Primary Sponsor(s): Bureau of Land Management (BLM).

Other Sponsors: Arizona Water Protection Fund (AWPF).

History: "In 1988 BLM acquired, though a land exchange, 45,000 acres within the Empire Cienega, and Rose-tree ranches in northeast Santa Cruz County and southeast Pima County, Arizona. Later exchanges have brought in 4,000 more acres. These lands, which became the Empire-Cienega Resource Conservation Area, have extremely high social, cultural, and resource values for the local and national public. . . Two segments of Cienega Creek have been proposed to Congress for designation as scenic river segments in the Wild and Scenic Rivers System." [107] In September 1999 Congressman Jim Kolbe introduced legislation to create the Las Cienegas NCA. The area includes five of the rarest habitat types in the American Southwest: cottonwood willow riparian areas, cienegas, sacaton grasslands, semi desert grasslands, and mesquite bosques.

Planning Objectives: "Las Cienegas NCA was designated 'to conserve, protect, and enhance for the benefit and enjoyment of present and future generations the unique and nationally important aquatic, wildlife, vegetative, archaeological, paleontological, scientific, cave, cultural, historical, recreational, educational, scenic, rangeland, and riparian resources and values of the public lands . . . while allowing livestock grazing and recreation to continue in appropriate areas."[108] Among the stated planning area vision and goals are to: maintain and improve watershed health; maintain and restore native plant diversity and abundance; protect water quality; protect water quantity; and ensure sustainability and a complementary relationship of mineral resources to the protection

107 Tucson Field Office, Bureau of Land Management. 2002. *Proposed Las Cienegas Resource Management Plan and Final Environmental Impact Statement.* Tucson: Bureau of Land Management. p 1-5

108 Ibid 2-2

of water quality and quantity. [109] On BLM lands within the Empire-Cienega Planning Area, the objective is to achieve and maintain properly functioning condition on 100% of the riparian areas by 2005 and achieve and maintain potential natural vegetation community on 95% of the riparian areas by 2010.[110]

Current Phase: Maintenance

Phases: In September 1999, Congressman Jim Kolbe introduced legislation to create the Las Cienegas NCA. The NCA was designated by congress in December 2000. Soon after, the Environmental Impact Statement (EIS) process was initiated, and a final EIS and management plan was released in June 2002.

Recommended or Implemented Plan: "Alternative two emphasizes ecosystem management and the use of partnerships and collaboration during implementation to achieve desired resource conditions. Biannually, a Biological Planning Team would collaboratively evaluate monitoring data and issues relating to livestock grazing, recreation, and wildlife management for the primary goal of maintaining or achieving desired resource conditions. BLM would designate all public lands within the area as an area of critical environmental concern to protect sensitive riparian and wetland habitats. Livestock grazing would continue on public land allotments, but grazing operations would incorporate variable stocking rates and flexible rotations. BLM would designate two utility corridors and a corridor for the Arizona Trail and would close or restrict the use of some roads to provide a mix of motorized and non-motorized recreation while ensuring that desired resource conditions are met. Both mechanized and motorized vehicles would be restricted to designated routes."[111]

Monitoring/Management: "Riparian condition will be reassessed every five years at key riparian monitoring sties for segments currently in proper functioning condition. Segments that are not in proper function condition will be monitored every 2 – 5 years depending on the type of management change being implemented."[112]

Funding and Cost: Las Cienegas NCA is funded by the federal government for operations and maintenance. Restoration was conducted under a grant from the Arizona Water Protection Fund for $210,700.

Land Ownership: Most of the land within Las Cienegas NCA is owned by the federal government and managed by the BLM. The remaining land within the NCA is state- owned land.

Water: The Las Cienegas NCA encompasses most of the Upper Cienega Creek watershed, which is important for the Tucson area for flood control and aquifer recharge. The Upper Cienega Creek watershed has been estimated to provide 10% of the recharge to the Tucson Active Management Area. The maintenance of the undeveloped watershed in good condition protects Tucson from floods that might surpass the city's flood control channel design. If the basin were fully developed, flood peaks could increase by and estimated 25-50%.[113] Upper Cienega Creek below Gardner

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109 Ibid p. 2-5

[110] Ibid. p. 2-7

[111] Ibid p. xv

[112] Tucson Field Office, U.S. Bureau of Land Management. 2003. Approved Las Cienegas Resource Management Plan and Record of Decision. Tucson: U.S. Bureau of Land Management. p. 78

[113] Ibid 3-8

Canyon was designated as a Unique Water[114] by Arizona Department of Environmental Quality in early 2002.[115] Cienega Creek has a perennial flow for 8.3 miles and its tributaries Mattie Canyon and Empire Gulch have perennial flows for 1.1 and 0.9 miles respectively. About 18.5 miles of riparian habitat occur along Cienega Creek and its tributaries.

Pubic Outreach: "In January 1995, BLM brought together people from federal, state, and local agencies with an interest in the Sonoita area to discuss forming a partnership to work with the community on public land issues. . . In July 1995, the Sonoita Valley Planning Partnership held a community workshop to review the questionnaire results and discuss other Sonoita Valley issues." Working groups were formed and met monthly from August 1995 to February 1999. During this time, the group created and agreed upon the area of concern, objectives, and alternative management strategies and reached a consensus on a preferred series of management strategies. From March 1999 to February 2000 the Partnership met four times to develop a monitoring program for the Empire-Cienega Planning Area.

Challenges/Lessons Learned: "Participants state that moving the plan off paper and onto the ground is the biggest challenge, and that continuing to fund staffing and monitoring will remain a pressing need… BLM officials say that, as Tucson continues to grow, new pressures for recreational use will emerge." [116]

Drivers: Maintenance of an ecosystem and prevention of urban encroachment.

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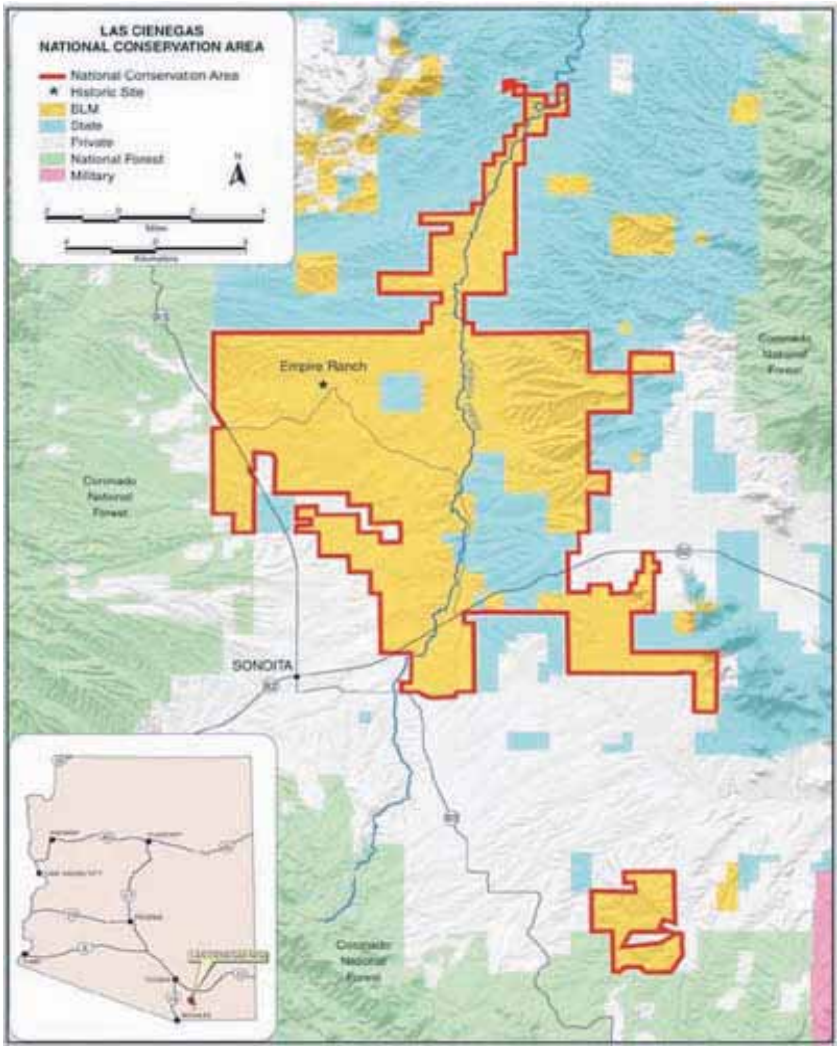
[114] ADEQ defines a unique water as: "A surface water classified as an outstanding state resource water under Arizona Administrative Code R18-11-112". ADEQ website http://azdeq.gov/environ/water/assessment/download/305-02/aadef.pdf

[115] Supra note 112

[116] Red Lodge Clearinghouse. 2005. Stories: Sonoita Valley Planning Partnership. http://www.redlodgeclearinghouse.org/stories/sonoita.html



Map of land ownership
Las Cienegas National NCA

Las Cienegas NCA

Las Cienegas NCA

Photos Courtesy of the
Bureau of Land Managment

San Pedro - Three Links Farm

Primary Information Source: Interview with Dave Harris from The Nature Conservancy and website review.

Location and Size: The Three Links Farm is located 15 miles north of Benson and contains 2,165 acres previously used for ranching and aquaculture.

Primary Sponsor(s): The Nature Conservancy (TNC).

Other Sponsors: Bureau of Land Management.

History: The San Pedro River flows from Mexico into the United States and is the last free-flowing river in Arizona. It is important for its migratory bird habitat as well as diversity of plants, insects, fish, reptiles, amphibians, and mammals. Human needs along the river, both for agriculture and development, have greatly decreased the river's flow and in many places the flow has disappeared entirely. It is estimated that the upper portion of the basin in the U.S. alone had a 2.3 billion gallon groundwater deficit in the year 2000.[117] The Nature Conservancy has declared the San Pedro River as one of the "Last Great Places," a list of natural areas in the United States, Latin America, Caribbean and Pacific that contains concentrations of rare species and excellent examples of endangered terrestrial or aquatic ecosystems.[118] As part of their campaign to preserve the San Pedro and its environs they have purchased land both for the purpose of establishing preserves and to place conservation easements on the land and then resell it.

Planning Objectives: "The Nature Conservancy selects Last Great Places based on the best available scientific information. Selection criteria include: the vulnerability of the site, the threats to it, and the ability to lessen those threats and sustain the diversity of life. What's crucial in all cases is that the places are still healthy, functioning ecosystems, which makes their conservation possible. The overriding goal at these places is to protect their biological diversity."[119]

The Three Links Farm sits at the upstream end of the Lower San Pedro River basin. The Conservancy purchased the Farm in order to retire nearly 4,200 acre-feet per year of groundwater pumping. The land was subdivided into five parcels and a conservation easement placed on the properties. The five parcels range in size, and each has a right to pump groundwater. The total pumping allowed

[117] http://www.nature.org/initiatives/freshwater/work/sanpedroriver.html
[118] http://www.lastgreatplaces.org/
[119] http://www.lastgreatplaces.org/

by the five parcels is 300 acre-feet per year. Hydrological modeling has shown that this reduction in groundwater pumping will benefit twenty miles of river with increased base flows and healthier riparian vegetation.

The conservation easement placed on the property also contains stipulations for further sub-division of the property, which allow for each parcel to be split one more time. The Nature Conservancy retains the right to approve the parcel sub-division. TNC also retains the right to approve site plans for development of the properties.

Current Phase: 2,100 feet of exclusion fence have been installed around the riparian area at Three Links Farm. Three of the five parcels have already been sold to private land owners. Monitoring and management of the riparian zone and fencing is continuing as well as monitoring of well pump rates to ensure that the easement allotments are not exceeded.

TNC is currently working with the U.S. Bureau of Reclamation and Salt River Project to secure the 4,200 acre-feet per year of groundwater that was retired from the land and maintain it as instream flow.

Phases: TNC purchased the land in 2003 and erected an exclusion fence around the riparian management zone. Revegetation of the riparian corridor was then conducted. A conservation easement was placed on the riparian management zone and adjacent land. The land was then subdivided into 5 parcels and marketed to the private sector. After selling the properties, the Nature Conservancy hopes to break even on their costs to acquire and rehabilitate the land as well as the costs incurred to establish the conservation easement.

Recommended or Implemented Plan: See phases.

Monitoring/Management: Monitoring of the riparian management zone includes well monitoring, transects across river, instream flow quality and quantity, habitat quality, wildlife, and geomorphology. Instream flow measurements are taken annually during the summer to determine the extent of "wet" water in the river. [120]

Funding and Cost: The Nature Conservancy used internal funding to acquire the land at a cost of $2,770,000. The total budget for the project was $4 million and included a grant from ADEQ of $130,000 for exclusionary fencing. The Nature Conservancy hopes to recoup all costs involved in the project by selling the property off in parcels.

Land Ownership: The Nature Conservancy. (Ownership the conservation easement on 2/3 of the property has been sold to BOR as part of the arrangement to secure instream water rights. The rest of the land will or has been sold to private land owners.)

Water: Protection of instream flows in the San Pedro River was the main objective of this project. The farming and ranching practices previously on the land used approximately 4,500 acre-ft of groundwater per year. The principle goal of the project was to extinguish this pumping and protect the water as an instream flow right. Some irrigation was used initially to establish native grasses and forbs along the river corridor during the first years after acquisition of the land.

A conservation easement was placed on 2/3 of the property and sold to the Bureau of Reclamation. Forty-two hundred acre-feet of groundwater pumping rights were included in the easement as well as some of the development rights and land use rights of the property. The sale of land to BOR is part of a larger plan to secure the water as an instream flow right. State law requires a state agency

[120] Harris, David (TNC- Director of Land and Water Protection) (2006) January. Interview with author (Schwarz).

with a property interest and the means to control use of the property in order to secure a water right as instream flow. The Nature Conservancy, BOR, and SRP have partnered to try to meet the requirements for severing water rights from a piece of property and securing them as instream flow. This process has never been completed before and may take several years to finish.[121]

Pubic Outreach: In the spring of 2003, The Nature Conservancy held an open house on the property to explain their and fully disclose the future plans for the property. All of the local residents were invited and allowed to ask any questions they had about the plan. The project has also been featured in a number of local and national newspaper and magazine articles.[122]

Challenges/Lessons Learned: Funding was a long and difficult process which took more than five years. Dedicating one person to be in charge of the project and ensure that it continued to move forward was instrumental in achieving success.

Projects like this one represent small successes to protect riparian habitat. However, these successes are always vulnerable and can be completely undone until all of the upstream property is protected. A proposed subdivision upstream of the Three Links Farm currently threatens the progress made by this project and others.[123]

Drivers: Reduce or eliminate groundwater pumping in order to maintain flows in the San Pedro River.

[121] Ibid.
[122] Ibid.
[123] Ibid.

San Pedro - Three Links Farm

San Pedro River through the property
San Pedro- Three Links Farm

Grasslands
San Pedro- Three Links Farm

All photos courtesy of
The Nature Conservancy

San Pedro Preserve

Primary Information Source: 1997 Arizona Water Protection Fund (AWPF) Application, 2000 AZWPF Award Amendment, 2003 Nature Conservancy-San Pedro Preserve Riparian Habitat Restoration Project Final Report, and 2001 AWPF Progress Reports.

Location and Size: Three river miles outside of Dudleyville in Pinal County. The restoration area is 850 acres.

Primary Sponsor(s): The Nature Conservancy (TNC).

Other Sponsors: Arizona Water Protection Fund and U.S. Bureau of Reclamation.

History: The San Pedro River Preserve was established by The Nature Conservancy in 1997 with funds from the Bureau of Reclamation for the mitigation of willow flycatcher habitat. The BOR provided these funds to mitigate impacts from the modification of Roosevelt Dam, which inundated willow flycatcher habitat. The area contains Sonoran desert scrub, river terraces, and primary floodplain on the San Pedro River. The uplands and terraces had been substantially modified for agricultural and aquaculture uses. A flood in 1993 severely damaged aquaculture ponds and the eroding banks in these areas created an unstable river shoreline.

For most of its history, the property was operated as a small livestock operation. The prior owners acquired the ranch in 1963 and operated it as the Sal Cattle Company from 1967 to about 1987. When cattle operations ceased, about 40 acres of bottomlands were converted to aquaculture ponds for production of channel catfish, large mouthed bass, and other exotic game fish. Aquaculture, pecan, and alfalfa cropping continued until early 1993 when a flood destroyed 15 acres of the orchard and many ponds. All but two ponds were allowed to dry up and the alfalfa operations ceased.[124]

Planning Objectives: The overall objective of the San Pedro Preserve is to protect and enhance willow flycatcher habitat. To this end, the restoration plan included: protect and enhance existing riparian forest habitat; restore native grassland communities on the river slopes and terraces; maintain these communities through a program of prescribed burning; stabilize banks and reestablish native riparian forest in areas where the old aquaculture ponds created unstable shorelines; and develop and demonstrate agricultural techniques for use in large scale habitat restoration.[125]

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[124] The Nature Conservancy. (1997) Application to Arizona Water Protection Fund, San Pedro River Preserve Riparian Habitat Restoration Project. Tucson: TNC.

[125] Ibid.

Current Phase: Monitoring and maintenance are the major activities proceeding on the property at this time. Continuous fence maintenance is required to maintain exclusion of cattle and unauthorized use (predominantly ATV's). The Nature Conservancy is also actively trying to manage invasive and non-native species on the property by depleting the seed bank within the soil. By successively irrigating the area until weeds germinate and then tilling them under before they go to seed, TNC hopes to eventually deplete the soil of its weed bank.[126] It is anticipated that this process will take several years. The AWPF grant was complete in July 2002.

Phases: Phases of the project included: draft revegetation and monitoring plans (Nov 2000); construct groundwater piezometers, conduct groundwater level monitoring, contour mapping, and install flow meters (Nov 1998 - May 2000); conduct groundwater flow modeling; fluvial geomorphic characterization study (May 2002); plant agricultural research plots (Nov1998 – May 2002); grade and restore ponds (Nov 99 – May 02); revegetate pond areas (Nov 2001); revegetate stream banks (Nov 2001); construct and maintain preserve fencing (Nov 98 – May 02); and photo point, floodplain, and vegetation monitoring (Nov 98 – Nov 02).[127]

Recommended or Implemented Plan: Restoration began with the installation of an ungulate exclusion fence to keep cattle and other unauthorized users out of the property. The fence was completed in 1999, and revegetation efforts began shortly after. Restoration planting zones were based on depth to groundwater. To gather information on hydrologic conditions, TNC installed piezometers, monitoring wells, flow meters, and stream flow monitoring transects. The information was then used to create a depth to groundwater map that was overlaid on a detailed contour map of the site. Restoration planning then proceeded based on the depth to groundwater in a given area.[128]

Restoration of abandoned agricultural fields and ponds consisted initially of repeated forced germination of weed seeds, tilling under of weeds, and drilling native seeds into tilled soil. Irrigation was used to supplement natural rains until vegetation was established.[129]

Monitoring/Management: "Monitoring will be done every fall for a minimum of three years beginning with the first fall after restoration sites have been planted. Approximately 10-15 permanent transects per site will be established perpendicular to the hydrological gradient using stratified random sampling. Plant species will be recorded at set intervals along each transect using the point intercept method, whereby the identity of the plant(s) intercepting a vertical line is recorded. This information can then be converted to percent cover. Monitoring will continue until the outcome of the restoration can be determined from the data collected and therefore may extend beyond the three-year minimum."[130]

Funding and Cost: Funding for this project came from the Central Arizona Project (CAP) Modified Roosevelt Dam under the authority of the Fish and Wildlife Coordination Act and the result of a Section 7 ESA consultation. Bureau of Reclamation funding totaled $4,422,804.00.

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[126] Harris, David (TNC- Director of Land and Water Protection). (2006) January. Interview with author (Schwarz).

[127] Arizona Water Protection Fund. (2000) Arizona Water Protection Fund Grant Award Contract Amendment No. 97-044 WPF-01. Phoenix: Arizona Department of Water Resources. pp. 3-13

[128] Harris, David and J. Douglas Sprouse. 2003. San Pedro Preserve Riparian Habitat Restoration Project Final Report Revised. Tucson: The Nature Conservancy. p 9

[129] Ibid.

[130] Ibid.

An "endowment" has also been established by BOR to fund management of the Preserve in perpetuity. The endowment funds are to be used for management of the riparian area aimed at directly benefiting the willow flycatcher.

Land Ownership: The Nature Conservancy (TNC obtained a grant from BOR in 1996 to acquire the land.)

Water: Twenty-five hundred acre-feet of groundwater pumping were retired from the property which had been used for ranching, alfalfa, cotton, and aquaculture. The water right is still exercised by application of groundwater for weed eradication. Groundwater was also initially used to irrigate new plantings during the revegetation stage.

Prior to implementation of restoration extensive hydrologic analysis was conducted. This analysis allowed the sponsors to divide up the area based on depth to groundwater and revegetate accordingly. The three area classes were: depth to groundwater less than eight feet, between eight and sixteen feet, and greater than sixteen feet.

Since groundwater pumping has been all but eliminated on the property, increased flows have been observed in the river. Beavers have also returned to the area and are especially active at times of higher flow.

Pubic Outreach: The group Volunteers for Outdoor Arizona helped TNC by setting up production of seedlings in the greenhouse and planting them in the field.

Challenges/Lessons Learned: Willow flycatcher habitat creation was one of the major objectives of the project and numerous breeding pairs live on the site. A strong link was observed between the presence of beaver and the presence of willow flycatchers. Willow flycatchers prefer a very specific riparian habitat with high vertical diversity. Action by beavers continuously changes the characteristics of the riparian zone supporting the continued formation of ideal willow flycatcher habitat.[131]

One of the objectives of this project was to determine the best way to facilitate re-vegetation of Giant Sacaton through seeding in a field setting. In the test plots used for this project, the restoration team found that germination times vary but that if the seeds are irrigated; there is a fair rate of germination. The plot that fared the best was one that received a post seeding treatment of herbicide. It was also found, in this case, that applying mulch to the seedlings did not increase the cover of Sacaton. [132]

The most challenging aspect of this project was weed control and "is possibly the most significant factor influencing the relative success of any restoration project." The project team learned an important lesson in the preparation of soil and fields. They intended to prepare a seed bed using tractor drawn discs and conduct multiple irrigations followed by disking to kill germinating weeds. The idea was that they would deplete the soil weed seed bank and thus effectively control weed growth. Due to funding restrictions, they could only go through this process twice. They found that it was not adequate to resolve the weed problems and that it created a seed bed as well suited for weed germination as for native seed. A better alterative turned out to be the use of a Truax no till range drill that cuts a series of one centimeter deep furrows into which native seed is introduced, this process minimized weed seed germination by reducing soil disturbance.

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[131] Supra note 126

[132] Supra note 128

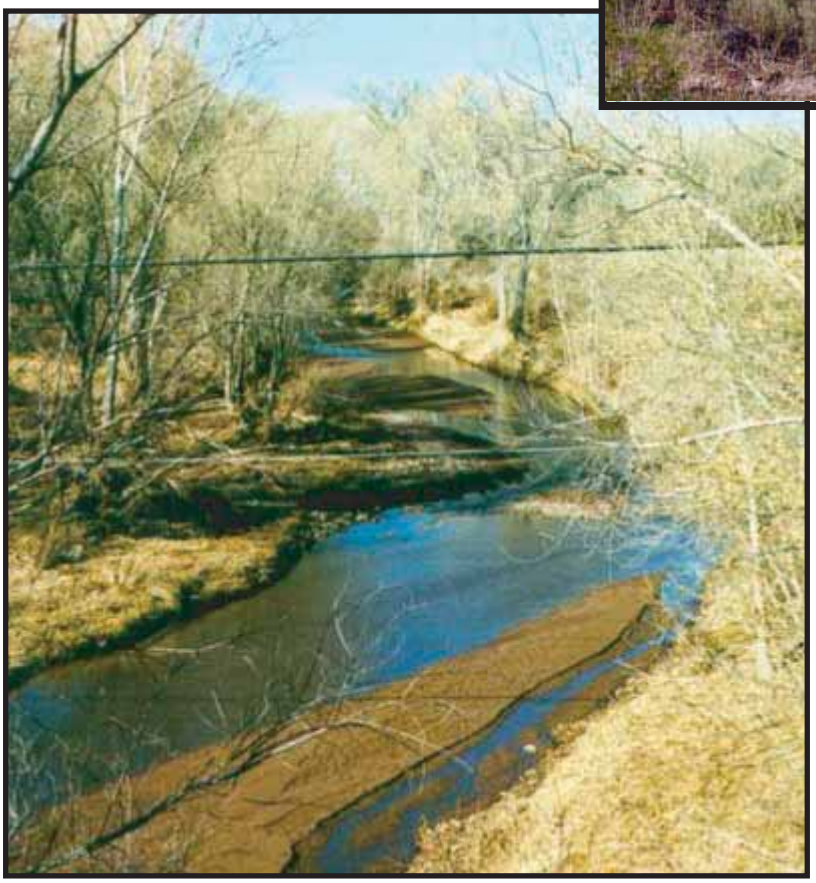
They have also found at this site (and others) that extended post germination irrigation favors non-native weeds over native grasses. However, longer-term monitoring may lead to other conclusions.[133] In general, the restoration team recommends that future restoration projects: "1) Don't depend on irrigation water in the desert country to make a successful project. Irrigation water is an unnatural commodity and its use brings unnatural results. Drought is natural but it is also a major obstacle to successful restoration of native riparian grasslands. Pray for rain at just the right time and don't expect to get it. 2) Be flexible and prepared to adaptively manage the process as new information becomes available or new conditions arise. And 3) Try to design so that the restoration process doesn't depend on a particular team of workers or equipment to accomplish the work as they will change many times."[134]

Drivers: Part of TNC campaign to restore and preserve San Pedro River watershed with an emphasis on willow flycatche habitat.

