Volume 1 of 4 : Final Feasibility Report

Volume 2 of 4 : Final Feasibility Report Technical Appendices

Volume 3 of 4 : Final Feasibility Report Technical Appendices

Volume 4 of 4 : Final Environmental Impact Statement

Va Shly'ay Akimel
FINAL Salt River Ecosystem Restoration Study

Prepared by:

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

In partnership with:

Salt River Pima-Maricopa Indian Community

and the

City of Mesa

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study September 2004

FINAL FEASIBILITY REPORT
TECHNICAL APPENDICES

VOLUME 3 OF 4

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VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

BIOLOGICAL ASSESSMENT

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Chapter 1.0
INTRODUCTION

The Endangered Species Act of 1973, as amended, requires that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat of such species. The proposed Va Shly'ay Akimel Environmental Restoration project is one such project and therefore must meet those regulations. The Proposed Action involves the restoration of approximately 1500 acres of wetland, cottonwood/willow, mesquite, and Sonoran desert scrub shrub habitat along an approximately 14-mile reach of the Salt River in Maricopa County, Arizona. The Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa are the local sponsors of this restoration effort.

This Biological Assessment (BA) is prepared for the U.S. Fish and Wildlife Service (USFWS), in compliance with the Endangered Species Act of 1973, as amended. This BA is the U.S. Army Corps of Engineers (Corps) evaluation of the potential effects of the Proposed Action on federally listed species or species proposed for listing. The analysis also evaluates the potential effect on designated and proposed critical habitat for those species, should it occur in the project area. This document is used to determine whether a formal consultation or conference is required. Upon receiving an acceptable BA and a request for consultation from a Federal agency, the USFWS enters into consultation with the Federal agency. Should the determination of the effects of the Proposed Action be "may affect but not likely to adversely affect" then informal consultation begins and culminates with a letter of concurrence from the USFWS. Should the determination of the effects of the Proposed Action be "may affect, likely to adversely affect", formal consultation will begin and culminate with a written Biological Opinion (BO), from the USFWS. The BO determines whether the action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat (i.e., a jeopardy opinion), or the action is not likely to jeopardize the continued existence of a listed species or result in adverse modification of critical habitat (i.e., a non-jeopardy opinion). Both forms of opinion shall include reasonable and prudent measures; if any, to be taken that will result in a reduction in the amount or extent of take.

The objective of this document is to provide the USFWS with the necessary information on the anticipated impacts to federally listed species occurring, or with the potential to occur, in the study area. The study area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. Extensive coordination with the USFWS Arizona Ecological Services Field Office occurred as part of the plan formulation for this project resulting in features that will enhance and increase the potential habitat for listed threatened and endangered species.

Chapter 2.0
PROPOSED ACTION – VA SHLY'AY AKIMEL ECOSYSTEM RESTORATION PROJECT

2.1 PROJECT LOCATION

The study area is located in Maricopa County, Arizona, and includes portions of the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa. The study area is approximately 14 miles long, extending along the Salt River between the Pima Freeway and Granite Reef Dam. The study area is approximately 2 miles wide and comprises approximately 17,435 acres.

2.1.1 PROJECT AREA

The land surrounding the project area is made up of a patchwork of jurisdictional and political boundaries between the City of Mesa, unincorporated areas of Maricopa County, and the SRPMIC.

Several gravel-mining operations are located along the Salt River, and processing operations occur along its banks. These facilities are expected to remain within the project area. The river also contains a large groundwater recharge basin in the central portion of the study area, just east of North Gilbert Road.

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

The SRPMIC consists of 52,600 acres, located 15 miles northeast of the City of Phoenix. The primary land use is 19,000 acres of natural preserve. The secondary land use is agriculture, which supports a variety of crops, including cotton, melons, potatoes, brown onions, and carrots (Salt River Pima-Maricopa Indian Community 2002). The majority of the central and eastern portions of the study area that are located directly north of the Salt River is a combination of natural preserve areas and agricultural lands. Gravel mining and processing, two closed landfills, and other industrial operations have a significant influence on land use patterns in the western portion of the study area that is located along the north banks of the river. Other land uses throughout the area along the north banks of the river include a shooting range, a recreational vehicle park, private farms, and a commercial golf course.

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

portion of the study area. The south banks of the river are also scattered with gravel mining and processing operations.

The proposed project will not change the usage within the area significantly. The primary usage of the river to date has been the sand and gravel mining operations. While their future plans have not yet been determined, it is assumed they will remain in some capacity. Recreation is not expected to increase significantly due to the SRPMIC's wishes to limit non-Community member's access to Community property. A more in-depth analysis of the effects of the proposed action can be found in the preliminary draft Environmental Impact Statement (EIS), Chapter 5, provided to your office.

2.2 PURPOSE AND NEED

The purpose of the proposed action is to restore ecosystem functions and processes to improve overall ecological health and return the project area to a less degraded, more natural condition. Implementation of the proposed action would increase the diversity of native plants and animals, enhance the ability of the area to sustain larger populations of key indicator species or more biologically desirable species, and produce a viable, self-sustaining ecosystem that would require only minimal ongoing human intervention. Additionally, the proposed action would provide other incidental benefits, including improving water quality and supply.

Flood control and water supply projects within the Gila River watershed have resulted in substantial alteration of the hydrological regime. This alteration, as well as increased agricultural development and urbanization of the metropolitan Phoenix area, has resulted in the substantial alteration of the native cottonwood/willow, mesquite bosque, freshwater marsh, and willow woodland habitat types. Without restoration, habitat values in the study area are expected to further decline within the next 50 years. This will decrease the overall habitat value for wildlife and reduce habitat for the endangered Yuma clapper rail, southwestern willow flycatcher, and other sensitive species.

This project is needed to provide an ecological connection between other riparian restoration projects that are currently underway along the Salt River (See Section 2.4.2, "Relationship to Other Projects," of the EIS). Restoration of the area may also provide limited passive recreational opportunities.

2.3 DESCRIPTION OF PROPOSED ACTION

The proposed project consists of restoring approximately 1500 acres of riparian and scrub shrub habitat along a 14-mile reach of the Salt River. The project is divided into nine reaches and is described in the following paragraphs. See Figures 1 and 2.

Figure 1. Va Shly'ay Akimel Environmental Restoration Project Reach and Sub-Area Delineations.

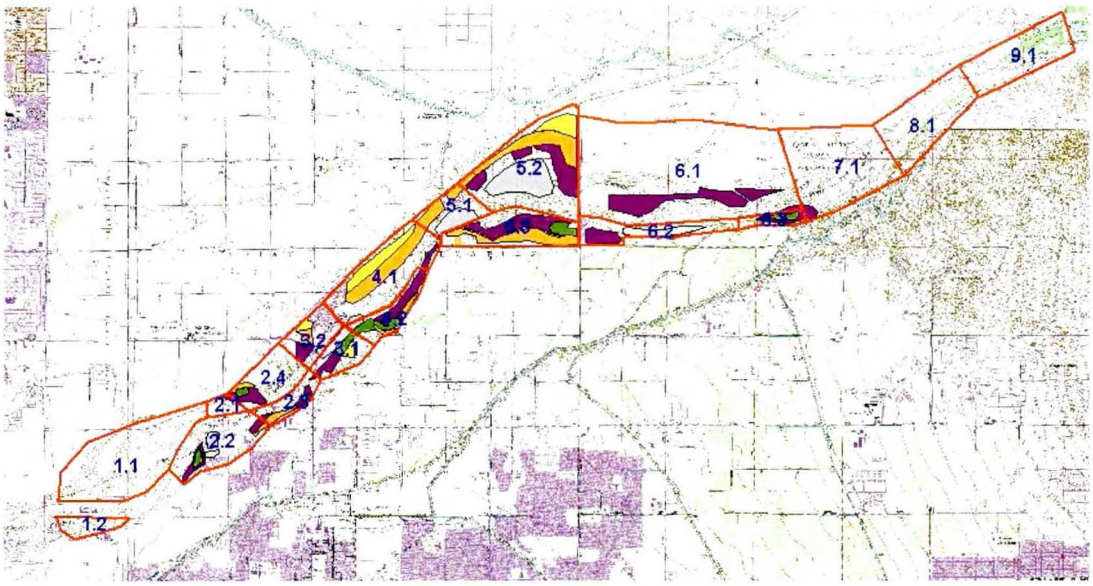
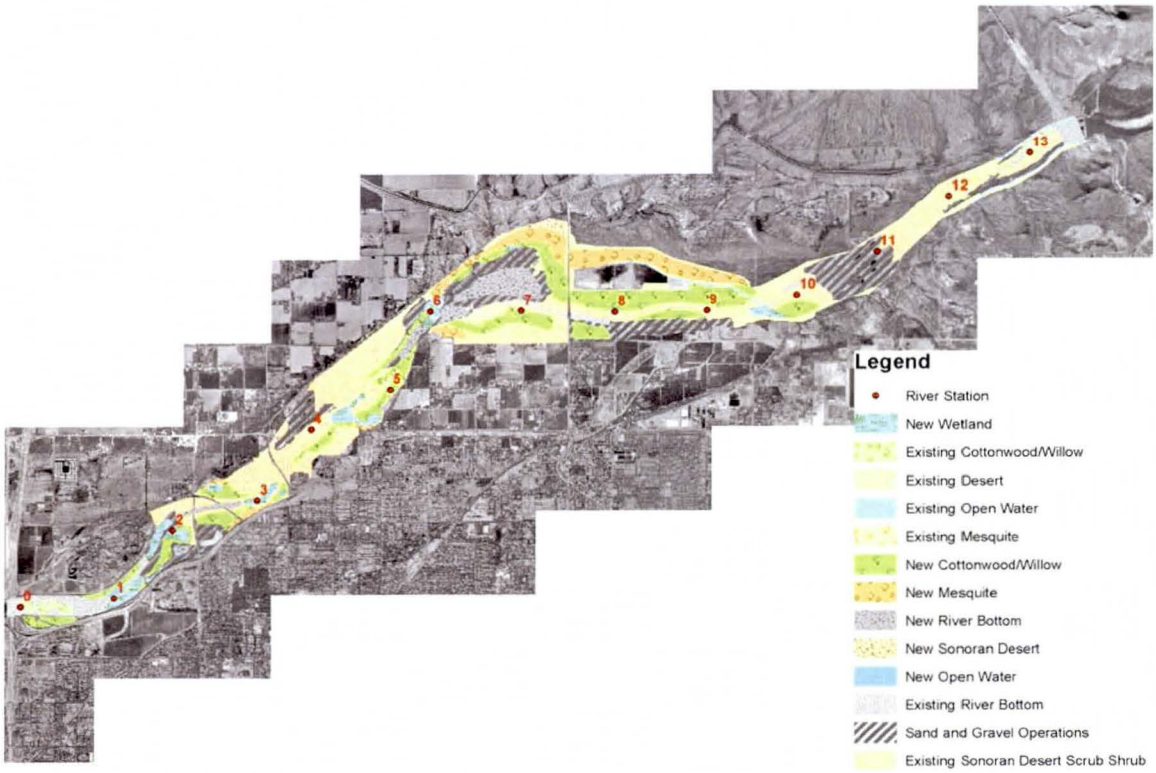


Figure 2. Va Shly'ay Akimel Environmental Restoration Project Proposed Action.



Reach 9 and 8: Reaches 9 and 8 begin at the Granite Reef Dam and continue down to the upstream boundary of the Higley Sand and Gravel plant. These reaches cover an area approximately 2.5 miles long and .5 miles wide. Currently, the habitat is dominated by cottonwood and willow vegetation interspersed with salt cedar (*Tamarisk sp*). Because of the relatively good habitat health, the only activity planned for these reaches is removal of the salt cedar and potential replacement with native species. The habitat is not currently considered viable for any threatened or endangered species (southwestern willow flycatcher), however, if conditions should change before construction begins and it is deemed necessary, surveys will be completed prior to construction. If sensitive species are present, then the invasive species removal will occur outside of the breeding season. To prevent rapid reestablishment of the invasive species, native vegetation will potentially be planted in its place.

Reach 7: The Higley plant is operated by Salt River Sand and Rock, a private company, on land owned by the SRPMIC; it encompasses Reach 7 in its entirety. Because of the disturbance associated with mining operations, no features or enhancements were proposed in this Reach. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. Because the SRPMIC has control of the land being mined, they have direct influence over what areas are mined and how those lands are left once the mining operations are complete. To reduce the affect of the Higley mining operations the quarry operators will be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition in Reach 7, bed load material will continue to flow downstream, maintaining the stability of the channel within Reach 6. At this time, the exact locations of future mining operations are unknown but coordination between the Corps, the SRPMIC and the Sand and Gravel mining operators is ongoing.

Reach 6: Reach 6 covers the area immediately downstream of the Higley plant down to Gilbert Road. Reach 6 covers an area approximately 2.5 miles long and 1 mile wide. Because this reach deals with three distinct feature sets, it has been divided into three sub-reaches. Area 6.1 is on the north side of the river, and stretches the entire length of Reach 6. Area 6.2 is on the south side of the river from Gilbert Road upstream to just below Va Vista Road. Area 6.3 is also on the south side of the river and is from Va Vista Road upstream to the Salt River Project water diversion point.

Large areas of cottonwood and willow (CW) and mesquite (MS) will be established in Area 6.1. The CW is located south of the Groundwater Recharge Underground Storage Project (GRUSP) site and will be irrigated using surface water from the Hennessey Drain. The MS is located on the north bank, immediately outside of the active channel, outside of the 10-year flood plain and will be irrigated using ground water from a new well. In both areas the water will be distributed using a flood irrigation method or the Surface Braided Irrigation Network (SBIN). Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. It is assumed that this infiltrated water is sufficient to maintain the vegetation; these assumptions will be verified during the Preliminary Engineering Design phase.

In Area 6.2, located on the south bank of the river, two areas of CW will be planted; one in an abandoned quarry depression directly east of Gilbert Road and within the 5-year flood plain, and a second narrow strip along the southern edge of the main channel. Both areas will be irrigated using surface water and storm water when available. Flood irrigation is the preferred method of irrigation.

Area 6.3 will have a wetland feature; it will be constructed on the riverbed near the existing Hennessey drain outlet. A berm of coarse rock will be constructed on the upstream side of the wetland. This will provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland will be clay lined to maintain the surface water level and allow for vegetation growth. The wetland will be flanked by a relatively large CW stand to the east, taking advantage of the saturated soil conditions, and will be irrigated using surface water from the Hennessy drain and SBIN or flood irrigation.

Reach 5: Reach 5 begins at Gilbert Road and ends downstream at approximately Horne Road. This reach is approximately 2 miles long and .5 to .75 miles wide, depending upon location. Reach 5 is also divided into three different sub-areas due to land features and water sources present in the area. Area 5.1 covers the area north of the river from Horne Road upstream to the downstream edge of the Gilbert Quarry pit. Area 5.2 encompasses the area including and surrounding the Gilbert Quarry pit found north of the river. And finally, Area 5.3 covers the entire southern portion of Reach 5 from Gilbert Road downstream to Horne Road.

In Area 5.1, the channel will be reshaped and converted to new river bottom. A wetland feature at the Evergreen drain outlet will be established, as will CW. The CW will be irrigated using a new ground water well, and the wetland will be supported by run off from the Evergreen drain outlet.

In Area 5.2, the Gilbert Quarry pit will be reshaped and converted to new river bottom. CW and MS, and a small pocket of Sonoran desert scrub shrub (SD) will be located on the overbank area. The MS and SD will be irrigated using groundwater from the new well. The CW will be irrigated using surface water diverted from an irrigation canal. The water will be distributed using SBIN.

A grade control structure will be placed in Area 5.2, in the main channel at the center point of the old Gilbert quarry. This structure would help protect the Gilbert Road Bridge from head cutting due to the extensive mining that has occurred downstream. The structure would span the entire width of the riverbed, approximately 1500 feet, and be designed to the estimated scour depth.

In Area 5.3, located along the south bank, CW will be established adjacent to a newly established small stand of MS. Surface water and storm water will be used to irrigate these areas. Irrigation of the CW and MS will be done by SBIN. The downstream portion of this area will also be reshaped and converted to new river bottom.

Reach 4: Reach 4 begins at Horne Road and continues downstream to approximately Center Street, or the downstream end of the Tri-City landfill. This Reach is roughly 1.5 miles long and .5 miles wide. Reach 4 is divided into two sub-reaches due to the characteristics found within the sub-areas.

Area 4.1 covers the Tri-City landfill. This area is tentatively planned for a SRPMIC run nursery operation, if the land is found suitable; therefore, no vegetation establishment is planned on the landfill land surface. A narrow strip of CW will be established, however, along the north bank, at the edge of the main channel. The area will be irrigated using surface and storm water and the SBIN.

Area 4.2, along the south bank, will support CW, MS and a large wetland feature. Two south bank surface water outlets will supply water to the SBIN used to irrigate the vegetation. The western outlet will support the wetland feature as well as surrounding CW and MS. Area 4.2 is relatively protected from the main channel so flood damages to the channel and the irrigation system are expected to occur less frequently.

Reach 3: Reach 3 is relatively small covering an area approximately .5 miles long and .5 miles wide. It too, is divided into two sub-areas to address the features found on the northern half of the river and the southern half of the river. Area 3.1 covers the southern half and will support a CW stand. A channel will be constructed to drain Area 4.2 to supply water to the CW vegetation of Area 3.1. This water will be dispersed using the SBIN. A sand and gravel pit restricts Area 3.2 and therefore no new features are planned.

Reach 2: Reach 2 is approximately 2 miles long and 1 mile wide. The upstream end of Reach 2 is marked by the Beeline Highway (Arizona 87); the downstream end of Reach 2 is just downstream of Longmore Road. Reach 2 is divided into four sub-areas to address the individual features planned for this area. Area 2.1 is a small area immediately downstream of Alma School Road on the north side of the river. Area 2.2 covers an area beginning at Alma School Road and continuing downstream to just below Longmore Road; it encompasses the area within and south of the main channel. Area 2.3 covers the southern half of the river beginning just downstream of Country Club Road and continuing downstream to approximately Alma School Road. And finally, Area 2.4 covers the same area as Area 2.3, but on the northern half of the river.

Area 2.1 is the smallest of the sub-areas and the only area where new features are not planned. This sub-area currently supports SD that surrounds an existing sand and gravel mining pit. Given the small size of this sub-area, the existing habitat and the restrictions due to the mining operations, establishing new vegetation was not justified.

Area 2.2 will support three new wetland features at Alma School Road downstream of and within the old quarry. The small wetland, on the western end of this Area, will be flanked by CW to the north. The larger wetland, to the east, will be surrounded by a CW stand. The CW will be irrigated using SBIN. A small area, south of the wetlands, will be reshaped and converted to new river bottom.

Area 2.3, along the south bank, will support two wetland features, and small areas of CW and MS. One small stand of CW will surround the wetland; a second larger stand will start in the eastern edge of Area 2.3 and extend into Area 2.2. The wetland will be constructed near the Country Club Storm drain on the existing river bottom and will be constructed to withstand storm water runoff.

Area 2.4 will support a wetland feature surrounded by CW to the west, south, and east. These features will be supported by surface water outlets, and irrigated using a SBIN. Additional water may be supplied by the golf course located north of the Salt River, if it is of sufficient quality.

Reach 1: Finally, Reach 1 begins downstream of Alma School Road and continues downstream to the terminus of the project at the Pima Freeway and Highway 202 Loop interchange. Like the others, Reach 1 is divided into two sub-areas to better identify the features. Area 1.1 covers the majority of Reach 1 extending from the 101 and 202 Loop interchange up to just below Alma School Road on the north side of the river and to Longmore Road on the south side of the river. Area 1.2 represents the percolation ponds owned by the City of Mesa to the south of the hard banking, immediately upstream of the 101 and 202 interchange on the south side of the river.

Area 1.1 will support four wetland features, and three CW stands. One wetland will continue from Area 2.2. A second smaller wetland will be located to the north, within the main channel and will connect with a CW stand to the north. The remaining two wetland features will be created to the west of the existing quarry, upstream of the hardbank. A CW stand will be established within the main channel, at the far west end of Area 1.1. Finally, a small CW stand will be established to the north of the existing quarry. Invasive species, primarily salt cedar, will be removed from this area if deemed necessary, to promote the establishment of native species.

The percolation ponds found immediately outside of the southern bank in Area 1.2, will be planted with CW. This area will be supported using the existing irrigation infrastructure.

2.4 OTHER ALTERNATIVES CONSIDERED

The Corps and local sponsors (SRPMIC and the City of Mesa) developed an initial array of 15 alternatives during the alternatives formulation process. The alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel modification, water source, infrastructure). Alternatives were initially developed based on the Corps' federal planning objectives for water resource projects, specific planning objectives developed for the Va Shly'ay Akimel Ecosystem Restoration Project, and project-specific opportunities and constraints for implementing restoration activities. These alternatives were later refined based on input received through public meetings and coordination with local and regional agencies. Details can be found in Chapter 3.3 of the EIS.