[133] Ibid. p 19
[134] Ibid. p 30

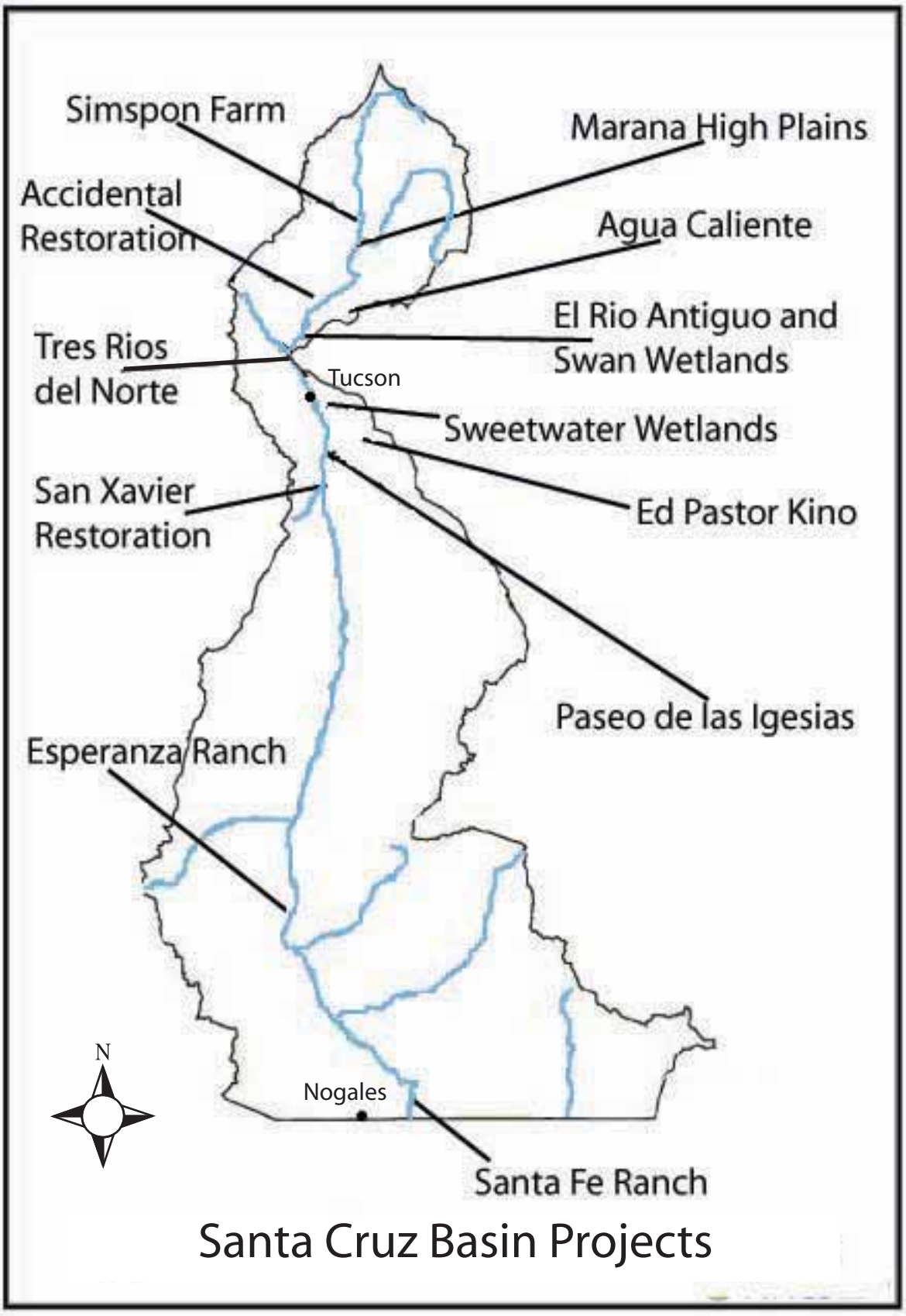
Aerial view of project site
San Pedro Preserve

San Pedro Preserve

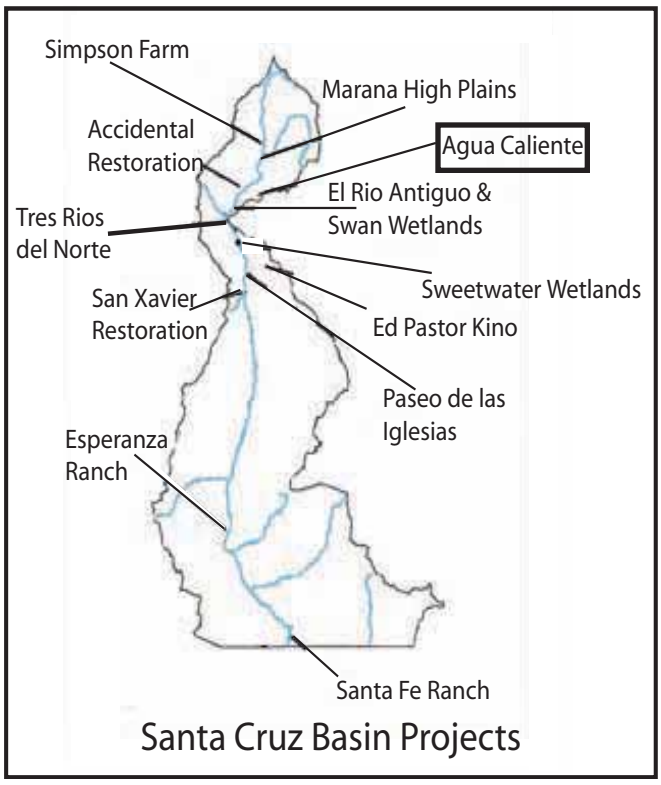


San Pedro River through preserve
San Pedro Preserve

Photos courtesy of AWPF



Santa Cruz Basin Projects



Agua Caliente Spring (Not Implemented)

Primary Information Source: 2002 U.S. Army Corps of Engineers Detailed Project Report.

Location and Size:: Roy P. Drachman Agua Caliente Regional Park 12325 E. Roger Road, Pima County, Tucson; Northeast corner of the Tucson Basin at the foot of the Santa Catalina Mountains. The site is 101 acres.

Primary Sponsor(s): Pima County Regional Flood Control District and U.S. Army Corps of Engineers.

Other Sponsors: Pima County Natural Resources, Parks, and Recreation Department.

History: From 1935 to the 1970's, the project area was utilized for ranching and farming (orchards and alfalfa fields). In the 1970's through mid 1980's, a development company planned to build lake-side homes, but the idea was never implemented. In 1985, Pima County Parks and Recreation purchased the property and opened the park to the public, which was named after Roy P. Drachman Sr., who donated $200,000 for the park.[136]

Planning Objectives: "Improve general ecosystem function; Increase the diversity of native vegetation structure and cover; Create habitat capable of supporting numerous rare native aquatic fish, amphibians, and reptiles; Restore the natural structure and function of the spring over at least a portion of the Park; Improve habitat for local native plant and animal species such as riparian birds; Create educational and recreational opportunities that improve public enjoyment of the Park; Facilitate a deeper public understanding of the plight of native aquatic species and their habitats in the southwest; Increase awareness of the impacts of non-indigenous species; and Improve appreciation of biological diversity."[137]

Current Phase: Due to lack of public support this project did not move beyond the planning stage.

Phases: Reconnaissance phase initiated in February 2000 and completed December 2000. Feasibility initiated September 2001. Final Detailed Project Report (DPR) issued on October 15, 2002.

Recommended or Implemented Plan: The alternative that was chosen for implementation includes the elimination of ponds two and three, the improvement of pond one, and the creation of a Cienega. The entire upper park area, including the open water in the upper pond and the lawn

136 Pima County. (2005) Agua Caliente Ranch. http://www.dot.co.pima.az.us/flood/AguaC/ranch/index.html
137 U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2002) Agua Caliente Spring Aquatic Ecosystem: Detailed Project Report. Los Angeles: U.S. Army Corps of Engineers. p. 2-3

and picnic facilities, will be maintained. The plan was considered to be the "best buy," the most cost effective alternative. [138]

Monitoring/Management: Project did not reach the monitoring and management phase because Pima County decided not to proceed with restoration. Flows from the spring, however, will continue to be monitored.

Funding and Cost: Funding and authority for this project came from Section 206 - Aquatic Ecosystem Restoration. Total estimated costs if the project had been implemented were $5.15 million, including the value of the land purchased to create the park.[139]

Land Ownership: Pima County.

Water: Agua Caliente is a thermal spring that has been impounded in a series of ponds.[140] Restoration of this ecosystem would have been achieved by allowing the water from the spring to flow naturally with fewer pond impoundments. Two of the three impoundments would have been removed and water from the spring would flow down a main channel and several secondary channels. The secondary channels would flow into the cienega and hummock habitats. The USACE anticipated that the restoration plan would reduce infiltrative and evaporative water losses for the area, and re-establish sites for aquatic and riparian plants and animals that have disappeared or are in the process of disappearing.

The channels were designed to maintain the minimum water depths required to support fish populations even during very low-flow periods and to convey large flows up to a 100 year event. Initially, it would have been required to divert water from the stream to irrigate emergent vegetation. There was no supplemental water requirement for this project. All water required to establish and support the restored vegetation would have been supplied by the spring as it meandered through the new riparian environment.

Pubic Outreach: Public outreach on this project was extensive.[141] A Citizen's Advisory Committee formed to communicate ideas between citizens, sponsors, and USACE. There were three public meetings by USACE and Sponsors (January, April, and August of 2002). Major concerns expressed at these meetings included: "limited future public access and recreation opportunities in the Park if restoration is to proceed; loss of Park aesthetics caused by conversion of open water habitats to native cienega-type wetlands; lack of public input into planning process; effect of system alteration on species currently using the Park; risk of increased mosquito populations with creation of native habitats and removal of non-native fishes; and lack of adequate spring discharge to maintain streams that can support the target habitats/species."[142]

Challenges/Lessons Learned: This project did not move out of the planning stage because there was not enough public support for it. The project sponsors believe that the project would have benefited from a much slower public input process. Public scoping and alternatives analysis was conducted for this project over the course of one year, at the end of which the community had to approve one of the alternatives. This timeline proved to be much too quick for the affected

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[138] Ibid. p. 3-60

[139] Ibid. Appendix A

[140] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2002) Agua Caliente Spring Aquatic Ecosystem: Detailed Project Report. Los Angeles: U.S. Army Corps of Engineers.

[141] Ibid.

[142] Ibid.

community. A lesson learned from this is the value of early assessments of the community's concerns and wants before presenting them with alternatives to either accept or reject.

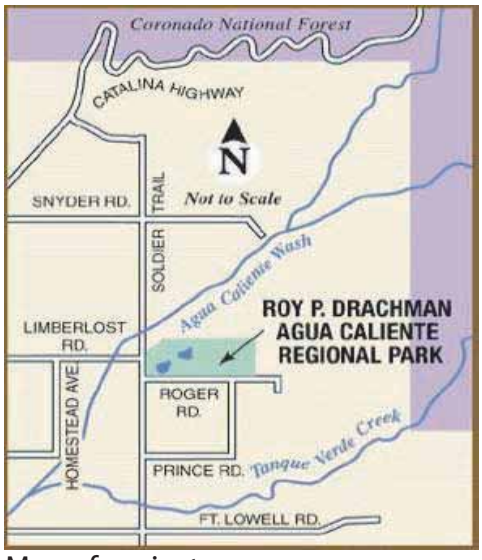
Another challenge created by the timing of the project was that the ecosystem appeared to be functioning fine at the time the scoping process for restoration was approved. The general public did not see the biological losses that were occurring because they had not reached a critical point. In fact, the summer after the restoration project was rejected, low stream flows caused two of the ponds to dry up. The project sponsors note that in retrospect it would have been better to initiate planning and public input in response to the drying ponds rather than beginning the project at a time when outwardly the ecosystem appeared to be fine.[143]

Drivers: Restoration for public use and enjoyment as well as to provide habitat for several priority species in the Sonoran Desert Conservation Plan.

[143] Pima Association of Governments. (2004) Riparian Areas: Restoration and Management in Eastern Pima County. Watershed Forum December 3, 2003. p. 6.

Agua Caliente pond in 2002
Agua Caliente Spring

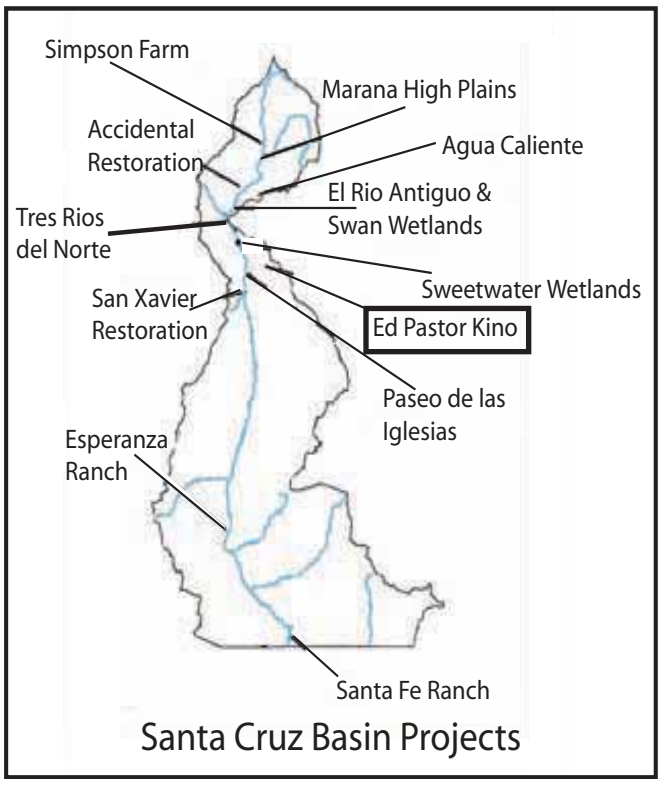
Agua Caliente pond in 2004
Agua Caliente Spring



Map of project area
Agua Caliente Spring

Mesquite bosque with trail
Agua Caliente Spring

Photos courtesy of Jennifer Jones and USACE



Ed Pastor Kino Environmental Restoration Project

Primary Information Source: 1998 US Army Corps of Engineers Final Ecosystem Restoration Report.

Location and Size: Along Tucson Diversion Channel, Pima County, Tucson; north of Ajo Way and west of Country Club Road. Project created 28 acres of riparian and open water and 21 acres of grassland, mesquite bosque and marsh in a 120 acre area.

Primary Sponsor(s): Pima County Flood Control District (PCFCD) and United States Army Corps of Engineers (USACE).

Other Sponsors: Pima County Wastewater Management.

History: The Tucson (Ajo) Detention Basin was constructed in 1966 along the Tucson Diversion Channel. The USACE built the basin as a flood control element, which intercepted and reduced peak flows from the Tucson Arroyo and Railroad Wash drainage areas. Downstream, flows were released gradually into the Tucson Diversion Channel, which would then merge with the Julian Wash and down to the Santa Cruz River. The basin had a flat earthen bottom and levee with scrub trees and grasses along the edges. In 1981, the USACE and Pima County developed a master plan for the diversion channel called The Tucson Diversion Channel Recreation Development Program. The plan called for improving the recreational opportunities on the land. With the exception of the construction of Sam Lena Park in 1986, little progress was made on the master plan between 1981 and 1995.

The master plan was updated in 1995 to include multi-use trails from Sam Lena Park to I-19 and additional recreational facilities around the Ajo Detention Basin. In 1997, a baseball field and other public facilities (Kino Sports Complex) were constructed around the basin. Due to continued development in the area, the basin continued to take on more runoff and deteriorated aesthetically.[144]

Planning Objectives: The original planning objectives for the project included: restoration, water harvesting for the area of vegetation and the Kino Ball Fields, and flood control. The original plans also included a golf course which was subsequently removed from the plan.

The original planning objectives state: **"**Restore wetland and riparian vegetative communities representative of historical/optimal conditions in the region; restore habitats for target/beneficial fish and wildlife species; maximize the acreage of functional wetland habitat within limits of the golf course design; achieve an optimal mix of habitats that supports the greatest diversity of target/

[144] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. 1998. Tucson (Ajo) Detention Basin, Pima County, Arizona, Final Ecosystem Restoration Report. Los Angeles: U.S. Army Corps of Engineers.

beneficial species while promoting the principal fish and wildlife objective proposed by a restoration alternative (balancing of objectives); minimize disturbance-type impacts to restored wetlands from the adjacent golf course and from pedestrian traffic; restore wetlands to be ecologically resilient and self-sustaining; minimize potential from sediment and organic matter accumulation in restored wetlands (low maintenance design); protect restored wetlands from feral predation; design for and maintain adequate vector control in restored wetlands; enhance water quality of the reclaimed water source (i.e., water treatment function of restored wetlands); maintain the existing flood protection capacity of the Tucson (Ajo) Detention Basin; accommodate incidental recreational values (e.g., interpretive centers, wildlife viewing, education, and research)."[145]

Recommended or Implemented Plan: The area is designed with nine separate zones based on quantity and frequency of inundation with each zone given ample space so that wildlife appropriate to each can easily establish. The watercourse and pond edge zones, however, were lined or minimized in an effort to control mosquito populations. Ed Pastor Kino project included seven elements: riparian area stream courses and ponds, including four stream courses (labeled A-D), a deep pond and a series of in-line ponds; a reclaimed water system that conveys water to the project via the City of Tucson's reclaimed water system; on-site irrigation system; a re-circulation system; conveyance facilities; site security, made necessary by the use of reclaimed water and the steepness of the ponds banks; and additional amenities such as trails.[146]

Monitoring/Management: Pima County is responsible for the operation and maintenance of the site. The site is managed to achieve a series of objectives including: maintain the flood control capacity of the basin; maintain an ecosystem habitat; maximize the use of harvested storm water and minimize the use of reclaimed water; minimize the mosquito population; and maintain water quality.[147] Once restoration was complete, extensive testing of the basin, species counts, water quality monitoring, and vegetation analyses were conducted. The goal of this monitoring is to determine the viability of the design and to attempt a cost-benefit analysis.[148] Audubon Society is monitoring bird life. Arizona Game and Fish is monitoring the establishment of a Burrowing Owl population.

Current Phase: Operation and maintenance, construction was complete in 2002.

Phases: In early 1997, the Corps initiated a Preliminary Restoration Plan (PRP) to determine the feasibility of modifying the basin features for restoration of riparian habitat. An Ecosystem Restoration Report (ERR) followed and was approved in April 1998. Plans and Specifications were initiated in June 1998. Construction was awarded in July 2000. Modifications were completed in 2002 and the original facility was expanded to 141 acres: 50 acres of riparian area within the basin, including freshwater marsh and riparian habitat; twelve acres of wildlife and open water areas; and 38-acres of mesquite bosque and ephemeral grassland. Though a golf course was originally proposed, it was not implemented in the final plan.

Funding and Cost: Funding and authorization for this project came from the USACE Section 1135 of WRDA of 1986 - Project Modification for Improvement of the Environment Total cost

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[145] Ibid. p. 3-14

[146] Supra note 143.

[147] Supra note 144

[148] Bennett, Paul. (2000) "A New Friendlier Corps." Landscape Architecture Magazine. 01/00 Washington, D.C.

of this project was approximately $12 million.[149] Total construction award cost approximately $8,215,444. Water cost is estimated to be $265,000 a year.[150]

Land Ownership: The Basin is owned by Pima County and there is a small parcel adjacent owned by Pima County Regional Flood Control District.

Water: Project uses storm water runoff and reclaimed water. Reclaimed water will be provided by the City of Tucson and is intended to be under contract before the project can move forward. Total water demand is estimated to be 574 acre-feet per year.[151] The project provides the ability to harvest and store storm water as well as reclaimed water. The water harvested and stored in the basin is then used for irrigation and habitat creation within the redesigned basin as well as for irrigation at adjacent parks and sport facilities.[152]

Public Outreach: A school program was developed at a local elementary school, where students created a 9'x 9' model to present to the local community. Audubon has provided outreach, as has Pima County Natural Resources, Parks, and Recreation.

Public access to the site is limited; however, teachers are allowed to take classes into the riparian areas.[153] The site is also being used by Tucson Audubon for Saturday morning bird walks, and a jogging trail is open to the public that goes around the basin.

Challenges/Lessons Learned: One challenge of this project was working through the regulatory issues surrounding the commingling of reclaimed water with storm water. At the present time (2005) changes in regulatory approaches to this issue continue. In addition the use of a "Waters of the U.S." posed challenging regulatory hurdles. Several permits were required for activity within the basin, including:

- Arizona Pollutant Discharge Elimination System (AZPDES) permit (Including a Management Plan as well as current testing requirements).
- An Arizona Aquifer Protection Permit (APP) (Including a Emergency Response Plan that necessitated training of personnel within several city and county agencies)
- A 401/404 permit for upkeep and reconstruction of the basin after flood events
- An Arizona Reclaimed Water Reuse permit for areas needing irrigation outside the basin
- A Pima County Industrial Wastewater Permit for any wet well sediment disposed of within the wastewater conveyance system
- Arizona Water Rights appropriation (for storm water harvesting and use)

[149] Bennett, Paul. 2003. "The Ed Pastor Kino Environmental Restoration Project: How the Use of Reclaimed Water and Harvested Storm water Have Created an Environmental Restoration Benefit." Paper presented at the 2003 Water Use Symposium.

[150] This estimate assumes a cost of $462 per acre-foot. The water will be supplied by the Tucson Water Before the construction phase begins a signed interagency agreement between Pima County and City of Tucson will be required to assure the cost of the water and water availability for the life of the project.
U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (1998) Tucson (Ajo) Detention Basin, Pima County, Arizona, Final Ecosystem Restoration Report. Los Angeles: U.S. Army Corps of Engineers. p. 5-22

[151] Ibid.

[152] Bennett, Paul. (2003) "The Ed Pastor Kino Environmental Restoration Project: How the Use of Reclaimed Water and Harvested Storm water have Created an Environmental Restoration Benefit." Paper presented at the 2003 Water Use Symposium.

[153] Bennett, Paul. (2000) "A New Friendlier Corps." Landscape Architecture Magazine. 01/00 Washington, D.C.

- Fifra and TSCA regulations on the application of pesticides within “a Waters of the US”
- Meeting the retention of FEMA 100-year flood events

Prior to the project, there were a number of problems with mosquitoes. Many design features such as lined channels and water recirculation strategies to vary elevations seem to be working to minimize the problem. Mosquito monitoring and management is still needed, but one of the lessons learned is that design can reduce the problem.

Vandalism of irrigation devices and of the burrowing owl nests has also been a problem in this urban environment.

Drivers: The main impetus for the project was to create riparian areas and address existing mosquito issues while maintaining flood storage. Water harvesting for the adjacent park use was a benefit. The site is now being used to establish burrowing owls displaced by development in and around Phoenix.[154]

[154] Julia Fonseca (Pima County Flood Control District) (2005) November. Review comments on draft report of this study.

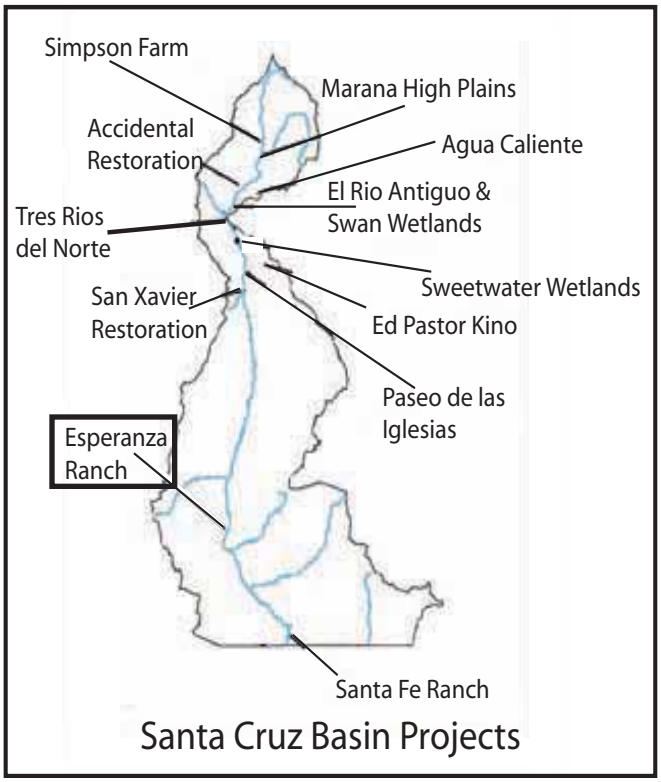
View of the deep pond
Ed Pastor Kino Environmental Restoration Project

Map of Kino Wetlands and vicinity
Ed Pastor Kino Environmental Restoration Project

Example of an inline pond
Ed Pastor Kino Environmental Restoration Project

Full view of Ed Pastor Kino Wetlands
Ed Pastor Kino Environmental Restoration Project

Photos by Jennifer Jones



Esperanza Ranch Riparian Restoration Project

Primary Information Source: 2004 Arizona Water Protection Fund grant application.

Location and Size: Santa Cruz County off of the I-19 at Agua Linda Road. The restoration project is on a 300-acre conservation easement. The project includes both sides of the Santa Cruz River for one mile and the land on the west side of the channel for another mile, one-half of a mile of the Chivas Wash and a 10-acre pond area.

Primary Sponsor(s): Tucson Audubon Society.

History: The Esperanza ranch has been the site of human endeavors since at least 1956 and has undergone degradation due to grazing, which caused erosion and allowed invasive plants to thrive. The flow of the Santa Cruz River is intermittent through the reach that will be restored. Most of the year the flow comes from effluent released from Nogales International Wastewater Treatment Plant about 20 miles upstream. A pond in the restoration area was created by sand and gravel removal during construction of Interstate 19 and has cottonwood and willow already growing on its banks.

Planning Objectives: "The goals of restoration are to increase the diversity, density and sustainability of riparian habitat for the benefit of birds and other wildlife; engage the local and regional community in site activities and develop a long-range strategy for stewardship of the site." The objectives for the site include conducting site planning; constructing a fence around the site to exclude cattle; increasing native plants through planting and seeding, stabilizing erosion-prone areas; monitoring site conditions to document changes; engaging the community in activities to raise awareness about riparian habitat; and establishing both a plan for long-term stewardship and an endowment to carryout the plan.[155]

Current Phase: The project began in December 2004. The planning stage is almost complete and restoration will begin in the spring of 2006 once the ungulate proof fencing is complete.[156] The project scheduled to be complete in 2008.

Phases: The schedule for design and implementation of the project includes: preparing and submitting plans including a fencing plan (January 2005); plans detailing restoration and revegetation, monitoring, and outreach (January 2006); and a site assessment report (January 2006). Reports on implemented work addressing these same topics will be prepared annually, and

[155] Tucson Audubon Society. (2004) *Application to Arizona Water Protection Fund for Riparian Restoration on Esperanza Ranch.* Tucson: Tucson Audubon Society. p. 6

[156] Phillips, Ann Audrey. (2005) Tucson Audubon Society Esperanza Ranch Riparian Restoration Project: Fencing Workplan. Tucson: Tucson Audubon Society. p. 1

a site stewardship plan will be prepared in 2007.

Recommended or Implemented Plan: The first stage of work on this project is the installation of fencing around the 27,226 foot perimeter of the lands designated under the conservation easement. Once the fence is in place new vegetation will be planted by seeding and planting around the river channel, in the ponds, along Chivas Wash, and in the broad floodplain west of the river. Planting techniques will include pole planting of cottonwoods and willow, seedling planting of riparian and uplands species, and seeding of the broad landscape. All planting will be placed in water harvesting basins and swales to concentrate rainwater around the plants until they can access nearby elevated soil moisture. Erosion around the pond perimeter and east end of Chivas Wash will be addressed through a combination of water harvesting and planting up gradient of erosion, and soil stabilization at the erosion points. Non-native species will be removed and suppressed by cutting and applying herbicides. An endowment will be establishing with contributions from the property owner and Tucson Audubon Society to fund long-term management of the site.[157]

Monitoring/Management: Monitoring will consist of observing habitat conditions, seedling survivorship, avian use, wildlife use, and photo monitoring. Photo monitoring will be used to document conditions before, during, and after restoration efforts. According to the fencing plan, the fencing will be monitored monthly throughout the project period, within 24 hours of significant river flows that could take out river crossing fencing, and within 24 hours of seeing vehicles, cows, or people within the conservation easement who are not supposed to be present.[158] The agreement with the AWPF indicates that the project sponsors must maintain the fence for 15 years after installation and operate and maintain the revegetation site for a minimum of 20 years. [159] A conservation easement has been established on the property to protect the riparian area from development and encroachment in perpetuity.

Funding and Cost: Funding for this project includes $279,411 from AWPF, $135,000 from Devon Energy Corporation (to establish an endowment for long-term stewardship), in-kind contributions of $6,500 from Stewart Loew and the Sky Island Alliance, and matching and in-kind contributions of $151,270 from the Tucson Audubon Society.

Land Ownership: At the time of the grant application, Devon Energy Corporation of Oklahoma City, OK owned the Esperanza Ranch. The 800-acre Esperanza Ranch property, including the 300-acre conservation easement portion, is now owned by Mr. James Olson of Green Valley, Arizona.

Water: At the restoration site, the Santa Cruz River flow is intermittent, consisting of effluent/storm water flow and base flow when the shallow water table is elevated. [160] No water will be pumped from groundwater wells nor diverted from surface water supplies at the Esperanza Ranch site to use in restoration activities due to an agreement entered into by previous owners that restricts pumpage here (the FICO Agreement). This provides an opportunity to conduct restoration activities using harvested rainwater as the sole water source for seedlings planted outside the river corridor.

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[157] Tucson Audubon Society. (2004) Application to Arizona Water Protection Fund for Riparian Restoration on Esperanza Ranch. Tucson: Tucson Audubon Society. p. 6

[158] Phillips, Ann Audrey. (2005) Tucson Audubon Society Esperanza Ranch Riparian Restoration Project: Fencing Workplan. Tucson: Tucson Audubon Society. p. 6

[159] Arizona Water Protection Fund. (2004) Arizona Water Protection Fund Operation and Maintenance Agreement, Agreement No. 05-132 WPF-OM. Phoenix: Arizona Department of Water Resources. p. 9

[160] Tucson Audubon Society. (2004) Application to Arizona Water Protection Fund for Riparian Restoration on Esperanza Ranch. Tucson: Tucson Audubon Society. p. 6

The project does, however, take advantage of the effluent flows coming from the Nogales International Wastewater Treatment Plant. Riparian species will be planted along the river bed that will be sustained by this manmade flow. There is no contract or agreement in place which secures these flows and guarantees that they will continue to be delivered. The project is designed to be resilient and dynamic so that if the effluent flows are removed from the ecosystem, the vegetation will shift to more meso-riparian species but will survive with altered characteristics.[161]

Pubic Outreach: The project will include extensive public outreach that will be outlined in their public outreach plan. Public involvement will include volunteer workdays, tours, and birding field trips at the site as well as public lectures and community participation off-site.[162]

Lessons Learned/Challenges: None noted. Project is in early stages.

Drivers: Increase and restore habitat, then protect the area in perpetuity.

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[161] Phillips, Ann (Tucson Audubon Society). (2005) November 15. Stakeholder meeting to discuss draft report of this study.

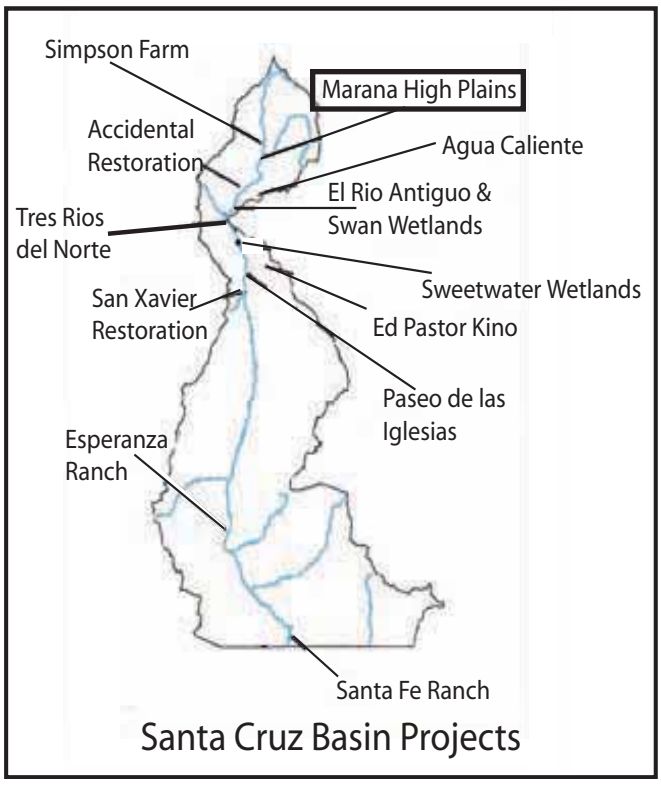
[162] Tucson Audubon Society. (2004) Application to Arizona Water Protection Fund for Riparian Restoration on Esperanza Ranch. Tucson: Tucson Audubon Society. p 13

Aerial view of floodplain
Esperanza Ranch

River cooridor
Esperanza Ranch

Grassland
Esperanza Ranch

Photos courtesy of Ann Phillips
and the Nature Conservancy



Marana High Plains Effluent Recharge Project

Primary Information Source: 1998 Biological Studies: High Plains Effluent Recharge Project conducted by Entranco, 2005 personal interview with David Scalero.

Location and Size: Near the Santa Cruz River in the town of Marana, off of Moore and Sanders Road in Pima County. The project site includes 18 acres of created riparian habitat along 1.2 miles of an oxbow channel of the Santa Cruz River.

Primary Sponsor(s): Pima County Regional Flood Control District (PCRFCD).

Other Sponsors: Bureau of Reclamation (BOR), Town of Marana, Cortaro-Marana Irrigation District, Mr. Robert Honea, and Arizona Water Protection Fund (AWPF).

History: The Marana High Plains Effluent project area historically had an ephemeral flow, and it is estimated that groundwater depth was never sufficient to support extensive stands of riparian vegetation. Records from a well near the High Plains site indicate groundwater depth of over 180 feet below the surface in 1939. Extensive livestock grazing in this area is also a contributing factor to the historical lack of vegetation.[163]

The Marana High Plains Recharge project began in 1995. The Bureau of Reclamation had secured funding for a demonstration recharge project. Originally, the Rillito River Recharge project had been selected as the demonstration project site. However, the project failed to gain political support and was never undertaken. Shortly afterward, the Marana High Plains Recharge project was selected and the BOR funding was allocated to it.[164]

Planning Objectives: The Marana High Plains project is a multipurpose effort. The objectives for the project include: evaluate infiltration rates in basins having side slopes vegetated with emergent plants and riparian trees; evaluate infiltration rates in basins fully vegetated with native grasses; revegetate the area outside recharge basins with plants that will improve wildlife habitat value and could survive if recharge activities cease; characterize wildlife, aquatic macro-invertebrates, and vegetative resources associated with an important effluent-dominated stream; identify and monitor any biological effects resulting from the establishment of habitat types that are now rare to the area; and provide trails, descriptive literature, and interpretive signs that describe the pilot project.[165]

Current Phase: The pilot project phase ended in March 2005. The PCRFCD has received a new permit for operation of the facility through 2007. Monitoring and maintenance is ongoing and the

[163] Entranco. (1998) Biological Studies: High Plains Effluent Recharge Project Marana, Pima County, Arizona. Tucson: Entranco

[164] Scalero, David. (2005) July 26. Personal communication with Author (Mott Lacroix).

[165] Supra note 163

PCRFCD has revegetated some portions of the site.[166]

Phases: Although the grant was provided for the Marana High Plains project in 1996, problems with staffing and permitting delayed the project initiation until 2000. As part of the AWPF grant, the PCRFCD: developed a facility concept design; prepared construction plans, vegetation plans, and a monitoring plan (July 00); revegetated the area (Dec. 2001); and developed educational interpretive displays and final trail design plans (Dec. 2001). Construction of the recharge basins began in March 2001 and was completed in May 2002. The pilot phase lasted for two and a half years and ended in March 2005.

Recommended or Implemented Plan: As constructed, the facility consists of one settling basin and four spreading basins covering a total of 4.2 acres. The facility contains five major units: influent lift station, equalization basin, distribution and metering system, recharge basins, and drip irrigation system for the riparian area. The revegetation proceeded through irrigation of the revegetation area and a combination of planting mature species as well as vegetation starts (*e.g.*, saplings and seedlings). [167]

Monitoring/Management: Monitoring of the recharge project and riparian restoration includes observing the daily inflows into project; bi-weekly recording of water levels recorded at on-site wells and monthly monitoring of off-site wells; monthly water quality sampling for nitrogen and quarterly for total metals and VOCs. [168] In addition, biological studies are being performed to monitor the diversity of vegetation species and increased canopy cover of vegetation at the recharge site. Biological studies are also attempting to determine the project's affect on surrounding terrestrial and aquatic wildlife. Biological monitoring consists of vegetation transects, sampling of aquatic algae and macro-invertebrates, butterfly observations, bird counts, reptile and amphibian transects, photo points, and incidental observations of mammals.[169] Maintenance consists of periodic scraping of vegetated basins to break up clogging layers and increase infiltration; pruning and weeding vegetation to facilitate maintenance of recharge equipment; repairs and recalibration of flow meters as needed; and periodic repair of diversion berm due to wash out from storm water runoff. In November 2002 a contract was entered into with BKW Farms, Inc. to perform the weekly operation and maintenance at the recharge facility, however, PCRFCD still performs the major repairs on site and is responsible for vegetation maintenance.[170]

Funding and Cost: Operation costs over the 2003 calendar year were approximately $28,000. A total of 277.39 acre-feet were recharged at the facility for a cost per acre-foot of recharge at $100. Bureau of Reclamation committed $600,000 as of 1995 for recharge aspect and a grant from AWPF provided $149,973 for riparian restoration.

Land Ownership: State of Arizona. The PCRFCD has a lease for the land through May 2, 2011.

Water: Water for the recharge aspect of the project is delivered via a remnant channel from the Santa Cruz River. A berm is used to divert some of the effluent from the main channel of the Santa Cruz to the site. The water source is effluent discharged from the Roger Road and the Ina Road wastewater treatment plants. The effluent flows down the channel about 1.2 miles before reaching

[166] Supra note 164

[167] Entranco. 1999. Marana High Plains Effluent Recharge Project Design Concept Report. Tucson: Entranco. p. 30.

[168] Pima County Regional Flood Control District. 2002. Project Summary Report Draft – June 2002 Marana High Plains Effluent Recharge Project. Tucson: Pima County Regional Flood Control District.

[169] Fonseca, Julia. 2005, November 17. Review comments on draft report of this study.

[170] Supra note 164

the recharge site. The effluent creates one of the densest riparian habitats on the Santa Cruz River as it flows to the recharge basin. Water is diverted pursuant to a surface water right with the Cortaro Marana irrigation district. [171] The PCRFCD has found that due to problems primarily with the berm used for water diversion and the pump used to move the water into the basins, they have only been able to recharge about 200-300 acre-feet per year.[172]

Pubic Outreach: As part of the project, trails were built around the area and a series of interpretive signs describing what the recharge process does, history of the Santa Cruz River area, and riparian vegetation were installed. The educational element was included in this project according to PCRFCD policy. The site is not currently open to the general public; however, a number of tours have been conducted. At this time the site gates are locked in order to prevent vandalism. The PCRFCD would like to have more visitor usage in the future and expect that visitors to the site will increase as the PCRFCD increases its outreach on the project. In addition, the town of Marana has discussed putting a park system through the area which would greatly increase the number of visitors to the site. [173]

Challenges/Lessons Learned: The Marana High Plains project faced a number of challenges associated with getting the water from the main channel of the Santa Cruz River to the project site. Perhaps most significantly, the berm used to divert water from the Santa Cruz River to the remnant channel is frequently washed out from flooding. The berm, as currently designed, cannot withstand flows of more than 500 cubic feet per second. Once the berm is washed out the PCRFCD must wait for the area to dry before they can rebuild it. During the monsoon and winter storms the PCRFCD is unable to repair the berm for months at a time because of successive storms which do not allow the needed time for drying. The PCRFCD has considered installing a French-drain[174] system to drain water away from the area to facilitate drying, and improve their ability to rebuild the berm. Another problem that has been encountered at the Marana High Plains site is the effectiveness of the pumps installed to move water from the channel into the recharge basins. Frequently these pumps cannot keep up with the volume of water coming into the system and therefore hinder the amount of water that can be recharged. Gravity-fed canals and weirs were initially considered; however, it was decided not to use this method because it would have been necessary to remove a large portion of riparian vegetation to construct the canals and weirs, and it was initially more expensive than the pumps.

The project also faced the dual challenge of staff turnover and sufficient staffing to devote the time necessary to the project. These problems made it difficult to move forward because every time a new person came onto the project they had to learn anew about how best to proceed. The situation was further complicated by the fact that this was PCRFCD's first recharge project and therefore there was no expertise in the agency for this type of work. Another institutional issue has been securing consultants to do the work on the site. The process for obtaining outside consultants can take months and so, because of staff time constraints, all of the work done on site was through existing contracts through Pima County. This has caused problems because the consultants used are not directly accountable to the project and often are not the best suited for the job. For example, the project has experienced a number of electrical problems and the electricians sent out by the

[171] Supra note 168

[172] Supra note 164

[173] Ibid

[174] A French drain is a gravity-fed trench filled with rocks, gravel, sand or other pervious material, designed to transmit water.

County are not necessarily experienced in repairs of the type of equipment that is on the Marana High Plains site.[175]

Drivers: Multi-purpose/multi-function project, intended to improve habitat for rare species in the area and to be used as a recreational and educational public facility. Funding was available for an artificial recharge project to compensate for depletion due to groundwater pumping in the Tucson area. Additionally, PCRFCD was interested in investigating whether a constructed recharge facility could create riparian benefits.

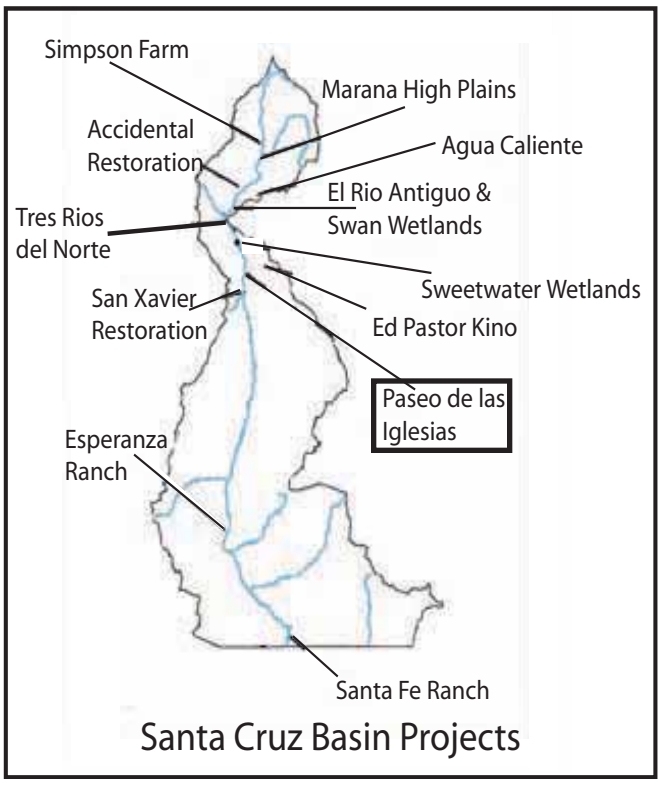
[175] Supra note 164.

Educational sign at recharge facility
Marana High Plains

Portion of the restored ox bow channel
Marana High Plains

Aerial view of recharge facility and oxbow channel
Marana High Plains

Photos Courtesy of AWPF and Kendall Kroesen,
Tucson Audubon Society



Paseo de las Iglesias

Primary Documentation: Santa Cruz River, Paseo de las Iglesias, Pima County, Arizona, Feasibility Report Summary USACE, September 2005.

Location and Size: Santa Cruz River and West Branch of Santa Cruz River, Pima County, Tucson; Los Reales Road to West Congress Street. Project encompasses 7.5 miles and 1,098 acres.[176]

Primary Sponsor(s): Pima County Flood Control District (PCFCD) and U.S. Army Corps of Engineers (USACE).

History: Prior to human intervention and degradation, the Santa Cruz River flowed year round past San Xavier del Bac to downtown Tucson, 10 miles north. At this time the Santa Cruz River was a shallow stream with a wide flood plain, containing cottonwoods, willows, and mesquite bosques. A wetland at the former confluence of the West Branch and the main branch of the Santa Cruz River was turned into a lake during the Spanish/Mexican period and in 1874 became Warner's Lake (approximately 50 acres) which was used for a mill. Later the area was converted into a resort named Silverlake. In the 1900's, the Tohono O'odham Nation at San Xavier and Tucson farmers diverted surface water for irrigating crops. In 1915 the West Branch of Santa Cruz River was diverted to the East Branch to prevent flooding of crops, leaving the current remnants of riparian habitat along the West Branch. In 1935 the WPA straightened the East Branch channel, known today as the main channel of the Santa Cruz River, from San Xavier downstream to Congress Street. Between 1950 and 1960, one million tons of garbage was dumped in and around the Santa Cruz River, artificially narrowing the channel. Construction of I-10 and I-19 helped to further channelize the River, as did the addition of soil cement in portions of the river bed to reduce bank erosion and flood damages. Currently, the Santa Cruz is an ephemeral river, little riparian habitat exists, banks are deeply incised, and groundwater levels are at 150 feet below the surface. The decline in depth to groundwater around the River is in part due to the fact that one-half of all of the groundwater pumped in Tucson comes from wells near the Santa Cruz River.[177]

Planning Objectives: "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,

[176] Becker, Jennifer (Pima County Regional Flood Control District). (2006) January. Review comments on draft report of this study.

[177] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2003) Santa Cruz River, Paseo de las Iglesias Pima County, Arizona Draft Feasibility Study Report Alternative Formulation Briefing. Los Angeles: U.S. Army Corps of Engineers.

and improved surface water quality consistent with ecosystem restoration goals; and integrate desires of local stakeholders consistent with federal policy and local planning efforts." [178]

Current Phase: The U.S. Army Corps of Engineers has finalized the feasibility study, Pre-Construction Engineering and Design is set to commence in 2006, and construction is scheduled to begin in 2008.

Phases: Draft Feasibility Report-December 2003; Draft Feasibility Report-July 2004; Final Feasibility Report-July 2005; and Final EIS July 2005.

Recommended or Implemented Plan: The recommended plan for Paseo de las Iglesias is Alterative 3E which 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 rainwater harvesting features scattered throughout the project. The construction and planting of subsurface water harvesting basins would occur at the confluences of eight tributaries and upstream of six existing grade control structures. A variety of methods would be used to provide permanent irrigation systems for all planted areas including the basins."[179]

Monitoring/Maintenance: Monitoring and maintenance is the responsibility of the local sponsors. The Paseo de las Iglesias project is vulnerable to damage by high flood flows, therefore, periodic maintenance will be necessary for successful restoration. Operation and maintenance will include periodic channel clearance, control of invasive plant species, pumps and irrigation maintenance, and periodic replanting of habitat areas damaged by flood.[180]

Funding and Cost: The feasibility study was funded by the USACE and Pima County through the USACE's General Investigation, Ecosystem Restoration funds. "The total first cost of the recommended plan is $92,058,546 and the total operation and maintenance costs excluding water are $807,046. The Federal share of the recommended plan is $59,666,768 and the non-Federal share is $32,391,778."[181] The cost of providing water for the project is an associated non-Federal cost, and 100 percent of these costs will be paid by the non-Federal sponsor (Pima County). These costs are currently estimated at $1,099,175 annually based on the use of reclaimed water from Tucson Water.[182] Other sources of water are currently (2005) under consideration.

Land Ownership: City of Tucson, Pima County, State of Arizona and private land.

Water: The USACE feasibility study process requires that one source be identified for analyses purposes. Rainwater harvesting and reclaimed water were the two sources of water looked at for the feasibility study; however, the local sponsor (PCRFCD) can use any water source(s) deemed most practical if the project is approved. At this time no water source has been determined for the project. The annual water budget for the tentatively recommended plan is estimated at 1,925 acre-feet per year.[183]

Several procurable sources of water are available to the potential project as well as funding to

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[178] Ibid. p. V-I

[179] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Santa Cruz River, Paseo de las Iglesias Pima County, Arizona Draft Feasibility Report. Los Angeles: U.S. Army Corps of Engineers. p. iii

[180] Ibid. VI-6

[181] Ibid. p. iv

[182] Ibid. p. VI-4

[183] Ibid.

supply the needed water. Leasing surface water from the Santa Cruz River and/or its tributaries has even been discussed. [184]

Pubic Outreach: Public outreach for this project included a Notice of Intent April 2001; Public Scoping Meetings, March 30 and 31, 2001 with tour of site on April 1, 2001; and an open house by PCRFCD, January 22, 2004. A public meeting was held on October 26, 2004 to present the feasibility study results and recommended plan overview.

"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; and incorporating civic amenities such as a self-guided historic walk with 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, and citizens from the local area.

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."[185]

Lessons Learned/ Challenges: Project is in initial stages, no lessons learned noted.

Drivers: Reversing the perception of the Santa Cruz River as a dumping ground, restoring both the cultural and ecological heritage of the area.

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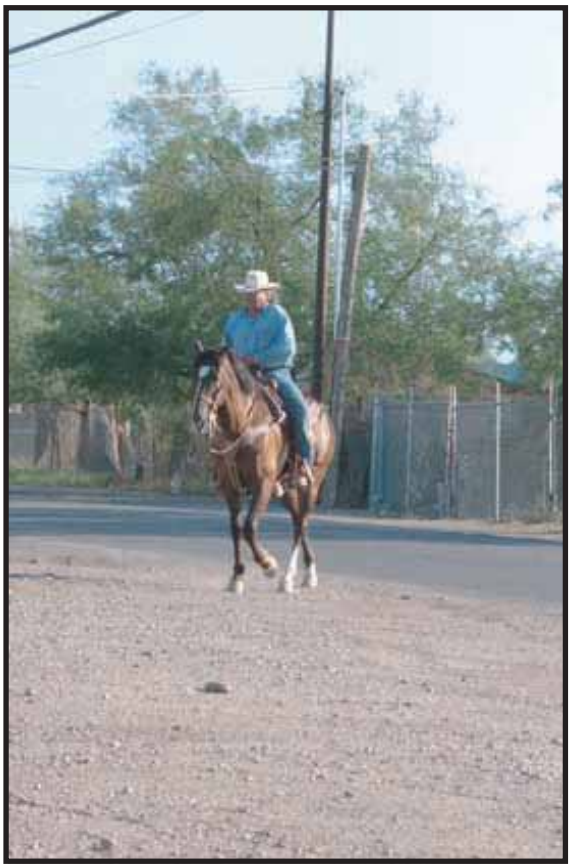
[184] Becker, Jennifer (Pima County Regional Flood Control District). (2006) January. Review comments on draft report of this study.

[185] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Santa Cruz River, Paseo de las Iglesias Pima County, Arizona Draft Feasibility Report. Los Angeles: U.S. Army Corps of Engineers. p. II-4



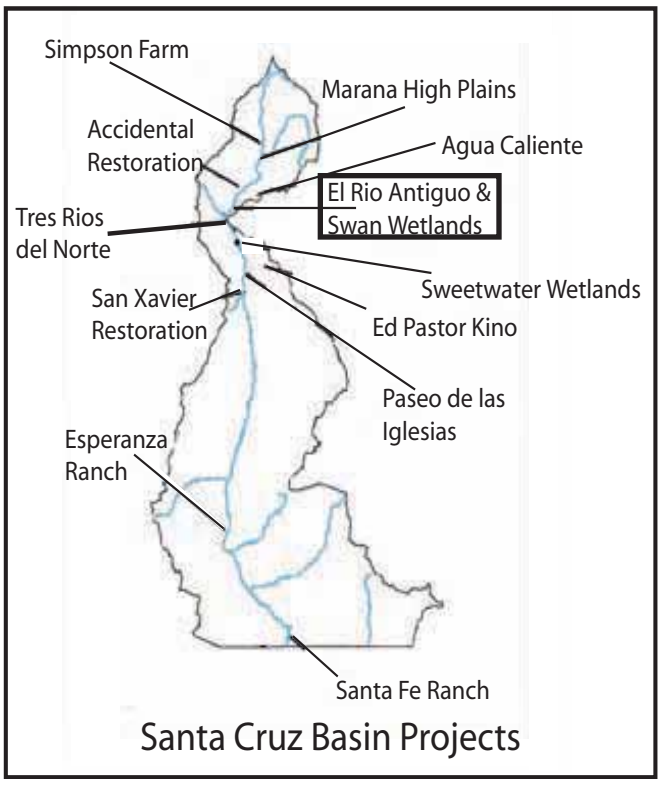
Horseback rider
Paseo de las Iglesias

West branch of Santa Cruz River south of Silverlake Rd.
Paseo de las Iglesias

View of Santa Cruz River from Sentinel Peak
Paseo de las Iglesias

Mesquite bosque and abandoned farmland adjacent to west branch of the Santa Cruz River
Paseo de las Iglesias

Photos by Jennifer Jones
Water Resources Research Center



Rillito River Riparian Area (Swan Wetlands)

Primary Documentation: 2003 U.S. Army Corps of Engineers Rillito River draft feasibility study, restoration report and environmental assessment.

Location and Size: Rillito River, Pima County, Tucson; South Bank of Rillito River, Craycroft Road (confluence of Tanque Verde Creek with Pantano Wash) to Columbus Boulevard. Project is 60.7 acres.

Primary Sponsor(s): Pima County Regional Flood Control District (PCRFCD) and United States Army Corps of Engineers (USACE)

Other Sponsors:

History: In the past, the Rillito River flowed perennially, meandering and supporting dense vegetation of cottonwood, willows, mesquite bosques, numerous beaver dams, and wetlands. Flows supported agriculture along the river. With growing agriculture, in the 1930's, Finger Rock Wash was cut off from the Rillito River and riparian vegetation was removed. Urbanization also increased and contributed to a loss in surface water flow and a decrease in the water table. Today much of the riparian habitat is degraded due to reduced water supply.[186]

Planning Objectives: "Restore riparian vegetative communities within the river corridor to a more natural state, increase the acreage of functional seasonal wetland habitat within the study area, minimize the potential for sediment and organic matter accumulation in restored areas, increase habitat diversity..., increase recreation and environmental education opportunities within the study area." [187]

Current Phase: A contract between the USACE and Pima County was signed February 15, 2005; construction is scheduled to begin in the spring of 2006.[188]

Phases: The preliminary Restoration Plan was approved in June 1999; Environmental Restoration Report and Environmental Assessment (ERR/EA) were completed in November 2003.

Recommended or Implemented Plan: Alternative - 1, Riparian/Xeroriparian Terrace "The alternative emphasizes the creation of riparian woodland habitat along created linear wet areas. Xeroriparian habitat would be used in the remaining areas to buffer the riparian habitat from adjacent land uses. The site is divided into distinct areas based on the restoration effort that will

[186] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Rillito River, Pima County, Arizona: El Rio Antiguo Draft Feasibility Study. Los Angeles: U.S. Army Corps of Engineers.
[187] Ibid. p. 2-2
[188] Wigg, Andy (Pima County Regional Flood Control District). (2006) January. Review comments on draft report of this study.

occur."[189] "The major factor in selection of this alternative was the desire of the local sponsor to not have surface water conditions that may be a liability concern. A contributing factor in the selection of this alternative is its design compatibility with the existing multi-use trail." [190]

Monitoring/Management: TBD

Funding and Cost: The project was funded and authorized through Section 1135 of WRDA - Modification of existing USACE projects for Ecosystem Restoration. The Rillito River Bank Protection Project was completed in 1996 by USACE and PCRFCD. [191] Total first costs are $2.7 million.[192] Under the cost sharing agreement, 75% of funding will come from the Army Corps and 25% from Pima County. Pima County expects to pay for their portion of the costs through Flood Control District Tax Levy receipts.[193] Under the recommended plan, the project requires 349 acre-feet of water per year, at approximately $230 per acre-foot the total cost of water will be approximately $81,000 per year.[194]

Land Ownership: Pima County

Water: Reclaimed water from the City of Tucson's Roger Road Wastewater Treatment Plant will be used for temporary irrigation. Water will also come from harvesting storm water runoff from Alamo Wash and other local tributaries.[195] Total annual water use is estimated at 349 acre-feet.

Pubic Outreach: A public workshop was held on Jan 6, 2000; The Draft of ERR/EA was released for public comment between March 21, 2003 - April 21, 2003; PCRFCD held two Open Houses April 17, 2003 and May 2004.

Lessons Learned/Challenges: None at this time.

Drivers: Habitat restoration, there are no public use elements in this plan.