Following formulation and refinement of the project alternatives, the alternatives were ranked and screened based on associated habitat benefits and implementation costs. The Hydrogeomorphic (HGM) wetland assessment method was used by the Corps' planning team to identify and quantify the anticipated habitat benefits associated with the proposed restoration alternatives. The HGM method assesses and quantifies the functional values of existing wetland habitat types (e.g., water storage, plant community characteristics) and evaluates and quantifies future changes in these characteristics and associated habitat benefits resulting from implementation of the restoration alternatives.

Results of the HGM assessment were incorporated into the Corps' standard cost evaluation analysis (ICA) to identify the alternatives that provided the highest habitat benefits per unit cost. The four highest-ranking alternatives were then evaluated in greater detail. A complete description of the alternatives and HGM assessment is provided in the EIS. The local sponsor's then determined that the above-described proposed action was considered their preferred alternative.

2.5 NO ACTION ALTERNATIVE

Under the No-Action Alternative, the Corps would take no action to restore the ecosystem and wildlife habitat within the study area. Plans with potential incidental benefits to improve water quality and water supply also would not be provided by the Corps. Although it is possible that local agencies would implement limited improvements, restoration efforts would not occur on the scale of the proposed project.

Chapter 3.0
SPECIES ACCOUNT and EVALUATION OF EFFECTS

Viable habitat for most species of concern is limited to an area immediately downstream of the Granite Reef Dam in Reach 9 and near the Pima Freeway and Highway 202 Loop interchange in Reach 1. The preferred alternative recommends exotic species removal in both Reaches 9 and 1, with potential replanting of native species to prevent reoccurrence; at the downstream end, new cottonwood/willow will be established on the eastern end of the existing habitat.

The project area has the potential to support the following list of federally threatened, endangered, or proposed species. This list was provided by the USFWS through the Arizona Ecological Services website (http://arizonaes.fws.gov).

Plant Species

Arizona agave (*Agave arizonica*) - endangered
Arizona cliffrose (*Purshia subintegra*) - endangered

Wildlife Species

Bald eagle (*Halieaetus leucocephalus*) – threatened
Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) – endangered
California Brown Pelican (*Pelecanus occidentalis californicus*) – endangered
Mexican spotted owl (*Strix occidentalis lucida*) – threatened
Southwestern willow flycatcher (*Empidonax traillii extimus*) – endangered
Yuma clapper rail (*Rallus longirostris yumanensis*) – endangered
Yellow-billed cuckoo (*Coccyzus americanus*) – candidate/wildlife species of concern
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*) – endangered
Sonoran pronghorn (*Antilocapra Americana sonoriensis*) – endangered
Desert pupfish (*Cyprinodon macularius*) – endangered
Gila topminnow (*Poeciliopsis occidentalis occidentalis*) – endangered
Razorback sucker (*Xyrauchen texanus*) – endangered
Gila chub (*Gila intermedia*) – proposed endangered

The assessment of impacts to species within the study area was performed by background literature searches, coordination with resource agencies, and completion of site evaluations and in some cases, wildlife surveys. Literature used in this analysis includes: *Birds of Phoenix and Maricopa County, Arizona; Clearing of phreatophytic vegetation from the Salt and Gila Rivers, Ninety-first Avenue to Gillespie Dam, Maricopa County, Arizona: Draft environmental assessment; Salt-Gila River baseline ecological characterization; Wildlife of special concern in Arizona; Clapper rail* (*Rallus longirostris*) *In: The birds of North America*; *Coccyzus americanus*; *Glaucidium brasilianum*; *Bats of the United States; Amphibians and reptiles of western North America;* and *Threatened native wildlife in Arizona.*

3.1 SENSITIVE PLANT SPECIES

Sensitive plants include those species that are listed by Federal or state resource agencies. Species that are proposed to be listed by the USFWS are assessed in a manner similar to actual listed species by the USFWS; however, in the case of proposed species, recommendations of the USFWS are advisory rather than mandatory. There are two listed plant species of concern that occur within Maricopa County: Arizona agave (*Agave arizonica*) and Arizona cliffrose (*Purshia subintegra*).

3.1.1 Arizona agave – No effect

Arizona agave has bright green leaves with dark mahogany margins and yellow flowers. This species of agave is found in the transition zone between oak-juniper woodland and mountain mahogany-oak scrub between 3000 and 6000 feet in elevation. It is usually found on steep, rocky slopes in the New River Mountains and Sierra Ancha. It is possibly found in the Mazatal Mountains and can occur on drainage bottoms or relatively gentle slopes or saddles. This species has experienced a decline in habitat due to herbivory of flowering stalks and historic overuse by livestock, feral burros, and wildlife (http://arizonaes.fws.gov).

The terrain that surrounds the project area is relatively flat with no significant or mountainous landforms in the near vicinity. The project elevation is roughly 1200 feet with no oak-juniper woodland or mountain mahogany-oak scrub present. The required habitat does not exist for this species within the project area. Therefore, the proposed project will have no effect on the Arizona agave.

3.1.2 Arizona cliffrose – No effect

The Arizona cliffrose is an evergreen shrub approximately 5 feet in height. The bark is pale gray and shreddy and the flowers have 5 white or yellow petals. It is found only on Teritiary limestone lakebed deposits at elevations below 4000 feet. The known site within Maricopa County is at Horseshoe Lake, although it may have the potential to occur at other sites where Teritiary limestone lakebed deposits occur. Threats to this species include its localized habitat, urbanization, mining, overuse by cattle and burros and off-road vehicle traffic (http://arizonaes.fws.gov).

The project site occurs within a river channel bed and does not support the necessary soil substrate or habitat for this species. Therefore, the proposed project will have no effect on the Arizona cliffrose.

3.2 SENSITIVE WILDLIFE SPECIES

Sensitive wildlife species include those federally or state-listed threatened or endangered species, those species proposed for Federal or state listing, and Federal candidate species. There are thirteen federally listed species that occur within Maricopa County: bald eagle

(*Halieaetus leucocephalus*), cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*), California Brown Pelican (*Pelecanus occidentalis californicus*), Mexican spotted owl (*Strix occidentalis lucida*), southwestern willow flycatcher (*Empidonax traillii extimus*), Yuma clapper rail (*Rallus longirostris yumanensis*), the proposed yellow-billed cuckoo (*Coccyzus americanus*), lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*), Sonoran pronghorn (*Antilocapra Americana sonoriensis*), desert pupfish (*Cyprinodon macularius*), Gila topminnow (*Poeciliopsis occidentalis occidentalis*), razorback sucker (*Xyrauchen texanus*), and the proposed Gila chub (*Gila intermedia*).

3.2.1 **Birds**

3.2.1.1 Bald eagle – May affect, not likely to adversely affect

The bald eagle was reclassified from endangered to threatened in July 1995 and in 1999 was proposed to be removed from the list of Endangered and Threatened Wildlife in the lower 48 states of the U.S. Although the nesting populations are increasing throughout the U.S., the bald eagle is still threatened by habitat loss, human encroachment on nesting sites, reduction in native fish species, illegal shooting, and heavy metals (http://arizonaes.fws.gov). Bald eagles nest in large trees near lakes and streams, and hunt for waterfowl and fish in wetlands and along rivers and lakes. They also feed on small mammals and carrion. Bald eagles have been reported nesting along the Salt River east of Phoenix since the 1930s (Witzeman et al. 1997). Although they do not nest in the project study area due to lack of suitable habitat, they occur in the area as winter visitors and migrants (Benham-Blair Associates 1980) and have been observed foraging along the rivers near the project study area (CH2M HILL et al. 1997).

The open water marsh near the project study area (immediately downstream of the Pima Freeway and Highway 202 Loop interchange) may be suitable foraging habitat for bald eagles. However, the area of open water currently found at the furthest downstream portion of the study area is very small in size, approximately 1 acre, and linear in shape (pers. comm., A. Gibbons, Jones & Stokes). A second open water area further upstream, but still within Reach 1 of the proposed project is approximately seven acres in size during the wet season. Due to the relatively small size and likely very low fish populations found within the open water currently on-site these areas are not likely a significant source of foraging habitat, considering the higher quality habitat further downstream.

In the furthest downstream area of existing open water, exotic vegetation species will be removed and potentially replaced with native vegetation creating insignificant effects to the eagle. Other construction activity includes new wetlands approximately .75 miles upstream. Standard construction practices will be utilized to minimize siltation, turbidity, and release of contaminants within surface waters. Multiple wetlands within the greater project area could increase the overall foraging habitat of this species by approximately 200 acres, providing a beneficial effect. Due to the temporary disturbance associated with construction near the existing open water, and the significant increase in wetland

features, the proposed project may affect but is not likely to adversely affect any potentially existing bald eagles.

3.2.1.2 Cactus ferruginous pygmy-owl – No effect

The cactus ferruginous pygmy-owl is a small reddish-brown owl with a cream-colored belly streaked with reddish-brown. The pygmy-owl's diet includes birds, lizards, insects, and small mammals. It is non-migratory throughout its range. Historically, the cactus ferruginous pygmy-owl occurred as far north as the confluence of the Salt and Verde Rivers but recent observations have been limited to Pima and Pinal Counties. This species occurs in riverbottom woodlands, and palo verde cacti-mixed scrub associations of the Sonoran desert. In southern Arizona, the pygmy-owl is currently found primarily in Sonoran desert scrub vegetation with some locations in riparian drainages and semi-desert grassland vegetation communities. It will nest in saguaro cacti or tree cavities below 4000 feet in elevation (http://arizonaes.fws.gov). Pygmy-owls have declined in part because of urban development, reduction of suitable habitat, and competition from other cavity-nesting birds (Arizona Game and Fish Department 1996, Arizona Game and Fish Department 2001a).

The proposed project will establish approximately 24 acres of new scrub, 380 acres of new mesquite and 880 acres of new cottonwood/willow habitat; significantly increasing the suitable habitat for this species. Because the project site is currently limited to creosote dominated scrub shrub, with only 4 acres of existing mesquite, and little mature cottonwood, and because no observations of cactus ferruginous pygmy-owls have been recently recorded within 50 miles of the project area (CH2M HILL et al. 1997, Witzeman et al. 1997), it has been determined that this project will have no effect on the cactus ferruginous pygmy-owl.

3.2.1.3 California brown pelican – No effect

The California brown pelican is a large bird with a white head and neck, often washed with yellow. It has a grayish-brown body with a blackish belly. During the breeding season, the hindneck is dark chestnut and a yellow patch appears at the base of the foreneck. These birds forage by diving for fish in larger bodies of water. It is considered an uncommon transient in Arizona on many Arizona lakes and rivers. The pelican has recently been observed on Tempe Town Lake; and there are tentative plans to conduct a relocation effort to move the Tempe Town Lake pelicans back to habitat more suitable for their needs (pers. comm., M. Martinez, USFWS).

During a recent Yuma clapper rail survey conducted in May 2003, two pelicans were observed flying over the project sight. However, the pelicans were not seen using the habitat and are not expected to nest in the area. Because the California brown pelican was not seen using the project site and is known to use Tempe Town Lake, an area approximately 4 miles from the project site, it has been determined that the proposed action will have no effect on this species.

3.2.1.4 Mexican spotted owl – No effect

The Mexican spotted owl is a medium sized owl with large dark eyes and no ear tufts. Its plumage is brown with numerous white spots and posterior underparts have short, horizontal bars or spots. It generally nests in older forests of mixed conifer or ponderosa pine/gambel oak type, in canyons. In forested habitat, uneven-aged stands with a high canopy closure, high tree density, a sloped terrain and cool microclimates appear to be of importance. The spotted owl's nests are found in live trees, snags, and on canyon walls between 4100 and 9000 feet (http://arizonaes.fws.gov). Currently, the Mexican spotted owl is patchily distributed in Arizona and occurs only in the eastern portion of the state.

The proposed project is found in the arid, western portion of Arizona and is completely void of the required habitat; therefore the project will have no effect on the Mexican spotted owl.

3.2.1.5 Southwestern willow flycatcher – No effect

The southwestern willow flycatcher is a small migratory bird with a grayish-green back and wings, a white throat, a light gray-olive breast, and a pale yellowish belly. Two wingbars are visible. It prefers nesting in dense willow riparian habitats and is also found in areas of saltcedar in the Sonoran Life Zone (e.g., the lower Big Sandy River, lower Santa Maria River, Bill Williams Delta, upper Gila River, Grand Canyon, and middle Salt River). Nests are found in thickets of trees and shrubs about 13-23 feet in height, among dense and homogenous foliage at elevations below 8500 feet. Historically, the southwestern willow flycatcher nested along the Salt, Gila, and Agua Fria Rivers (CH2M HILL et al. 1997). Currently, there are just over 900 breeding pairs documented in the Southwest and recent statewide surveys indicate that fewer than five nesting pairs occupy most sites. Individuals in Arizona are found in the middle Salt River and upper Verde River, among sites along other rivers (http://arizonaes.fws.gov) and are currently considered an uncommon transient in Maricopa County, with only a few historic summer records (Witzeman et al. 1997). The flycatcher has declined for a variety of reasons, including habitat loss and fragmentation resulting from flood control projects, development, and intensive grazing. Brown-headed cowbird nest parasitism may also have contributed to the species' decline (Arizona Game and Fish Department 1996).

The project area has approximately 130 acres classified as willow, cottonwood/willow, and willow saltcedar habitat. However, these acres are sparse, patchy and the cottonwoods are almost exclusively a single row of trees (pers. comm., A. Gibbons, Jones & Stokes). To date, focused surveys have not been completed due to lack of suitable habitat (pers. comm., A. Gibbons, Jones & Stokes; T. Corman, AGFD). Prior to construction, if suitable habitat has developed in any project area scheduled for disturbance (likely in the form of salt cedar thickets), the Corps will re-evaluate, in coordination with the USFWS, and conduct surveys if necessary.

The proposed project will increase the cottonwood/willow habitat by approximately 880 acres, creating a significant positive benefit for this species by creating habitat for potential future populations. Because of the current lack of suitable habitat, and proposed

increase in cottonwood/willow, the proposed project will have no effect on the southwestern willow flycatcher.

3.2.1.6 Yuma clapper rail – No effect

The Yuma clapper rail is a long marsh bird with long legs and a short tail. Its bill is long, slender, and curved downward slightly. It is mottled brown on a gray background; its flank and underside are dark gray with narrow vertical white stripes (http://arizonaes.fws.gov). This inland clapper rail occurs in cattail, sedges, and bulrush marshes along the Colorado River, the lower Gila and Salt Rivers below the Verde/Salt River confluence, and Pichacho Reservoir (Arizona Game and Fish Department 1996, Eddelman and Conway 1998) and is often associated with dense riparian and marsh vegetation. This species has declined because of the loss and fragmentation of river marshes. Toxic levels of heavy metals, such as selenium, could also have contributed to the species' decline (Arizona Game and Fish Department 1996). Its current distribution is along the Colorado River, from Lake Mead to Mexico; on the Gila and Salt rivers upstream to the area of the Verde confluence; at Picacho Reservoir; and on the Tonto Creek arm of Roosevelt Lake (http://arizonaes.fws.gov). The Yuma clapper rail is known to occur as a rare and local summer resident in cattail marshes in the Salt River south and west of Phoenix (Witzeman et al. 1997).

There is sufficient marshland habitat for this species to occur within the downstream portion of the project study area, therefore, a USFWS protocol level survey was conducted in May 2003. A copy of the survey report can be found in Appendix A of this document. Surveys resulted in no indication of Yuma clapper rails found within the project area and vicinity. Therefore, the proposed action will have no effect.

3.2.1.7 Yellow-billed cuckoo – No effect

The yellow-billed cuckoo is a medium-sized bird with a slender, long-tailed profile. It has a fairly stout and slightly down-curved bill, which is black with yellow on the basal half of the lower mandible. The bird is grayish-brown above and white below with rufous primary flight feathers. The tail feathers are boldly patterned with black and white below. In Arizona, the yellow-billed cuckoo is found locally in streamside cottonwood and willow groves, and prefers to nest in willow or mesquite thickets (Arizona Game and Fish Department 2001b). Historically, this species was widespread and locally common in Arizona; currently, based on preliminary results of a statewide survey, one hundred sixty-eight pairs and 80 individuals were located in Arizona in 1999 (http://arizonaes.fws.gov). The primary reason for population decline is the loss, degradation, and fragmentation of riparian habitat.

Prior to 1998, approximately thirteen cuckoo territories were found along the Salt River, although none were located within this proposed project site. Additional surveys have been completed by state agencies since 1998. Results showed one pair of cuckoos between upstream of the Granite Reef Dam and the confluence of the Salt and Gila rivers (pers. comm., B. Wilson, Jones & Stokes). Consequently, the yellow-billed cuckoo is considered an uncommon local summer resident (Witzeman et al. 1997). Although

candidate species do not benefit from the same protection as listed species, their current rarity warrants protection. Due to lack of suitable habitat, and no findings within the project area during recent surveys, it is determined that the proposed project will have no effect on the yellow-billed cuckoo.

3.2.2 **Mammals**

3.2.2.1 Lesser long-nosed bat – No effect

The lesser long-nosed bat, previously known as Sanborn's long-nosed bat, is medium-sized with yellowish-brown or pale gray above and cinnamon-brown below. It has a slender elongated nose with a small nose-leaf on the tip, and a minute tail. It is found mainly in desert scrub habitat, and roosts in caves, abandoned mines, and unoccupied buildings at the base of mountains where agave, saguaro, yucca, and organ pipe cacti are present (http://arizonaes.fws.gov; Harvey et al. 1999). It forages at night on nectar, pollen, and fruit of panicultate agaves and columnar cacti. Considerable evidence exists for the interdependence of *Leptonycteris* bat species and certain agaves and cacti (http://arizonaes.fws.gov). The lesser long-nosed bat population has declined for reasons that include: human disturbance at breeding and roosting sites, habitat loss, and excessive harvest of certain agaves and cacti; however, the population appears stable (Arizona Game and Fish Department 1996).

This bat is a summer resident (April – September) of central and southeastern Arizona. Although there are records for this species from the Phoenix area, the project area does not support roosting sites, nor does it support the necessary foraging vegetative species. Desert areas within the project site are dominated by creosote bush with scattered white bursage and other small shrubs, and limited areas of creosote bush, saguaro, yellow paloverde, cholla and barrel cactus. Because the proposed project site does not support the necessary foraging species or roosting sites for the lesser long-nosed bat, the project will have no effect.

3.2.2.2 Sonoran pronghorn – No effect

The Sonoran pronghorn are long-legged, small-bodied artiodactyls (hoofed animals with an even number of toes on each foot). Their upper parts are tan; the underpart, rump and two bands across the neck are white. Both sexes have horns, although they are larger in males. All Sonoran pronghorn populations occur in Sonoran desert scrub vegetation communities; creosote and white bursage comprise the major vegetation in the Lower Colorado River Valley subdivision. Plant species along major watercourses include ironwood, blue palo verde, and mesquite; species in the Arizona Upland include foothill palo verde, catclaw acacia, chain fruit cholla, teddy bear cholla, buckhorn cholla and staghorn cholla. Typical habitat ranges between 2,000 and 4,000 feet in elevation within broad intermountain alluvial valleys separated by block-faulted mountain and surface volcanics (http://arizonaea.fws.gov). Historical ranges within southwest Arizona included south of the Bill Williams River and east to the Santa Cruz River. Currently, an extant population exists in southwestern Arizona. The primary cause of pronghorn

population decline includes barriers to movement caused by roads, canals, and fences, and conversion of habitat to other uses (http://arizonaes.fws.gov).

The proposed project study site is at approximately 1200 feet in elevation and is surrounded by development and urban areas to the south. Therefore, the project site does not contain suitable habitat and will have no effect on the Sonoran pronghorn.

3.2.3 Fish

3.2.3.1 Desert pupfish – No effect

The desert pupfish is a small fish with a smoothly rounded body shape and narrow, vertical dark bars on its sides. Breeding males are blue on the tops and sides, and have yellow fins. Females and juveniles are tan to olive colored on their backs and silvery on their sides. These fish are found in shallow water of desert springs, small streams, and marshes below 5,000 feet in elevation. The pupfish also tolerates high salinities and high water temperatures. This species was once common in desert springs, marshes, backwaters, and tributaries of several large rivers in Arizona but is currently restricted to one natural population in Quitobaquito Spring Pond in Pima County due to the introduction of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, stream channelization, and habitat modification (http://arizonaes.fws.gov). Reintroductions have been made in Maricopa County in the past but were unsuccessful. Additional reintroductions were made northwest of Lake Pleasant and others are planned (pers. comm., J. Voeltz, AGFD). While the pupfish was found in the Salt River 50 years ago, it would be highly unlikely for it to be within the project area due to predatory species (pers. comm., D. Duncan, USFWS) and limited habitat.