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[189] See Rillito River Pima County Ecosystem Restoration Report and Environmental Assessment. p. 3-6 for more information.

[190] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. 2003. Rillito River Pima County Ecosystem Restoration Report and Environmental Assessment. Los Angeles: U.S. Army Corps of Engineers. p. 3-24

[191] Ibid.

[192] Ibid. table p. 3-29

[193] Pima County Regional Flood Control District. Swan Wetland Ecosystem Restoration Fact Sheet. Tucson: Pima County Regional Flood Control District.

[194] The $230 per acre-foot charge is based on the cost to obtain the water from the Tucson Water Department. Ibid. p. 3-14.

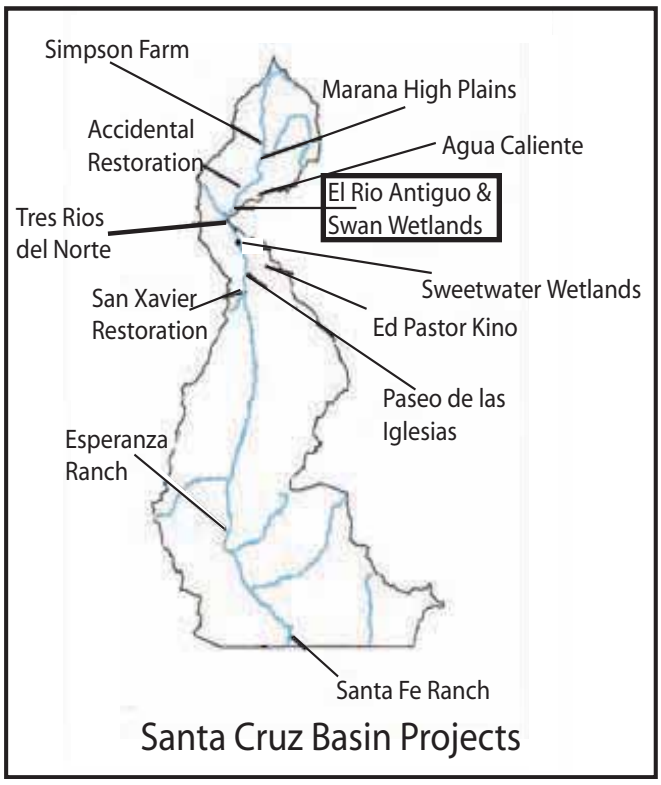
[195] Wigg, Andy (Pima County Regional Flood Control District). (2006) January. Review comments on draft report of this study.

Cottonwood
Swan Wetlands site

Degraded habitat
Swan Wetlands site

Project area
Swan Wetlands

Photos by Jennifer Jones
Water Resources Research Center



El Rio Antiguo

Primary Documentation: 2004 U.S. Army Corps of Engineers El Rio Antiguo draft feasibility study, restoration report and environmental assessment

Location and Size: Rillito River, Pima County, Craycroft Road downstream to Campbell Avenue. The study area for the project includes a 4.8 mile reach of the Rillito River and 1,066 acres, the project area will actually cover 284 acres of the study area.

Primary Sponsor(s): Pima County Regional Flood Control District (PCRFCD) and United States Army Corps of Engineers (USACE).

History: In the past, the Rillito River flowed perennially, meandering and supporting dense vegetation of cottonwood, willows, mesquite bosques, numerous beaver dams, and wetlands. Flows supported agriculture along the river. With growing agriculture, in the 1930's, Finger Rock Wash was cut off from the Rillito River, and riparian vegetation was removed. Urbanization, along with agriculture, increased and contributed to a loss in surface water flow and a decrease in the water table. Today much of the riparian habitat is degraded due to the reduction of water.[196]

Planning Objectives: "Restore riparian vegetative communities within the river corridor to a more natural state; increase the acreage of functional seasonal wetland habitat within the study area; increase habitat diversity by providing a mix of habitats within the river corridor including the riparian fringe and buffer; provide incidental flood control through ecosystem restoration to the extent that it does not adversely impact the restoration objective; increase recreation and environmental education opportunities within the study area." [197]

Current Phase: Feasibility Complete. In October 2004 under WRDA of 2004, USACE will ask Congress for funding for Pre-Engineering Design Phase.

Phases: Reconnaissance Report completed September 2001; Draft Feasibility Report Study published October 2003 and May 2004, Draft EIS Nov 2003.

Recommended or Implemented Plan: Alternative 2H– 1-Terrace without buffer. A set of terraces would be constructed in the area known as the "Bend." Cottonwood/willow, mesquite, shrub and grasses would be planted in the channel, tributary mouths, and in rainwater harvesting basins along the tributaries. Soil cement will be used to stabilize the stream bank with a culvert and pipeline from upstream to allow water to flow behind the soil cement during severe storm water events (larger then 2-yr). The plan also includes a high and low-flow channel created to support a mesquite

[196] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Rillito River, Pima County, Arizona: El Rio Antiguo Draft Feasibility Study. Los Angeles: U.S. Army Corps of Engineers.
[197] Ibid. p. V-1

community and connect the Finger Rock Wash to the Rillito River. Rainwater harvesting basins at each upstream tributary mouth will collect and detain storm water. An effluent distribution system would also be installed to support the establishment of planted vegetation during dry periods.[198]

Monitoring/Maintenance: Project is still in the planning phase. No monitoring or maintenance plan exists at the present time.

Funding and Cost: The project is funded and authorized through USACE's General Investigation, Ecosystem Restoration. Total First Costs are $66,657,000. Current annual water cost to non-Federal sponsor is approximately $852,000.[199] It is estimated that annual operation and maintenance costs will be $1.26 million. This project is funded through a cost share agreement between the USACE and PCFCD, with the USACE covering 65% of the cost.

Water: The recommended plan requires a total irrigation need of 1,490 acre-feet of water per year.[200] Irrigation for the establishment and maintenance of new vegetation is provided by effluent, rain water harvesting, and surface water diversions from tributaries of the Rio Antiguo.[201]

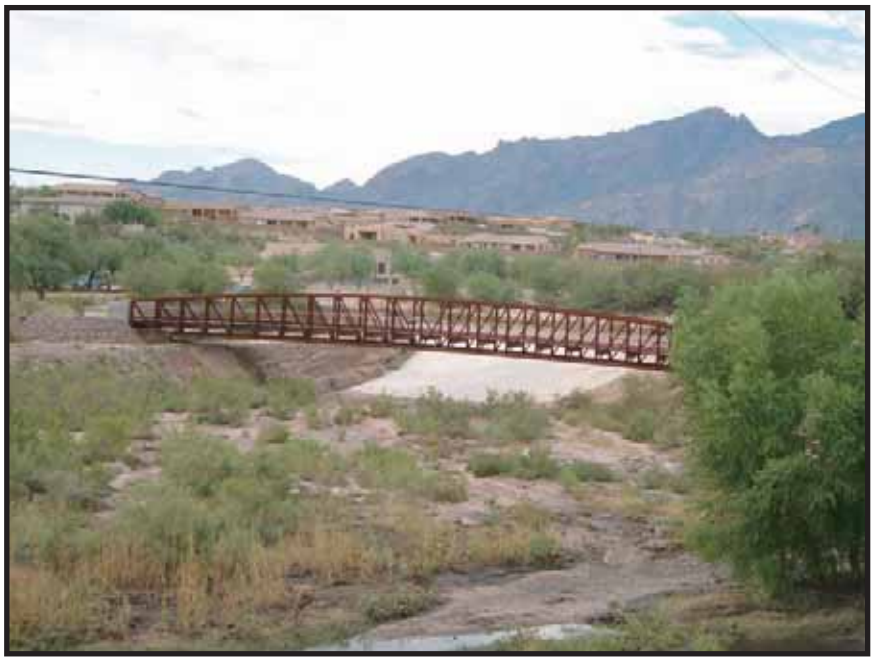
Public Outreach: During the planning process, public opinion was solicited from a variety of sources. The El Rio Antiguo Work Group, facilitated by Novak Inc. and initiated on May 8, 2002, included seven months of field trips and meetings. The major concerns of the group included: "access to the Rillito River and existing trails; use of native vegetation for restoration; wise use of water; providing wildlife habitat; visual impact of project; using interpretive signage; and working with surrounding neighbors."[202] The final Corps public meeting for the feasibility stage was held on January 28, 2004.

Lessons Learned/Challenges: Project is in early stages, none at this time.

Drivers: Habitat restoration, returning an area to its pre- World War II beauty.

198 Ibid.
199 Ibid. p. VI-13
200 Ibid. Appendix C
201 Ibid.
202 Ibid. p. VIII-2

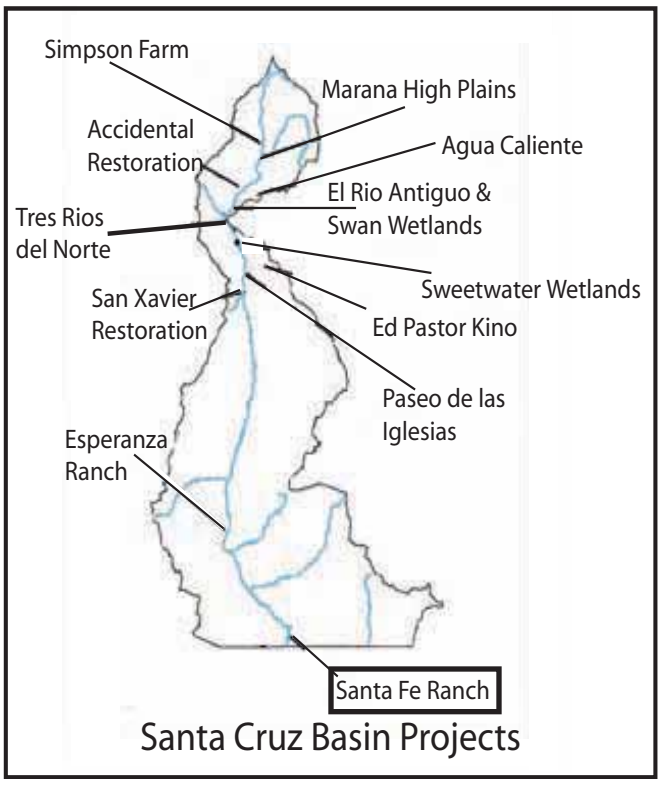
South bank of Rillito River west of Swan Road
El RIo Antiguo



Pedestrian Bridge at Rillito River
El Rio Antiguo

Rillito River east from Swan Road
El Rio Antiguo

Photos by Jennifer Jones
Water Resources Research Center



Santa Fe Ranch Riparian Restoration

Primary Documentation: 2000 Coronado Resource Conservation and Development Area Inc. grant application to Arizona Water Protection Fund.

Location and Size: The project is located five miles north of Nogales in Santa Cruz County and encompasses 1,200 feet of river, through a 10-acre project area.

Primary Sponsor(s): Coronado Resource Conservation and Development Area, Inc. **Other Sponsors:** Arizona Water Protection Fund (AWPF), Arizona Department of Environmental Quality (ADEQ), and Natural Resources Conservation Service (NRCS).

History: In 1967 a flood destroyed mature cottonwoods and other riparian vegetation in the Santa Fe Ranch section of the Santa Cruz River. The storm left timber and large rock piled in the river channel, causing storm water to flood out onto adjacent pasture, eroding tons of topsoil and removing vegetation from those areas that served as buffers and habitat. The project area continued along a downward trend in condition until the initiation of this restoration project.[203]

Planning Objectives: The goal of the Santa Fe Ranch Riparian Restoration project is to reestablish a corridor of historic vegetation on a segment of the Santa Cruz River that will create diverse habitat and reduce stream bank erosion. The three objectives are: erosion control, revegetation of the area, and increased public awareness of riparian systems and values.[204]

Current Phase: Monitoring and outreach activities continue on the site. The final project report for the AWPF was completed in September of 2005.

Phases: Three phase project: Phase one – grant from ADEQ to install Kellner Jacks[205] (Jetty Jacks) to stop further erosion and trap sediment (2000), Phase two – revegetate the area through use of pole plantings (March 2004), Phase three -monitoring, outreach and education to provide information to local schools and land users about the value of riparian areas and options in restoration and techniques for monitoring of such projects (Sept 02 – Sept. 2005).[206]

Recommended or Implemented Plan: The Santa Fe Ranch restoration used a series of plans

[203] Coronado Resource Conservation and Development Area, Inc. (2000) Application to Arizona Water Protection Fund for Riparian Restoration at the Santa Fe Ranch. Benson: Coronado Resource Conservation and Development Area, Inc.

[204] Ibid.

[205] A Kellner Jack or Jetty Jack is a steel structure consisting of 3- 16' long 4"x4"x1/2" steel angles bolted together at their midpoints oriented at right angles to each other. The purpose of a Kellner Jack is to trap sediment and debris during flood events so as to build up its own levee to confine the river channel.

[206] Supra note 203 p. 1

for different aspects of the project. The fencing plan, implemented in October of 2001 included installing fencing between irrigated pasture and the revegetated bank stabilization area to exclude livestock access.[207] The project also implemented an irrigation plan to provide supplemental irrigation to approximately one acre of the site to establish riparian vegetation. The system was used during establishment of trees, shrubs forbs and grasses in a 60 feet wide 700 feet long area. The irrigation schedule during peak use (May and June) is to operate the system for 24 hours every 2.5 days.[208] The revegetation plan designated three planting zones: the floodplain, the scarp (which is the transition zone between upland area and floodplain), and the upland area.[209]

Monitoring/Management: Monitoring activities are focused on determining survivability of pole planting used for revegetation on severely eroded area and to determine the overall benefits of restoring riparian corridors. In order to determine this, the sponsors established a database of baseline conditions using survey and photographic methods. This database included information on plant counts, corresponding well data, and gauging station data from the Arizona Department of Water Resources and United States Geological Survey.[210] After revegetation, the project site was inspected at least on a weekly basis by Santa Fe Ranch personnel. Weekly inspections included: inspecting fencing for breaks or gaps, inspecting the irrigation system for breaks or malfunctions, and observations of plant materials for overall vigor and health. Monitoring also included replacement of dead trees or shrubs and control of invasive species until the revegetated site was decided to be in fully functional condition.[211] According to the May 2005 report to AWPF, the survival rate of willow is 57% and mesquite 63% (35 plantings for each species were conducted originally).[212] Under the agreement with the AWPF, the operation and maintenance period for grant-assisted fencing construction is 15 years following completion of the structure; for all other grant-assisted structures, the operation and maintenance period is 20 years.[213]

Funding and Cost: The project received $49,008 from AWPF, $13,996 from NRCS, and provided $5,063 in matching funds. The project also received funding from an ADEQ 319(h) grant to install the Kellner Jacks and erosion control structures.

Land Ownership: Private –Sedgewick family.

Water: Competing land interests such as a County road on the west side and irrigated pastures on the east side of the river forced NRCS to propose a stream corridor that is less than ideal. The ideal corridor would contain the stream, its banks, the floodplain, and the valley slopes. The proposed corridor will create a pattern of habitat that crosses the stream area and flood plain, connecting

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[207] Coronado Resource Conservation and Development Area, Inc. (2001) Fencing Plan for Water Protection Fund Contract 00-103 WPF. Wilcox: Coronado Resource Conservation and Development Area, Inc. p. 1

[208] Coronado Resource Conservation and Development Area, Inc. (2003) Riparian Restoration on the Santa Cruz River, Santa Fe Ranch: Revised Irrigation Plan. Wilcox: Coronado Resource Conservation and Development Area, Inc.

[209] Ibid. p. 3

[210] Supra note 203.

[211] Coronado Resource Conservation and Development Area, Inc. (2003) Riparian Restoration on Santa Cruz River Santa Fe Ranch: Revegetation Plan. p. 6

[212] Coronado Resource Conservation and Development Area, Inc. (2005) Riparian Restoration on the Santa Cruz River Santa Fe Ranch: Project Report #8. Wilcox: Coronado Resource Conservation and Development Area, Inc. (monitoring summary)

[213] Arizona Water Protection Fund. (2001) Grant Award Agreement Grant no. 00-103. Phoenix: Arizona Department of Water Resources. p. 10

the riparian areas to the upland areas. The proposed corridor will also function to trap sediment and provide hydraulic storage during floods and will trap organic matter necessary for the health function of the stream system.[214] Irrigation of riparian plantings comes from a well that is currently being used to irrigate pasture adjacent to the site. Water table levels have not been conducive to pole planting success at this site.[215] According to the irrigation plan, the estimated peak irrigation need for 70 trees, 130 shrubs, 1,800 grasses and forbs is 19,950 gallons per day.

Pubic Outreach: The project included an Outreach Plan that outlined steps that the restoration team would take to reach individuals in the community. Examples of items in the plan are: a teachers guide to riparian education in desert ecosystems to be used in grades 3 – 8, technical team work with the Nogales High School science class to use the plant nursery at the high school to propagate plants for the project, fact sheets on riparian systems, a power point presentation, and an informational tour for the public and partner agencies of the project site. [216]

Challenges/Lessons Learned: In a later survey of plantings, other vegetation had grown up around plantings, making it difficult to find/identify them. It was suggested that in the future, all plantings be clearly flagged so that their survival rate could be more easily determined. The number of cottonwood plantings were reduced during the project because of survival concerns caused by the drought and a lowering of the water table. At the beginning of the project, the water table was 10-15 feet below the surface and during the project dropped to 24 feet.

Drivers: Previous flood events had decimated the system, the primary goal in restoration was to stabilize bank erosion and reestablish a riparian corridor in order to improve water quality.

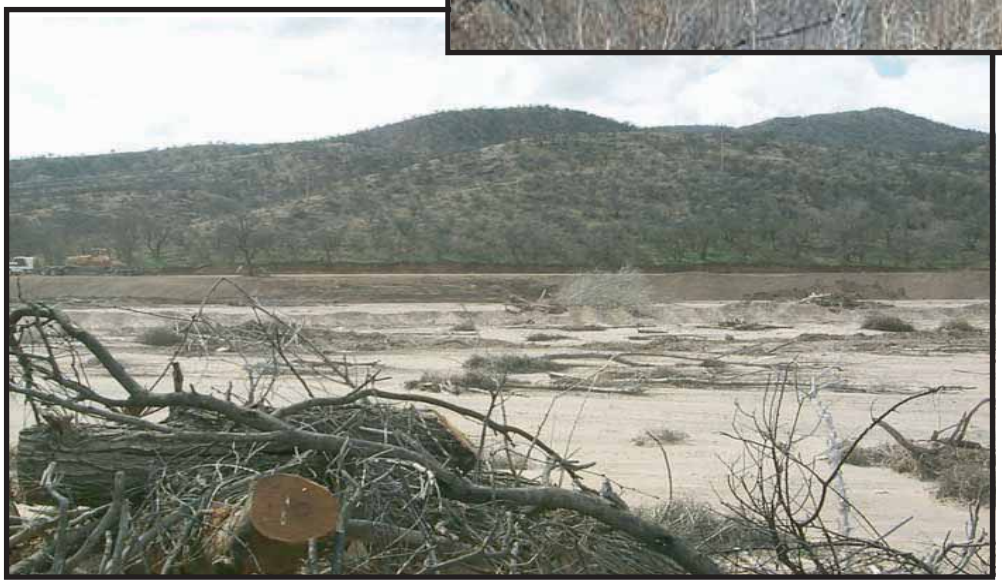
[214] Supra note 203

[215] Supra note 212

[216] Coronado Resource Conservation and Development Area, Inc. 2003. Revised Outreach Plan for Arizona Water Protection Fund Project Contract 00-103 WPF. Wilcox: Coronado Resource Conservation and Development Area, Inc. p. 3

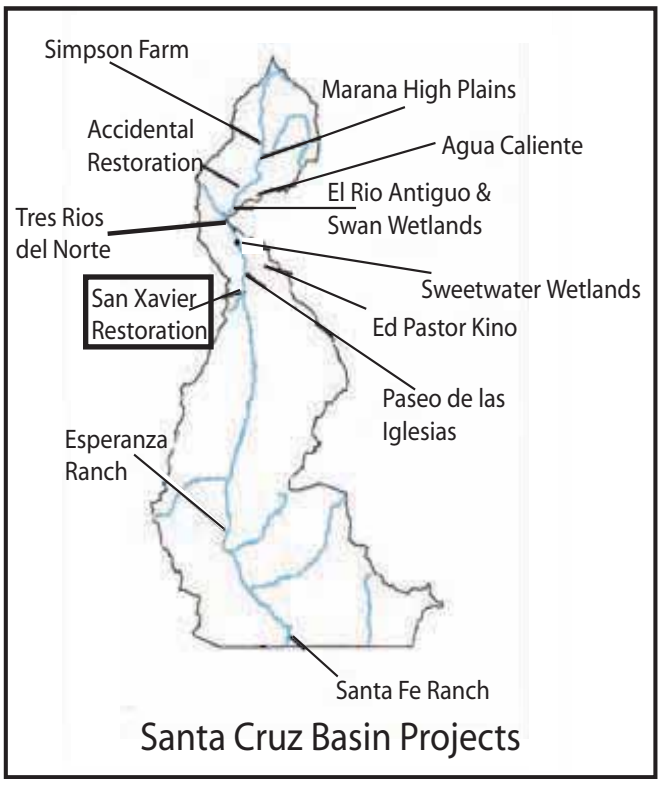
Revegetation site
Sante Fe Ranch

Ungulate proof fence
Sante Fe Ranch



Kellner jack site
Sante Fe Ranch

All pictures courtesy
of AWPF



San Xavier Indian Reservation Riparian Restoration

Primary Documentation: 1996 San Xavier Indian Reservation grant application to Arizona Water Protection Fund.

Location and Size: Site one is located on the west side of the Santa Cruz River approximately 0.57 miles southeast of the intersection of San Xavier Road and the I-19 bridge in Pima County. Site two is located 1.5 miles upstream from site one. Site one of the project is 12.5 acres and site two is five acres.

Primary Sponsor(s): San Xavier District community.

Other Sponsors: Arizona Water Protection Fund (AWPF), Natural Resource Conservation Service (NRCS), Bureau of Reclamation (BOR), Sonoran Joint Venture, and U.S. Fish and Wildlife Service (USFWS).

History: At the turn of the century, the Santa Cruz River flowed perennially through the restoration area, making it unique amongst the restoration projects studied on the Santa Cruz. At this time, the water table was only 10-15 feet below the surface, and two springs flowed year round creating marshy areas. The vicinity supported a 3,200 acre mesquite bosque, cottonwood-willow groves, and other riparian vegetation. Groundwater pumping began in earnest in the 1940s and over time has lowered the water table over 100 feet, killing mesquites and riparian vegetation. In an effort to address growth and environmental concerns in their region, the San Xavier Reservation community adopted a Vision document in 1990 and Land Use Plan in 1992 that developed a long-term plan for riparian restoration on the reservation.[217] In the two restoration areas, the predominant prior land use was farming by the San Xavier Cooperative Farm.

Planning Objectives: The overall objectives for riparian restoration on the San Xavier Reservation are: develop an ecosystem approach to resource management for the Reservation and surrounding region; conduct a feasibility study on riparian restoration possibilities on the Reservation; enhance and restore riparian vegetation along two arroyos on the Reservation; and establish a grazing management plan to enhance and restore riparian vegetation.[218]

Restoration of the first site began with the process of selecting eligible sites. Objectives for the site selection process included: evaluate and compare the current ecological conditions of the five proposed sites; discuss the ecologic changes that had occurred at the sites in recent years and the reasons for these changes; propose a preliminary plan to restore or at lease improve ecologic

[217] San Xavier Indian Reservation Community. (1996) Application to AZWPF for Riparian Restoration on the San Xavier Indian Reservation Community. Tucson: San Xavier Reservation Community.
[218] Ibid.

conditions for each of the five sites; develop a budget for each of the proposed restoration plans; and provide a ranking of the five sites proposed for restoration activities. [219]

Objectives for the restoration itself at the first site were: develop a resource management guide that identifies specific appropriate riparian restoration strategies and implement the selected strategies. The objectives at site two were: re-establish a mesquite bosque plant community; establish a biologically significant area where tribal members can actively participate in the restoration and management of a desert riparian system; and improve understanding of what restoration strategies can be most effective in bringing back bottomland habitat throughout the Santa Cruz River reach within the San Xavier District.[220]

Current Phase: Restoration activities have been completed and monitoring and maintenance of site one is ongoing. Restoration at the second site is underway.

Phases: Restoration of site one, the Wa:k Hikdañ site, was conduced in four phases: 1) technical and community assessment and site selection between five potential bottomland restoration sites (spring 1999 – winter 2000);[221] 2) pre-implementation phase (winter 2000 – summer 2002); 3) project implementation phase (summer 2002 – spring 2003); and the final phase is monitoring and maintenance (ongoing).[222] Site two will follow the same four phases with the exception of phase one which was completed at the time of Wa:k Hikdañ's restoration.[223]

Recommended or Implemented Plan: Five sites were reviewed and ranked according to nine ecological and three non-ecological parameters on a scale of 1 to 3 (three highest) with the parameter of meets restoration objective receiving twice as much weight as any other parameter. Examples of other parameters include: depth of saturated soils, livestock impacts, undesirable vegetation, restoration potential, distance to Central Arizona Project (CAP) line, community access, and budget.[224] Based on this evaluation, the Wa:k Hikdañ site was chosen with a score of 28 out of 39. Once the site was chosen, a thorough ecological assessment was conducted that included an assessment of channel morphology, hydrology, vegetation, and land use. Once the assessment and permits were in place, the sponsors installed 2,900 feet of cattle exclusion fence, as well as a rock revetment approximately 938 feet long along the eastern edge of the project site for bank stabilization.[225] The final step in the pre-implementation phase was construction of a pipeline link from the main CAP pipeline to the project. The original plan was for a six inch diameter pipe, however; in the spring of 2002, the San Xavier Cooperative Farm approached the AWPF about using the project pipe to convey water to their fields as well. They offered funding and technical assistance from BOR in return for increasing the size of the pipeline to make this possible. [226]

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[219] Briggs, Mark Rome Hammer, Greta Anderson and Ronald Felix. 2003. Restoring the Wa:k Hikdañ: A Riparian Restoration Effort along the Santa Cruz River, San Xavier District of the Tohono O'odham Nation. Tucson: San Xavier District. p. 11

[220] San Xavier District. (2004) Application to Arizona Water Protection Fund for Riparian Restoration on the San Xavier District: Project Two. Tucson: San Xavier District p. 6

[221] The grant from the Water Protection Fund was awarded in 1996 however problems with grant management and administration delayed, and almost ended the project.

[222] Supra note 219

[223] San Xavier District. (2005). San Xavier Restoration Site Two Site Preparation Plan. p. 1

[224] Supra note 219

[225] A revetment is a masonry facing used to support an embankment.

[226] San-Xavier is a fence out district, therefore it is the responsibility of the landowners, not the cattle owners, to construct fences to keep cattle out. Additional funding for this fence was obtained from NRCS through the Wildlife Habitat Incentive Program in 2001

During the implementation phase for site one, undesirable plants were removed, focusing predominantly on the non-native tamarisk and tumbleweed. Once many of the invasive species were removed, the restoration team delineated the areas to be revegetated according to riparian, mesquite bosque, and wetland zones. Irrigation systems were then installed, and construction of the wetland and revegetation of the project area began.