The Arizona Department of Fish and Game has conducted regular fish surveys from the Granite Reef Dam upstream to the Stewart Mountain Dam, with the most recent complete survey done in March 2003 and spot surveys completed as recently as October 2003 (pers. comm., S. Bryan, AGFD). No populations of desert pupfish were found. The project proposes to remove exotic vegetation from the Granite Reef Dam and the Pima Freeway/Highway 202 Loop interchange areas. Native vegetation will be planted, if necessary, in areas where exotics were removed to improve the likelihood of native vegetation establishment. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat.

Because no fish were found above Granite Reef Dam during recent surveys, no other population is known to allow for immigration into the project site, and the presence of predatory species would make their survival highly unlikely, the proposed project will have no effect on the desert pupfish.

3.2.3.2 Gila topminnow – No effect

The Gila topminnow is a small guppy-like, live-bearing fish that lacks dark spots on its fins. It occurs in small streams, springs, and cienegas below 4500 feet in elevation primarily in shallow areas with aquatic vegetation and debris for cover. This species can also tolerate relatively high water temperatures and low dissolved oxygen. Historically it was one of the most common fish found throughout the Gila River drainage in Arizona. However, due to the introduction and spread of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, groundwater pumping, stream channelization, and habitat modification, it is restricted to the Santa Cruz River system and other small streams in several counties, including Maricopa (http://arizonaes.fws.gov).

The Arizona Department of Fish and Game has conducted regular fish surveys from the Granite Reef Dam upstream to the Stewart Mountain Dam, with the most recent complete survey done in March 2003 and spot surveys completed as recently as October 2003 (pers. comm., S. Bryan, AGFD). These surveys have come back negative for the Gila topminnow. While lower quality potential habitat exists immediately below the Granite Reef Dam and at the Pima Freeway and Highway 202 interchange, and it could be argued that the Gila topminnow could find its way into the project area if there was an overtopping of Granite Reef Dam, the negative surveys indicate that there currently is not a population source upstream. Therefore, we can assume this species is not present.

The project proposes only to remove exotic vegetation from the Granite Reef Dam area and the Pima Freeway/Highway 202 Loop interchange area and replace it with native vegetation, if necessary, to ensure native species recruitment. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat. Because no Gila topminnows have been discovered in recent surveys conducted upstream of the Granite Reef Dam, and because overtopping of the dam is the only reasonable way for this species to enter into the project area, we can conclude that the fish is not present in the proposed project area and therefore the project will have no effect.

3.2.3.3 Razorback sucker – No effect

The razorback sucker has a head that is flattened on top with a stout body with olive-brown above to yellowish on the belly. A long, high, sharp-edged keel-like hum is found behind the head. This fish is found in backwaters, flooded bottomlands, pools, side channels and other slower moving habitats below 6000 feet in elevation. Historically the sucker was found near strong currents in all major rivers and larger streams in the Colorado River Basin. Currently, in the Lower Basin, populations are isolated to Lakes Mohave, Mead, and the lower Colorado River below Havasu. Alteration of river conditions and loss of habitat caused by dam construction, irrigation dewatering and channelization, as well as the introduction of exotic fish, are all responsible for this species decline (http://arizonaes.fws.gov). Several areas of critical habitat have been designated but none are found within Maricopa County.

Reintroductions have been done in the Salt and Verde rivers with ongoing introductions near Childs, AZ (pers. comm., J. Voeltz, AGFD). Because of the recent introductions and the potential for suitable habitat for the razorback sucker, this species could survive within the proposed project area, if it where to migrate there. It is likely that the only way the razorback sucker could be found within the project area is if the fish were found above the Granite Reef Dam and if the dam overtopped, carrying the razorback within the flood flows. The Arizona Department of Fish and Game has conducted regular fish surveys from the Granite Reef Dam upstream to the Stewart Mountain Dam, with the most recent complete survey done in March 2003 and spot surveys completed as recently as October 2003 (pers. comm., S. Bryan, AGFD). These surveys came back negative for the razorback sucker. There is therefore no probable source of fish to enter into the project area.

The project proposes only to remove exotic vegetation from the Granite Reef Dam area and the Pima Freeway/Highway 202 Loop interchange. Native vegetation will be planted in these areas, if necessary, to ensure native species recruitment. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat. Because recent surveys showed there are no razorback suckers in the Salt River above the Granite Reef Dam, eliminating the population sources for immigration, the proposed project will have no effect.

3.2.3.4 Gila chub – No jeopardy

The Gila chub is a small-finned, deep-bodied chubby member of the minnow family. It is dark colored with diffuse lateral bands that are rarely present. They are commonly found in pools, springs, cienegas, smaller streams, and artificial impoundments between 2,000 and 3,500 feet in elevation. Common riparian plants associated with these populations include willow, tamarisk, cottonwoods, seep-willow, and ash. Historically, the chub's range likely included suitable habitat throughout the entire Gila River basin, except the Salt River drainage above Roosevelt Lake. Currently, they have been recorded in approximately 30 rivers, streams, and spring-fed tributaries throughout the Gila River basin, although none have been recorded in Maricopa County. Roughly 90% of suitable habitat has been degraded or destroyed due to extensive grazing, mining operations, increased recreation usage and the introduction of exotic species (http://arizonaes.fws.gov). Proposed critical habitat sites have been identified, but none exist within Maricopa County.

The Gila chub is currently only proposed for listing and therefore, an effect determination is not required. Instead, a jeopardy or no jeopardy determination is required. Because the Gila chub has not been recorded in Maricopa County within recent surveys and its lowest habitat elevation range is approximately 800 feet above the elevation of the proposed project, it can be determined that the proposed project will not jeopardize the continued existence of this species.

Chapter 4.0
CONCLUSIONS

Extensive coordination occurred with the USFWS throughout the plan formulation, HGM habitat analysis, and species survey and BA phases, as they relate to the Va Shly' ay Akimel Ecosystem Restoration project. Coordination also occurred with Arizona Game and Fish Department. As a result, project features that would most likely increase and improve habitat conditions for a variety of species, including those listed as federally endangered or threatened, were given greatest consideration. Given the rarity of riparian ecosystems within the arid southwest, the proposed project attempted to establish as many acres of wetland, and cottonwood/willow as was practicably feasible, given the limitations of available surface water and current land use. Additional acres of new mesquite and desert scrub shrub are also planned to complete the upper slopes of desert riparian systems.

Through examination of the project site, current literature searches, survey results, and discussions with USFWS and Arizona Game and Fish Department personnel, the proposed project was determined to have either "no effect" or "no adverse affect" on the 15 federally listed threatened, endangered, proposed, or candidate species. The determinations are as follows:

Arizona agave (*Agave arizonica*) – No effect
Arizona cliffrose (*Purshia subintegra*) – No effect
Bald eagle (*Halieaetus leucocephalus*) – May affect, not likely to adversely affect
Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) – No effect
California brown pelican (*Pelecanus occidentalis californicus*) – No effect
Mexican spotted owl (*Strix occidentalis lucida*) – No effect
Southwestern willow flycatcher (*Empidonax traillii extimus*) – No effect
Yuma clapper rail (*Rallus longirostris yumanensis*) – No effect
Yellow-billed cuckoo (*Coccyzus americanus*) – No effect
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*) – No effect
Sonoran pronghorn (*Antilocapra Americana sonoriensis*) – No effect
Desert pupfish (*Cyprinodon macularius*) – No effect
Gila topminnow (*Poeciliopsis occidentalis occidentalis*) – No effect
Razorback sucker (*Xyrauchen texanus*) – No effect
Gila chub (*Gila intermedia*) – No jeopardy

This BA serves as the documentation of these determinations and will be accompanied by a cover letter asking for written concurrence of the above determinations by the USFWS, and therefore a conclusion of Section 7 consultation. The Corps understands that should the project or project site conditions change in a way that may adversely affect threatened or endangered species, or the determinations made in this document, the USFWS would be notified and Section 7 Consultation would be reinitiated.

Chapter 5.0
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VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

August 2004

YUMA CLAPPER RAIL SURVEY REPORT

APPENDIX

Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area Maricopa County, Arizona

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Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area, Maricopa County, Arizona

Project Location

The U.S. Army Corps of Engineers (Corps) is proposing restoration of the Salt River between Granite Reef Dam and the interchange of the Loop 101 and Loop 202 in Maricopa County, Arizona. The area proposed for restoration has been designated by the Corps the "Va Shly'ay Akimel Project Study Area." Project boundaries encompass both banks of the Salt River channel between dam and Loop 101/202 to a distance of ½-mile to either side of the *thalweg*, or deepest portion of the river channel. Suitable habitat for the Yuma clapper rail is located within the boundaries of the project area in Township 1 North, Range 5 East, Section 18 (Figure 1).

Survey Area

Elevation of the project area is approximately 1,200 feet above mean sea level, and topography in the vicinity is predominantly flat. The project area is located within the Lower Colorado River Subdivision of the Sonoran Desertscrub biotic community (Brown et al. 1994). However, the project area is within an urban setting and the river bottom exhibits signs of long-term disturbance, including roads, landfills, mining operations, and illegal trash dumping.

During the planning process for the restoration project, it was determined that suitable habitat for the Yuma clapper rail is present in wetlands located adjacent to the interchange of the Loop 101 and Loop 202. The wetland has year-round water present and vegetation in the survey area is dominated by cattail (*Typha domingensis*). Table 1 details plant species occurring in and around the surveyed wetland during field activities.

Table 1. Plants Documented in the Salt River During Surveys

Species Name (Common Name)	Scientific Name
Bermuda-grass	*Cynodon dactylon*
Rabbits-foot	*Polypogon monspeliensis*
Fountain-grass	*Pennisetum ciliare*
Mexican sprangletop	*Leptochloa dubia*
Curly-dock	*Rumex crispus*
Cattail	*Typha domingensis*
Yellow nut-sedge	*Cyperus esculentus*
Bulrush	*Scirpus validus*
Bulrush	*Scirpus paludosus*
Knotweed	*Polygonum argyrocoleon*
Water speedwell	*Veronica anagallis-aquatica*
Salt heliotrop	*Heloptropium curassavicum*
Euphorbia	*Euphorbia albomarginatus*
Desert bedstraw	*Stephanomeris pauciflora*
Sweetbush	*Bebbia juncea*
Sowthistle	*Sonchus asper*
London rocket	*Sisymbrium irio*
Brittle-bush	*Encelia farinosa*
Cockle-bur	*Xanthium strumarium*
Turpentine-bush	*Apolopappus* sp.
Arrowweed	*Pluchea sericea*
Goodding's willow	*Salix gooddingii*
Fremont cottonwood	*Populus fremontii*
Salt-cedar	*Tamarix ramosissima*
California fan palm	*Washingtonia filifera*

Survey Information

Yuma Clapper Rail (*Rallus longirostris yumanensis*)

Life History

The Yuma clapper rail is a grayish-brown marsh bird with long legs and a short tail; adults of the species are typically 35–41 centimeters (14–16 inches) tall. During the breeding season, adult Yuma clapper rail males display a tawny-orange or burnt-orange breast and orangish beak while females display a brick-orange breast. (Arizona Game and Fish Department 2001)

The current range for the Yuma clapper rail includes the Lower Colorado River drainage from the Gulf of California in Mexico north to Topock Marsh in the Havasu National Wildlife Refuge (NWR), Arizona. In Arizona, this subspecies also occurs in several major river drainages in the central and southwestern portions of the state, including the Bill Williams River drainage, the Lower Gila River drainage, and the lower Salt and Verde River drainages (Arizona Game and Fish Department 2001).

Breeding occurs after territories are established in March or April. Breeding activities are known to occur at Mittry Lake, Bill Williams River drainage, Topock Gorge and Topock Marsh in the Havasu NWR, and Cibola NWR (Arizona Game and Fish Department 2001). Average clutch size is 8 to 10 eggs with incubation lasting about 21–23 days. Hatching success is usually high, but mortality among young is usually high as well. Family groups of clapper rails stay together for approximately 24–30 days post-hatching. Chicks become independent from their parents at 35–42 days, and first flight usually takes place 63–70 days post-hatching (Terres 1980).

This subspecies is the only clapper rail to breed in freshwater marshes. They also inhabit brackish water marshes and river sidewaters. They prefer tall, dense cattail and bulrush marshes found in the Lower Colorado River Subdivision of the Sonoran Desert Biome at an elevation between below sea level to approximately 400 meters (1,300 feet) above mean sea level. Clapper rails prefer to feed on crustaceans, including amphipods, but will also feed on fish, frogs, clams, spiders, large insects, and aquatic plant seeds. On the Colorado River, introduced crayfish are the most common food consumed in bulk (Arizona Game and Fish Department 2001).

The decline in numbers of this species has been attributed to river channelization, dredging, drying and flooding of marshes, wildfires, and toxic levels of heavy metals.

Survey Methodology and Results

Yuma clapper rail surveys were conducted May 21, May 23, May 28, and May 30, 2003. Biologists Ron Van Ommeren and Amy Gibbons, Jones & Stokes, conducted all surveys under U.S. Fish and Wildlife Service (USFWS) permit number TE013086-0.

Observation Methodology

Topographic maps and a site visit were used to determine the boundaries of the survey area. A total of 30 call points were established, approximately 100 feet apart, and GPS coordinates of these points were logged for quality control purposes (Table 2). These points are shown in Figures 2 and 3.

Table 2. GPS Coordinates for Survey Call Points (UTM)

Call Point	Easting	Northing
1	0417270	3700084
2	0417257	3700111
3	0417255	3700141
4	0417258	3700170
5	0417255	3700200
6	0417258	3700232
7	0417287	3700239
8	0417293	3700221
9	0417288	3700197
10	0417289	3700160
11	0417284	3700126
12	0417289	3700099
13	0417319	3700104
14	0417315	3700136
15	0417315	3700168
16	0417311	3700198
17	0417314	3700231
18	0417316	3700266
19	0417349	3700131
20	0417347	3700159
21	0417346	3700193
22	0417377	3700187
23	0417407	3700174
24	0417408	3700206
25	0417377	3700214
26	0417351	3700229
27	0417376	3700248
28	0417413	3700238
29	0417441	3700252
30	0417381	3700145

All surveys were conducted in compliance with the USFWS *Yuma Clapper Rail Survey Protocol* (U.S. Fish and Wildlife Service 2000). Call playback tapes were used at the 30 call points in an effort to elicit a response from resident Yuma clapper rails. In addition to recording responses, a log was kept of other species of birds that were seen or heard at the call sites (Table 3).

Table 3. Bird Species Documented in the Salt River During Surveys

Species Name (Common Name)	Scientific Name
Abert's towhee	*Pipilo aberti*
American avocet	*Recurvirostra americana*
American coot	*Fulica americana*
Black phoebe	*Sayornis nigricans*
Black-crowned night-heron	*Nycticorax nycticorax*
Brown pelican	*Pelecanus occidentalis*
Brown-headed cowbird	*Molothrus ater*
Cliff swallow	*Petrochelidon pyrrhonota*
Common moorhen	*Gallinula chloropus*
Common yellowthroat	*Geothlypis trichas*
Costa's hummingbird	*Calypte costae*
Double-crested cormorant	*Phalacrocorax auritus*
Gambel's quail	*Callipela gambelii*
Great blue heron	*Ardea herodias*
Great egret	*Adrea alba*
Great Horned owl	*Bubo virginianus*
Great-tailed grackle	*Quiscalus mexicanus*
Green heron	*Butorides virescens*
House finch	*Carpodacus mexicanus*
Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Marsh wren	*Cistothorus palustris*
Mourning dove	*Zenaida macroura*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Red-winged blackbird	*Agelaius phoeniceus*
Rock dove	*Columba livia*
Snowy egret	*Egretta thula*
Song sparrow	*Melospiza melodia*
Turkey vulture	*Cathartes aura*

Survey Results

The survey did not result in a response from a Yuma clapper rail. However, two brown pelicans, a species federally listed as endangered, were observed in flight in the project area.

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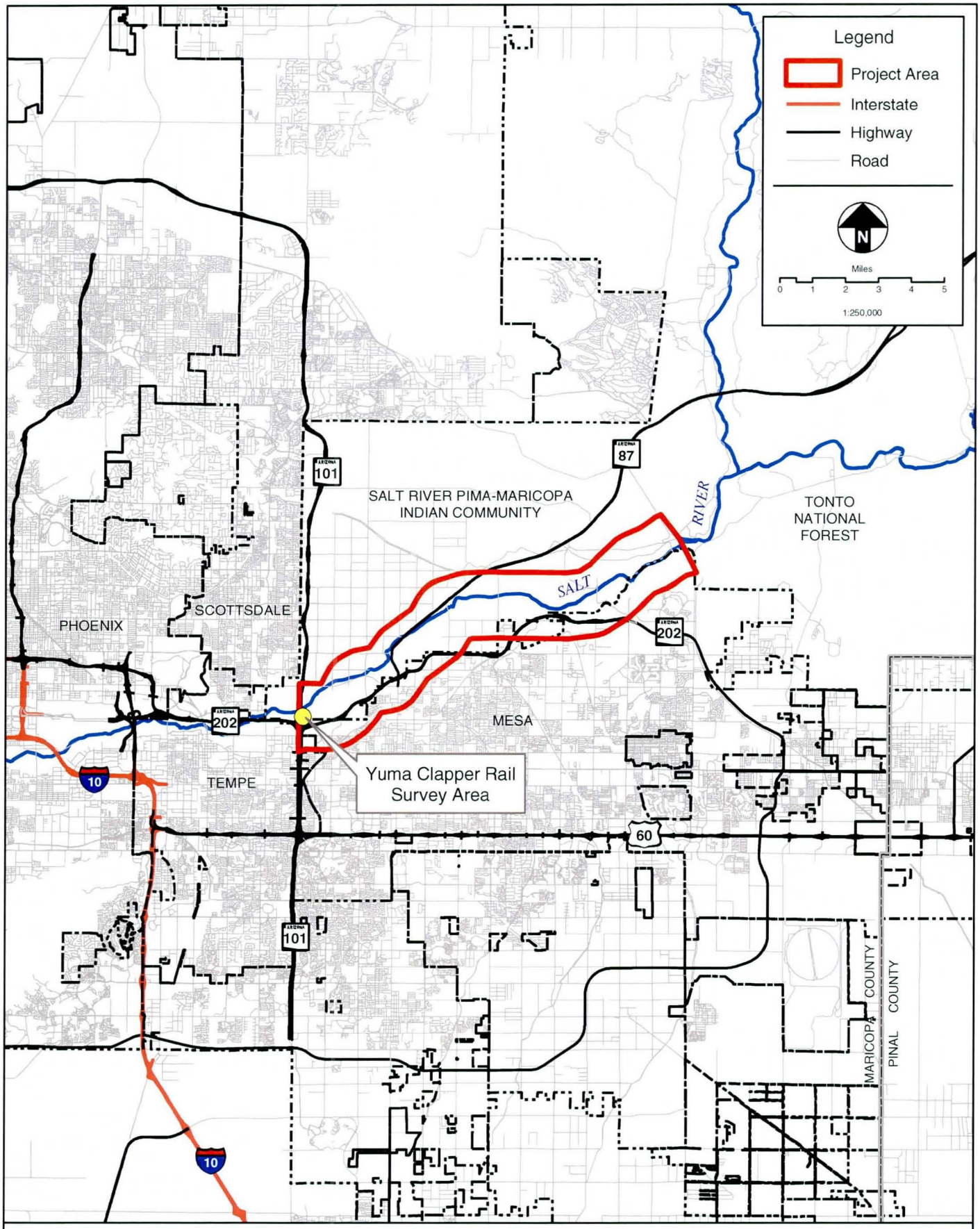
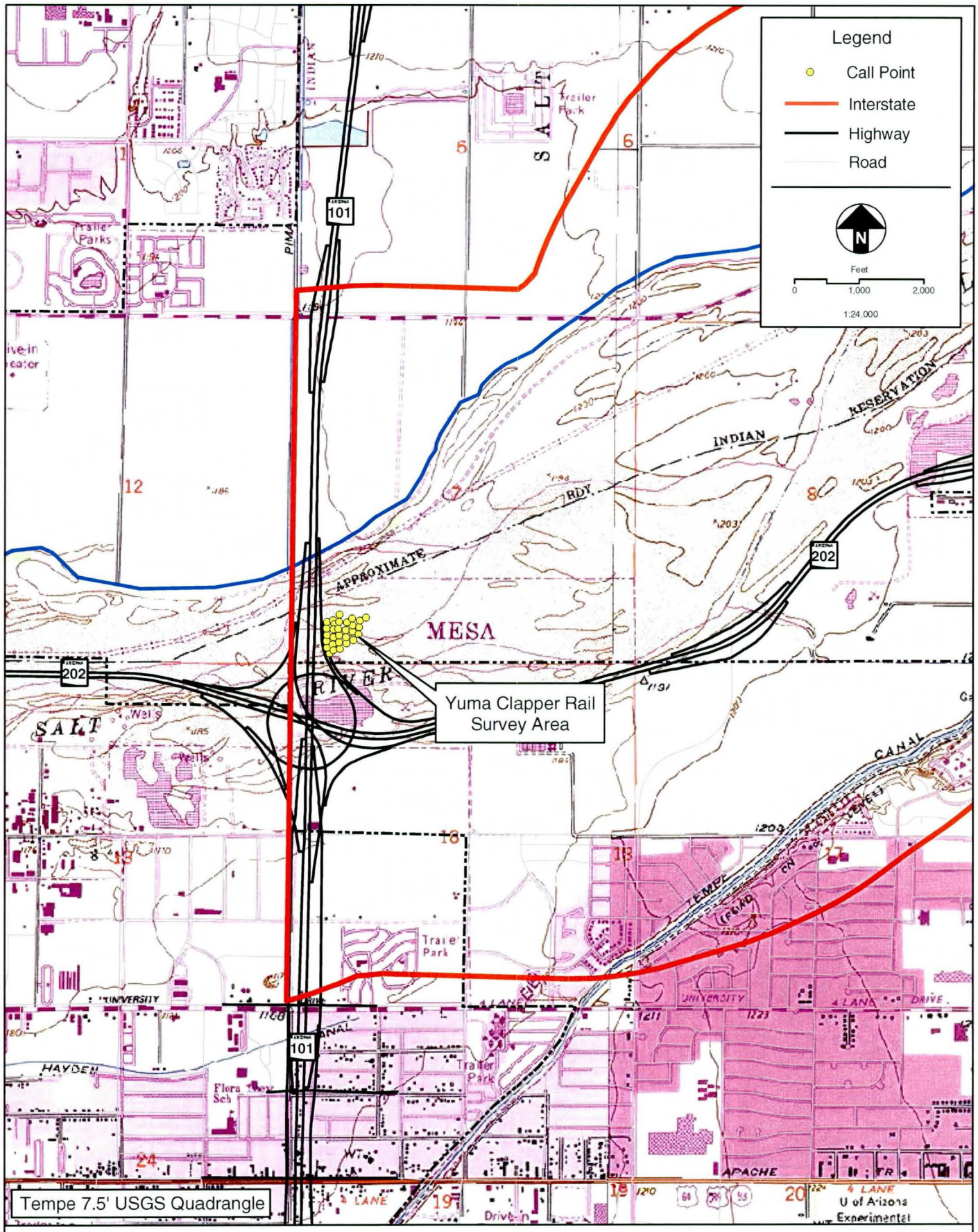


Mapped for: U.S. Army Corps of Engineers

Mapped by: Jones & Stokes

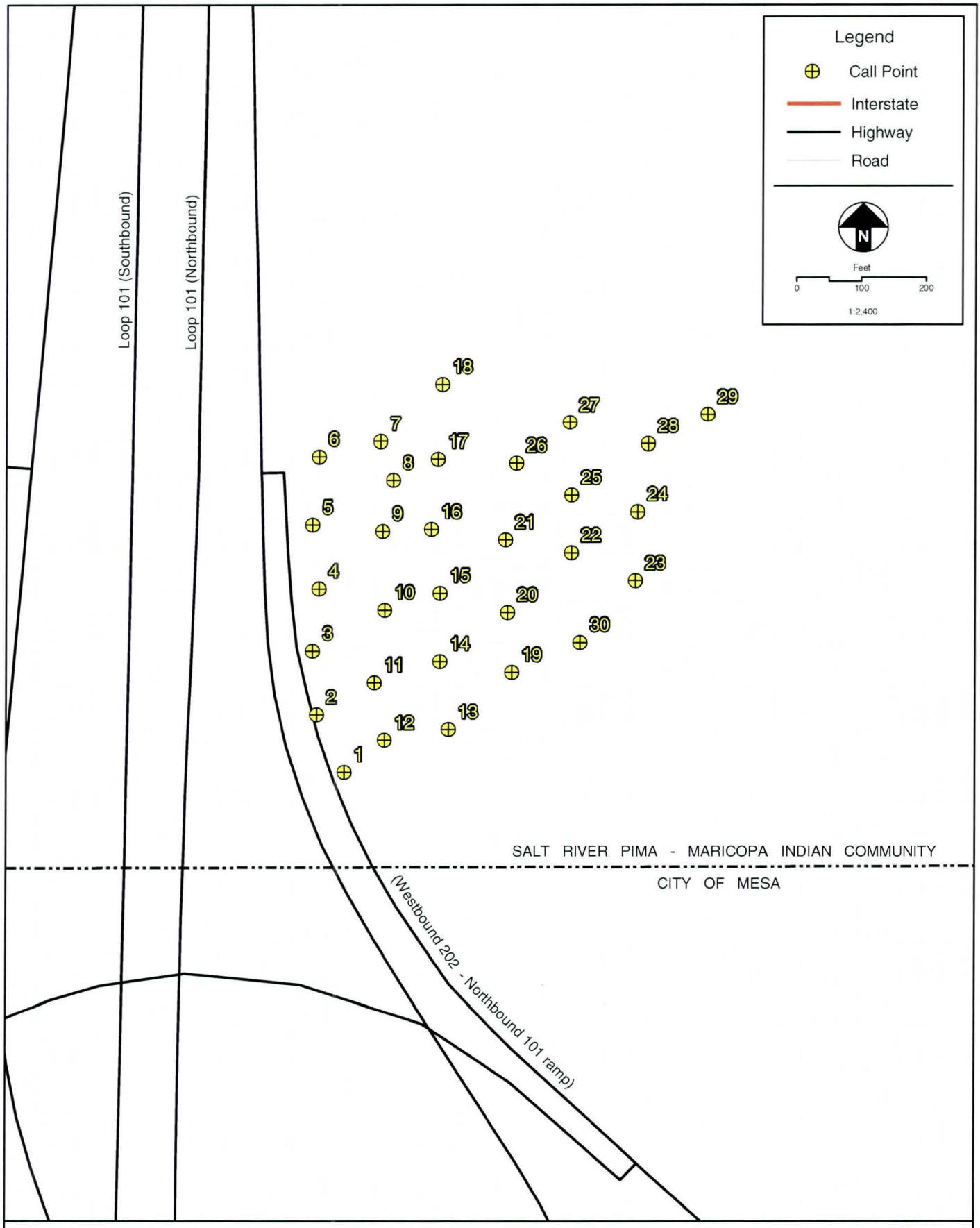
Figure 1
Vicinity Map
Va Shly'ay Akimel Project Study Area



Mapped for: U.S. Army Corps of Engineers

Mapped by: Jones & Stokes

Figure 2
Call Point Location Map
Va Shly'ay Akimel Project Study Area



Mapped for:
U.S. Army Corps of Engineers

Mapped by:
Jones & Stokes

Figure 3
Call Point Detail Map
Va Shly'ay Akimel Project Study Area

APPENDIX

I

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

HYDRO-GEOMORPHIC MODEL ASSESSMENT

Prepared in coordination with:

U.S. Army Corps of Engineers
Los Angeles District

U.S. Army Corps of Engineers
Engineer Research and Development Center

WASS Gerke & Associates, Inc.
Phoenix, Arizona

Executive Summary

This report contains the analysis, results, and documentation of the Va Shly'ay Akimel HGM assessment. The Va Shly'ay Akimel study area is an approximately 17 mile degraded reach of the Salt River located approximately 10 miles east of Phoenix Arizona (see Fig. 2-1). The non-federal sponsors for this feasibility study are the Salt River Pima Maricopa Indian Community and the City of Mesa.

Ecosystem restoration benefits resulting from the proposed alternatives were determined using an HGM assessment. The specific HGM assessment tool was the Arizona Riverine Model developed with the input of regional experts (page 12, and Table 2-6). In the summer of 2002 the Va Shly'ay Akimel E-team (Table 2-7) met to discuss baseline (e.g., without project) conditions and to estimate the future (e.g., with project) conditions for the HGM model analysis. During the alternative formulation phase of the project the E-team identified 15 alternatives ranging from a xero-riparian dominated ecosystem to a meso-riparian dominated system with extensive vegetation establishment (page 59 and Tables 3-1, 3-3). Each alternative was further subdivided based on irrigation method (drip (1) or surface braided inflow (2)) giving a total of 30 alternatives. Details of each alternative are available in the AFB document.

The HGM assessment evaluated future changes in quantity (acres) and quality (functional capacity) of the aquatic, wetland, and terrestrial ecosystems. Average Annual Functional Capacity Units (AAFCU's) were calculated for the 50-year life of the project. All 30 alternatives were evaluated using USACE cost evaluation procedures as irrigation method affected cost but not AAFCU's produced by the alternative.

The top three alternatives based upon results of the HGM analysis, were F (1035 AAFCU's and 447 acres habitat gain), O (963 AAFCU's and 442 acres habitat gain), and G 943 AAFCU's and 457 acres habitat gain) (page 66 and table 5-1). All three of these alternatives exceeded the performance target of 915 AAFCU's. The top three alternatives based on Incremental Cost Analysis (ICA) were A2 ($4.00/AAFCU and 373 AAFCU's), O2 ($10.00/AAFCU's and 963 AAFCU's), and F2 ($15.00/AAFCU and 1035 AAFCU's) (Table 5-2).

Based upon HGM, ICA analyses, and sponsor input, alternative O2 is the recommended plan. Alternative O2 exceeds performance targets for three of the five priority vegetation communities identified by the E-team (cottonwood by 733 acres, river bottom by 350 acres, and mesquite by 80 acres) (page 21). Alternative O2 exceeded the performance target for AAFCU's by 48 AAFCU's. Although alternative O2 produces 72 fewer AAFCU's than alternative F2 the cost per AAFCU is also $5.00 less per AAFCU than F2. The sponsors expressed a strong preference for Alternative O2.

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CHAPTER 1 - Introduction

The U.S. Army Corps of Engineer Los Angeles District is actively engaged in the Va Shly'ay Akimel Ecosystem Restoration Feasibility Study (ER-FS). The study area is located on the Salt River extending approximately 17 river miles from the Granite Reef Dam to the Pima Freeway 101. The non-federal sponsor(s) for this feasibility study include the Salt River Pima-Maricopa Indian Community and the City of Mesa, Arizona. Activities to be completed by the Corps during the feasibility study include investigating and evaluating all reasonable alternatives to provide for the restoration of Sonoran-desert riparian vegetation and associated native wildlife, to increase flood protection, and where possible, to provide increased passive recreation and educational opportunities afforded by ecosystem restoration facilities.

To determine the ecosystem restoration benefits resulting from the proposed wetland alternatives in the Va Shly'ay Akimel Project, HydroGeoMorphic Wetland Assessment procedures (HGM) were completed. The HGM assessment was designed to evaluate the future changes in quantity (acres) and quality (functional capacity) of aquatic, wetland, and terrestrial ecosystems. Outputs, Average Annual Functional Capacity Units (AAFCUs) were calculated in terms of annualized changes anticipated/estimated over the 50-year life of the project. Results for each alternative were compared using the standard U.S. Army Corps of Engineers (USACE) cost evaluation procedures. Early in the evaluation process, an evaluation team (E-Team) was convened. This E-Team was comprised of project mangers, planners, and technical experts from both the private and public sectors, and academia. Also included on the E-Team were individuals who represented the non-federal sponsors and actively participated in the HGM assessment.

The Va Shly'ay Akimel ER-FS HGM assessments in their entirety, in addition to the results of the cost analyses are presented in the following chapters. The body of this report is divided into five (5) chapters:

Chapter I: Introduction
Chapter II: Methods
Chapter III: Va Shly'ay Akimel HGM Results
Chapter IV: Trade-Offs
Chapter V: Summary and Conclusions

In addition, three (3) chapters that lend support to this report, (Literature Cited, Glossary, and Appendix A) are included at the end of the text.

Chapter 2 presents the HGM tool and describes the methods used to develop the models and conduct the HGM assessment. A description is provided that details the selection, development, verification, and deployment of the functional model(s) used to assess the

efficacy of the proposed Va Shly'ay Akimel ER-FR. The E-Team is introduced in this chapter and the decisions and assumptions made during the HGM development and evaluation processes are fully documented. Technical terminologies utilized in the description and application of the HGM tool are also included in this chapter.

Chapter 3 provides the results of the analysis of the proposed Va Shly'ay Akimel ecosystem restoration effort. First, a description of the baseline habitat conditions is provided including the documentation of sampling techniques, delineation of cover types and Partial Wetland Assessment Areas (PWAA's), data handling techniques, decisions made in the utilization of data in the analysis, and the derivation of baseline functional capacity units per PWAA. Next the assumptions and projected data used in the HGM are presented with the results of the analyses detailed at the end of the chapter. Details of the functional habitat gains are summarized in a series of "Results" tables located within this chapter.

Chapter 4 discusses the trade-offs process and used for the Va Shyl'ay Akimel Environmental Restoration Study. Although the biological study Team did not adopt the formal trade offs process, during the HGM process alternatives were compared based upon the model outcomes with respect to wetland functions achieved, plant communities present, and the overall species mixture of the proposed system. This chapter discusses the rational used in foregoing the formal trade off process in lieu of assumptions made at the variable level of the model development process.

Chapter 5 provides an overall project summary of the results and conclusions of the HGM analysis. Included is a summary of the top three biological (HGM), and top three incrementally cost effective alternatives.

CHAPTER 2 - Methods

Setting ecosystem restoration objectives and performance criteria on the recovery of "non-use" benefits, such as ecosystem functions and wildlife habitat, were critical to the overall planning process. The basic premise behind species and community restoration is the recovery of limiting habitat features, defined by their primary components, such as food, water, cover, or reproduction. The primary goal of this study focuses on the restoration of such components within the study area. To measure the success of the ecosystem restoration proposals, the best available science was used. In most ecosystem restoration studies, benefits are measured using quantifiable techniques rather than qualitative assessments. It was important that the technique selected to quantify benefits be repeatable, efficient, and effective, as results could be questioned by outside interests, and there was a finite amount of time available for the study schedule and participants. Although many rapid assessment techniques were applicable, for reasons described in the next section, the USACE Los Angeles District selected the HGM (HydroGeoMorphic Assessment of Wetlands) to quantify the anticipated habitat benefits gained/lost by proposed ecosystem restoration alternatives for the Va Shly'ay Akimel ER-FS.

Introduction to the HGM Process

Wetland ecosystems often occur under a broad range of climatic, geographic, geologic, and physiographic situations. In turn wetland systems often exhibit a wide range of physical, chemical, and biological attributes and processes (Ainslie et al. 1999; Ferren, Fiedler, and Leidy 1996; Ferren et al. 1996a, b; Mitch and Gosselink 1993; Semeniuk 1987; Cowardin et al. 1979). Wetlands do however, posses a number of common attributes including significant periods of inundation or saturation, the presence of hydrophilic vegetation, and hydric soils. The challenge is to develop assessment methods that are both accurate and practical, that not only take into account similar traits, but also the variability. There are existing "generic" methods designed to assess multiple wetland types throughout the United States that are relatively rapid, but lack the resolution necessary to detect significant change(s) in wetland function.

Reducing the level of variability exhibited by the wetlands being considered is one way to achieve an appropriate level of resolution within an available timeframe (Smith et al. 1995). The HydroGeoMorphic Assessment of Wetlands (HGM) approach was developed specifically to accomplish this task (Ainslie et al. 1999; Brinson 1993). HGM identifies groups of wetlands that function similarly using three criteria: 1) Geomorphic Setting, 2) Water Source, and 3) Hydrodynamics. These criteria are assumed to fundamentally influence how the wetlands function. Geomorphic Setting refers to the landform and position of the wetland in the landscape. Water Source refers to the primary water source in the wetlands, e.g. precipitation, overbank flooding, or groundwater. Hydrodynamics refers to the level of energy and the direction that water moves in the wetland. Based on

these three criteria, any number of "functional" wetland groups can be identified at different spatial or temporal scales. As a first approximation, the HGM approach uses seven wetland classes (groups) as described below in Table 2-1 (Smith et al. 1995).

Table 2-1
Hydrogeomorphic Wetland Classes on a Continental Scale

Wetland Class	Class Description
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depression wetlands may have any combination of inlets and outlets or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands. The predominant direction of flow is from higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that range from diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, vernal pools, and cypress domes are common examples of depression wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries, and are under the influence of sea level. They intergraded landward with riverine wetlands where tidal current diminishes and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between tidal fringe and riverine classes is where bi-directional flows from tides dominate over unidirectional ones controlled by the floodplain slope of the riverine wetlands. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in the higher elevation marsh areas where flooding is less frequent, and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, these wetlands consist of a floating mat attached to the land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional, usually controlled by water-level fluctuations resulting from wind or seiche. Lacustrine wetlands lose water by flow returning to the lake after flooding and evapotranspiration. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.

Table 2-1 continued.

Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or sites with saturated overland flow with no channel formation. They normally occur on the sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by down-slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of groundwater/interflow water source. Fens are a common example of slope wetlands
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become organic soil flats. They typically occur in relatively humid climates. Pine flat woods with hydric soils are an example of mineral soil flat wetlands.
Organic Soil Flats	Organic soil flats, or extensive peat lands, differ from mineral soil flats in part because their elevation and topography are controlled by the vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peat lands are examples of organic soil flat wetlands.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and the wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from the riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwoods on floodplains are an example of riverine wetlands.

The level of variability in the continental-scale wetland hydrogeomorphic classes presented above is still usually too immense to develop assessment models that can be rapidly applied while still being sensitive enough to detect changes in function at a level of resolution appropriate to the USACE planning process in Arizona. As such, the three classification criteria (geomorphic setting, water source, and hydrodynamics), were applied at a smaller, regional geographic range to identify regional wetland subclasses. Examples of such regional wetland subclasses are provided in Table 2-2.

Table 2-2
Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source and Hydrodynamics

Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina Bays	California vernal pools
Fringe (tidal)	Ocean	Bi-directional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bi-directional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Uni-directional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (organic soil)	Precipitation	Vertical	Peat Bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forests	Riparian wetlands

The resulting regional riverine wetland subclasses adopted for the Va Shly'ay Akimel project were all associated with low gradient perennial and ephemeral river systems in Arizona. Within these regional subclasses, homogenous zones exhibiting analogous vegetative species, geographic similarities, and physical conditions that make the area unique were defined as a Partial Wetland Assessment Area (PWAA). In all, 19 PWAA's were defined for the Va Shly'ay Akimel Project on the basis of species recognition and dependence, soil types, and topography. The dominate vegetative cover types were used within the PWAAs included Cottonwood – Willow, Wetland Marsh, Mesquite, and Scrub-Shrub. River Bottom was defined as the active channel and included pool/riffle aquatic areas, and open areas characterized by sand, cobble, and/or gravel. During the planning and project formulation processes, various combinations of PWAA's were located within the project area and used to develop a range of restoration alternatives.

In the HGM process, a Variable Sub index (VSI) is a mathematical relationship that reflects a wetland function's sensitivity to change in a limiting factor or variable within the PWAA. In HGM VSIs are depicted using functional capacity curves where the VSI value ranges from 0.0 to 1.0. A VSI = 0.0 represents a variable that is extremely limiting while a VSI = 1.0 represents a variable in abundance for the wetland under consideration. Hence the VSI is used to bridge the gap between measured variables and the functional value of an existing or proposed PWAA.

HGM model variables represent the characteristics of the wetland ecosystem (and surrounding landscape) that influence the capacity of a wetland ecosystem to perform a function. HGM model variables are ecological quantities that consist of five components (Schneider 1994). These include: 1) a name; 2) a symbol; 3) a measure of the variable and procedural statement for quantifying or qualifying the measure directly or calculating it from other measurements; 4) a set of values [i.e., numbers, categories, or numerical estimates (Leibowitz and Hyman 1997)] that are generated by applying the procedural statement; and 5) units on the appropriate measurement scale. Table 2-3 provides several examples.

Table 2-3
Components of a Model Variable.