The plan for the second site involves three steps: site preparation, irrigation design and installation, and planting the vegetation. The site preparation activities included removing or treating with herbicide non-native, invasive vegetation, as well as cutting a small trench along the center portion of the floodplain for irrigation water and plant sites for riparian species. Irrigation will consist of a main delivery pipeline bringing water from the CAP pipeline to a drip irrigation system at the site similar to the Wa:k Hikdañ site. Revegetation is divided into two zones for design purposes: terrace surfaces and floodplain surfaces. Terrace surfaces will be planted with mesic species such as mesquite, netleaf hackberry, and desert willow, which are plants that can survive in drier environments where depth to saturated soils can be considerable. Floodplain surfaces will be planted with riparian plants that are capable of withstanding frequent high flow events.[227]

Monitoring/Management: According to the AWPF agreement for both sites "grantee shall develop monitoring and project site maintenance plans. Grantee shall monitor the operation of the irrigation system for as long as it is in use. The Grantee shall monitor plant performance for at least five years; the intensity of monitoring efforts will decrease over time until the fifth year after revegetation. The grantee shall fund monitoring and maintenance work conducted after the termination of this agreement."[228]

Funding and Cost: Site one was funded by AWPF, NRCS, BOR, and the San Xavier District. The total cost of the site selection phase was $184, 260. Restoration of site one cost $413,432. Site two funding included $32,688 from AWPF and $37,555 matching funds which came from the San Xavier District Community, the U.S. Fish and Wildlife Service, and Sonoran Joint Venture.

Land Ownership: The restoration sites are both located on reservation allotted land with a lease administered by the Bureau of Indian Affairs. Before restoration could begin, permission had to be obtained from all of the allottees.[229] No compensation was initially provided to landowners. All but two allottees agreed without payment, and these two landowners were provided a one time payment of $500, an amount derived from an appraisal of an adjacent allotment.

Water: Supplemental water for the project is provided by a diversion of CAP water. The CAP diversion is part of the Southern Arizona Water Right Settlement Act of 1983. The water flows through a created stream and wetland area, nourishing the riparian species and seeping into the aquifer. The primary use of supplemental water is to recharge a perched aquifer under the site. Exploratory drilling during the feasibility phase showed that the perched aquifer was about 47 feet below the surface and extended to the area under both project sites. It is believed that recharge from the stream and wetland areas will create a mound within several years of implementation. It is feasible that this mound will eventually reach sufficient size to support the riparian plant community with scaled-back irrigation.[230] Under the agreement with the AWPF, supplemental irrigation and

[227] Supra note 223

[228] Arizona Water Protection Fund (2003) Amended Grant Award Contract No. 96-0026 amendment no. 7. Phoenix: Arizona Department of Water Resources p. 12

[229] Supra note 219. p. 14

[230] Arizona Water Protection Fund. Amended Grant Award Contract No. 96-0026 amendment no. 7. p 12

maintenance of the irrigation system is the responsibility of the San Xavier Reservation community.[231] Despite the long-term water requirement for the wetlands, the majority of the project was designed to survive without irrigation (after initial establishment). "A significant portion of the site is occupied by deciduous riparian and mesquite bosques plant communities, which will hopefully be able to survive with out long-term inputs of artificial water."[232]

This project was the first to use CAP water in the Tucson basin for riparian restoration and laid the groundwork for the use of as much as 50,000 acre-feet of CAP water for restoration purposes on the Reservation in the years following project.

Pubic Outreach: Quarterly project updates were published in the Wa:k Community newsletter as well as an annual project newsletter for the San Xavier District community members. "In the case of the San Xavier revegetation effort, the restoration project is considered critical to not only meeting documented goals, but also of tantamount importance to many elders and other community members who would like to see a semblance of how the Santa Cruz River used to be before it was affected by human impacts." [233] "The [Citizen's Steering] Committee was particularly effective in obtaining information from community elders on past site conditions, the plant and water conditions that they saw along the Santa Cruz River in Wa:k Hikdañ, their youth, and their ideas as to how the Wa:k Hikdañ should look when completed."[234]

Challenges/Lessons Learned:[235] The restoration team believed that the formation of a citizen steering committee to guide the project's implementation was critical to their success. Initially, they encountered problems with attendance and achieving quorum for monthly meetings. This problem was remedied in part by providing stipends and dinner to attendees.

Another challenge they faced was obtaining the necessary signatures and permission from land allottees, many of whom no longer live near the Wa:k Hikdañ restoration site. As a result, the restoration team recommends that as part of developing restoration efforts on allottee land, a considerable amount of time should be allocated to the pre-implementation phase to allow for the allottee approval process.

The restoration team found that the additional water provided for restoration attracted both desirable and undesirable animals. They noted that the significant time and money invested in the construction of the fence proved critical in realizing restoration objectives, and recommend that it be considered for similar efforts. One of the major construction efforts as part of this restoration was the pipeline. The restoration team ran into problems when the final pipeline design did not include several design features that were included in the Standards and Specs, but not drawn on the pipeline plans, and the contractor did not include them in his bid. They recommend that future projects are careful to include everything from the official plan in the bid plans.

With regards to planting, the majority of the site was planted during the hot months of June through September, which caused the black plant containers to heat up to significant temperatures in the mid-day sun, potentially cooking the roots of the plants and killing the plant before it was put in the ground. They found that plant containers of one-gallon and five-gallon sizes were not as

[231] Arizona Water Protection Fund. 2005. Arizona Water Protection Fund Operation and Maintenance Agreement No. 05-130 WPF-OM. Phoenix: Arizona Department of Water Resources. p. 9

[232] Briggs, Mark (Briggs Restoration). 2006, February. Review comments of draft report of this study.

[233] Supra note 219

[234] Ibid.

[235] Challenges and lessons learned are from the Wa:k Hikdañ restoration site.

vulnerable to this threat as were seedlings grown in long and narrow tubex tubes that encourage the development of long tap roots, and skinny seedlings. Trees grown with the tubes in the nursery had a high rate of survival when planted in the ground; however, they will not survive if they are subject to extreme heat or sun prior to planting. As important and troublesome as keeping the plantings alive was removing undesirable plants. During the course of the project, the restoration team found that removing non-natives from the site is critical to overall project success, yet it is one of the most tedious and difficult activities to perform. Several strategies were useful in improving the effectiveness of weeding as well as maintaining the energy of maintenance staff. Examples of these strategies are: developing a schedule where groundskeepers focus on only one particular part of the restoration site during any given day, which helped to concentrate the work and maintain the focus of the groundskeepers; focus weeding only in planted areas with the goal of reducing competition, giving planted vegetation more of a chance to survive the critical first year following planting; and bringing in temporary laborers to assist groundskeepers in weeding parts of the site where weeds are particularly problematic.

Another challenge faced was the large turnover of maintenance staff. To combat this problem, the restoration team has implemented several strategies designed to maintain the interest and energy of the groundskeeper team including field trips, training activities, and participation of other staff and technical consultants in various aspects of the work. Conducting 'weeding days' where consultants and staff help groundskeepers to remove undesirable vegetation has been particularly helpful in maintaining a team spirit and interest of the groundskeepers.

Finally, the project ran into problems when in June 2003, the controllers on the irrigation system all failed within a matter of days of each other. The irrigation system was down for several days before the problem was discovered, and close to 10% of the trees in the affected areas died. As a result, the irrigation maintenance schedule was altered to include performance checks of all irrigation programs and weekly tests of the controllers. The restoration team notes that providing additional training in irrigation maintenance after revegetation was finished may have prevented the irrigation system's failure from significantly affecting plantings.[236]

The restoration team also noted the importance of post-implementation maintenance, monitoring, and evaluation activities. They assert that the project would not have succeeded without diligent weeding, replacement of dead plants, and irrigation system maintenance. Mark Briggs of Briggs Restoration recommends that 20% of the entire budget of project be devoted to these post-implementation activities.[237]

Drivers: San Xavier Community created a visioning document where one of the primary objectives was riparian restoration. "One of the other principal reasons for implementing this project [aside from restoration of habitat] was the San Xavier community's desire to create an area for residents to visit for low intensity recreational uses, such as walking, contemplation, and observing wildlife."[238]

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[236] Supra note 219

[237] Briggs, Mark (Briggs Restoration). (2006) February. Review comments of draft report of this study.

[238] Supra note 219

Large wetland before
San Xavier Environmental Restoration

Large wetland after
San Xavier Environmental Restoration

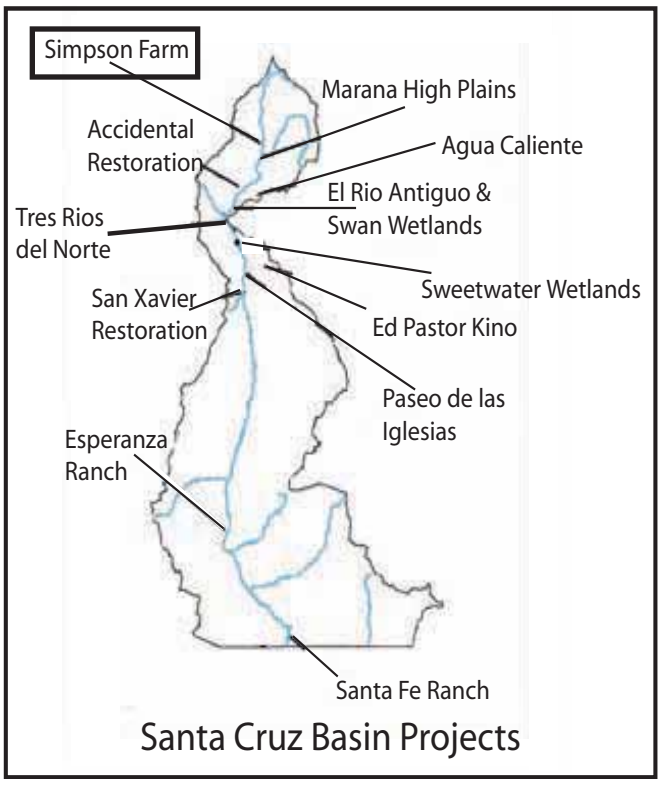
Mesquite zone at planting
San Xavier Environmental
Restoration

Mesquite zone after planting
San Xavier Environmental Restoration

Map of Project area
San Xavier Environmental Restorationa

Wetland habitat
San Xavier Environmental Restorationa

All photos courtesy of AWPF



North Simpson Site Riparian Restoration

Primary Documentation: 2001 Tucson Audubon Society grant application to Arizona Water Protection Fund for riparian recovery project. 2005 Tucson Audubon Society Final Report, Santa Cruz River Habitat Project-North Simpson Site. Additional information from site visit and personal communication with Tucson Audubon staff.

Location: Northern Pima County in the northern Avra Valley northwest of the City of Tucson and west of the Town of Marana. Seventeen hundred acre restoration site with 20 acres of restoration completed through the Arizona Water Protection Fund (AWPF) grant,[239] 25 acres funded through a Phase 2 AWPF grant, six acres funded through U.S. Fish and Wildlife Service (USFWS), and an additional 51 acres of intensive planting and erosion control and 150 acres of seeding funded through in-lieu mitigation fees for Clean Water Act Section 404 permits managed by the U.S. Army Corps of Engineers (USACE).

Primary Sponsor(s): Tucson Audubon Society and City of Tucson.

Other Sponsors: AWPF, USFWS, and in-lieu mitigation fees managed by USACE.

History: Historically, the Santa Cruz River at the North Simpson site was ephemeral, flowing only during flood events. Since the 1970s, however, this area has had a near constant flow of treated effluent released from regional wastewater treatment plants.. The North Simpson Riparian Restoration project does not attempt to recreate the historically-present ephemeral riparian habitat at the site; rather, it attempts to take advantage of the effluent flow to expand the cottonwood and willow habitat (hyporiparian habitat) that is developing at the site. It also attempts to increase the diversity and resiliency of mesoriparian, xeroriparian, and upland habitat to offset habitat losses in other areas. Historically, the Santa Cruz River had several sections that flowed perennially, creating rich hydroriparian habitat. Overtime, cattle grazing, prolonged droughts, stream diversion, groundwater pumping, and other impacts degraded the watershed, down cut the river bed, severely lowered the ground water table, and reduced surface water flow. Today, most of the formerly rich hydroriparian habitat has largely vanished. Of the 9,720 miles of streambeds and tributaries of the Santa Cruz River watershed only 73 miles now contain perennial flows.

In 1993, flood waters deposited tons of silt in the river bed. This silt was subsequently bulldozed out of the river and used to create 20- foot tall earthen flood control berms along the channel. In this process, the channel was straightened, and several meanders were cut off. Subsequent flood

[239] Tucson Audubon Society. (2005) December. Final Report- Santa Cruz River Habitat Project-North Simpson Site Arizona Water Protection Fund Phase 1 Area. p. 8.

events have begun to slowly erode the channel banks and berms as the river naturally returns to a meandering course.

The North Simpson Site is part of a total of 23,000 acres of Avra Valley farmland purchased by the City of Tucson during the 1970s and 1980s to obtain associated groundwater rights.[240] In 2001, the City of Tucson entered into a 99-year right-of-entry agreement allowing Tucson Audubon Society to undertake restoration within the 1,700 acres of former farmland. Restoration work has been concentrated to date in the northeast portion of this 1700-acre area. The North Simpson Site is the most northerly of a series of planned and/or implemented riparian restoration projects along the Santa Cruz River including Paseo de las Iglesias, El Rio Medio, Tres Rios del Norte, and the San Xavier District restoration project.

Planning Objectives: The goals and objective stated in the original AWPF grant application submitted by Tucson Audubon Society generally apply to work performed throughout the North Simpson Site.[241] "The overall goals of the project are enhancement of the vegetative cover by increasing diversity and resiliency, and work with the interaction between the riparian corridor and the adjacent abandoned farmland within the natural climatic conditions of the region."[242] Objectives for the project are to: assess the site to identify favorable areas for AWPF habitat recovery efforts; develop a restoration and rainwater harvesting plan; increase plant diversity, decrease erosion and improve the sustainability of the riparian corridor with adjacent abandoned agricultural land to expand habitat available to birds, animals and plants using the site; monitor the results of the restoration efforts with varying rainwater harvesting, mulching, seeding, and planting regimes to determine rates of survival of plantings; engage local and regional members of the public and governmental bodies in learning and recovery activities at the site to promote a sense of stewardship; and educate and act as a model for other habitat recovery efforts.[243]

Current Phase: AWPF Phase 1 work has been completed, and the final report has been submitted. AWPF Phase 2 work is underway. USFW work was completed in 2003. In-lieu mitigation work is ongoing. Photo monitoring and avian monitoring will continue in all work areas into the foreseeable future. Maintenance is ongoing.

Phases: The AWPF Phase 1 project commenced in 2001 and was completed in 2005, encompassing 20 acres. AWPF Phase 2 work commenced in 2004 and will be completed in 2007. It encompasses 25 acres. In-lieu mitigation work commenced in 2000 and is ongoing. To date, it has encompassed approximately 200 acres. USFW-funded seeding and planting trials commenced in 2000 and was completed in 2003 on six acres.[244]

Recommended or Implemented Plan: Water is provided to plants at the site by constructing strategically placed water harvesting basins and swales that focus runoff around plantings and control erosion, as well as by installation of a drip irrigation systems to deliver groundwater to plantings for the first two years after establishment. Part of the project plan was to integrate the

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[240] Kroesen, Kendall, Ann Phillips. (2002) "Habitat Restoration: In the Trenches". Tucson Audubon Vermillion Flycatcher, May – June. Tucson: Tucson Audubon Society.

[241] Ann Phillips (Tucson Audubon Society). (2006) January 19. Email communication with the author (Schwarz).

[242] Pima Association of Governments. (2003) Riparian Areas: Restoration and Management in Eastern Pima County. Watershed Forum, December 3. Tucson, Arizona. p. 13

[243] Tucson Audubon Society. Application to Arizona Water Protection Fund. p. 10

[244] Phillips, Ann Audrey, Scott Wilbur, and Kendal Kroesen. (2002) Tucson Audubon Society Site Assessment and Concept Design: Santa Cruz River Habitat Project North Simpson Site. Tucson: Tucson Audubon Society. p. 4

riparian habitat around the river corridor with adjacent xeroriparian and upland areas to provide an integrated habitat. [245] Non-native species such as tumbleweed, shrubby deciduous tamarisk, and arundo are present throughout the site. Some eradication has been done to control these species. However, because cooperative agreements for control are not in place on adjacent properties and upstream on the river, there is a constant influx of seeds which make it nearly impossible to fully eradicate the non-natives. In some locations, species such as saltbush have been planted to try to compete with the tumbleweed. In other locations, the less invasive, large evergreen tamarisk trees have become habitat for barn owls and other wildlife and have been left undisturbed.

One of the major strategies of the restoration design was the use of rainwater harvesting to catch rainwater and focus it around plantings. The rainwater harvesting was accomplished by placing multiple horseshoe-shaped basins and swales on the sloped flood control berms and other surfaces. Plantings were placed in the bottom of the basins. In many of the basins, multiple species were planted that could provide mutual shade and other symbiotic functions. For example, native trees were planted in the center of basins, flanked by a heat-tolerant shrub on the west and a more heat-sensitive shrubs or forbs on the east side. After two years, most of the rainwater harvesting earthworks are still intact[246].

At the North Simpson Restoration site, special attention was paid to microclimate factors such as wind exposure, solar orientation, and slope when determining which species to plant and how. In the lower terraces, selected sites were restored using cottonwood and willow poles, as well as by the removal of undesirable plants. Efforts to establish the cottonwood and willow riparian communities focused on floodplain surfaces where: depth to saturated soils did not exceed three meters during summer months; the area was not excessively vulnerable to flood scour; there was not already significant amounts of riparian vegetation; and invasive species were dominant.[247] In the upper terraces, selected sites were revegetated with the goal of creating a diverse meso-riparian habitat. Efforts were focused on sites that are located above the active floodplain, where depth to saturated soils was generally greater than three meters. The area was not considered unstable or very vulnerable to large scale erosion events. It did not already have significant amounts of riparian plants, and areas where invasives dominate, creating a need for revegetation.[248] The flood control berms were revegetated with the goal of creating a dense upland vegetation array by treating them to reduce tumbleweed infestation, as well as with the goal to repair of erosion gullies and rivulets where necessary.[249]

Another water source on the property has facilitated creation of a second mesoriparian area in addition to that found on the corridor around the river. On the north side of the site, irrigation tail water released from adjacent agricultural fields flowed into a ditch along the north property boundary. The water was initially a nuisance, creating dense colonies of tumbleweed. In order to take advantage of the water source, a 1000-foot long meandering trench was dug to pull this water south into an otherwise barren part of the site. Small “chicken foot” branches were constructed periodically along this trench to extend flow out from the main channel. The area was planted with

[245] Ann Phillips. (2006) January. Personal interview and site tour with author. (Schwarz).

[246] Ibid.

[247] Phillips, Ann Audrey, Scott Wilbur, Kendal Krosen, and Mark Briggs. (2002) Project Work plans: Exotic Species Control and Native Species Revegetation Plan Monitoring Plan and Public Outreach Plan Tucson: Tucson Audubon Society

[248] Ibid.

[249] Ibid.

native species and has quickly turned into a dense riparian habitat.[250]

Monitoring/Management: Maintenance of grant-supported work will continue for 20 years as required under the AWPF and USFW agreements. Five types of monitoring are currently used on the North Simpson site: photo point monitoring, vegetation monitoring, avian monitoring, erosion monitoring including stream cross section monitoring, and hydrologic data monitoring. Photo monitoring is generally performed annually during the same month each year. Additional rounds of photo monitoring are performed early in grant-funded projects to document restoration implementation and early plant growth. Vegetation monitoring is conducted to determine the survival and growth of introduced plants and to document the changes to habitat quality resulting form restoration efforts. Survival and growth monitoring at AWPF -funded areas is conducted monthly at first to track initial plant growth, then reduced to quarterly, then finally to annual measurements. Vegetation monitoring for habitat conditions is conducted at the beginning and end of AWPF projects to document changes in habitat due to restoration efforts and natural system changes. Avian monitoring has been conducted quarterly since 2001 at multiple locations of the site and will continue indefinitely into the future. Erosion monitoring was preformed initially in September 2002 and will be repeated following flow events of 3,000 cubic feet per second or more during the duration of the AWPF grants. Collection of stream gage data and rainfall data are conducted by downloading internet data from the US Geological Survey website and the Arizona Meterological Network website. This data collection effort will be on-going. [251]

Funding and Cost: In-lieu mitigation fees for section 404 of the Clean Water Act, grants from the Arizona Water Protection Fund, and U.S. Fish and Wildlife Service Partners for Wildlife grant.[252] Funding has totaled $550,000 (as of Dec 2003).[253]

Land Ownership: City of Tucson. A resolution between the City of Tucson and Tucson Audubon Society allows Tucson Audubon access to the site for 99 years to conduct habitat recovery and restoration projects.

Water: Water at the North Simpson site comes from pumped groundwater, rainwater harvesting, and effluent released into the Santa Cruz River from regional wastewater treatment plants in Tucson. Average daily effluent flows through the site are generally less than 40 cubic feet per second and are usually present, except following flood events when the river bottom is scoured and an increase in infiltration rates allows the effluent to infiltrate prior to arriving at the site.[254] There is no agreement or contract currently in place to guarantee that effluent flows will continue indefinitely at the site.

Supplemental water used to nourish plantings during their first two years after establishment is provided by the City of Tucson through their groundwater wells on site. A Water Use Agreement between the City of Tucson and Tucson Audubon Society allows Tucson Audubon to use up to ten acre-feet of water per year for the irrigation.[255] Groundwater use has consistently been less than

[250] Supra note 245
[251] Ibid
[252] Supra note 240
[253] Pima Association of Governments. 2003. Riparian Areas: Restoration and Management in Eastern Pima County. Watershed Forum, December 3. Tucson, Arizona. p. 13
[254] Ibid. p. 8
[255] Arizona Water Protection Fund. 2001. Arizona Water Protection Fund Grant Award Contract for Tucson Audubon Society North Simpson Farm Riparian Recovery Project. Phoenix: Arizona Department of Water Resources. p. 13

this allotment, five acre-feet per year. [256] Rainwater harvesting was also used extensively on the site to capture and focus rainwater around plantings.

Pubic Outreach: Public outreach has consisted of semi-annual articles in the Vermillion Flycatcher, the Tucson Audubon Society's newsletter; volunteer workdays; restoration workshops for adults; educational programs with area schools; site tours and birding field trips; and off-site lectures and slide shows.[257] Although the project has full time staff members and a number of contractors assisting with restoration, many volunteer hours were used in the first restoration phase, a practice that will continue as the site restoration proceeds.

Challenges/Lessons Learned: One important lesson learned from the North Simpson Site Restoration project, according to the Tucson Audubon Society, was the value of having a partner like the City of Tucson involved in the project. The city provided fencing, heavy equipment and operators when needed as well as enforcement against illegal uses of the property. The city was able to deploy resources that insured the success of the project, and the TAS was able to concentrate on restoration activities.

One lesson learned is that periodic safety meetings with the crew were well worth the time and expense. They brought the crew together to discuss safety issues as well as other topics. They also gave the staff a chance to discuss response procedures. This was especially important because of the large number of volunteers on the site during volunteer days.

Vehicle access to the site proved to be extremely valuable. The site is long and narrow. A narrow dirt road snakes through the site allowing deliveries of irrigation pipes, plants, tools and other materials to be brought very close to where they would be used.

Installation of irrigation piping for over 2000 plants elicited several lessons learned. Pipe expansion and contraction caused many problems. Temperatures on the site fluctuated almost 100 degrees over the four years from 2000-2004. Pipes installed at either side of the temperature spectrum tended to experience separation at glued joints. It was found that installing pipes when the temperature was between 60 and 80 degrees produced the best results as temperatures changed. In addition, installing expansion couplings every 1000 feet for above-ground pipes and every 2000 feet for below-ground pipes increased their ability to withstand temperature fluctuations.

Flushing and draining the irrigation lines was also an issue. Drain valves were initially installed at the end of each pipe run, but it was found that additional drain valve needed to be installed at low spots and at the end of each branch line. The team also found that flushing the lines to remove scale and ants was required monthly to keep the system functioning properly.

No mechanical timers were used in the irrigation system so that human oversight would be present whenever the system was on. This turned out to be a very effective strategy for detecting leaks and reducing erosion from pipe breaks.

Use of pole planting was a simple cost-effective method of facilitating colonization by some species. The restoration team noticed that cottonwoods and willows along the river corridor naturally oriented themselves in lines parallel to the river banks. The most upstream tree growing in this stringer pattern takes the brunt of the flood impact, reducing impact to downstream trees

[256] Supra note 245
[257] Ibid.

from detritus and high flows. Pole plantings were placed in this same pattern.[258]

Drivers: Restoration of a portion of the Santa Cruz River to provide riparian habitat in an area where much of the historic habitat is degraded or has disappeared entirely.

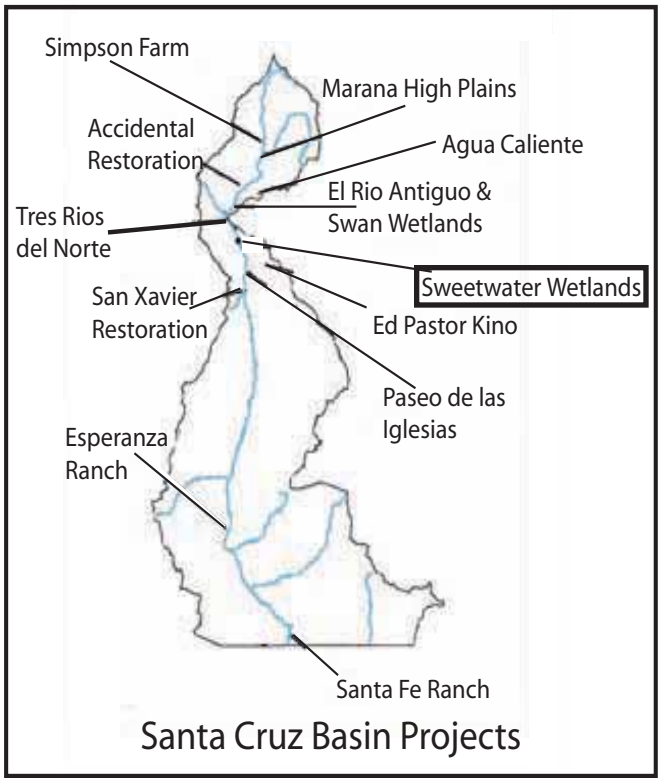
[258] Tucson Audubon Society, (2005) Final Report- Santa Cruz River Habitat Project-North Simpson Site Arizona Water Protection Fund Phase 1 Area. December 2005. Tucson: Tucson Audubon Society.

Santa Cruz River through site
North Simpson Riparian Recovery

Santa Cruz River through site
North Simpson Riparian Recovery

Cottonwoods, rainwater harvesting swales foreground
North Simpson Riparian Recovery

Photos courtesy
of AWPF



Sweetwater Wetlands

Primary Documentation: 2005 Sweetwater Recharge Facilities Fact Sheet and personal interviews with Tucson Water.

Location and Size: The Sweetwater Wetlands are located on Sweetwater Drive in Tucson, Arizona, just east of the Santa Cruz River. The site, including recharge facilities, is 109 acres with 17.3 acres of constructed wetlands.

Primary Sponsor(s): City of Tucson

History: In November 1993, the Arizona Department of Environmental Quality (ADEQ) issued the City of Tucson a letter of warning citing 24 violations of state drinking water laws and rules. ADEQ then filed suit in May 1994 and Tucson, which did not admit to any wrongdoing, settled in July 1994. As part of the settlement, Tucson agreed to pay between $300,000 and $400,000 to create a wetlands utilizing backwash water used to clean filters at the Tucson Reclaimed Water Treatment Plant. Construction began on the Sweetwater Wetlands in June 1996 and the facility was opened to the public two years later in March 1998. [259]

Planning Objectives: The consent agreement signed with ADEQ required three principal actions: 1) address the backwash issue, 2) create wildlife habitat, and 3) provide public education. The wetlands were therefore designed to address these three issues. Trails, informational signs, and public viewpoints were placed around the eastern wetland pond for public education and passive recreation. The western wetland pond was created with limited signage and one public viewpoint, reserving the rest of the area for wildlife.