Name (Symbol)	Measure/Procedural Statement	Resulting Value(s)	Units (Scale)
Redoximorphic Features (VREDOX)	Status of redoximorphic features/visual inspection of soil profile for redoximorphic features	Present / Absent	Unitless (nominal scale)
Floodplain Roughness (VROUGH)	Manning's Roughness Coefficient (n) observe wetland characteristics to determine adjustment values for roughness component to add to base value	0.01 0.1 0.21	Unitless (interval scale)
Tree Biomass (VTBA)	Tree basal area/measure diameter of trees in sample plots (cm), convert to area (m^2), and extrapolate to per hectare basis	5 12.8 36	m^2/ha (ratio scale)

HGM model variables occur in a variety of states or conditions in reference wetlands (Ainslie et al. 1999). The state or condition of the variable is denoted by the value of the measure of the variable. For example, tree basal area, the measure of the tree biomass variable could be large or small. Similarly, recurrence interval, the measure of overbank flood frequency variable could be frequent or infrequent. Based on its condition (i.e., value of the metric), model variables are assigned a variable sub index. When the condition of a variable is within the range of conditions exhibited by reference standard wetlands, a variable sub index of 1.0 is assigned. As the condition diverges from the reference standard condition (i.e., the range of conditions that the variable occurs in reference standard wetland), the variable sub index is assigned based on the defined relationship between model variable condition and functional capacity. As the condition of a variable deviates from the conditions exhibited in reference standard wetlands, it

receives a progressively lower sub index reflecting its decreasing contribution to functional capacity. In some cases, the variable sub index drops to zero. For example, when no trees are present, the sub index for tree basal area is zero. In other cases, the sub index for a variable never drops to zero. For example, regardless of the condition of a site, Manning's Roughness Coefficient (n) would always be greater than zero.

A desired result of the Va Shly'ay Akimel ER-FS process was to assess the functional values of wetland habitat types (PWAAs) currently existing within the project area. Further, estimates of these functional values were needed for PWAAs at selected times in the future considering the Without Project scenario and With Project alternatives. Wetlands perform a wide variety of functions, although not all wetlands perform the same functions, nor do similar wetlands perform the same functions to the same level of performance. The ability to perform a function is influenced by the characteristics of the wetland and the physical, chemical, and biological processes within the wetland.

Wetland characteristics and processes influencing one function often also influence the performance of other functions within the same wetland system. The eleven (11) functions evaluated with HGM Functional Capacity Index (FCI) models used in the Va Shly'ay Akimel ER-FS are found in Table 2-4.

Table 2-4
Wetland Functions Evaluated in HGM and Their Descriptions.

Wetland Function (symbol)	Description
Function 1: Maintenance of Channel Dynamics (CHANNELDYN)	Physical processes and structural attributes that maintain characteristic channel dynamics. These include flow characteristics, bedload, in-channel coarse woody debris inputs, channel dimensions, and other physical features (e.g. bank vegetation, slope).
Function 2: Dynamic Surface Water Storage/Energy Dissipation (WATSTORENR)	Dynamic water storage and dissipation of energy at bankfull and greater discharges. These are a function of channel width, depth, bedload, bank roughness (coarse woody debris, vegetation, etc.), presence and number of in-channel coarse woody debris jams, and connectivity to off-channel pits, ponds, and secondary channels.
Function 3: Long Term Surface Water Storage (WATSTORLNG)	The capability of a wetland to temporarily store/retain surface water for long durations; associated with standing water not moving over the surface. Water sources may be overbank flow, overland flow, and/or channelized flow from uplands, or direct precipitation.

Table 2-4, continued.

Function 4: Dynamic Subsurface Water Storage (WATSTORSUB)	Availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic drawdown of water table.
Function 5: Nutrient Cycling (NUTRIENT)	Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
Function 6: Detention of Imported Elements and Compounds (ELEMENTS)	The detention of imported nutrients, contaminants, and other elements or compounds.
Function 7: Detention of Particles (DETPARTICL)	Deposition and detention of inorganic and organic particulates (> 0.45 μm) from the water column,; primarily through physical processes.
Function 8: Maintain Characteristic Plant Communities (PLANTS)	Species composition and physical characteristics of living plant biomass. The emphasis is on the dynamics and structure of the plant community as revealed by the species of trees, shrubs, seedlings, saplings, and herbs and by the physical characteristics of the vegetation.
Function 9: Maintain Spatial Structure of Habitat (HABSTRUCT)	The capacity of the wetland to support animal populations and guilds by providing heterogeneous habitats.
Function 10: Maintain Interspersion and Connectivity (INTERSPERS)	The capacity of the wetland to permit aquatic organisms to enter and leave the wetland via permanent ephemeral surface channels, overbank flow, or unconfined hyporheic gravel aquifers. The capacity of the wetland to permit access of terrestrial or aerial organisms to contiguous areas of food and cover.
Function 11: Maintain Protection Zone from Urban Encroachment (BUFFER)	Land use immediately adjacent to the wetland should be compatible and afford a gradual transition from the wetland habitat to developed areas.

HGM is an accounting system that can be used to estimate the functional value of the study area wetland habitat(s) relative to the functional value of reference wetland habitat(s). In the HGM process, the currency denoting functional value is defined as Functional Capacity Units (FCU's). A functional capacity unit considers two factors: 1) the quality of the wetland habitat and 2) the quantity of the wetland habitat providing the functional value(s).

The quality of the habitat is measured as the Functional Capacity Index (FCI). The FCI is derived from limiting environmental factors (variables) associated with the various functions attributable to wetland ecosystems. It is a function made up of arithmetic, geometric, or multiplicative combinations of the VSI scores for each Cover Type within each PWAA. VSI scores were obtained using a combination of field measurements made in the project area and at reference site locations. Due to time and economic constraints, and the need to estimate future conditions, several limiting environmental factors are obtained through the use of literature searches, aerial photographic analysis, historical and contemporary mapping and GIS products.

Reference wetlands are wetland sites selected from a reference domain (a defined Geographic area), selected to "represent" sites that exhibit a range of variation within a particular wetland type, including sites that have been degraded/disturbed as well as those sites with minimal disturbance (Ainslie et al. 1999). The use of reference wetlands to scale the capacity of wetlands to perform a function is one of the unique features of the HGM approach. Reference sites provide the standard for comparison in the HGM approach. Unlike other methods which rely on data from published literature or best professional judgment, the HGM approach requires identification of wetlands from the same regional subclass and from the same reference domain, collection of data from those wetlands, and scaling of wetland variables to those data. Since wetlands exhibit a wide range of variability, reference wetlands should represent the range of conditions within the reference domain. A basic assumption of the HGM approach is that the highest, sustainable functional capacity is achieved in wetland ecosystems and landscapes that have not been subject to long-term disturbance (Smith et al. 1995). It is further assumed that under these conditions the structural components and physical, chemical, and biological processes within the wetland and surrounding landscape reach a dynamic equilibrium necessary to achieve the highest, sustainable functional capacity. Reference standards are derived from these wetlands and used to calibrate variables. However, it is also necessary to recognize that many wetlands occur in less than standard conditions. Therefore, data must be collected from a wide range of conditions in order to scale model variables from 0.0 to 1.0, the range used for each variable sub index. To assist the user, a list of key terms related to the reference wetland concept in the HGM methodology is listed in Table 2-5.

Table 2-5
Reference Wetland Terms and Definitions

Term	Definition
Reference Domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected.
Reference Wetland	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and disturbance and from human alteration.
Reference Standard Wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that the wetlands is both sustainable and characteristic of the least human altered wetland sites in the least altered human landscapes. By definition, the functional capacity index for all functions in the reference standard wetlands are assigned a 1.0.
Reference Standard Wetlands Variable Condition	The range of conditions exhibited by model variables in reference standard wetlands. By wetland variable definition, reference standard conditions receive a variable sub index score of 1.0.

Table 2-5, continued.

Site Potential – Mitigation Project Context	The highest level of function possible, given local constraints of disturbance history, land use, mitigation project or other factors.
Project Target – Mitigation Project Context	The level of function identified or negotiated for a restoration or creation project.
Project Standards – Mitigation Project Context	Project standards, performance criteria, and/or specifications used to guide the restoration or creation activities (mitigation context) toward the project target. Project standards should specify reasonable contingency measures if the project target is not being achieved.

A FCI score varies between 0.0 and 1.0 because the value is determined as the ratio of the study area conditions to those measured or estimated at a reference wetland standard. An index of 0.0 indicates the wetland does not perform the function at a measurable level and will not recover the capacity to perform the function through natural processes. Conversely, an index of 1.0 indicates that a wetland performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An HGM model developed for a given subclass of wetlands is essentially an assimilation of several FCI models to evaluate overall site functionality. All FCI models are described using a single FCI formula. Some examples of HGM FCI models include floodwater detention, internal nutrient cycling, organic carbon export, removal and sequestration of elements and compounds, maintenance of characteristic plant communities, and wildlife habitat maintenance.

The quantity is merely the number of acres of a cover type or partial wetland assessment area (PWAA) receiving the FCI score. When the FCI is multiplied by the number of acres present, the results is the relative value (FCU) of the wetland habitat being considered. More precisely, the resulting FCU value provides a means of assessing the gains or losses in functional value for a single target year of interest. In order to assess the functional value of restored wetland habitats relative to reference wetlands over time, gains and losses are averaged over the life of the project. This resulting meter is termed the AAFCU or average annual functional capacity units.

In summary, HGM combines both the wetland functionality (FCIs) developed with measured/estimated variables and areal extent of a site to generate a measure of change referred to as Functional Capacity Units (FCUs). Once the FCI and PWAA quantities have been determined, the FCU values can be mathematically derived with the following equation: FCU = FCI x Area (measured in acres). When the HGM process is employed, one FCU is equivalent to one optimally functioning wetland acre. HGM can be used to evaluate future conditions and the long-term effects of proposed alternatives by generating FCUs for wetland functions over several target years (TYs). In such cases, future wetland conditions are estimated for both Without Project and With Project conditions. Projected long-term effects of the project are reported in terms of Average

Annual Functional Capacity Units (AAFCUs) values. Based on the AAFCU results, alternative designs can be formulated and trade-off analyses can be simulated to optimize ecosystem restoration efforts.

Ecosystem Evaluation Using HGM

The process of applying the HGM methodology involves 12-steps. The following sections will define each step and provide a narrative of how it was applied specifically to the Va Shly'ay Akimel ER-FS. To begin, the 12 steps involved in the application of HGM while assessing this ecosystem project were:

1. Build a multi-disciplinary Evaluation Team (E-Team).
2. Define the project.
3. Determine goals and objectives, project life, and Target Years.
4. Cover type mapping of the site(s).
5. Select, modify, and/or create model(s).
6. Conduct field sampling.
7. Perform data management and statistical analyses.
8. Calculate Baseline Conditions.
9. Generate Without Project Conditions and calculate outputs.
10. Generate With Project Conditions and calculate outputs.
11. Develop relative value indices and perform trade-offs.
12. Report the results of the analyses.

Build a Multi-Disciplinary Evaluation Team (E-Team)

In HGM, an interagency, interdisciplinary evaluation team (E-Team) must be established to lead the model selection and model development phase of the project. Most importantly, this team must be composed of individuals that are well-versed in the natural history, ecology, and institutional constraints of the project area so that baseline and future conditions of the site(s) can be established.

The Va Shly'ay Akimel ER-FS activities were coincident with four other ecosystem restoration project feasibility studies in Arizona. Three of these projects are located in and around the Tucson, Arizona metropolitan area in reaches of the Santa Cruz and the Rillito Rivers. The fourth is located downstream of the Va Shly'ay Akimel project on the Salt River in the Phoenix, Arizona metropolitan area. Evaluation teams were developed for each of these projects and team commitments were established at a 3-day meeting held in Tucson, Arizona March 26 – 28, 2001. The goal of this meeting was to develop an Arizona Riverine Model based upon the HGM methodology. The overall evaluation team was comprised of individuals from agencies, project stakeholders, private

consultants, and academia. Together these individuals brought together the necessary technical expertise to support planning efforts requiring disciplines related to botany, soils, hydrology, and wildlife ecology. In addition, the project team included individuals responsible for project design and management. Those individuals that attended the March 2001 Tucson meeting are provided in Table 2-6 located below.

Table 2-7 provides a listing of the E-Team members that attended the Tucson Meeting, but were assigned specific tasks relating to the Va Shly'ay Akimel ER-FS. These individuals participated in the model selection and modification activities conducted at the Tucson meeting, but were also responsible for assisting the Va Shly'ay Akimel study managers with the selection of reference wetlands, collection of field data, data management and reduction, mathematical calculations, and alternative formulation specific to the study area. Field data were collected on two sampling events during the week of April 22, 2002. In June of 2002, the team met to discuss Baseline and Without Project results. The team then met in August, 2002 to project future With-Project conditions for the HGM models.

Table 2-6
Attendees to "The HGM Approach for the Arizona Streams Restoration Model Development Meeting", March 26-28, 2001, Tucson, Arizona.

Name	Organization /Company Name	Discipline	Name	Organization /Company Name	Discipline
Nick Adel Meyer	CE LA District	Hydrologist/Hydraulic Engr.	Robert MacAller	RECON	Biologist
Sam Arrowood	CE LA District – PHX	Study Manager	Kevin MacKay	Jones & Stokes	Ecosystem Restoration Planner
Kathy Bergmann	CE LA District – PHX	Study Manager	Ralph Marra	Tucson Water Department	Hydrologist/ Groundwater
Mark Briggs	Briggs. Inc.	Ecologist & Soils	Mike Martinez	USFWS	Biologist
Kelly Burks-Copes	CE ERDC	Facilitator	Glenn Mashburn	CE LA District	Hydraulic Engr.
Karen Dada	City of Phoenix	Study Manager	Mark Meyers	Marana	Biologist
Carla Danforth	Pima County	Hydrologist	Lynn Orchard	Pima County	Hydrologist
Dawn Daw	SRPMIC	Biologist	Dixie Padilla	SRPMIC	Range Manger
Steve Dibble	CE LA District – Env Coord.	Archeologist	Becky Pearson	Pima County	Civil Engineer
Kayla Eckert	CE LA District – PHX	Study Manager	Phil Pearthree	AZ Geological Survey	Hydrologist/ Geomorphologist

Table 2-6, continued.

Scott	CE LA District	Study Manager	Phil Rosen	Pima County	Ecologist &

Estergard	– PHX				Soils
Mike Fink	CE LA District – PHX	Biologist	Sherry Ruther	AZ G&F	Ecologist
Julia Fonseca	Pima County	Ecologist & Soils	Linda Smith	Tucson Water Department	Planner
Debra Fein	SRPMIC	Biologist	Pam Sponholtz	AZ G&F	Fisheries Biologist
Jonathan Fuller	JE Fuller & Assoc.	Hydrologist/ Geomorphologist	Julie Stromberg	Arizona State University	Botanist
Sara Gerke	Wass Gerke & Assoc., Inc.	Hydrologist	Michele Waltz	Jones & Stokes	Project Manager
Douglas Green	Arizona State University	Soils	Jennifer Ward	Marana	Study Manager
Tom Helfrich	Pima County	Hydrologist	Roland Wass	Wass Gerke & Assoc., Inc.	Aquatic Biologist & Soils
Collum Hunter	City of Mesa	Biogeochemical	Antisa Webb	CE ERDC	Facilitator
Martin Karpiscak	University of Arizona (OAL)	Biologist/Botanist & Soils	Bill Werner	AZ G&F	Ecologist
Ken Kingsley	SWCA	Biologist	Lori Woods	RECON	Biologist
Michael Langley	Jones & Stokes	Biologist			

Table 2-7
Va Shly'ay Akimel Evaluation Team

Name	Organization /Company Name	Discipline	Name	Organization /Company Name	Discipline
Nick Adelmeyer	CE LA District	Hydrologist/Hydraulic Engr.	Sarah Laughlan	CE LA District	Biologist
Kelly Burks-Copes	CE ERDC	Facilitator	Mike Martinez	USFWS	Biologist
Dawn Daw	SRPMIC	Biologist	Glenn Mashburn	CE LA District	Hydraulic Engr.
Kayla Eckert	CE LA District – PHX	Study Manager	Ralph Marra	Tucson Water Department	Hydrologist/ Groundwater
Debra Fein	SRPMIC	Biologist	Dixie Padilla	SRPMIC	Range Manger
Sara Gerke	Wass Gerke & Assoc., Inc.	Hydrologist	Michele Waltz	Jones & Stokes	Project Manager
Douglas Green	Arizona State University	Soils	Roland Wass	Wass Gerke & Assoc., Inc.	Aquatic Biologist & Soils
Collum Hunter	City of Mesa	Biogeochemical	Antisa Webb	CE ERDC	Facilitator
Michael Hrzic	CE LA District	Hydrologist/Hydraulic Engr	Bill Werner	AZ G&F	Ecologist

Defining the Va Shly'ay Akimel Project

The following information (geographic location, project purpose, presettlement conditions, and the overall ecosystem restoration approach) gathered by the LA District, Phoenix Planning Group has been used to the define the overall Va Shly'ay Akimel ER-FS project.

Geographic Location, Counties, Watersheds, and Primary Water Sources
The Va Shly'ay Akimel study area is located in south central Arizona, in the eastern portion of Maricopa County. The project study area is entirely within the Lower Salt watershed (USGS Cataloging Unit: 15060106). The project reach is bounded on the upstream by Granite Reef Diversion Dam and on the downstream by the Pima Freeway 101. The Salt River is ephemeral throughout this 17 mile reach.

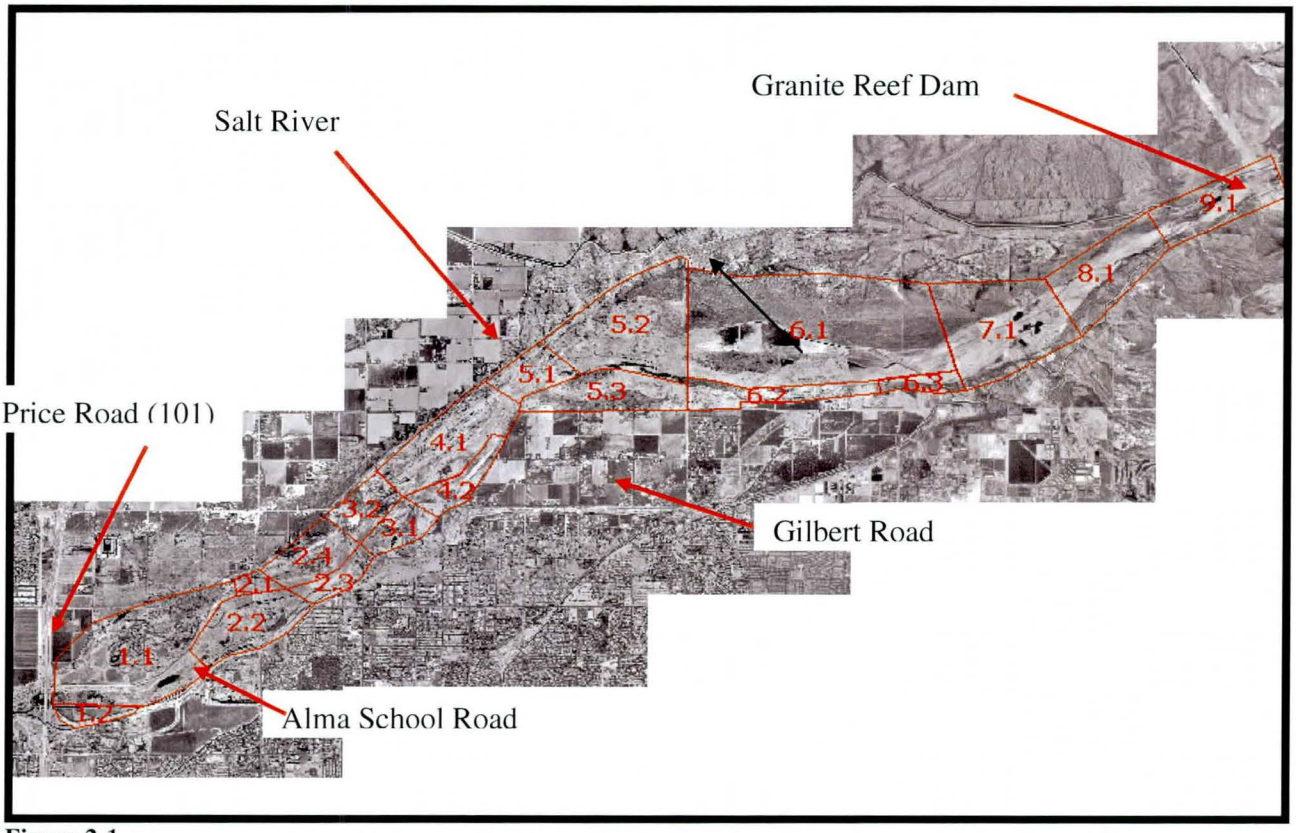

Figure 2-1.
Location Map for the Salt River Va Shly'ay Akimel Project identifying key features and project sub-areas.

The primary water resources for this project include five potential water sources: 1) Salt River Project water from the Hennessey drain and diversion channels, 2) groundwater from existing and new wells, 3) storm water, 4) City of Mesa Wastewater Treatment Facility water and 5) surface water available for use by the Pima Maricopa Indian Community, as shown in Figure 2-2. The current alternatives rely solely on surface

water. According to the Pima Maricopa Indian Community staff, a sufficient amount of this water can be allocated to this project. Therefore, only surface water outlet sources are considered. This does not however, preclude the necessity of a secondary water source in future alternative iterations.