Current Phase: Monitoring and maintenance

Phases: Recharge at the site that includes the Sweetwater Wetlands, known as the Sweetwater Recharge Facility, was first conducted as a demonstration/pilot project from 1984 through 1989. The success of the demonstration project led Tucson Water to develop and construct four large, excavated recharge basins beginning in the summer of 1989. In 1996, construction began on the wetlands as well as on four additional recharge basins. The wetlands were completed and opened to the public in March 1998.[260]

Recommended or Implemented Plan: The 17.3 acres of wetlands were built to operate in parallel or in series. With regard to the parallel configuration, the wetland facility could be operated utilizing two flow pathways, one on each side of the wetlands. Each pathway has one settling basin and one wetland pond. The final step is the discharge of the wetland water into the recharge basins. The

[259] Riparian Areas Regulatory Controls in Eastern Pima County. (2003) Water Quality Forum January 9, 2003

[260] Kmiec, John P. and Tim M. Thomure. (2005) "Sweetwater Recharge Facilities: Serving Tucson for 20 Years." Water Reuse. Forthcoming publication Sept. 2005.

facility can also be operated in series where only one settling pond is used, after which the water is conveyed to the eastern wetland pond and then to the western pond. The water is then recharged. In either configuration, the backwash water is filtered by cattail and bulrush colonies throughout the wetland. By design, the settling basins and wetland ponds are situated over a natural clay layer that minimizes infiltration during wetland treatment. However, recharge basins are placed on more permeable soils where infiltration rates are higher.[261] The various wetland components rely on gravity flow to convey water from one point to another along the various flow paths.

Monitoring/Management: The principal focus of monitoring and management of Sweetwater Wetlands revolves around containment and control of the mosquito population. Mosquito management is conducted through the application of larvacide to the vegetated areas on a weekly basis for about 36 weeks per year using a remote control helicopter. The larvacide used is rotated periodically to prevent the mosquitoes from developing a resistance. Adulticide is used only when the number of mosquitoes rises above a certain threshold.[262] Vegetation management at the wetlands consists of controlling bulrush and cattail overgrowth. After a few seasons, both species will die out, causing a dense thatch to form in the wetland ponds which affects the wetland's ability to filter water. To remove the thatches of bulrush and cattail, Tucson Water has instituted a controlled burn program with a strategy of burning a third of the wetlands every third year. This strategy retains a balance between providing habitat for migratory birds and the maintenance of the system.[263] Water quality is measured at eight sampling points throughout the wetlands as well as at the source of water for the wetlands.[264]

Funding and Cost: Approximately $1.6 million. Project was paid for by bonds approved by the voters in the City of Tucson. Annual maintenance cost for the wetlands is $72,000.[265]

Water: The wetlands process approximately 1.6 million gallons per day of secondary effluent and filtered backwash water. The adjoining recharge facility recharged about 57,000 acre-feet between October 1986 and May 2005. Of that, 8-10 percent is water from the wetlands. The remaining water used for recharge is secondary treated effluent.

Pubic Outreach: The community was involved in the planning and designing of this project through the Citizens' Wetlands/Recharge Advisory Committee, with members appointed by the Mayor and Council of Tucson. The committee was assisted by various federal, state, and local agencies. Ten committee meetings and three open houses were held from December 1994 through early September 1995. At these meetings the public was invited to provide their input into the design of the wetlands. As a consequence of public input, all native vegetation was used at the wetlands as well as a more natural looking design for the ponds themselves. In addition to the Advisory Committee, a Wetlands/Recharge Educational Outreach Program was established that produced an official wetlands logo designed by local students.[266] In August 1999 a documented case of mosquito-borne, Western Equine Encephalitis at the wetlands prompted some to call for the closing of the facility. In response to the public's concerns, Tucson Water modified its mosquito control procedures to 1) commence weekly adulticide fogging and 2) remove much of the thatched,

[261] Riparian Areas Regulatory Controls in Eastern Pima County (2003). Water Quality Forum January 9, 2003 pg
[262] Prior, Bruce. (2005) Personal communication with author (Mott Lacroix). July 25, 2005.
[263] Ibid.
[264] Tucson Water. (2005) Sweetwater Recharge Facilities Fact Sheet. Tucson: Tucson Water. p. 2
[265] Ibid.
[266] Gelt, Joe. (1997) "Constructed Wetlands: Using Human Ingenuity, Natural Processes to Treat Water, Build Habitat." Arroyo. March, Tucson: Water Resources Research Center.

dead vegetation that blocked granular larvicide from contacting the water.

Challenges/Lessons Learned: One of the challenges at the Sweetwater Wetlands was the removal of the overgrown cattail and bulrush. The maintenance team first tried to remove the vegetation using mechanical means. This process was problematic, however, because in order to get the equipment into the areas that needed to be thinned, the wetland area had to be completely dried out. Once the machines were in the area and had removed the vegetation, it was then necessary to remove and dispose of the material. Tucson Water found that it was much more efficient to burn about one-third of the wetlands each year to control overgrowth. Burning the vegetation eliminates the need for drying the ponds as well as hauling away debris. These burns do not require a permit from the Arizona Department of Environmental Quality and are used as wildland fire training for the Tucson Fire Department.

Another challenge in managing the wetlands is mosquito control. Three different technologies have been employed to apply granular larvicide: using a land-based, truck-mounted hydro-seeder, a tracked, aquatic water craft with a seed spreader, and a remote controlled helicopter. Tucson Water staff found that the truck-mounted hydro seeder was unable to broadcast the larvacide beyond 100 feet from the edge, and the wetlands were up to 400 feet across in some areas. The tracked aquatic water craft could traverse the cattail and bulrush but could only disperse the granular larvacide in a 30-foot swath. The best, and at this point only, solution is a remote controlled helicopter that is able to cover the entire wetland area in less than two hours.

Finally, Tucson Water noted that designing the ponds so that some of the pools can be drained while leaving others full has proved to be a valuable element of the design. For example, during an outbreak of avian botulism, operations crews contained the epidemic by draining the ponds in the areas most affected by the disease. At the same time, other ponds remained full in adjacent areas providing undisrupted habitat.

Drivers: Multiple use wetland-treatment facility, research, public education, and passive recreation. Initial funding and minimum project requirements for a wetlands project were established through a settlement between the City of Tucson and the Arizona Department of Environmental Quality over alleged drinking water quality violations.[267]

[267] Burchell, Joe. (1994) July 8. Water Suit to Cost City up to $450,000, Arizona Daily Star.

Project Site- Before
Sweetwater Wetlands

Project Site- After
Sweetwater Wetlands

Waterfowl at the wetlands
Sweetwater Wetlands

Photos courtesy o Tucson Water

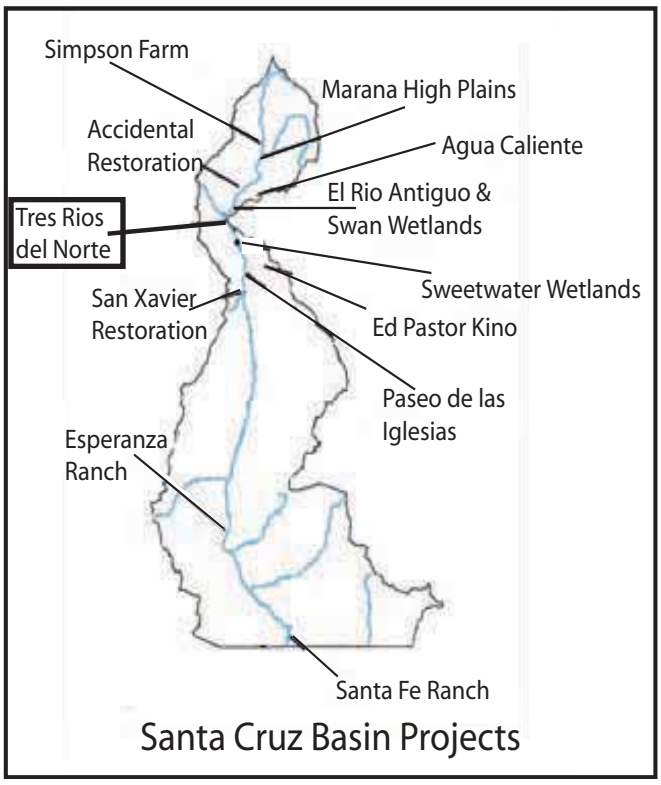
Birdwatcher at wetland
Sweetwater Wetlands

Educational signage
Sweetwater Wetlands

Operations- removing vegatation
from infiltration basin
Sweetwater Wetlands

Operations- loading remote controlled helicoper
for pesticide application
Sweetwater Wetlands

Photos by Andrew Schwarz
and Kelly Mott Lacroix



Tres Rios del Norte

Primary Documentation: 2004 U.S. Army Corps of Engineers, Tres Rios del Norte – Ecosystem Restoration Feasibility Study F4A Milestone - Alternative Formulation

Location and Size: Santa Cruz River, Pima County, Prince Road to Sanders Road, West Moore Road, and West Avra Valley Road. The project area encompasses 19 miles of the Santa Cruz River.

Primary Sponsor(s): Pima County Regional Flood Control District (PCFCD), Town of Marana, City of Tucson and United States Army Corps of Engineers (USACE).

History: Prior to degradation, the Santa Cruz River flowed year round past San Xavier del Bac to downtown Tucson, ten miles north. At that time, the Santa Cruz River was a shallow stream with a wide flood plain containing cottonwoods, willows, and mesquite bosques. Today, a riparian habitat nourished by natural perennial river flows no longer occurs along the river within the project area. Due to past agriculture and current municipal use, groundwater levels today are approximately 100 to 250 feet below the surface contributing to reduced river flows. In addition, sand and gravel mining, which began in the 1970s and '80s near Ina and Cortaro roads and continues today, has further altered the characteristics of the river course. Today, the only water in the river comes from effluent discharge from the Roger and Ina Road Wastewater Treatment Plants and storm water runoff. The effluent flow is variable in its delivery and extent, fluctuating seasonally and throughout the day. Future releases of effluent are not reliable and can not be planned on. In the future, it is expected that growth and development pressures will increase the economic value of effluent to a point where most if not all of the water will be used for purposes other than direct discharge into the river.

Planning Objectives: "Restoring wetland and riparian vegetative communities within the river corridor to a more natural state; increasing the acreage of functional seasonal wetland habitat within the river corridor; minimizing disturbance-type impacts to restored wetlands; minimizing the potential for sediment and organic matter accumulation in restored wetlands; increasing habitat diversity by providing a mix of habitats both in the river corridor and along the riparian fringe

and buffer; recharging and recovering municipal water supplies that also will facilitate vegetation restoration, and reducing potential flood damages in specified areas"[268]

Current Phase: The project's F4 milestone has been completed. The next public meeting is expected to occur February 2006. It is anticipated that public release of the feasibility report will occur in late 2006.

Phases: Reconnaissance Report initiated February 2000 and completed December 2000 (Sec 6 of Flood Control Act of 1938); Feasibility F4A Milestone (AFB) January 2004.

Recommended or Implemented Plan: The Recommended Plan will likely be a combination of enhancements that provide for ecosystem restoration, water supply (recharge and recovery), and recreation. Restoration goals are to improve mesquite, cottonwood-willow, and emergent wetland habitats to a condition supportive of wildlife, and for the benefit of residents and visitors to the area.[269]

Monitoring/Maintenance: Operations and maintenance will consist of regular monitoring of restoration performance, invasive species control, maintenance of water delivery system, replacement of non-surviving vegetation, water and electricity. The annual monitoring is estimated at $60 per acre with control of invasive species costing an additional of $60 per acre.[270]

Land ownership: City of Tucson, State of Arizona, Pima County, Town of Marana, and private.

Funding and Cost: Funding and authorization for this project is from the USACE General Investigation, Ecosystem Restoration. "The tentative plan is currently estimated at a construction cost of approximately $292 million. The Federal share of construction is currently estimated at approximately $170 million, and the non-Federal share at $117 million."[271] The annual cost of water is estimated to be $13,209,560.[272]

Water: Currently, effluent discharge flows perennially from the Roger and Ina Road Wastewater Treatment Plants. The tentative plan includes piped delivery of tertiary reclaimed water and in channel effluent flows. These flows of approximately 44,000 acre-feet in water annually would be used to sustain vegetated areas.[273] "Site work would include micro-grading for individual tree basins, flood irrigation, bubblers, drip irrigation, and implementation of micro- and macro-scale storm water-harvesting features." The revegetated area will include over 3,000 acres of watered and storm water-nourished habitat.[274]

Public Outreach: Public outreach activities have included one public meeting in 2001 and two public meetings in 2003. The next public meeting will take place in February 2006. Public release of the feasibility report will occur later in 2006.

Challenges/Lessons Learned: Project is in initial stages, no lessons learned reported.

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[268] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2003) Preliminary Draft Environmental Impact Statement, Tres Rios del Norte Feasibility Study. Los Angeles: U.S. Army Corps of Engineers.

[269] U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division. (2004) Tres Rios del Norte – Pima County, Arizona Ecosystem Restoration Feasibility Study F4A Milestone - Alternative Formulation. Briefing Report Los Angeles: U.S. Army Corps of Engineers. p. iii

[270] Ibid. p. 6-14

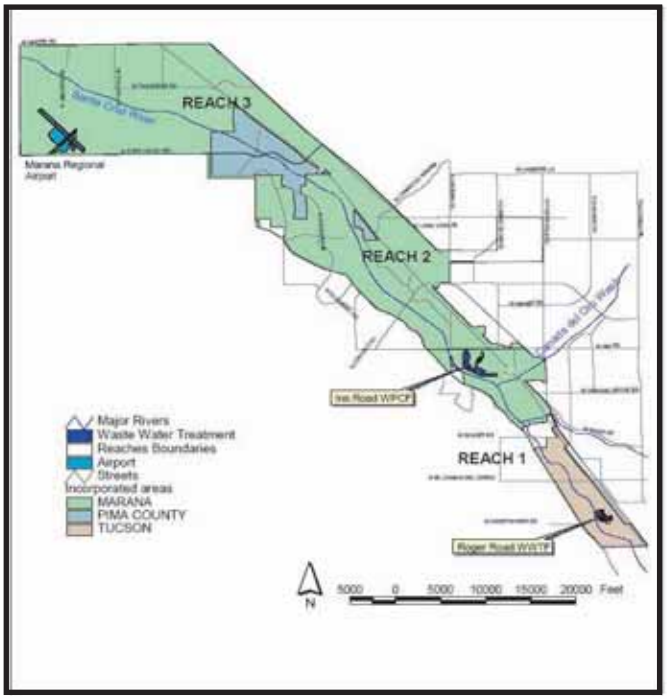
[271] Ibid. p. iv

[272] According to the F4A Feasibility report water will cost $105 per acre-foot at the assumed source (This number has since been changed to $260 per acre foot.). Ibid. p. 6-14.

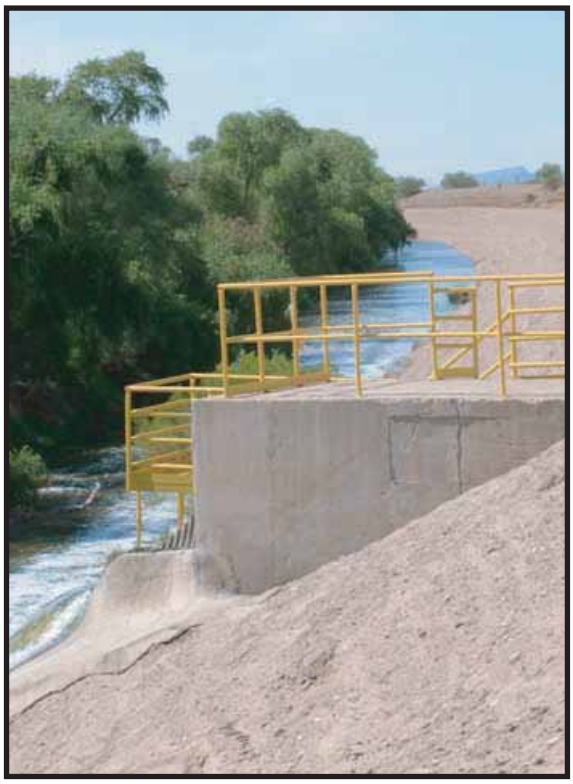
[273] Smith, Linda (City of Tucson). (2006) January. Review comments of draft report of this study.

[274] Supra note 269

Drivers: Provide mitigation for lost riparian habitat.

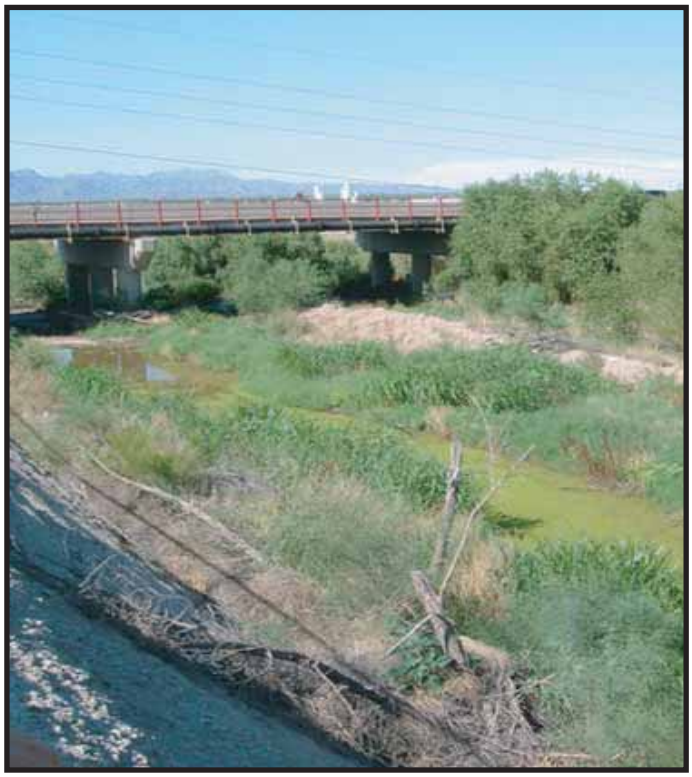


Project study area
Tres Rios del Norte



Roger Road Wastewater Treatment plant outfall into the Santa Cruz River
Tres Rios del Norte

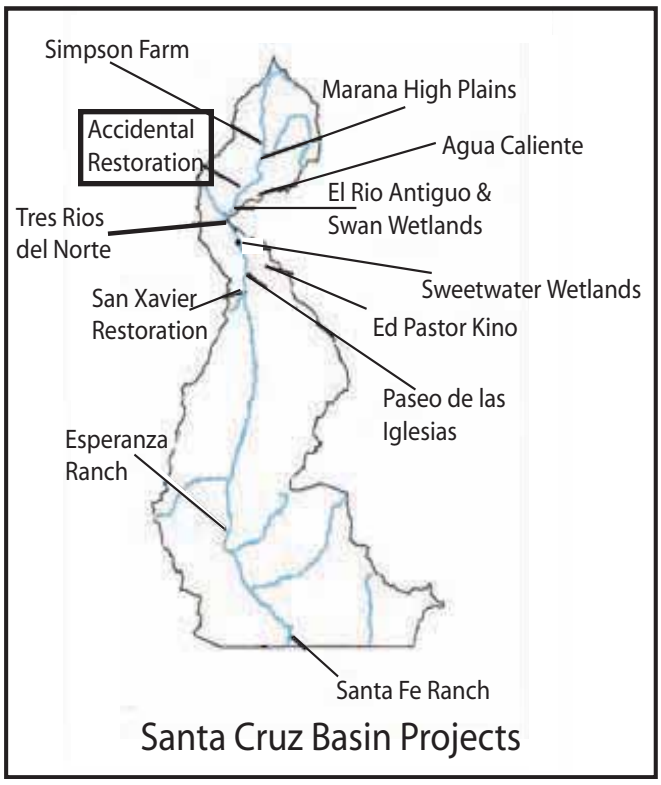
Effluent dominated Santa Cruz, view south from the Ina Road Bridge
Tres Rios del Norte



Santa Cruz River, view of Ina Road Bridge
Tres Rios del Norte

Santa Cruz River channel view to the north
Tres Rios del Norte

Photos courtesy of Jennifer Jones, Map courtesy of USACE



Discharge of Wastewater in Pima County

Primary Information Source: 2003 Pima Association of Governments Watershed Forum Proceedings.

Location and Size: Santa Cruz River north of the Roger Road and Ina Road wastewater treatment facilities.

Primary Sponsor(s): Water comes from the Pima County wastewater treatment plant but there is no "sponsor" per se.

History: The portion of the Santa Cruz River north of Tucson was historically dry for most of the year, containing flows only during flood events. Effluent from the Tucson area was first discharged into the River in the 1970s, creating water flows where none previously existed. Today, approximately 50,000 to 60,000 acre-feet of effluent is released into the River each year. The sources of this water are the Roger Road and Ina Road wastewater treatment plants. This restoration "project," unlike the others in this study, does not involve any plans or phases; it is simply the result of adding water to an ecosystem. [135]

Recommended or Implemented Plan: The presence of the effluent stream has created a thriving riparian community consisting of both native and non-native plant and animal species. Examples of established native species are Goodding's Willow and Fremont Cottonwood. Invasive species such as tamarisk, Bermuda grass, buffelgrass, and castor bean are also present. The system almost always contains water, however; the extent and reach of the water varies because infiltration is impeded by algal mats. During large flood events, the streambed gets scoured, which increases infiltration and reduces the reach of the stream. Daily and seasonal output cycles from the plant lead to varying water depths and stream reaches throughout each day and each season. The dependable water flows and increased vegetation have also led to the return of birds and some other wildlife, though a diversity of invertebrates are not prevalent, most likely due to the habitat limitation of an effluent dominated river

Monitoring/Management: A number of bird surveys have been conducted of the area as well as brief investigation of invertebrate species. Arizona Game and Fish Department has reviewed the area and recorded a few fish; however, no native species are known to exist in this portion of the river at this time.

Land Ownership: Public and Private

Water: Between 50,000 to 60,000 acre-feet of water flow down this portion of the Santa Cruz River each year from the wastewater treatment plants. Because the River is effluent dominated in

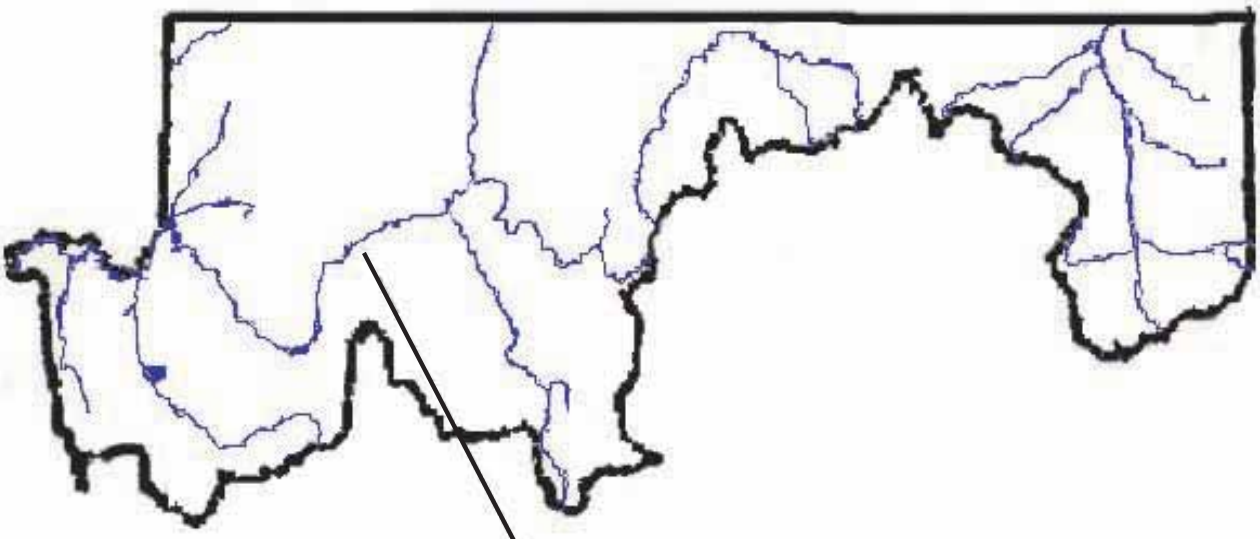
135 Pima Association of Governments. 2003. Riparian Areas: Restoration and Management in Eastern Pima County. Proceedings from the Watershed Forum, December 3. Tucson: Pima Association of Governments. p. 21

this reach, the water quality is lower than in a natural stream. The dissolved oxygen levels are low, concentration of ammonia is high, and there is a lot of sand as well as other chemicals not removed in the wastewater treatment process.

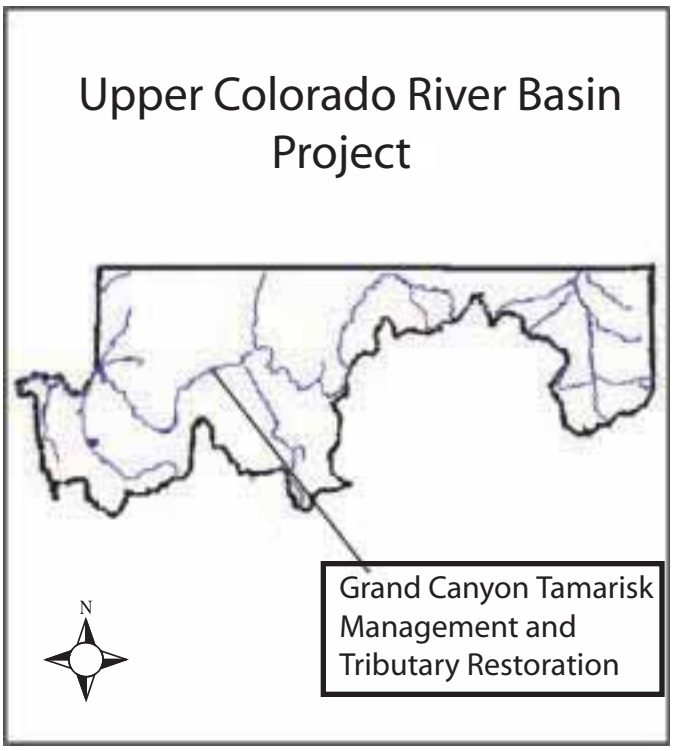
Challenges/Lessons Learned: The most important lesson learned here is that much can be accomplished by simply adding water to a riparian corridor.

Drivers: The need to dispose of effluent in a cost effective manner. (As water demand increases, effluent discharge to the river is expected to decrease.)

Upper Colorado River Basin Project



Grand Canyon Tamarisk Management
and Tributary Restoration



Grand Canyon Tamarisk Management and Tributary Restoration

Primary Documentation: 2005 Grand Canyon Wildlands Council final report to Arizona Water Protection Fund for Glen and Grand Canyon Riparian Restoration Project.

Location and Size: Lees Ferry, Glen Canyon National Recreation Area and 63 tributaries of the Colorado River between Lees Ferry and Grand Canyon National Park. The project is located in both Coconino and Mohave Counties.

Primary Sponsor(s): Grand Canyon Wildlands Council, Grand Canyon National Park Science Center, and Fred Phillips Consulting. Phase II is sponsored by the Grand Canyon National Park Foundation.

Other Sponsors: Arizona Water Protection Fund (AWPF).