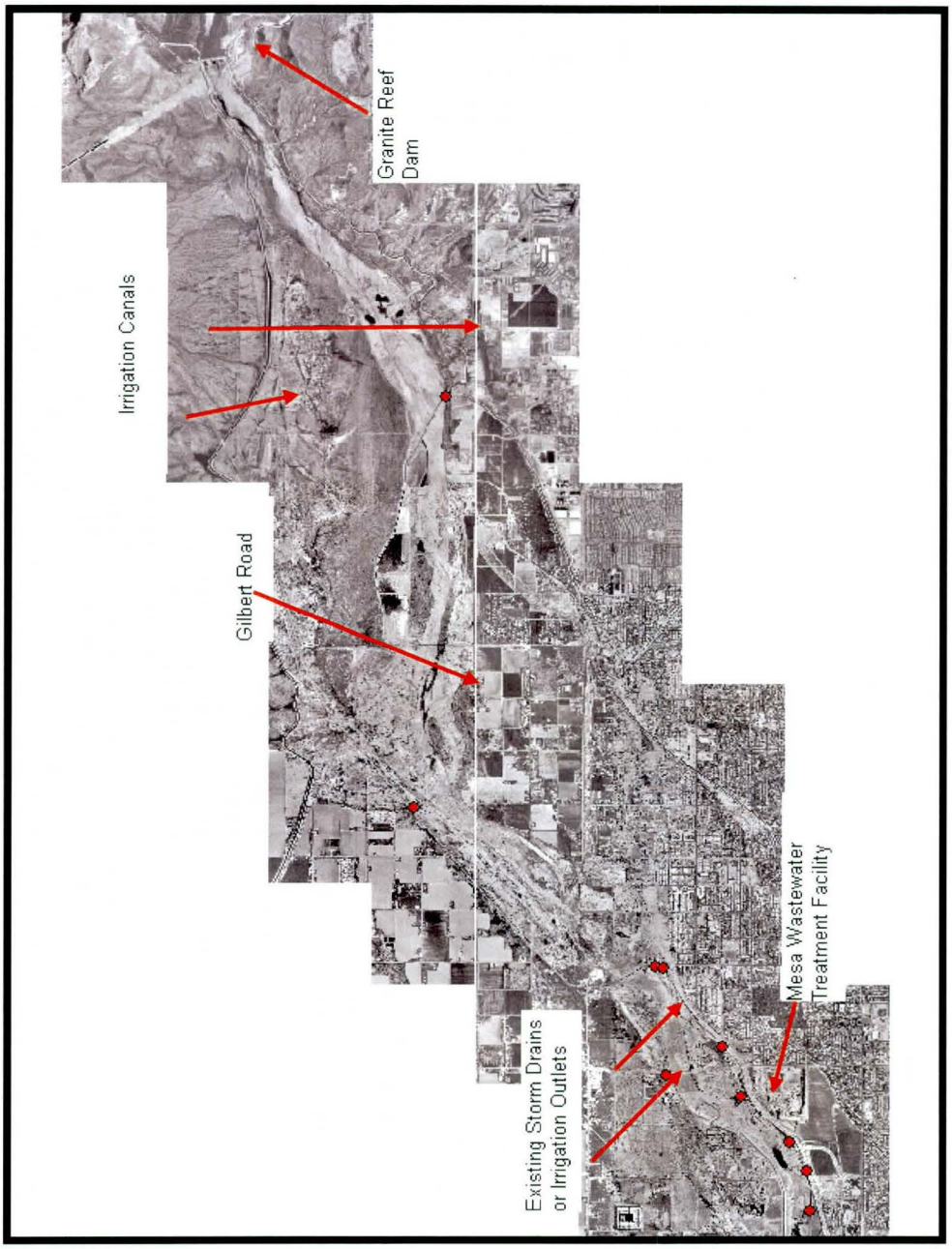

Figure 2-2

Potential primary water resources for the project.

Lead District
The Va Shly'ay Akimel ER-FS falls under the purview of the USACE Los Angeles District, South Pacific Division. The Environmental Coordinator is Mr. Steve Dibble, and the Study Manager is Ms. Kayla Eckert. The local sponsors are the Salt River Pima Maricopa Indian Community (SRPMIC) and the City of Mesa, Arizona. Study efforts are being conducted in coordination with USACE, SRPMIC, City of Mesa, other federal agencies, state resource agencies, and concerned members of the public.

Project Evolution and Purpose
Problems and opportunities were identified, defined, and assessed through coordination with local and regional agencies, the public involvement process, site assessments, interpretation of prior studies and reports, and review of existing water projects. Several significant problems and opportunities specific to the Va Shly'ay Akimel project reach are provided below:

- Degraded river and adjacent overbank areas, due to upstream water resources development, has eliminated native riparian plant species and wildlife habitat. Perennial base flow conditions critical to the needs of native vegetation no longer exists in the river corridor through the study area.

- The average depth to groundwater beneath the river channel is much greater than historic conditions. Riparian vegetation that depends on groundwater has largely disappeared from the river channel.

- Lack of natural flood regime. Hydrologic changes in the river system have impacted the surface/groundwater interactions and sedimentation dynamics that are important for sustaining and recruiting riparian vegetation.

- Land Use changes, including landfills and mineral extraction (sand and gravel mining), have degraded and contributing towards continued degradation of the river corridor.

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

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

The purpose of this feasibility study is ecosystem restoration on the Salt River. Riparian habitats are the most valuable wildlife habitats found within Arizona. Approximately 70-80% of all wildlife species in the state are obligate or totally dependent on these habitats for their survival. The cottonwood-willow (*Populus fremontii-Salix gooddingii*) community, in riparian systems, is by far the most valuable of all the community types to wildlife, especially birds.

Historically the Salt River was ephemeral and supported significant amounts of riparian and wetland vegetation. Unfortunately, much of the cottonwood-willow community has been lost or degraded over the past century. The opportunity exists to restore riparian habitat along the Salt River from the Granite Reef Diversion Dam to Price Road (101). Historical records contain descriptions of the cottonwood-willow community along the Salt River, which has since been lost to water management activities. Today the Salt River in the Va Shly'ay Akimel study area is ephemeral and dominated by facultative or obligate upland species. Exceptional hydro riparian areas exist in the upper most and downstream most sections and despite intensive land use and hydraulic alterations still persists as vestiges of important riparian areas. The Va Shly'ay Akimel project intends to restore new and augment these existing riparian areas.

Of the roughly 260,000 acres of floodplain in the state, only 4% or about 10,000 to 11,000 acres support this valuable wildlife community. Therefore, any opportunity to revegetate floodplain habitats with this community is a valuable addition to the landscape and the wildlife.

Presettlement Conditions of the Region

Along the Va Shly'ay Akimel reaches of the Salt River, water once flowed perennially and supported substantial growth of cottonwoods, willows, and mesquites. Historical accounts of conditions on the Salt River by Hiram C. Hodge (1877) describe a tree-lined, narrow river approximately 200-ft wide and 2 to 4-feet deep during low water periods. During the past 150 years, the lower Salt River underwent modifications attributable to both natural and anthropogenic functions and activities.

The Ecosystem Restoration Approach

By definition, an ecosystem can be described as an integrated unit, identified as a biotic community conjoined with its physical environment. Inherent within this definition is the concept of a structural and functional system, unified through life processes. Ecosystems are hierarchical and can be viewed as nested sets of open systems in which the physical, chemical, and biological processes form interactive subsystems. Ecosystem restoration efforts can be directed at different-sized ecosystems within the nested set, spanning multiple states, more localized watersheds, or smaller complexes of habitat. The Va Shly'ay Akimel project provides a unique opportunity for ecosystem restoration. The study site is small enough to adequately assess the biotic communities and implement meaningful restoration efforts, yet large enough to function as an important biological area in an urban setting, providing habitat and corridor to species in and around the study site.

Discharges to the Va Shly'ay Akimel reach of the Salt River are controlled by a series of dams located upon the upper Salt and Verde River systems. These dams create reservoir storage and are integral to the social and economic development of the downstream communities. However, coupled with mineral extraction, recreation, illegal dumping, and stressors arising from adjacent land uses the altered hydrology of the reach has resulted in degradation of riparian habitat and its associated habitat benefits in the project reach. The fact that the project reach has been altered from a perennial to an ephemeral system drives the Va Shly'ay Akimel ES-FS. As such, for those areas within the project that have access to an existing or proposed perennial water sources, hydro riparian cottonwood and willow communities could be established or existing one augmented. At areas within the project reach that lack a perennial water source, facultative upland vegetation native to the Sonoran desert could be restored and/or created.

Setting Planning Objectives and Goals

Objectives

The Va Shly'ay Akimel project planning objectives were developed by the LA District USACE Phoenix office. The objectives developed reflect the problems and opportunities and represent desired positive changes in the Without Project conditions. The first planning objective is to increase the native riparian plant and wildlife habitat values, diversity and functions from the Granite Reef Dam to the Pima Freeway 101. Elements of diversity include establishing multiple native riparian plant species, providing sufficient open space for wildlife, and providing open-water aquatic and wetland features for wildlife benefits. Another objective of this project is to attract wetland and riparian avian species to the study area. Further, this project should establish and augment the presence of native species diversity in the study area, while suppressing undesirable and nonnative vegetation, fish, and wildlife species.

During October, 2002, members of the Va Shly'ay Akimel E-Team and the study managers developed a refined list of objectives and identified constraints to guide the formulation of alternatives. The six (6) objectives are provided in Table 2-8.

Table 2-8
Va Shly'ay Akimel study objectives and constraints refined during an E-Team Meeting October 17, 2002.

Objective	Constraint(s)
Mimic the mosaic of riparian habitat found in HGM Arizona reference sites.	Do not introduce non-native species. Do not worsen vector problems. Do not cause erosion problems. Do not increase regulatory burden. Do not increase bird strike hazards.
Reduce flood damages on the Salt River between Granite Reef Dam and the Pima Freeway (101) through the year 2050.	Do not worsen flood hazards. Minimize structural solutions.

Table 2-8, continued.

Increase the number of sustainable acres of Cottonwood-Willow forests.	Accept the loss of existing habitat by offsetting losses with creation of new cottonwood-willow forest at a level of 0.5 acres.
Increase the number of sustainable acres of Mesquite Bosque in the project reach.	No net loss of mesquite habitat.
Increase the number of sustainable acres of desert riparian scrub shrub habitat.	Accept some loss of this habitat type due to creation of new habitat types.
Increase the number of sustainable acres of emergent wetlands.	Accept loss of up to 50% of river bottom and offset losses with the creation of new river bottom that includes emergent marsh features.
Convert 656.3 acres of degraded sand and gravel, agricultural, desert and river bottom areas into sustainable riparian habitat.	Coordinate with Salt River Sand and Rock to the level that the Tribal Council desires. Do not degrade the river's economic benefits to the community.
Secure the local project sponsor's commitment to water supply for the life of the project.	Remain sensitive to SRPMIC citizens concerns regarding use of treated effluents. Do not limit use to existing drains and outfalls. Do not degrade or otherwise negatively impact groundwater resources. Do not ignore limited water resources.
Provide appropriate level of recreation consistent with environmental restoration.	Do not increase public access "too much". Provide appropriate level of access and egress to/from the river corridor.
Reestablish culturally significant resources.	Do not degrade existing cultural sites.
Increase public awareness of the Salt River ecology.	
Establish a comprehensive Operations and Maintenance manual including a monitoring and adaptive management plan.	
Establish appropriate connectivity and coordination with downstream ecorestoration project(s).	

Goals

The primary goal in the Va Shly'ay Akimel ER-FS is ecosystem restoration. The ecosystem restoration goal consists of hydraulic, vegetation, then eventually species restoration. First, hydraulic connections between the river and washes, channels, basins,

and adjacent vegetation communities would be restored to the extent practicable. These restoration efforts should mimic historic, natural conditions harvesting water, trapping sediments, facilitating water absorption, and providing water to vegetation. Next, the vegetation communities, both in and adjacent to the river channel, should be enhanced and additional planting should occur. Irrigation would be necessary to help establish some vegetation communities. With the restoration of the vegetation communities, habitat structure should improve with a commensurate increase in the wildlife species in the area. This approach to restoration, focusing on the wetland functions as well as the habitat and vegetation structure, eventually will lead to a more natural ecosystem with wetland functions, habitat structure, and dynamic processes that are currently degraded.

As part of the process of setting project goals, performance targets were established for HGM model functions that indicate the quality of the functions. These are discussed in greater detail in the section titled, "Selecting and Modifying the FCI Models for HGM Analysis" of this report.

The Va Shly'ay Akimel Team considered various desert riparian vegetation communities and eventually identified five (5) that were deemed important to the success of this ecosystem restoration effort. These communities include:

Rank	Community
1	Cottonwood/Willow Forest
2	Mesquite
3	Emergent Wetlands
4	Lower Sonoran Desert (Scrub/shrub)
5	River Bottom

The general physical requirements for implementation of each habitat type are as follows:

1) Cottonwood/Willow (CW) – CW stands are restricted to the near over bank area of streams and rivers, or other areas with saturated soil conditions. They require a water table, or saturated soil conditions, less than 10-ft below the ground surface and have annual water demands ranging from 4 to 8.5 ft/yr. For the purpose of this study, the assumed water demand is an average of 6.3 ft/yr. Soils range from finer sediments to sandy soils that are low in nutrients, allowing for maximum water retention and therefore a higher survival rate of seedlings in select areas. In areas where grading may be required, uneven grading is most beneficial, allowing for depressions where sediment can collect and shelter seeds for establishment. Due to the relatively high water demands of CW, a drip irrigation system may be used to help ensure establishment. Once established, CW stands will rely on a local Surface Braided Irrigation Network (SBIN) for its water needs.

2) Mesquite (MS) – MS are commonly found 5-20 feet above the river channel where soil moisture is sufficient. They require a water table, or semi-saturated soil conditions, 10-30 ft below surface elevation, and can withstand occasional saturated conditions 1-3 feet below surface. The annual water demand for MS is between 2.0 and 4.0 ft/yr. For the purpose of this study, assume a water demand average of 3.0 ft/yr. Soils can be fine to gravelly with some rocky areas and are typically rich due to nitrogen fixation. A drip irrigation system may be necessary to establish the MS. However, once established, the MS will rely on a SBIN for its water needs. Previous restoration efforts have shown that MS can survive on natural precipitation alone, even when groundwater is not available. However, this cannot be assumed true for all locations. Therefore, a site specific evaluation should be performed before determining if or how much supplemental water is required.

3) Emergent Wetland (WT) - WT areas can consist of open water, submerged vegetation or muddy shorelines, all requiring a high water table level at or near the surface. The annual water demand is between 6 and 16 ft/yr. For the purpose of this study, assume a water demand average of 12.5 ft/yr.

   Due to the porous soils found in this project area, lining the WT will be required to maintain surface water in areas not underlain by low permeability soils. Excavation and layering of a silt clay soil substrate overlain by a mixed gravel, and finally, cobble layer, is recommended. The proposed soil structure would reduce disturbance of the soil-clay layer by reducing piping of fine material and reducing turbulent forces acting on the layer.

   Storm drain outlets located near WT will require erosion control and energy dissipation measures at the outlets to prevent scouring. To distribute water from the WT laterally, a series of drainage ditches will be constructed from the WT and incorporated into other areas that require irrigation. The ditches will be semicircular in shape with a top width of 4 ft and maximum depth of 2 ft. The drains will increase lateral dispersion of runoff to maximize the storm water benefit.

   The WT will also be designed with an outlet channel leading to the main channel. The preliminary design of the outlet channel calls for a 20 ft bottom width, 4 ft maximum depth, 2:1 side slopes, 300 ft in length and large cobble bottom. Design Q =. Not all proposed WT would require an outlet channel.

4) Sonoran Desert (SD) – The specific vegetation species can vary depending upon the site's soil aggregate type. However, proposed vegetation types will not require saturated soil conditions and will have an annual water demand between 0.5 to 2.5 ft/yr. For the purpose of this study, assume an average water demand of 2.0 ft/yr. The SD may need to be periodically inundated the first 1-5 yrs to

establish the vegetation. Once established, SD should be sustained by annual precipitation or with periodic inundation during extreme drought periods.

5) River Bottom (RB) - RB will require only surface material reshaping including, partially filling large depressions and excavating large mounds to reduce possible impacts to restoration efforts. River bottom areas may also require hydro-seeding with a variety of native river bottom shrub species to help establish vegetation. These plants will be sustained with natural precipitation and any tail water that may enter the river from other feature irrigation systems. Irrigation is not recommended.

In general, wetlands and cottonwood willow forests require more water than Sonoran desert and mesquite bosques, the latter which typically occur adjacent to river channel and are subject to periodic inundation. The goal is to restore these vegetation communities to a functioning "PWAA" with hydrologic connections to the river and other ecosystem functions. Additional details regarding performance targets are discussed in the section titled "Cover Typing and PWAAS".

Selection of Project Life and Target Years

Given the project goals and objectives, a "project life" of 50 years was designated for the Va Shly'ay Akimel ER-FS. A series of target years within this 50-year setting were designated to generate projections of both Without Project and With Project activities. Target years for the study include TY0 (baseline conditions), TY1 (year of construction), TY6 (year the planting efforts would be completed), TY26 (year to capture significant anticipated ecosystem changes), and TY51 (end of project). TY26 was added to capture significant anticipated changes in vegetative cover, structure, and hydraulic functions in the study area as the habitat develop and mature.

Cover Typing

The goal of the Va Shly'ay Akimel ecosystem restoration study is to restore significant ecosystem functions, structure, and dynamic processes that have been degraded. In the HGM process, the study area is divided into manageable sections and quantified in terms of hectares or acres, in order to evaluate the habitat conditions for a species or community. Such sections are called cover types or PWAAs. A cover type is a parcel of land (or water) that has similar physical, chemical, and biological characteristics contained within its borders. A PWAA is an area of land (or water) that has similar physical, chemical, and biological characteristics, as well as a hydrologic connection to the ecosystem. In HGM the basic difference between a PWAA and a cover type is that the PWAA has a functioning hydraulic connection to the ecosystem. For example, a mesquite bosque area that is periodically inundated by water flow from the river channel

is considered to be a mesquite PWAA, whereas a mesquite bosque area that is disconnected from the hydraulics of the river channel (i.e., behind a soil cement levee) and is not inundated, is considered a mesquite cover type outside the PWAA. The purpose in distinguishing between PWAA's and cover types in HGM is to emphasize the functional hydrologic connection between ecosystem components. Frequently in HGM, cover types (i.e., buffer, ag crop, etc.) are listed in tables along with PWAA's for convenience, but it is important to remember the difference.

In HGM, the functionality of each PWAA is determined by measuring variables that are associated with functions. Some examples of HGM variables include course woody debris, porosity, subsurface inflow, flood-prone area, and depth to saturated soil. In most instances, these variables are measured using aerial photographs, maps, or on-site sampling activities.

For the Va Shly'ay Akimel ER-FS, PWAA's and cover types were delineated. The list of existing cover types in the study area along with the baseline acreages is listed in Table 2-9. In addition, PWAAs were identified that reflect the desired functioning vegetation communities in the restoration alternatives. These "newly developed" PWAAs are also listed in Table 2-9.

Table 2-9
Cover types and baseline acreages for the Va Shly'ay Akimel study area.

No.	Code	PWAA Description	Baseline Acres (TY0)
1	AGCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa	249.70
2	BUFFER	Existing Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00
3	CTWWFOR	Existing Cottonwood-Willow Forests in the Active Channel	69.50
4	DESERT	Desert Areas - Bare Earth, Cacti, Rabbitbush, Acacia	961.90
5	DITCHES	Ditches	56.50
6	MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.10
7	NEWBUFFER	Newly Planted Upland Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00
8	NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00
9	NEWMESQUIT	Newly Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00
10	NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel	0.00
11	NEWRVRBOTM	Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0.00
12	NEWSCRUB	Newly Planted Scrub-Shrublands in the Active Channel	0.00
13	OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.50
14	PARKS	Parks and Recreation Areas	9.60
15	RIVERBOTTM	Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.60
16	SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	1651.60
17	SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	2057.10
18	SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	33.90
19	URBAN	Existing Residential, Industrial and Transportation Avenues	341.60
		TOTAL:	5870.60

After the PWAAs were identified, the E-Team attempted to set quantifiable restoration performance measures for the proposed study (Table 2-10). In most instances, these success criteria focused on the recovery of a specific PWAA, defined on the basis of quantity recovered (measured in acres), and obtainable habitat quality (measured in terms of Variable Suitability Indices or VSIs).

Table 2-10
Goals and objectives per PWAA.

PWAA Code	PWAA Description	Target Acreages	Notes
CTWWFOR	Existing Cottonwood-Willow Forests in Active Channel	63.0	Accept 10% loss of Existing CTWWFOR Acreage
MESQUITE	Existing Mesquite Woodlands – on the Terraces and in Active Channel	4.0	Preserve/Protect Existing Mesquite
NEWCWWFOR	Newly Developed Cottonwood-Willow Forests	150.0	Convert from SANDGRAVEL
NEWMESQUIT	Newly Developed Mesquite Woodlands on Terraces and in Active Channel	300.0	CONVERT from SANDGRAVEL, DESERT
NEWRVRBOTM	Newly Developed River Bottom Areas within the Active Channel – Largely Unvegetated (Includes Emergents)	75.0	Convert from SANDGRAVEL
NEWSCRUB	Newly Developed Scrub-Shrublands in the Active Channel	1,000.0	Convert from SANDGRAVEL
RIVERBOTTOM	Existing River Bottom Areas within the Active Channel – Largely Unvegetated (Includes Emergents)	334.0	Accept no net loss of RIVERBOTTOM
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel	2056.0	Preserve Existing SCRUBSHRUB

Selecting and Modifying the HGM Models

In HGM assessments, FCI models for HGM subclasses are only just beginning to become available for application. The ERDC-EL team is currently leading a research work unit under the Ecosystem Management and Restoration Research Program (EMRRP) for the

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

Models can be single formula, considering only a few variables, or multiple- formula, considering many variables. An example of a single formula model would be the dynamic subsurface water storage function, which considers the depth to saturated soil. An example of a multiple formula model would be the dynamic surface water storage and energy dissipation function which considers water variables such as frequency of flooding and the flood-prone area, as well as, habitat variables such as total vegetation volume and course woody debris. For the Arizona Riverine Overbank HGM Model, 11 FCI models were selected that can be sorted into three general "groups". Four FCI models were selected that focus on water functions, three models were selected that focus on biogeochemical functions, and four models were selected that focus on habitat functions. These FCI model functions are listed in Table 2-11, along with the associated variables for each function formula, while Appendix 1 provides details of the mathematical calculations used for each function. It is important to note that many of the variables are applicable to several of the functions in all three of the groups.

Table 2-11
FCI function models, variables, and performance target.

Code	Name	Variable Association	Performance WP TY 51 Target (FCI)	Performance WP TY51 Target (AAFCUs)	Anticipated WP TY 51 AAFCU Gains
CHANNELDYN	Function 1: Maintenance of Channel Dynamics	FPA Q SED	0.28	689	0
WATSTORENR	Function 2: Dynamic Surface Water Storage/Energy Dissipation	FPA FEQ TOPO	0.57	1324	369
WATSTORLNG	Function 3: Long Term Surface Water Storage	PORE SUBIN TOPO	0.09	234	163
WATSTORSUB	Function 4: Dynamic Subsurface Water Storage	DEPSATSED	0.08	194	63

Table 2-11, continued.

NUTRIENT	Function 5: Nutrient Cycling	CWD DEC'AY FWD	0.50	1152	346
ELEMENTS	Function 6: Detention of Imported Elements and Compounds	FREQ LITTER PORE	0.33	821	95
DETPARTICL	Function 7: Detention of Particles	FPA FWD SED	0.50	1157	456
PLANTS	Function 8: Maintain Characteristic Plant Communities	SPECRICH TVV WIS	0.70	1617	264
HABSTRUCT	Function 9: Maintain Spatial Structure of Habitat	FWD LITTER VEGSTRATA	0.45	1040	151
INTERSPERS	Function 10: Maintain Interspersion and Connectivity	FREQ TOPO TRIB	0.40	926	72
			Average Net AAFCUs	**915**	**198**

Variables Used in the HGM FCI Models

Thirty-five (35) HGM variables was considered for use in the Arizona Riverine HGM Model development. Some of the variables were deemed not necessary and/or redundant so the Master List for the Va Shly'ay Akimel ER-FS resulted in a total of 27 variables as shown in Table 2-12 along with a brief description. The variables that were changed or deleted from the original list of 35 are provided in Appendix A, along with the justifications for their removal or modification.

Table 2-12
Variable names and descriptions used in the Va Shly'ay Akimel ER-FS HGM assessment.

Variable Code	Variable Description	Variable Code	Variable Description
AGSA	Algal Growth Surface Area as an indicator of past inundation.	LITTER	Abundance of leaf litter and other detrital matter in the FPA.
BUFFCOV	Percent of native vegetation cover in the buffer.	PORE	Soil pore spaces available for storing subsurface water. Performance is related to soil texture and permeability.

Table 2-12, continued.

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

FCI Model Selections

The team identified five (5) communities (PWAAs) and four (4) wetland functions that were deemed important to the success of the wetland subclasses. These PWAAs and FCI models were selected on the basis of their representation of ongoing critical ecosystem processes within each PWAA. Table 2-12 above lists the functions, associated variable, and performance target for FCIs. The five priority PWAAs and the four priority FCI model functions selected by the Team include:

Rank	Community
1	Cottonwood/Willow Forest
2	Mesquite
3	Wetlands
4	Lower Sonoran Desert (Scrub/shrub)
5	River Bottom

Rank	Function
1	Function 1 – Characteristic Channel Dynamics
2	Function 3 – Long-Term Surface Water Storage
3	Function 9– Maintain Spatial Structure of Habitat
4	Function 8 – Maintain Characteristic Plant Communities

Performance targets for the study are also listed in Table 2-12. The reference sites for Va Shly'ay Akimel ER-FS projected included an area at the confluence of the Salt and Verde River systems and a reach of the Hassayampa River located on preserve lands immediately downstream of Wickenburg, Arizona. Detailed locations and photographs of the Salt/Verde and Hassayampa reference wetland sites are included in Appendix A as are those for three other Arizona reference sites.

Overall, the existing baseline conditions in the study site ranged from very poor to mediocre. Only Function 8: Maintain Characteristic Plant Communities, had an FCI $\geq$ 0.50. The remaining functions had FCIs that ranged from 0.047 (Function 3) to 0.422 (Function 2: Dynamic Surface Water Storage/Energy Dissipation). At the Hassayampa reference site, FCI values ranged from 1.0 for Function 1, to 0.467 for Function 5: Nutrient Cycling, which was the only function exhibiting an FCI < 0.50. The second reference site, the Salt River confluence with the Verde River, produced two functional models exhibiting FCIs less than 0.50; Function 3 and 4. All remaining functions for the

Salt River reference site ranged from 0.554 to 0.778. Given this information, it is reasonable to expect that there is a lot of room for improvement at the study site; however, realistic performance targets must be set. For example, with such poor existing study site conditions, and only fair conditions at one of the reference sites (Salt/Verde Confluence), it would be unrealistic to think that restoring conditions to a 0.9 or 1.0 FCI is possible. It is reasonable to assume that the study site can be restored to a level of quality close to the reference site, which would be improving the existing conditions two, three, or in some cases, four times better than the existing conditions. Setting what seems to be somewhat modest performance targets of 0.5 for the FCIs, will still be a dramatic improvement compared to the current study site conditions. In addition, restoration would greatly increase the habitat and wildlife value of the area, not to mention the importance of the area as a wildlife corridor for migratory birds, as well as, species traversing the project area from surrounding habitat types and downstream restored environments.

Conducting the Field Sampling

Adequate site characterization is the critical foundational stem in the HGM process. A variety of methods to measure environmental variables exist, to produce a successful HGM, methods used to characterize the project area and reference reaches should have the following features:

1. Repeatability – different individuals after adequate training should produce data that will lead to similar conclusions about a site.
2. Based in scientific literature – The method should have a solid foundation in the scientific literature, this ensures data produced and used in the HGM process are creditable with the scientific community, free as possible from bias, and defendable in the legal arena.
3. Quantitative – Quantitative data are easier to compare across study sites and through time.
4. Appropriately sensitive – The method should focus on data that are sensitive to the objectives of the study and change on a temporal scale that is appropriate. Data that are too sensitive to environmental conditions will introduce excess noise into the model limiting the usefulness of the model. Biomass of annual species offers a good example of a variable that is very sensitive to environmental conditions. Biomass of annuals can vary several fold depending upon environmental conditions prior to sampling.
5. Inexpensive and easy to measure – In as much as possible, the method should involve a minimum of time and expense to produce the desired data.

The above considerations inevitably involve trade-offs for example, the best method to collect species richness data may be costly and involve multiple site visits. This would

conflict with the objective of the current HGM sampling which was to produce a "snapshot" of the study site and reference reaches. Methods that produce data with the best mix of the above features can be selected by consultation with experts experienced in the local area.

The data collected for the variables were specific to functions within the Arizona Riverine HGM model. The variables can be divided into two major groups, data that were collected without field sampling and data that required sampling in the field. Data collected without field sampling include information on historical conditions, landscape scale habitat conditions, land use characteristics, ownership, pattern of ownership and jurisdictional boundaries. Field level characterization for the Va Shly'ay Akimel study included gathering data on water quality geochemistry, hydrology, fluvial geomorphology, substrate, flora and fauna. Special attention was given to adjacent land use, habitat alteration, and presence of invasive species. Much of the data collected was stored in a GIS for later use in the planning effort.

Basic site characterization and data collection are the first steps in inventorying an ecosystem restoration site (USACE 2000; Fischenich 1999). Characterization for the Va Shly'ay Akimel study included gathering data concerning water quality, geochemistry, hydrology, fluvial geomorphology, substrate conditions, flora, and fauna, and to the greatest extent possible, identifications of underlying stressors in the region. In particular, land use activities, physical habitat alterations, and invasive species were identified. In addition to the physical and chemical characteristics of the study area, land ownership and regulatory jurisdictions played an important role in determining opportunities for restoration. Much of this information is geographically based, and is stored in a geographic information system (GIS). As part of the basic site characterization, historical data on landscape-scale habitat conditions, land use characteristics, and ownership patterns was reviewed. Site- and landscape-level data were collected in the spring of 2002. These datasets were used to characterize the baseline conditions of the Va Shly'ay Akimel study area.

Variables Measured in the Field

Many FCI variables were measured during the field sampling effort. These variables are described in detail in the Master Variable List provided in Appendix A. Protocols used in obtaining these data are also listed in these tables. Specific methods, techniques and assumptions made in measuring these VSI/FCI variables is discussed below, as is the logic behind a given variables use to capture the wetland function. PWAAs in which the variables were measured are also provided.

The variable AGSA was determined by estimating the percent of a 1-meter quadrant with algae, algal remnants, or water present. AGSA is used in two FCI functions NUTRIENTS AND ELEMENTS. The logic being that algal growth is an indicator for moisture at the land surface. If there is water present long enough for algal mats to grow, then the water is there long enough for vegetation to take up nutrients in the system. AGSA was measured in the following PWAAs: CRWWFOR, RIVERBOTTOM,

MESQUITE, SCRUBSHRUB.

BUFFCOV was measured as the percent cover of native vegetation versus bare-ground and/or non-native vegetation within a 1-meter quadrat. BUFFCOV is used in the BUFFER function where buffer cover is important for protecting animals as they travel from one wetland area to another or to upland areas. Native vegetation is highly preferable to non-native vegetation. BUFFER is the only PWAA in which this variable is measurable.

CWD or coarse woody debris was measured as class data. In all there were seven classes:

0 = No data	4 = CWD 1-2%
1 = CWD 9-15%	5 = CWD 0 - < 1%, recoverable
2 = CWD 6-8%	6 = CWD 0 - < 1%, not recoverable
3 = CWD > 15%	

The CWD variable is used in four (4) FCI functions. In WATSTORENR, coarse woody debris along with microtopography and trees serve as indicators of roughness as a surrogate for Manning's "n" values. In the function NUTRIENT, coarse woody debris in various stages of decay indicates that the function is on-going and sustainable. The variable DETPARTICL considers coarse woody debris because they provide surface roughness which reduces water velocity. Low velocity areas allow organic and inorganic particles to settle out of suspension and be retained. CWD is also an important variable of the function HABSTRUCT. Coarse woody debris detain coarse and fine particulate matter, and therefore influences channel morphology (e.g. pool-riffle complexes). Coarse woody debris also provides energy sources and substrates for microbial activity that is important in nutrient cycling and other biogeochemical processes. Coarse woody debris also provide habitat. PWAAs in which CWD was measured include CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

FWD is another class data. In this case, 8 classes were utilized to describe the range of FWD found in a given PWAA. These data are provided below:

0 = No data	4 = 13-24% FWD
1 = 38-68% FWD	5 = 3-12% FWD
2 = 25-37% FWD	6 = 0-2% FWD, recoverable
3 = > 73% FWD	7 = 0-2% FWD, unrecoverable

FWD is used in three functions, NUTRIENT, DEPARTICL, and HABSTRUCT. FWD in various stages of decay indicates that the function NUTRIENT is on-going and sustainable. In the function DETPARTICL, FWD provide surface roughness which reduces velocity. Organic and inorganic particulates can then settle out and be detained. Fine woody debris contribute to HABSTURCT in that they provide energy sources and substrates for microbial activity that is important in nutrient cycling and other

biogeochemical processes. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB are PWAAs where this variable was measured.

The variable HERB was measured by recording the number of decimeter hits within each meter interval as delineated on a long rod. A hit is defined as any vegetation within a 10-cm radius of the rod, per vertical decimeter. Estimates of volume above 10-m in height are recorded as either three (3) or seven (7) hits per interval. Such estimates can be based on comparison with lower intervals where hits can be directly measured. Four (4) functions utilize this variable. NUTRIENT is impacted in that herbaceous vegetation cycles nutrients through soil and water nutrient uptake, biomass accumulation and litter production. ELEMENTS considers herbaceous vegetation because the vegetation is a long term sink for elements and compounds. Vegetation slows the velocity of water which must move around it and provides roughness to the systems, hence HERB influences the function DETPARTICL. The roughness dissipates hydrologic energy and allows for particulate settling to occur. HERB is also a component of the function PLANTS. In arid regions, the abundance of biomass or vegetation is a key factor in influencing animal abundance and diversity. For example, bird species abundance and diversity in arid regions increases with vegetation volume. Vegetation volume provides a 3-dimesnional measure of abundance and serves as a rough surrogate for above-ground vegetation biomass. It thus provides more information about structural habitat value than does 2-dimensional cover estimates. PWAAs in which HERB was measured included CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

The variable LITTER uses eight (8) data classes which are shown below:

0 = No data	4 = 9-17% Litter cover
1 = 28-46% Litter cover	5 = 2-8% Litter cover
2 = 18-27% Litter cover	6 = 0-1% Litter cover, recoverable
3 = < 46% Litter cover	7 = 0-1% Litter cover, unrecoverable

In the functions NUTRIENT and ELEMENTS, this variable is considered because the litter/detrital layer of debris provides energy and substrates for microbial processes which result in the conversion of elements and compounds. LITTER is also an important variable of the function HABSTRUCT in that the litter layer is important for cover, food, and nesting of various vertebrates and invertebrates. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB were the PWAAs where LITTER was assessed.

The SHRUB variable was measured using the methods described for the variable HERB. The number of decimeter hits within each vertical meter interval was recorded and subsequently converted to class data as shown below:

0 = No data	4 = 849 – 1697 stems/acre
1 = 2547 – 4245 stems/acre	5 = 170 – 848 stems/acre
2 = 1698 – 2546 stems/acre	6 = 0 – 169 stems/acre, recoverable
3 = > 4245 stems/acre	7 = 0 – 169 stems/acre, unrecoverable

In the function NUTRIENT, shrubs cycle nutrients soil and water uptake, biomass accumulation, and litter production. SHRUB measurements are also used in the function ELEMENTS because shrubs are long-term sinks for elements and compounds. Shrubs slow the velocity of water moving through and around them and provide roughness to the system which dissipates energy and facilitates particulate settling. Therefore, the function DETPARTICL considers the variable SHRUB. SHRUB is also in the function PLANTS because in arid regions, the abundance or biomass of vegetation is a key factor influencing animal abundance and diversity. SHRUB was measured in the following PWAAs: CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

SPECRICH was measured by counting, and if possible identifying, the number of plant species present. Although this project only measured SPECRICH in the late spring, herbaceous sampling should be conducted twice per year, once in the summer dry season, and once in the summer rainy season. SPECIRICH was used only in the PLANTS function. It was used in PLANTS because some measure of plant species diversity is needed if one is to assess the function of maintaining characteristic plant communities. Riparian ecosystems can be species-rich. Maintaining or enhancing regional biodiversity is a key riverine function. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB were the PWAAs where SPECRICH was measured.

The variable TOPO refers to both macro and microtopographical features. TOPO was measured in the field using the classes indicated below:

0 = No data
1 = Macro and microtopic relief
2 = Homogenous surfaces with macro and microtopic relief
3 = Homogenous surface and lacks macro and microtopic relief
4 = Steep bank, recoverable
5 = Steep bank, unrecoverable

Six (6) functions utilize the TOPO variable. WATSTORENR and WATSTORLNG consider it because topographic features such as pits and ponds provide areas that can store water as well as provide roughness. The function DETPARTICL considers this variable because macro and microtopographic relief provide surface roughness and complexity to the system. Flowing water must move into, over, through, or around these features. Velocity is reduced, facilitating detention of particulates. TOPO is also a variable used in the functions PLANTS, HABSTRUCT, and INTERSPERS. Topographical complexity offers a variety of ecozones and ecotones that supply the habitat needs of wetland and edge-adapted species. PWAAs in which TOPO was measured include: CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

The variable TREE was measured in the field using a technique similar to that described for the variable HERB. TREE was measured by recording the number of decimeter hits within each vertical meter interval on a long rod. A hit was defined as any vegetation

within a 10-cm radius of the rod, per vertical decimeter. Estimates of TREE in vegetation greater than 10-m tall was done by estimate. These estimates were based upon comparisons with lower intervals where hits could be directly measured. Five (5) functions utilize the variable TREE. WATSTORENR considers it because coarse woody debris along with microtopography and trees serve as indicators of roughness as a substitute for Manning's "n" values. The function NUTRIENT uses TREE because trees cycle nutrients through soil and water nutrient uptake, biomass accumulation, and litter production. Trees are long-term sinks for elements and compounds, hence the function ELEMENTS considers the variable TREES. The function DETPARTICL uses the variable TREES because trees slow the velocity of water, dissipating energy, and facilitating particle deposition and detention. PLANTS also uses this variable because tree density, as determined from reference standards, is characteristic of healthy systems. Tree density will vary with degree of perturbation. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB were the PWAAs where the variable TREE was measured.

The last variable measured in the field was VEGSTRATA. VEGSTRATA was measured by recording the number of layers present in selected areas of the CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB PWAAs. The layers included:

Tall (> 10-m) broad-leaved tree	Short microphyllous shrub
Short broad-leaved tree	Vine
Tall microphyllous tree	Epiphyte
Short microphyllous tree	Bunch grass
Tall (> 1-m) broad-leaved shrub	Non-bunch grass
Short broad-leaved shrub	Forb
Tall (> 1-m) microphyllous shrub	Lichens or biotic soil crusts

HABSTRUCT is the only function to utilize this variable. As the number of vegetation layers at a site increases, so do the number of niches for bird species. The use of 1-m height increments may provide a more sensitive measure of this diversity-related structural property than does the use of only 3-l'ayers (e.g., ground, shrub, tree).

Variables Obtained Without Field Sampling

Some variables could be obtained through various historical records, aerial photographs, or mathematical calculations rather than through active field sampling. The FCI variables that were not measured with field sampling techniques are located below:

BUFFLENTH	PORE
BUFFWIDTH	Q
CONTIG	SED
DEPSATSED	SUBIN
FPA	SURFIN
FREQ	TRIB
LANDUSE	WIS

Certain variables were quantified without field sampling. Data to quantify these variables were derived from air photos, flow records, ownership and similar data types. FCI variables quantified without field sampling are discussed below. Variable quantified with out field sampling were divided into landscape level and site specific variables. Each variable includes a brief justification for its use, which function the variable was used in class boundaries for the variable (if applicable), and a list of applicable PWAAs. Additional information on these variables can be found in (Table X).

Landscape Level Variables

Buffer length (BUFFLENGTH) – The percent of area with sufficient buffer length This variable was measured to capture the concept of the buffer as a protective zone against encroachment on the riparian zone by other land uses. Specific function using this variable: FXN 11: BUFFER. In the BUFFER function, the length of buffer is one component that determines the effectiveness of the function. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Classes used were as follows:

0 = no data
1 = 100% of the reach has right and left bank buffers
2 = Only one side of the reach has 100% buffering
3 = 75% of the reach has right and left bank buffers
4 = Only one side has 75% buffering
5 = 50% of the reach has right and left bank buffers
6 = Only one side has 50% buffering
7 = 25% of the reach has right and left bank buffering
8 = Only one side has 25% buffering
9 = 0% of the reach has right and left bank buffers

BUFFER is the only PWAA that Buffer length is measured.