History: Tamarisk is a widespread exotic that was introduced into the southwest around the turn of the last century. Since its introduction, tamarisk has expanded to cover nearly 500,000 hectares of the western United States. Several areas have become completely infested with tamarisk, leading to the decline of native cottonwoods, willows, and various riparian shrubs on which native birds and other wildlife depend. This project focused on tamarisk removal on tributaries and side canyons of the Colorado River, as well as seeps and springs in Grand Canyon National Park. These areas are considered extremely important because they are among the most pristine watersheds and desert riparian habitats remaining in the United States.

The recent encroachment of tamarisk poses a significant threat to the ecological integrity of these natural ecosystems. Tamarisk is problematic in riparian habitats because it increases fire frequency in an area where fire has not typically played an evolutionary role. The increase in fire frequency can lead to a simplification of the ecosystem and monoculture stands. Tamarisk can also lower water tables because of its high water consumption. Both the monoculture and lower water tables can negatively affect native plant and wildlife communities. Tamarisk is adapted to a wide range of environmental conditions and can colonize habitats from open grassland to rocky arroyos. Finally, once established in an area, it typically spreads and persists, pushing out native plants. [275]

Planning Objectives: The overarching objectives for the project are to reduce tamarisk cover by 95% within project areas in Grand Canyon National Park over the next five years.[276] Specific objectives for phase one were to: synthesize existing research on tamarisk control and ecology;

[275] Grand Canyon Wildlands Council. (2005) Glen and Grand Canyon Riparian Restoration Project: Final Report for Arizona Water Protection Fund Contract Number 99-075. Flagstaff: Grand Canyon Wildlands Council, Inc. p. 95

[276] National Park Service. (2002) Environmental Assessment: Tamarisk Management and Tributary Restoration. Grand Canyon: Grand Canyon National Park. p. 6

transform a well-established tamarisk stand at Lees Ferry back into riparian habitat dominated by native vegetation; and help the National Park Service in the Grand Canyon meet its administrative goal of eliminating non-native species.[277]

Specific objectives for phase two include: remove/control at least 35,000 tamarisk trees in year one at 35 separate project sites; control all known, or newly discovered, populations of date palm, Himalaya blackberry and Russian olive within 35 target project areas; install a long-term interdisciplinary monitoring system that includes vegetation transects, wildlife transects, hydrological sampling, archeological inventorying, photo prints, and GPS data collection; develop standardized recruitment and training procedures to ensure effective utilization of volunteers; and prepare public information/education material on the management of non-native vegetation.

Current Phase: Removal of tamarisk continues through a grant provided by AWPF in 2004 to begin phase two. The project work plan for phase two has been completed, and the phase two pre-project assessment trip is scheduled for the summer of 2005. The phase two grant is scheduled to be completed in December 2006.

Phases: Phase one of the project included the following steps: establish a project administrator and preparation of monitoring and revegetation plans (May – June 2000); assemble a database of and evaluate information on tamarisk control and ecology (Sept. 2000); conduct pre-revegetation and avian census at Lees Ferry (Sept. 2000); pre-tamarisk eradication monitoring in the Colorado River Tributaries (June 00 and Dec. 2000); revegetate at Lees Ferry (Dec 00 – Sept 01); monitor at Lees Ferry (June 02 – March 03); post revegetation avian census (March 03 – Jan 04); and tamarisk eradication and post tamarisk eradication monitoring along the Colorado River tributaries (Jan. 04 – Sept 04).[278]

Phase two will involve the following: obtain permit clearances, authorization and agreements; prepare and submit plans (March 05); invasive vegetation management and control activities; and create public education materials. Once phase two is complete planning will commence for phase three.

Recommended or Implemented Plan: Under the recommended plan for all three phases of the project, the restoration will occur using both mechanical and chemical options to remove the tamarisk. The method selected is site specific and determined by the restoration biologist or project leader. Manual removal involves hand pulling and the use of leverage devices to ensure that the entire root system is removed. Chemical applications include: Garlon lance injection, which inserts small herbicide capsules inside the tree; "hack and squirt method" where a tree girdler is used to cut into the core of the tree and them herbicide is applied to the cut; the cut stump method where tree trunks are cut near ground level and then stumps are sprayed with Garlon; and basal bark application where the entire stem is treated with Garlon.

Under the recommended plan, native species restoration will be used in phase three and in certain areas in phase two, primarily in somewhat dense tamarisk stands. [279] Native species restoration also occurred during phase one at the Lees Ferry site.

Monitoring/Management: A long-term monitoring system, including vegetation transects and photo points, will be installed to monitor vegetative change over time. A monitoring plan was

[277] Supra note 275
[278] Ibid. p. 11
[279] Supra note 276

prepared for phase one of this project and the plan will be expanded to include phase two and three project locations.[280]

Monitoring for phase one of the project consisted of observing percent survival and growth rates for the newly planted native vegetation in the Lees Ferry area; calculation of foliage volume and density; and determination of species survivability based on variations in depth to the water table and salinity levels.[281] Avian monitoring was also conducted at Lees Ferry because "[b]irds are excellent, conspicuous and well-known indicators of habitat quality and dynamically change in response to stand and environmental changes." [282] In the tributaries where only tamarisk eradication took place (not eradication and replanting), vegetation cover was monitored, and each area was revisited one to two times following eradication.[283]

Funding and Cost: For phase one of this project, 2000-2004, AWPF provided $371,285. An additional $146,720 was provided through matching funds and in-kind services from project collaborators. For phase two the AWPF will provide $189,394, Grand Canyon National Park Foundation will contribute in kind $14,000, $70,000 is contributed in the form of 5,000 volunteer hours and $70,000 is expected in the form of federal support for the project.

Land Ownership: Federal, National Park Service

Water: Tamarisk competes with native vegetation for water and can lower water tables. Tall, dense stands of tamarisk can use over nine acre-feet of water per year for every acre of infestation. Water uptake such as this can reduce, or in extreme cases eliminate, water flow along drainages. Saltcedar eradication is also important because the protruding root wads of the plants extend into river courses, decreasing the water velocity and thereby increasing the deposition of sediment, overtime the sediment deposition will narrow the course of the river.[284]

Pubic Outreach: Public outreach was conducted initially as part of the scoping for the Environmental Assessment. In addition, the Environmental Assessment was mailed to all identified interested parties for comment. As part of phase one volunteers donated a total of 7,956 hours to the project, a value of more than $115,000 dollars.[285] These volunteers participated in many ways including multi-day boating trips into the tributaries of the Colorado to remove tamarisk.

Public information will also be produced to serve as educational materials that will be used in the National Park. The materials will educate park visitors on the threats to park ecosystems from invasive species as well as the Park Service's efforts to control the problem.

Challenges/Lessons Learned: According to the final report on phase one to the AWPF, "This effort is also an excellent example of successful collaboration between federal, state, and non-governmental organizations on ecosystem restoration. The site at Lees Ferry is effectively a pilot project for demonstrating the potential success of site-specific riparian restoration along the Colorado River main stem in the Grand Canyon region."[286] Preliminary survey results indicated that in Phase I of the project, they would be able to remove 22,589 tamarisk trees. During project

[280] Ibid
[281] Supra note 275
[282] Ibid. p. 76
[283] Ibid. p. 71
[284] Montana State University Extension. 2005. Saltcedar (Tamarisk) http://www.montana.edu/wwwpb/pubs/mt9710.html
[285] Supra note 275
[286] Ibid. p. 9

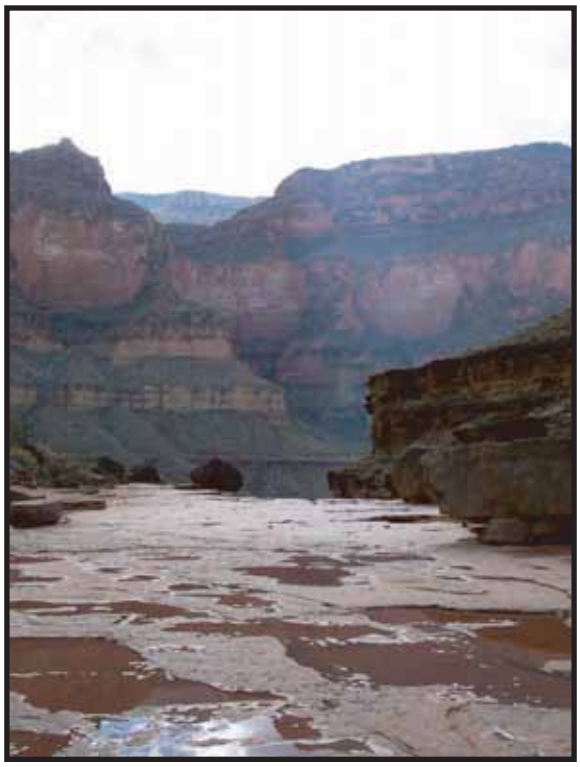
implementation, crews removed 70,616 tamarisk trees from the project area. "The re-treatment data from the project area showed that only 7% of the initially treated trees required follow-up treatment. With the refinement of control techniques, project coordinators anticipate the re-treatment needs declining in the future as this project expands."[287]

Drivers: This project was driven by the removal of invasive species to reestablish native ecosystems. Focus is on removal of tamarisk because "Park biologists consider tamarisk removal to be the linchpin in for their efforts to restore riparian habitat in the Park."[288] The project was also driven by a need to improve techniques for invasive species eradication.

[287] Ibid. p. 142

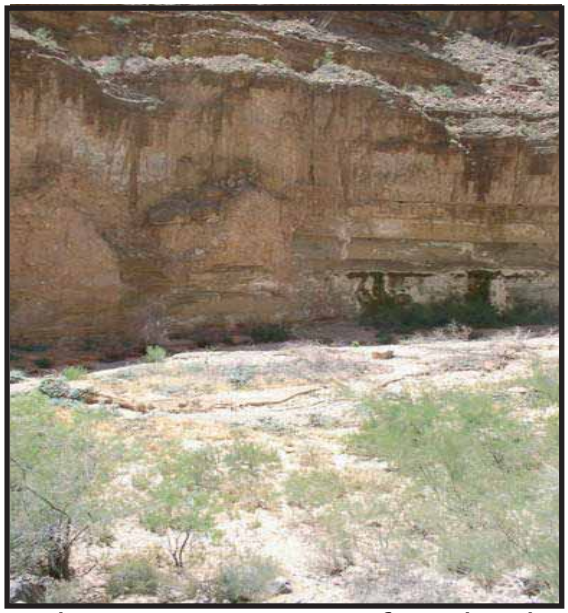
[288] Grand Canyon National Park Foundation. 2004. Application to Arizona Water Protection Fund for Management and Control of Tamarisk and Other Invasive Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park (First Year of Phase II of Comprehensive Project). Grand Canyon: Grand Canyon National Park Foundation.

Using herbicide to remove tamarisk
Grand Canyon Tamarisk Removal

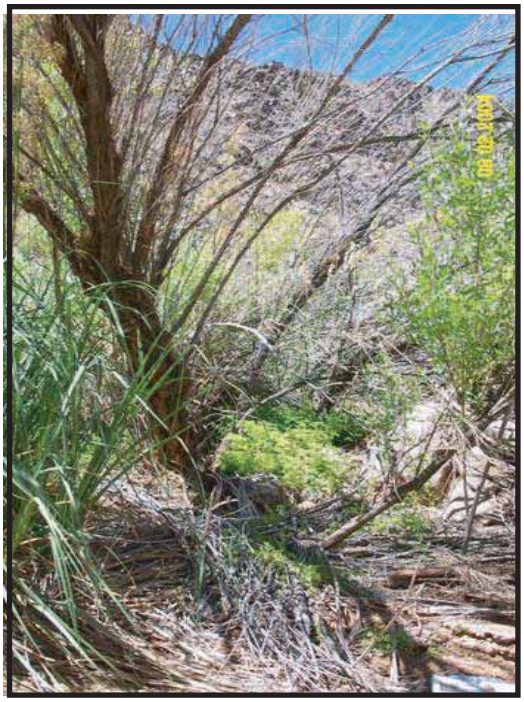


"122 Mile" backcountry restoration area
Grand Canyon Tamarisk Removal

Irrigation lines at Lees Ferry restoration site
Grand Canyon Tamarisk Removal



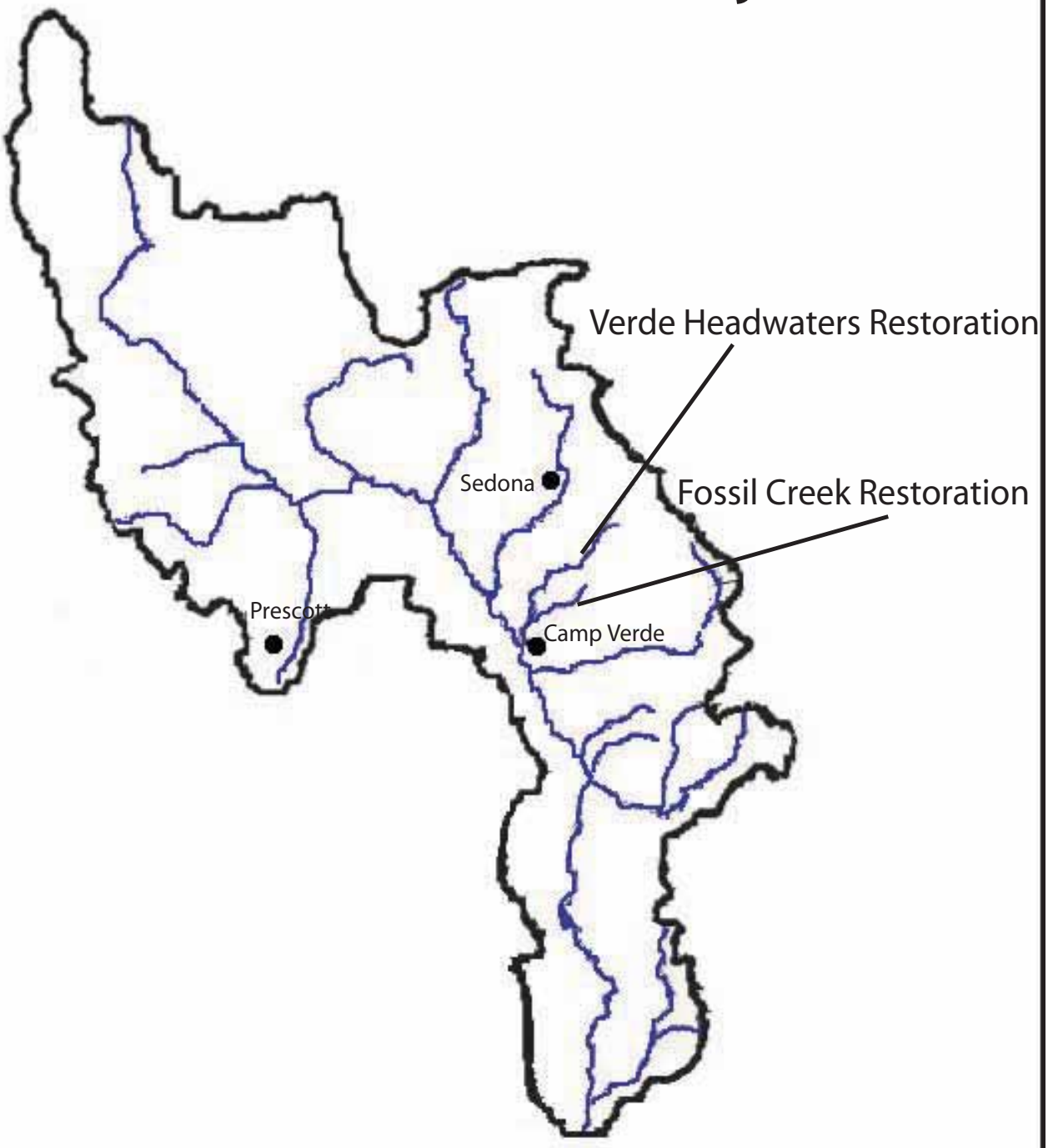
Backcountry area once infested with tamarisk
Grand Canyon Tamarisk Removal



Native vegetation recolonizing in an area where tamarisk was removed
Grand Canyon Tamarisk Removal

All photos courtesy of AWPF

Verde River Basin Projects



Fossil Creek Dam Removal and Riparian Restoration

Primary Documentation: 2004 Comprehensive Monitoring Plan for Fossil Creek Watershed Restoration.

Location: Fossil Creek is a tributary of the Verde River located seven miles west of Strawberry in Yavapai and Gila Counties. Restoration activities are taking place on a 14 mile stretch of the creek.

Primary Sponsor(s): U.S. Forest Service (USFS), Northern Arizona University (NAU), and Arizona Public Service (APS).

Other Sponsors: Federal Energy Regulatory Commission (FERC), U.S. Bureau of Reclamation (BOR), U.S. Fish and Wildlife Service, Salt River Project, American Rivers, and The Nature Conservancy.

History: Fossil Creek is fed by Fossil Springs, which once provided year-round water at about 300 gallons per second. The system is unique because the mineral content of the springs creates a travertine system. The travertine system is formed by the super-saturation of the limestone aquifer that feeds the spring with calcium carbonate and dissolved carbon dioxide. This creates an environment where calcium carbonate can precipitate onto existing rocks, logs, etc. to form travertine deposits. In 1891 the waters in Fossil Creek were described as "so impregnated with mineral that they are constantly building great round basins for themselves, and for a long distance flow down over bowl and bowl."[289]

Early in the 1900's this flow was harnessed by a series of canals, pipes, and tunnels that diverted water from the springs to the Childs and Irving power plants, built by APS. As a result of the hydroelectric operation, a 14 mile stretch of Fossil Creek beneath the dam was reduced from about 40 cubic feet per second to two to three cubic feet per second on average. The Childs-Irving plants could generate seven megawatts of power at full capacity. Given the minimal amount of energy generation and the uniqueness of the stream, many environmental groups have pressured APS to decommission the dam for years. In 1999, the plant was up for review by the FERC. At this time, APS decided to decommission the dam and restore the creek.

Planning Objectives: The restoration effort involves a series of goals to be implemented both before and after the dam is decommissioned. These goals are: "document the baseline condition of the watershed prior to restoration of full flows; design and initiate a long-term monitoring and assessment program to measure restoration progress and identify changes in the watershed after flows are restored; provide tangible, science-based recommendations to the USFS, APS, FERC, and other decision makers; facilitate participatory meetings among management agencies,

289 Arizona Public Service. (2002) Childs Irving Environmental Assessment. Phoenix: Arizona Public Service. p. 13

conservation organizations; and local stakeholders to identify concerns related to monitoring and restoration and further refine the monitoring plan and restoration process; develop an adaptive management process to continuously improve and modify the monitoring plan and provide long-term input to the restoration process; and disseminate lessons learned for Fossil Creek." [290] In addition to these goals, the project also included the eradication of non-native fish species in the river and construction of a fish barrier to prevent non-native re-colonization.

Current Phase: APS is decommissioning the Childs-Irving Facility.

Phases: December 1992 APS filed an application for a new license for the Childs-Irving plants. August 1997 FERC issued a Draft Environmental Assessment with a recommendation that the new license be issued. September 2000 APS filed an Offer of Settlement requesting that FERC approve surrender of the license to operate and APS' Removal and Restoration Plan included in the settlement. October 2004 FERC approved APS' license surrender (this was upon completion of a NEPA analysis as well as historical structure and ESA reports). March 2004, FERC approved decommissioning construction documents. Fall 2004 BOR constructed a fish barrier, salvaged existing native species, removed non-natives with chemical application, and restocked the creek with native species that had been removed from creek prior to chemical application. June 2005 full flows were restored to Fossil Creek.

Recommended or Implemented Plan: Prior to restoring full flow to the creek, exotic fish were eradicated by treating the creek with a chemical called Antimycin A. Before treatment, native fish were removed, kept in holding tanks, and released back into the stream after it was safe. BOR constructed a barrier at the downstream end of the chemical treatment that will prevent reinvasion of exotic fish from the Verde River. Full flow was restored to the river on June 18, 2005. Over the next four years, APS will dismantle all but seven structures associated with the power plants, and the Fossil Springs Dam will be lowered by 14 feet.[291]

Funding and Cost: Cost of lowering the Fossil Springs dam by 14 feet and removing other structures associated with the Childs-Irving plants is estimated at $11,766,000. This cost will be paid by APS.[292] NAU is conducting the monitoring and research of the site before, during and after restoration. The funds for these activities currently come from a grant from the Nina Mason Pullman Charitable Trust.

Land Use: The entire area is federal land, Coconino (326 acres) and Tonto (17 acres) National Forests.

Monitoring/Management: Northern Arizona University, together with U.S. Forest Service, Coconino and Tonto National Forests, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and U.S. Bureau of Reclamation, will monitor in the following six areas: travertine development; aquatic species and interactions with travertine; sediment, stream morphology and hydrology; springs characterization; recreation impacts and visitor use; and coordination, education, and outreach. The United States Forest Service will be responsible for maintaining the roads and other facilities in 2009 when APS finishes deconstruction of the dam.

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[290] Northern Arizona University. (2004) A Comprehensive Monitoring Plan for Fossil Creek Watershed Restoration. Flagstaff: Northern Arizona University.

[291] Ibid

[292] It should be noted that if the plants were to remain operational it would have cost APS an average of $827,000 a year.

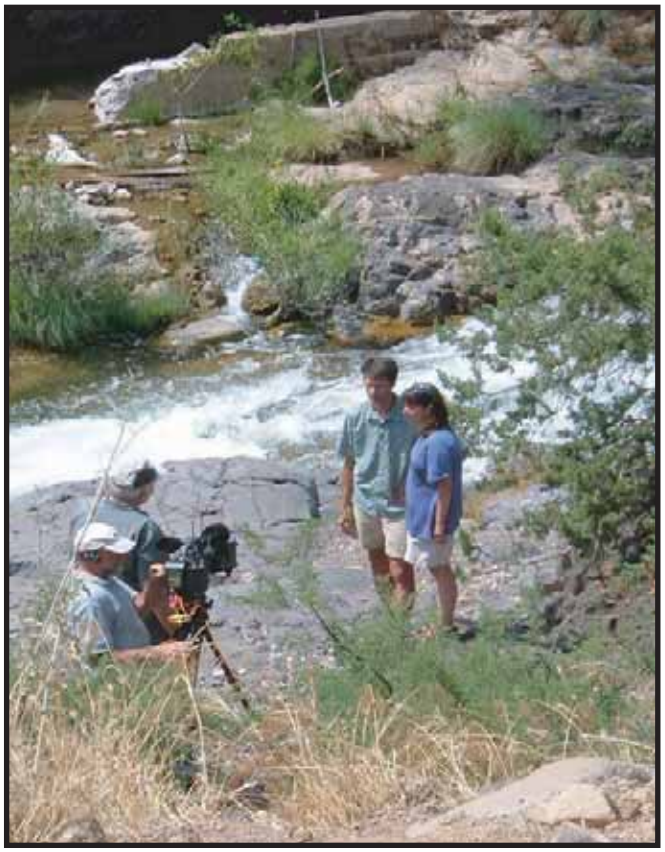
Water: Fossil Creek is fed primarily by Fossil Spring, however, snow melt and precipitation events also contribute to the creek. It is estimated that Fossil Spring provides 300 gallons per second to the flow of Fossil Creek. Once restored, Fossil Creek will be the fourth largest travertine system in North America.

Pubic Outreach: Northern Arizona University conducted a series of participatory meetings beginning in June 2004. The first meeting was limited to agencies and groups directly involved in the restoration at Fossil Creek. The second set of meetings was held in October of 2004 in Pine and Camp Verde. The format was an open-house designed to provide information on research and decommissioning activities. Close to 50 people attended these two meetings. The third meeting was held in April of 2005 and was designed to provide updates to conservation groups and tribes as well as to solicit feedback on the project. The two hour meeting included presentations by NAU on research and monitoring at Fossil Creek and management issues caused by the anticipated increase in recreation use of the area.[293] PBS is also producing a documentary on the process of decommissioning the dam.

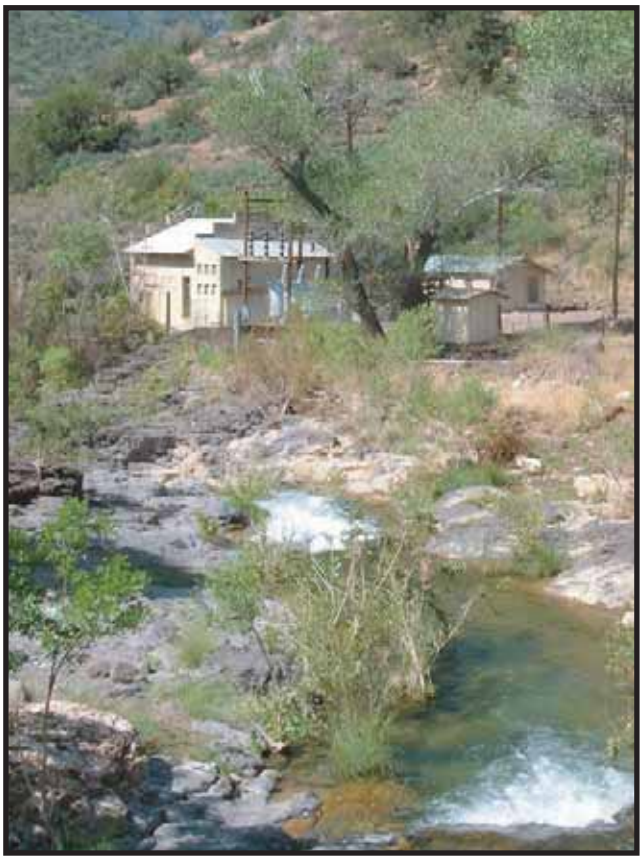
Challenges/Lessons Learned: Decommissioning of the dam took almost a decade. During this time, it was necessary for many groups with diverse interests to come together and compromise in order to achieve a result that everyone could live with. Throughout the project, the team from NAU has found that it is very difficult to secure funding for monitoring.[294] Now that flows have been restored, the Fossil Creek system faces new management challenges, and the USFS will need to write a new comprehensive management plan for the watershed. The most pressing issues that the creek now faces are increased recreational use, exotic species such as crayfish, and solidifying the in-stream water right.[295]

Drivers: Fossil creek is a unique water system with high recreational potential. The dam which confined the flow of the creek was no longer economical. Collaboration between diverse interests was also a driver.

[293] http://verde.nau.edu/fossilcreekproject/meetings.htm Accessed May 27, 2005.
[294] Marks, Jane. (2005) August 2. Interview with author (Mott Lacroix).
[295] Flood, Tim. (2005) "The Arizona Riparian Council and Fossil Creek." Arizona Riparian Council. Volume 18, Number 2, May.

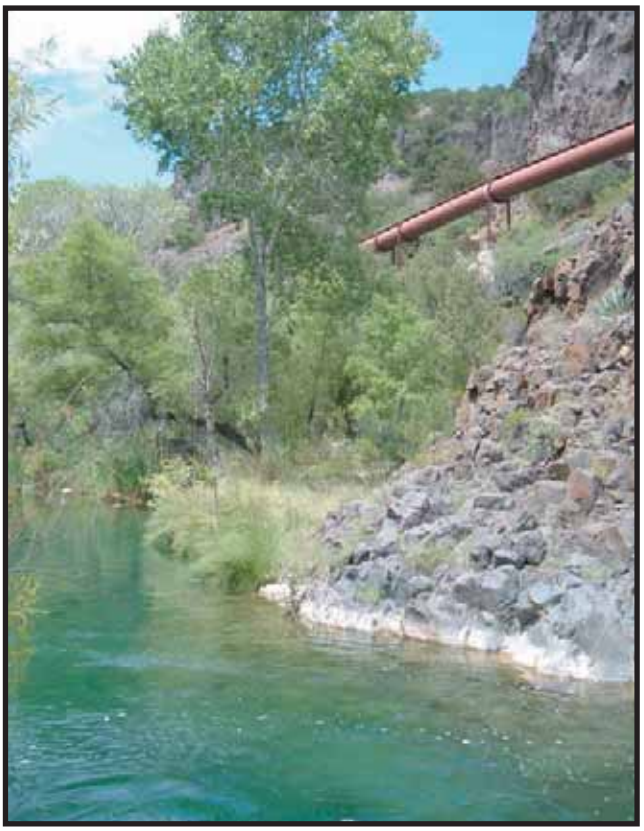


Filming the PBS special
Fossil Creek



Childs Power Plant
Fossil Creek

Exposed travertine dam
Fossil Creek



Pool and pipeline
Fossil Creek

Photos by Kelly Mott Lacroix

Verde River Headwaters Riparian Restoration

Primary Documentation: 2000 USFS Environmental Assessment for the Verde River Headwaters Riparian Restoration Demonstration Project, 1998 NAU grant application to Arizona Water Protection Fund for Verde River Headwaters Riparian Restoration Demonstration Project.

Location and Size: Coconino County, approximately 40 miles outside of Flagstaff off of Forest Road 142. The project restored 2,600 feet of stream channel at Clover Creek and 500 feet of stream channel at 44 Canyon. The project area is about 2,800 acres including 28 acres of restored riparian habitat.[296]

Primary Sponsor(s): United States Forest Service, Coconino National Forest (USFS) and Northern Arizona University (NAU).

Other Sponsors: Arizona Water Protection Fund (AWPF) and Arizona Department of Environmental Quality (ADEQ).

History: "Perennial streams occur rarely on upland areas of the Colorado Plateau. Where they do exist, they are typically supported by groundwater discharging though seeps or springs. Wetland meadows are unique and valuable resource within the dry ponderosa pine forest above the Mogollon Rim in Central Arizona. Many of these meadows have been severely impacted by stream instability caused by both human and natural activities. One such spring and associated perennial reach of stream occurs at Clover Springs."[297]

Geomorphic analyses suggest that the natural channel configuration has withstood several moderate climatic changes during the past 7,000 years. Changes in land use coupled with climate change at the turn of the 20th century resulted in dramatic down cutting of the stream channel. Clover springs is a wetlands meadow, and although there are no spring discharge records, anecdotal information indicates that the springs are perennial.

In 1990, the Forest Service initiated the Clover Springs Erosion Project, which called for wooden structures to stop the head cutting and side cutting in Clover and 44 Canyons. These structures were installed in the summer of 1990 and 1994. Monitoring, however, showed that the structures were failing. Water was cutting around the sides of the structures and "the height of the structures above the creek create[d] a long hydraulic fall that [was], in turn, causing deep scouring to the

[296] Long Valley Ranger District, Coconino National Forest, USDA Forest Service. (2000) Environmental Assessment for the Verde River Headwaters Riparian Restoration Demonstration Project. Coconino County: Coconino National Forest. p. 1

[297] Northern Arizona University. 1998. Application to the Arizona Water Protection Fund for the Verde Headwaters Riparian Restoration Demonstration Project. Flagstaff: Northern Arizona University.

areas below the structures."[298] In 1998, the Forest Service met with several professors from NAU who were interested in studying and restoring the stream because of its unique high elevation montane meadow.

Planning Objectives: "The purpose of this project is to restore proper functioning riparian condition to Clover Springs Draw and 44 Canyon Draw, and to have a transportation system that does not negatively impact Clover Springs Draw."[299] Specific project goals were as follows: improve riparian vegetation through increasing species diversity, specifically of sedges and rushes; maintain satisfactory soil conditions and long-term soil productivity, this includes maintaining 90% of potential effective ground cover; design and construct roads that meet the needs of the public, while minimizing negative impacts to riparian systems in Clover and 44 Canyons; maintain current satisfactory watershed condition; maintain full compliance to water quality standards through Best Management Practices; maintain or enhance suitable habitat for threatened, endangered, sensitive, and candidate species; maintain access to West Clear Creek Wilderness area and to the popular day use area north of the project area; and minimize impacts to the Pivot Rock grazing allotment from project activities.

The project also had a number of objectives associated with the partnership between NAU and the USFS. These objectives include: develop a better understanding of the natural processes of riparian systems and how they relate to riparian restoration techniques; build upon past partnership opportunities (Hoxworth Springs); and improve partnering efforts in the future that are mutually beneficial to both parties.[300]

Current Phase: Monitoring and maintenance, AWPF grant ended in Feb 2003.

Phases: The project had three phases: the study phase, the implementation phase, and the information exchange phase. In the study phase, NAU determined the factors causing the degradation of the stream banks and monitored groundwater and spring flow as well as vegetation. In the implementation phase, Forest Road 142 was removed, all existing stream channel structures in both the Clover and 44 Canyons were removed, the site was revegetated, and ungulate proof fences were installed to protect most of the plantings.[301] The final phase, the information exchange phase, included producing a video of the entire process, placing two information kiosks at the Clover Springs Draw site, and placing signs along Highway 87 to direct the public to the Clover Springs Draw site.[302]

Recommended or Implemented Plan: On-site stabilization and revegetation took place in July 2001 resulting in a reconfigured channel that was rejoined with the abandoned floodplain. Stream bank stabilization incorporated a variety of natural channel approaches for incised systems. In the upper portion of the reach, the channel grade is controlled by the elevation of a culvert under Highway 89 near Clover Springs and in the end of the reach a rock structure drops the channel floor in a series of steps to meet the elevation of the incised downstream channel. Parameters

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[298] Ibid. p. 2

[299] Long Valley Ranger District, Coconino National Forest, USDA Forest Service. (2000) Decision Notice and Finding of No Significant Impact: Verde River Headwaters Riparian Restoration Demonstration Project. Coconino County: Coconino National Forest. p. 1

[300] Ibid.

[301] The original plan called for all areas to be enclosed in elk fencing, however, during implementation a number of small areas were not fenced because of their proximity to Highway 89 and concerns about trapping elk on the road.

[302] Supra note 299

for channel design were obtained through topographic survey, viable reference reach, and other methods such as development of localized hydrologic models.[303] Revegetation involved four actions: hydromulching of the disturbed upland surfaces, placement of erosion mat on disturbed upland surfaces, revegetation of the newly created riparian area with plugs of native sedge and rush species, and construction of an 8 foot high elk fence.[304]

Monitoring/Management: Surface water and groundwater quantity were monitored as part of the project to help document success of restoration and for baseline characterization. Surface water monitoring consisted of monthly measurements of spring discharge. Channel stability was monitored through two sets of annual measurements during the project's funding and will be monitored at least once every three years thereafter.[305] Channel stability was monitored though longitudinal profile and cross sectional profiles with ten permanent cross sections at locations most susceptible to erosion of channel banks and at locations that best characterize the nature of the cross sectional shape of the channel.[306] Vegetation was monitored and measured according to percent aerial cover of plant species and abiotic material in rectangular plots in the stream channel and in the adjacent bank or bench. Data was collected prior to restoration on the percent cover by species in order to determine the degree of success of restoration.[307] Finally, photographic monitoring was also used to document changes in the project site. Changes recorded include the channel plan morphology, cross-sectional channel morphology, and vegetative cover in the channel and on the upland areas.[308] Under operation and maintenance agreements between AWPF and USFS, USFS must maintain and protect vegetation on the site for 20 years.

Funding and Cost: The AWPF contributed $204,629. Other funds for restoration efforts during the AWPF grant period, $113,540 total, came from ADEQ and matching funding from the USFS and NAU.

Land Ownership: Federal, United States Department of Agriculture, Forest Service

Water: Springs feed 100% of the stream flow in Clover Creek for most of the year. Coconino National Forest has a surface water right to Clover Creek for 1000 gallons per day for domestic use and 1500 gallons per day for stock watering use. Under the Arizona Department of Environmental Quality grant, a series of Best Management Practices were implemented to protect surface water quality standards. Examples of these practices are: filter strips to mitigate impact from road construction and use, road out slope to minimize runoff and minimize stream sediments, site revegetation, revegetation site protection through ungulate proof fence, and riparian plant establishment. Irrigation of the plantings was used until they were established. Irrigation water was supplied by piping water 1,500 feet from Clover Spring though the project site to revegetation areas.[309]

Pubic Outreach: As part of the project two informational kiosks that demonstrate stream

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[303] Anderson, Diana, Abe Springer, Jeff Kennedy et. al. (2003) Final Report Verde Headwaters Restoration Demonstration Project. Flagstaff: Northern Arizona University. p. 13

[304] Ibid. p. 14

[305] NAU has made plans to resurvey the channel in the winter of 2005.

[306] Supra note 303

[307] Ibid p. 22

[308] Ibid. p. 29

[309] Arizona Department of Environmental Quality. 2000. Water Quality Improvement Grant Program Grant Agreement no. 00-0117. Phoenix: Arizona Department of Environmental Quality.

restoration techniques were installed at the restoration site. NAU also produced a twenty minute video showing the project process and results. Prior to implementation of the project, as part of the Environmental Assessment, the USFS conducted public scoping and solicited comments on the draft EA.

Challenges/Lessons Learned: The need for restoration of this area was due in large part to previous failed restoration attempts. Previously, a series of constructed features were used to try to stop the head cutting of the stream. These structures failed largely because the sediment in the area is very fine and would flow around any built structure. As a result, in this restoration only one major structure was installed, and the USFS is not sure how long this structure will be useful. Throughout most of the restoration area an erosion control mat was used, which as designed, should biodegrade in a few years. The USFS has found, however, that the mat is not biodegrading and is causing some down cutting in areas where it meets the stream edge. The mat has also proved troublesome in areas where the elk still have access because they pull it up and get tangled in it.[310]

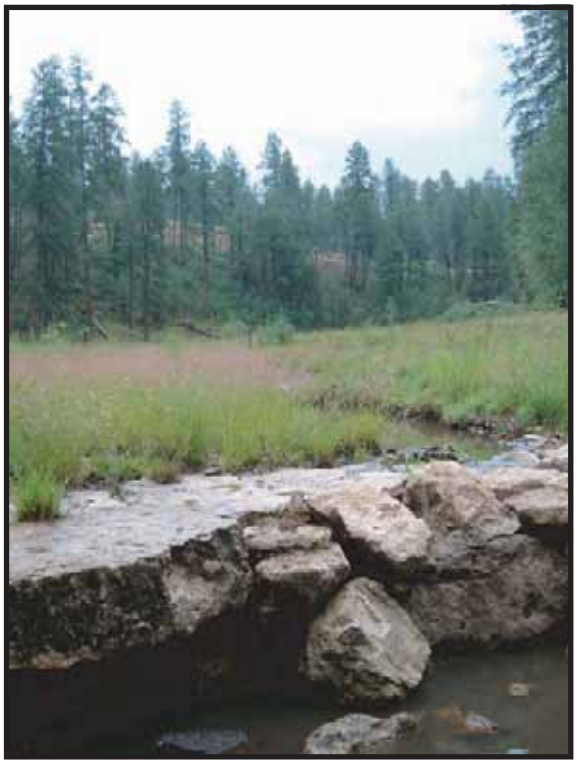
Drivers: Presence of FR 124 was degrading an otherwise healthy system, therefore, project revolved around moving the road and restoring the system.

[310] Fleischman, Dick (United States Forest Service). (2005) August 5. Interview with author (Mott Lacroix).

Clover Springs before, FR 124 is on the left
Verde River Headwaters Restoration

Clover Springs immediately after bulldozing
Verde River Headwaters Restoration

Informational kiosk
Verde River Headwaters Restoration



Dam structure at Clover Springs summer 2005
Verde River Headwaters Restoration

Clover Springs summer 2005
Verde River Headwaters Restoration

Photos courtesy of Abe Springer and
Kelly Mott Lacroix

Appendix A. Project Survey used to verify information

Print Form

Project Characterization Confirmation Form

BOR/U of A-WRRC Report: "Projects to Enhance Arizona's Environment: An examination of their function, water requirements and public benefits"

Project

Thank you for taking the time to review the information that we have gathered about your project. There are seven questions about your project each regarding a specific section of the report. In most cases we have filled in the boxes that we feel most appropriately represent the characteristics of the project. Please check the information to make sure that you agree with the characterizations. If you disagree please click on the check boxes to select and de-select information. When you are through save a copy of the file (to save the information you have provided) and return the file to us via email at *schwarza@cals.arizona.edu.* Surveys can also be returned by mail at:

Water Resources Research Center
Attn: Andrew Schwarz
350 N. Campbell Ave
Tucson, AZ 85719

Project Water Requirements

uestion

Please check the box that applies to your project.

- ◯ Project does not require an supplemental water o supplemental water was supplied to the project site during any phase of the project and none will need to be provided to support vegetation in its current form. ***Please proceed to question 3.***

- ◯ Project requires onl temporar supplemental water Water is artificially supplied to the project area for to years to foster the establishment of vegetation. fter this period no supplemental water is supplied and vegetation is expected to continue to develop with similar diversity and distribution as during irrigation. ***Please proceed to question 2.***

- ◯ Project requires supplemental water to be applied for more than ears Project vegetation diversity and distribution will change significantly if supplemental water is not supplied to the project area. ***Please proceed to question 2.***

uestion

Please specif the source of water used to suppl water to the project Please check all boxes that apply to your project.

urface Water	roundwater	torm Water	Rainwater arvestin	Effluent
◯ Source is firm	◯ Source is firm	◯ Source is firm	◯ Source is firm	◯ Source is firm
◯ Source is not firm	◯ Source is not firm	◯ Source is not firm	◯ Source is not firm	◯ Source is not firm
◯ o surface water was used	◯ o groundwater was used	◯ o storm water was used	◯ o rainwater harvesting was used	◯ o effluent was used

Water source is considered firm if there is a contract or agreement in place which guarentees the provision of water to the project site for the entire period of time for which supplemental water is required.

dditional omments	

Project ponsorship

uestion

Please specif who is/was the primar sponsor for the project . The primary sponsor is the group or groups who did the restoration work. (This is not funding).

Please specify agency

- ☐ Federal overnment
- ☐ tate overnment
- ☐ Cit / ocal overnment
- ☐ Count A enc
- ☐ O
- ☐ Private Entit
- ☐ ribal overnment
- ☐ Universit

dditional omments

Project Benefits

uestion

Please specif what benefits are derived from the project . enefits should be considered broadly and do not have to accrue to human populations. Please check all that apply.

- ☐ Repair ama e from Over razin
- ☐ Part of a eneral Restoration Plan
- ☐ mplementation tud
- ☐ Cultural i nificance
- ☐ Economic Redevelopment
- ☐ Water ualit mprovement
- ☐ Flood Protection
- ☐ Provide abitat
- ☐ ulti-use Facilit
- ☐ Public Use and Enjo ment
- ☐ Protection of a Unique Water stem
- ☐ Rechar e Water to Aquifer
- ☐ Prevent Urban Encroachment
- ☐ Environmental Education
- ☐ aintain a hreatened stem
- ☐ Collaboration of iverse nterests
- ☐ Research/ nowled e mprovement
- ☐ Other

Please pecif

dditional omments

Project rivers

uestion

Please specif what rove the project to be underta en . Project drivers differ from benefits in that they are the specific reason or force that led to the project being undertaken. Please check all that apply

- ☐ Repair ama e from Over razin
- ☐ Part of a eneral Restoration Plan
- ☐ mplementation tud
- ☐ Cultural i nificance
- ☐ Economic Redevelopment
- ☐ Water ualit mprovement
- ☐ Flood Protection
- ☐ Provide abitat
- ☐ ulti-use Facilit
- ☐ Public Use and Enjo ment
- ☐ Protection of a Unique Water stem
- ☐ Rechar e Water to Aquifer
- ☐ Prevent Urban Encroachment
- ☐ Environmental Education
- ☐ aintain a hreatened stem
- ☐ Unintentional
- ☐ Collaboration of iverse nterests
- ☐ Research/ nowled e mprovement
- ☐ Other

Please pecif

Project essons earned

uestion

Please describe an additional not alread detailed in the report lessons that were learned durin the plannin , implementation or mana ement of the project that mi ht benefit other entities underta in similar wor

Presentation of nformation and Findin s

uestion

a ow can we ma e this information available to restoration professionals li e ourself so that it would be most useful and accessable

b What addional information would ou li e to see included in future studies

a

b

Thank you for completing this fact checking form your information will ensure that we accurately portray your project in the report. If you have any further comments questions or concerns please don t hesitate to contact ndrew Schwarz at schwarza cals.arizona.edu

Reviewed by:

Organization:

Date

Please return completed surveys via email by saving a copy of the file (to save the information you have provided) and emailing the file to *schwarza@cals.arizona.edu.* r by printing the completed survey and mailing it to:

Water Resources Research Center
Attn: Andrew Schwarz
350 N. Campbell Ave
Tucson, AZ 85719

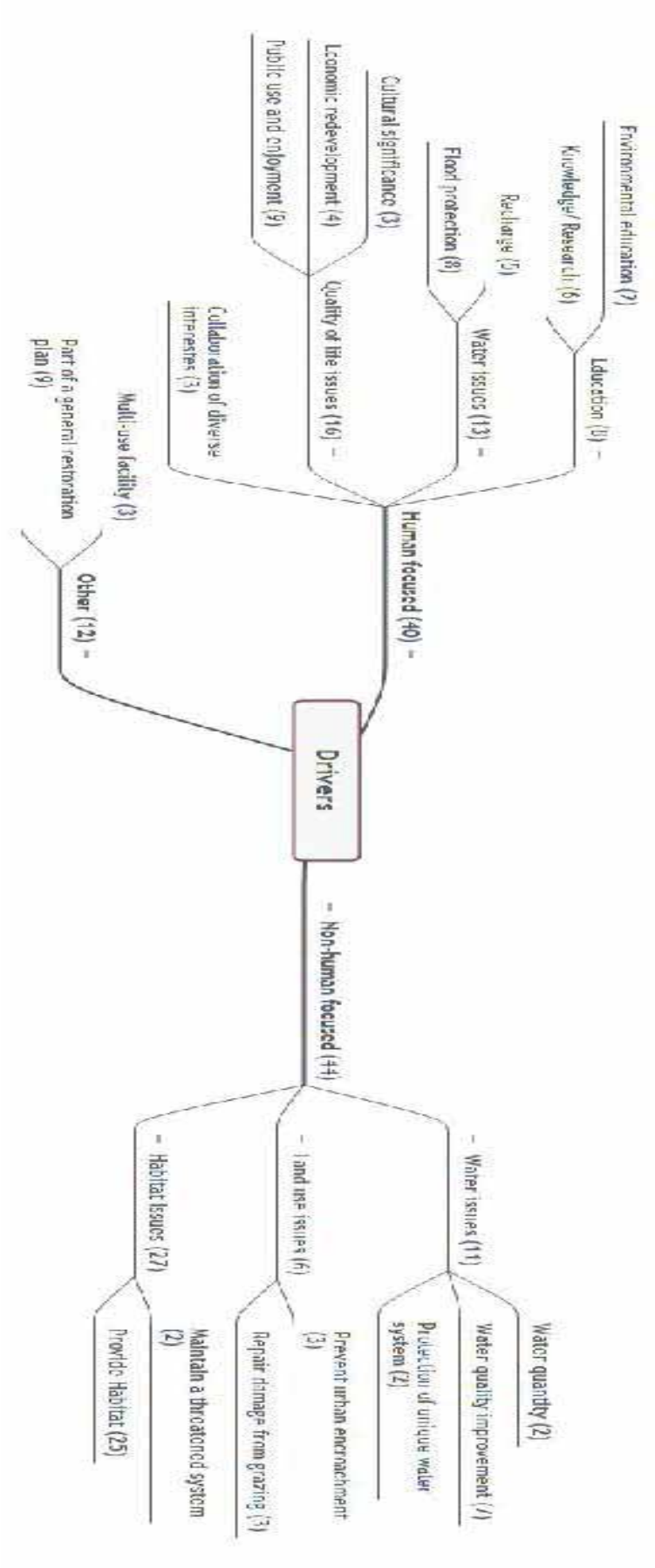
Appendix B1. Drivers Matrix

PROJECT DRIVERS	Repair amage rom Grazing	Part o a General restoration Plan	Cultrual Signi icance	Economic Redevelopment	Water uality Improvement	Flood Protection	Provide Habitat	Multi se Facility	Public se and Enjoyment	Protection o a ni ue water system	Recharge water to a ui er	Prevent rban Encroachment	Environmental Education	Maintain a threatened system	Collaboration o diverse interestes	Knowledge research	Water uantity
Accidental Restoration																	
Agua Caliente		x					x		x								
Ahakhav Tribal Preserve			x				x										
Bingham Cienega						x	x										
EC Bar Ranch	x	x			x		x										
Ed Pastor Kino Park						x	x	x									
Esperanza Ranch	x				x		x								x		
Fossil Creek				x			x		x	x						x	
Grand Canyon Tamarisk Removal		x					x			x						x	
Las Cienegas							x				x	x					
Little Colorado River Enhancement		x			x											x	
Marana High Plains Recharge					x		x	x	x		x						
North Simpson	x	x					x										
Paseo de las Igesias		x					x					x					
Rillito River Swan							x										
Rio Antiguo							x										
Rio Salado Oeste				x		x	x		x								
Rio Salado Phoenix						x	x		x								
Rio Salado Tempe						x	x		x								
San Pedro Three Links Farm		x					x							x	x		x
San Pedro Preserve		x					x							x			x
San Xavier			x				x		x								
Santa Fe Ranch					x												
Sweetwater Wetlands								x			x						
Tres Rios					x	x	x				x						
Tres Rios del Norte						x	x									x	
Va shly ay Akimel		x															
Verde Headwaters							x				x					x	
Yuma East			x	x	x	x	x		x				x		x	x	
Yuma West				x			x		x			x	x				
	3	9	3	4	7	8	25	3	9	2	5	3	2	2	3	6	2

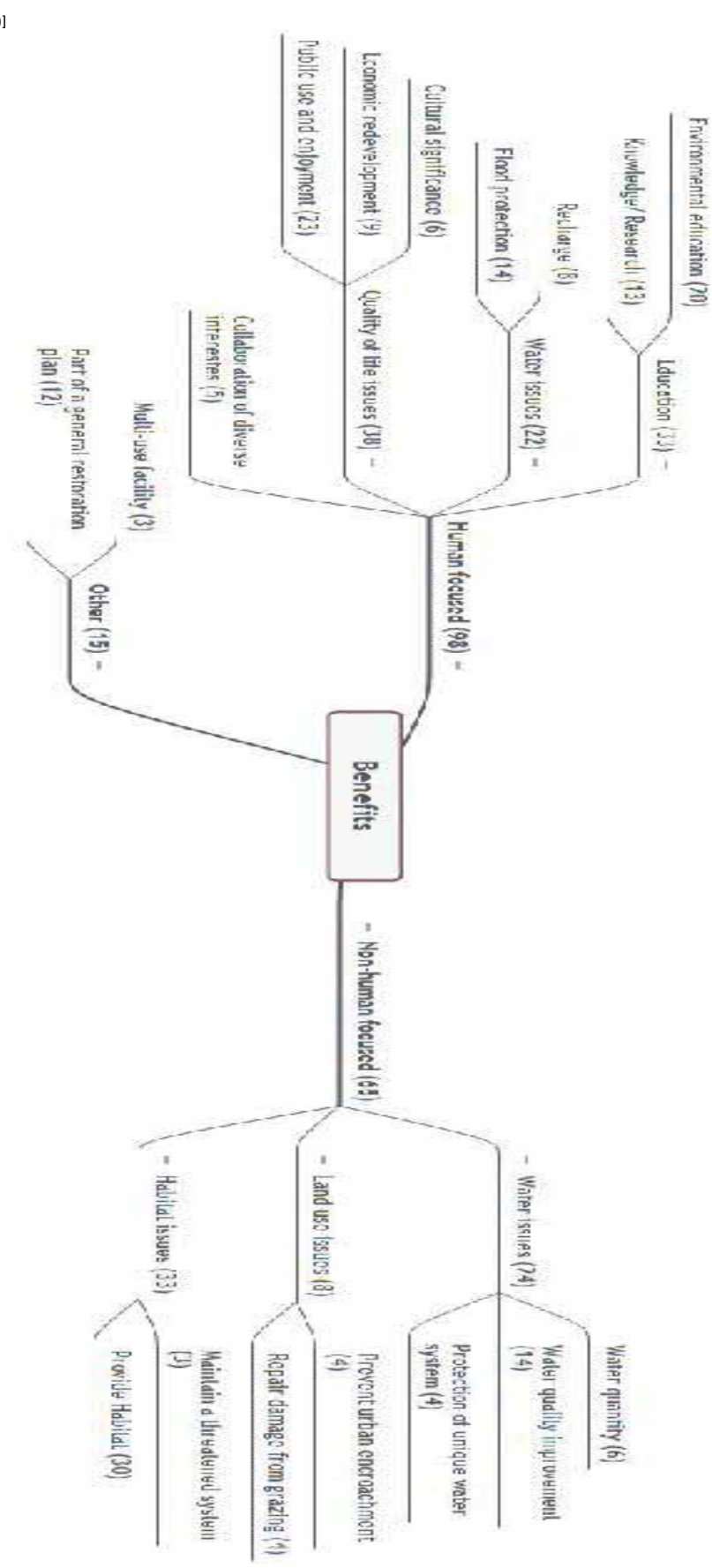
Appendix B2. Benefits Matrix

PROJECT BENEFITS	Repair amage rom Grazing	Part o a General restoration Plan	Cultrual Signi icance	Economic Redevelopment	Water uality Improvement	Flood Protection	Provide Habitat	Multi se Facility	Public se and Enjoyment	Protection o a ni ue water system	Recharge water to a ui er	Prevent rban Encroachment	Environmental Education	Maintain a threatened system	Collaboration o diverse interestes	Knowledge researc h	Water uantity
Accidental Restoration							x		x		x						
Agua Caliente		x				x	x		x				x				
Ahakhav Tribal Preserve			x				x		x							x	
Bingham Cienega						x	x									x	
EC Bar Ranch	x	x		x	x		x						x				
Ed Pastor Kino Park					x	x	x	x	x				x				
Esperanza Ranch	x	x			x	x	x		x			x	x		x	x	
Fossil Creek		x		x	x		x		x	x			x		x	x	
Grand Canyon Tamarisk Removal		x					x		x	x			x	x		x	
Las Cienegas					x		x		x	x	x	x	x				x
Little Colorado River Enhancement		x			x	x	x		x				x			x	
Marana High Plains Recharge					x		x	x	x		x		x			x	x
North Simpson	x	x					x		x	x					x	x	
Paseo de las Igesias		x	x		x	x	x		x			x					
Rillito River Swan					x		x										
Rio Antiguo					x	x	x		x				x				
Rio Salado Oeste				x		x	x		x				x				
Rio Salado Phoenix				x		x	x		x				x				
Rio Salado Tempe				x		x	x		x				x				
San Pedro Three Links Farm		x					x							x	x	x	x
San Pedro Preserve	x	x					x							x			x
San Xavier			x	x			x		x		x		x				
Santa Fe Ranch					x		x						x				
Sweetwater Wetlands					x		x	x	x		x		x				x
Tres Rios				x	x	x	x		x		x		x			x	
Tres Rios del Norte		x				x	x				x					x	
Va shly ay Akimel		x	x				x		x				x				
Verde Headwaters			x		x		x		x		x					x	
Yuma East			x	x		x	x		x				x		x	x	x
Yuma West				x		x	x		x			x	x				
	4	12	6	9	14	14	30	3	23	4	8	4	20	3	5	13	6

Appendix C.1 Classification of drivers (human focused vs. non-human focused)



Appendix C.2 Classification of benefits (human focused vs. no



Appendix D.1 Water use flow diagram