Buffer width (BUFFWIDTH) – Width of buffer in meters. Buffer width measures the width of the buffer as a measure of the potential effectiveness of the buffer to protect the riparian area from impacts by adjacent land use. Specific function using this variable: FXN 11: BUFFER. Buffer width is one component that determines the effectiveness of the function. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Buffer width classes used were:

LANDUSE is 1.0 (ideal) and buffer width is 100, score = 1.0
LANDUSE is 1.0 and buffer width is 0, score = 0.9
LANDUSE is less than optimum the formula is LANDUSE X BUFFER
LANDUSE is 0 and BUFFER width is 100m the score is 0.0

BUFFER is the only PWAA that Buffer width is measured.

Contiguousness (CONTIG) – The percent of contiguous vegetation cover. This variable provides a measure of the connectivity through the riverine system. Specific function using this variable: FXN 10 INTERSPERS. Data were derived from air photos and maps then manipulated within a GIS framework. CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB were the PWAAs that contiguousness was applied.

Flood prone area (FPA) – Flood prone area is defined as the area that is twice the bank full thalweg depth. Flood prone area is a class variable that captures impacts of channel modification and/or degradation on channel dynamics (erosion transportation, and deposition of sediment), and particle detention. Specific functions using this variable: FXN 1: CHANNELDYN, FXN 2: WATSTORENR, and FXN 7: DETPARTICL. Data were derived from historical information, elevation maps and then manipulated within a GIS framework. Classes used were as follows:

0 = no data
1 = FPA not clearly modified
2 = FPA confined on one side
3 = FPA confined to an arroyo and bank to bank width is recoverable
4 = FPA confined to an arroyo and bank to bank width is not recoverable
5 = FPA confined to t concrete channel

Applicable PWAAs for flood prone area are CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Land use (LANDUSE) – Type of adjacent land use. Land use measures impacts of adjacent land use on the riverine system. Adjacent land use impacts the buffer length and width needed for protection. Specific function using this variable: FXN 11: BUFFER. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Classes in the land use variable were:

0 = no data
1 = Active sand and gravel operations
2 = Commercial and/or industrial
3 = Paved roads
4 = Multi-family residential (apartments, duplexes)
5 = Single-family residential (individual houses)
6 = Gravel roads, dirt roads, bike paths, and infrequently visited structures
7 = Inactive sand and gravel operations
8 = Agricultural cropland
9 = Open space (parks golf courses, etc)
10 – Pristine, uninhabited areas

Buffer is the only PWAA that land use was measured.

Tributaries (TRIB) – This variable measures the presence of tributaries and their degree of connectivity to the mainstem. The tributaries variable addresses the ecological function of tributaries in the area (connectivity, corridors, etc). Specific function using this variable: FXN 10: INTERSPERS, the number of tributaries can influence the degree of interspersion in a riparian system. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Classes used were as follows:

0 = No data
1 = All tributaries (channel and riparian corridor are unmodified and connect to the mainstem
2 = Some tributaries are modified (consolidated, redirected, or channelized) but still connected the mainstem
3 = Tributaries are highly modified or channelized or not connected to the mainstem

Applicable PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Site Specific Variables
Depth of saturated sediment (DEPSATSED) – Depth to saturated sediment in meters. This variable captures the concept of sediments as a site for water storage and availability of stored water during periods of reduced flows. Specific function using this variable: FXN 4: WATSTORSUB. Data were derived from historical information and ground water maps and treated as a class variable. Depth to saturated sediment classes depend upon the PWAA, the classes used are:

For the CTWWFOR PWAA
0 = no data
1 = 0 m
2 = 1 to 3 m
3 = > 3 m

For the MESQUITE PWAA
0 = no data
1 = 0 m
2 = 1 to 7 m
3 = > 7 m

For the RIVERBOTTM PWAA
0 = no data
1 = 0 m
2 = 0.01 to 0.25 m
3 = > 0.25 m

PWAAs where depth of saturated sediment was measured are CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Frequency of inundation (FREQ) – Frequency of inundation of a site. This variable addresses the concept of inundation as an important driver in biogeochemical, biological an physical processes. Specific functions using this variable: FNX 1: CHANNELDYN, FXN 3: WATSTORLNG, and FXN 6: ELEMENTS. Data were derived from historical information, elevation maps and then manipulated within a GIS framework as a class variable. The following classes were used:

0 = no data
1 = Perennial flow
2 = Intermittent flow.
3 = Saturated
4 = Temporally flooded by seasonal high flow (Q1 to Q2)
5 = Temporally flooded at bankfull flow (Q2 to Q10)
6 = Temporally flooded at large flood (Q10 to Q25)
7 = Temporally flooded at major flood (Q25 to Q100)
8 = Temporally flooded at super flood (>Q100)

Frequency of inundation was determined for CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Soil pore space (PORE) – This is the pore space available for storing subsurface water. The variable addresses the concept of infiltration on a site. Specific functions using this variable: FXN 3: WATSTORLNG and FXN 6: ELEMENTS. Data were derived from published soil surveys, field samples and historical data. Data were treated as a class variable, classes used were:

0 = No data
1 = Soil texture is a sand to sandy loan with no restrictive layers
2 = Soil texture is finer than sandy loam and has a restrictive layer
3 = Soil texture is finer than a restrictive layer
4 = The modal soil profile is highly compacted in the upper 24"
5 = Presence of a non-porous layer

Applicable PWAAs were CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Alteration to hydro regime (Q) – Alteration of hydrologic regime in the assessment area. This variable captures the concept that flow alterations can impact channel dynamics of a site. Specific function using this variable: FXN 1: CHANNELDYN. Data were derived from air photos, maps, and historical information then manipulated within a GIS framework and treated as a class variable. Classes used were as follows:

0 = No data
1 = No additions, diversions, of damming of flow affecting the assessment area
2 = Evidence of additions, diversions or damming of flow, but now evidence of significant impacts to channel pattern, dimension, and profile
3 = Evidence of additions, diversions or damming of flow, and there is evidence of changes in vegetation abundance. No evidence of increase sediment or scour
4 = Evidence of additions, diversions or damming of flow, and there is evidence of increase in sediment scour
5 = Evidence of additions, diversions or damming of flow, and there is evidence of significant impact to channel pattern, dimension, and profile. Variable is recoverable.
6 = Permanent alterations to hydroregime are evident.

Alteration to hydroregime was determined in the following PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Sediment delivery (SED) – Extent of sediment delivered to the site from culturally accelerated sources. Sediment delivery addresses rates of sedimentation in excess of that expected in less disturbed systems. Specific functions using this variable: FXN 1: CHANNELDYN and FXN 7: DETPARTICL. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Sediment delivery classes were as follows:

0 = No data
1 = No sediment disturbance
2 = Disturbance evident
3 = Disturbance and delivery evident
4 = Disturbance extreme and vegetation mortality
5 = Area filled

Sediment delivery was applicable in the following PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Subsurface flow (SUBIN) – Subsurface flow into the area via interflow and return flow. This variable captures concept of subsurface movement of water that can influence nutrient fluxes and water storage on a site. Specific functions using this variable: FXN 3: WATERSTORLNG and FXN 6 ELEMENTS. Data were derived from maps and historical information then manipulated within a GIS framework and treated as a class variable. The following classes were used:

0 = No data
1 = Undisturbed, subsurface flow evident
2 = Undisturbed and subsurface inflow is observed

3 = Disturbed soils and plant communities
4 = Utilized for agricultural activities
5 = Fill
6 = Impervious surface
7 = Concrete channel

Applicable PWAAs include: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Surface inflow (SURFIN = SURFINRILL + SURFINLAT) – Surface inflow via sheet flow. This variable captures the concept that water can be delivered to the site via surface runoff occurring when precipitation rate exceeds infiltration rate. Specific function using this variable: FXN 6: ELEMENTS, transformations, leaching or deposition of elements are linked to water delivery. Data were derived from 10 m belt transect in the field and by air photos and maps. Data were treated as a class variable, classes used were:

0 = No data
1 = Any of the following indicators are present and similar to the reference site: rills on adjacent upland slopes,, lateral tributaries entering the floodplain and not connected to the channel
2 = Both indicators are present, but less than the reference standard
3 = Both indicators are absent
4 = Both indicators are absent and channelization prevents sedimentation on the wetland surface.

Applicable PWAAs include: CTWWFOR. RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Topography (TOPO = MACROTOPO+MICROTOPO) – Topography measures large scale and small scale topography of the flood prone area. Topography accounts for water storage, detention of sediments, habitat features, and interspersion of habitats that are associated with topographic irregularities of the floodplain. Specific functions using this variable: FXN 2: WATSTORENR, FXN 3: WATSTORLNG, FXN 7: DETPARTICL, FXN 8: PLANTS, FXN 9: HABSTRUCT, and FXN 10 INTERSPERS. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. This variable was also measured in the field. The following topography classes were used:

0 = No data
1 = Macro and microtopographic relief
2 = Homogenous surfaces with macro and microtopographic relief
3 = Homogenous surface and lacks macro and microtopographic relief
4 = Steep bank, recoverable
5 = Steep bank not recoverable

Topography was applicable in the following PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Wetland indicator score (WIS) – This is the wetland indicator score for each species in SPECRICH. Wetland indicator score captures the concept of plant species as indicators of the degree of wetness on a site. Increasing number of wetland species is an indicator a healthy wetland community. Specific function using this variable FXN 8: PLANTS. Wetland indicator scores are derived by conversion of SPECRICH data. WIS are found on the US Fish and Wildlife Service web site. Scores are as follows:

1 = Obligate
2 = Facultative wet
3 = Facultative
4 = Facultative upland
5 = Upland

Field Sampling Locations

Field data were collected in April 2002 at two reference sites: 1) Salt River confluence with the Verde River and 2) Hassayampa River Preserve south of Wickenburg, Arizona. Although these were the focal sites for the Va Shly'ay Akimel E-Team, data from all 5 Arizona reference sites were used in this HGM assessment. The three additional sites are located in southern Arizona and area associated with the San Pedro river, Tanque Verde Wash, and Tumacacori.

Field Sampling Protocol

Certain variables in the HGM required field sampling to quantify. A variety of methods were used to obtain the data; a brief description of the field sampling protocol follows.

The sampling team consisted of 4 individuals. Each team had one member experienced with HGM data collection. Other team members had expertise in a field related to the sampling effort. Each team had a designated recorder for the sampling day to record data reported by team members. Prior to sampling observers standardized their estimates of cover with each other, discussed the kinds of species present, and discussed their impressions of the site. To minimize observer error, the same observers estimated the same components on all transects.

At each PWAA, a 100 m long transect was established generally parallel to the river channel (fig. X). In some PWAAs the transect had to curved or was broken into two 50 m transects. Along the 100 m transect a series of 10m X 10m quadrat was established

creating a belt transect. Each 100 m transect had 10, 10m X 10m quadrats. At the center of the quadrat the recorder notes the presence of rills on adjacent slopes. Within the 10m X 10m quadrat the following were recorded as reported by team members:

1. number of vegetation layers
2. species composition
3. microtopographic features (small scale pits and hummocks)
4. logs and stage of decay

Within the 10 m quadrat, a 1m X 1m quadrat was randomly located. Within this quadrat the following data was recorded:

1. percent coarse woody debris (% CWD)
2. percent fine woody debris (% FWD)
3. percent litter cover
4. percent algal mat
5. percent tree canopy
6. percent shrub cover
7. percent herbaceous cover

The percent cover of all components was estimated occularly. Percent cover of coarse woody debris, fine woody debris litter cover, algal mat, shrub and herbaceous components was estimated by vertically projecting the cover of each onto the ground surface. Due to the multilayered nature of vegetation total vegetative cover can exceed 100 percent. An example of this is the occurrence of herbaceous species under shrub canopies. Tree canopy cover was estimated by viewing the tree canopy upwards through a sighting tube. The sighting tube was divided into quarters by a cross-hair. The percent of the sky obscured by tree canopy as viewed through the sighting tube was determined and recorded. At the center of each 1m X 1m quadrat, a 9.5 meter pole graduated in meters and decimeters was placed vertically within the foliage. The number of decimeter hits within each meter interval were recorded. A hit was defined as any vegetation within a 10 cm radius of the rod per vertical decimeter. Estimates of volume above 10-m in height are recorded as either three (3) or seven (7) hits per interval. Such estimates can be based on comparison with lower intervals where hits can be directly measured.

Performing Data Management and Statistical Analysis

Some limits to the assessment's data should be acknowledged. In some instances, notes on field sheets were difficult to interpret, so corrections were made when possible, and the results were discussed with Team members. In some instances, data on field sheets was disregarded. When data management problems arose, ERDC-EL consulted with the Team prior to data handling, and solutions were devised with their knowledge and consent.

Calculating Baseline Conditions

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

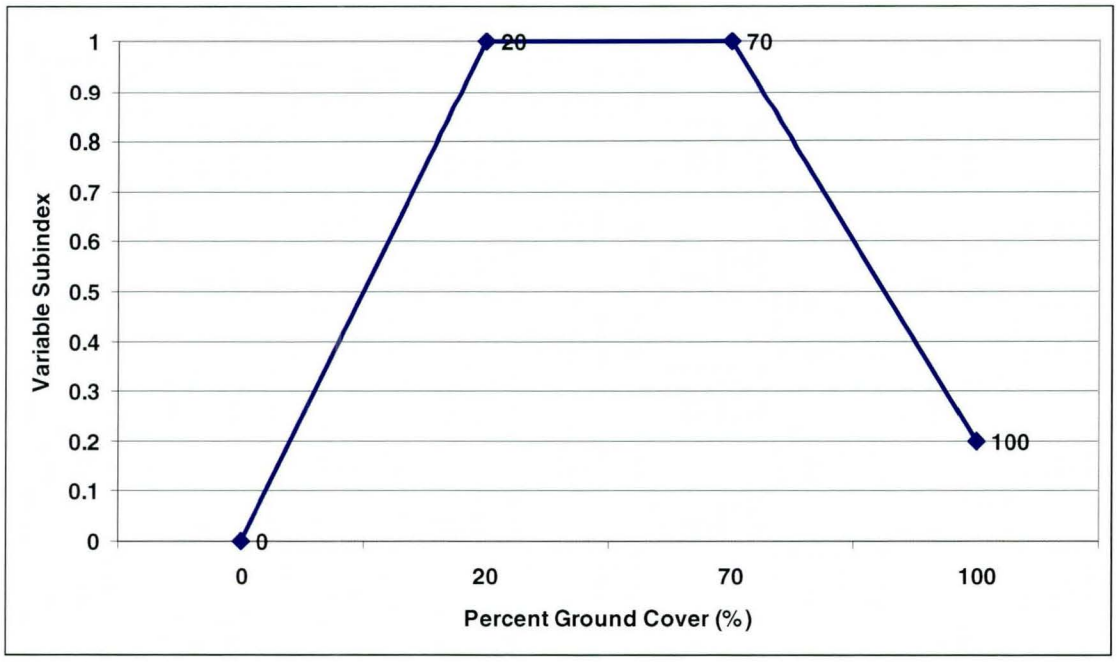

Figure 2 – 3
Example variable subindex (VSI) curve.

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

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

where:

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

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

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

where:

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

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

Generating Without Project Conditions and Calculating the Outputs

Predicting both the short-term and long-term condition of the environment is a necessity when developing ecosystem restoration plans for a community or region (USACE 2000). Forecasting, the process of developing predictions for future conditions, is undertaken to identify patterns in natural systems and human behavior, and to discover relationships among variables and systems, so that timing, nature, and magnitude of change can be estimated over time. In HGM, a judgment-based method, supported by the scientific and professional expertise of the evaluation team, is often relied upon to forecast the effectiveness of ecosystem restoration alternatives, assess project performance, and determine many other aspects of both the Without Project and With Project scenarios.

The Without project condition is regarded as an important element of the HGM evaluation (USACE 2000). A critical element in the planning process is the prediction of likely future conditions in the study area if no action taken. The No Action Alternative in NEPA is the Without Project condition of the study site should no action be taken. When formulating plans, NEPA regulations require that the No Action Alternative always be considered.

The Without Project descriptions should adequately describe the future conditions (USACE 2000). Significant variables, elements, trends, functions, and processes should be sufficiently described to support good decision-making. Without Project descriptions must be rational to be defensible. Forecasts are typically based on appropriate and acceptable methods, and must adhere to professional standards of the time. Accuracy is important and should take into account assumed rational behavior by future decision makers. Scenarios that rely on an unlikely series of event or irrational behavior do not support sensible predictions.

"Before and after" comparisons should not be confused with estimates of the Without Project conditions. "Before and after" comparisons can overlook the causality that is important to effective plan evaluation. Without Project conditions are a "look" into the future. Forecasts that concentrate on causality of existing conditions, and focus too narrowly on how existing conditions might change, fail to be future-oriented. Without Project conditions should be oriented toward comparing alternative future scenarios, not just extensions of existing conditions. Information used to forecast scenarios should not be misleading or withheld. Both the strengths and weaknesses of future scenarios must be considered. Forecast scenarios should be based on empirical data. This complete analysis in needed to enable an interested stakeholder or a decision maker to make a qualitative assessment of the study. Scenarios should point out weaknesses in the analysis, and state the implications of such drawbacks. Significant differences in future scenarios should be accurately described. Finally, the Without Project condition is subjected to review and comment as part of the coordination and review process, as well as the public participation process.

Specific Without Project Trends

Forecasting of the without project condition relied upon forecasting the future water supply and changes to land use within the project boundary and contributing watershed. Considering such trends as a baseline condition allowed for the formulation of alternatives that would improve the wetland functions and values within the project area over time. An overriding consideration was water supply. In the absence of coordinated and timed discharges from the upstream reservoir system, it was assumed that the majority of the project area would be ephemeral in flow character. Further, it was assumed that in the future, only those features that were scaled to a dedicated and available water supply would be sustainable.

Several prominent land use categories are present in and immediately adjacent to the Va Shyl'ay Akimel project area and hence influenced the future without project trends. Several land use categories were considered in the formulation of without project trends. Sand and gravel operations past, present, and future, influence sediment, surface water and ground water regimes. This was taken into account by assuming a general degradation of existing habitat in extraction and processing areas. Agricultural and open space areas on the east side of the project will likely turn to urban or residential land use and as such restrict immediately adjacent restoration options.

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

Calculating Annualized Units for the Without Project Condition
Most federal agencies use annualize results as a means to display benefits and costs. Ecosystem restoration analyses should therefore provide data that can be directly compared to the traditional benefit: cost analyses typically portrayed in standard evaluations of this nature. Federal projects are evaluated over a period of time commonly referred to as the "life of the project", which is defined as that period of time between when the project becomes operational and the end of the project as dictated by construction effort or lead agency. However, in many cases, gains or losses in wildlife habitat may occur before the project becomes operational and these changes should be considered in the assessment. Examples of such changes include construction impacts, implementation and compensation plans, or other land use impacts. Ecosystem restoration analyses incorporate these changes into their evaluations by using a "period of analysis" that includes pre-start impacts. If the no pre-start changes are evident, then the "life of the project' and the "period of analysis" are equivalent.

In HGM, FCUs are annualized by the summing FCUs across all years in the period of analysis and dividing the total (cumu8lative FCU) by the number of years in the life of the project. In this manner, pre-start changes can be considered in the analysis. The results of this calculation are termed AAFCUs, and can be expressed by the following relationship:

AAFCUs = $\sum$ (Cumulative FCUs / Number of years in the life of project)

Where: Cumulative FCUs = $\sum (T_1-T_2)[((A_1F_1+A_2F_2)/3) + ((A_2F_1+A_1F_2)/6)]$

and where:

T_1 = First Target Year time interval
T_2 = Second Target Year time interval
A_1 = Area of available habitat at beginning of T_1
A_2 = Area of available habitat at end of T_2
F_1 = FCI at beginning of T_1
F_2 = FCI at end of T_2

The equation presented above is a generalized formula and requires that the FCI and the area available for habitat be considered for each target year. The numbers "3" and "6" are constants derived from the integration of (FCI **x** area) for the interval between any two target years. This formula is applied to the time intervals between target years and was developed to precisely calculate cumulative FCUs when either the FCI or area or both change over a given time interval of interest. The rate of change of FCUs may be linear if either FCI or area change over the time interval. The FCU values for all years in the period of analysis are calculated by summing the products of the FCI and area of

available habitat for all years in the period of analysis. All HGM results developed for the Va Shly'ay Akimel ER-FS were calculated in this manner and are reported in terms of annualized units for the Without and With Project conditions.

Generating With Project Conditions and Calculating the Outputs

Several meetings were held over the course of the Va Shly'ay Akimel Environmental Restoration Study in which Team members were asked to estimate the future conditions of the project area under differing scenarios. In the early stages the source and amount of water to the project was in question. As such, the original alternatives focused upon maintaining and enhancing the existing vegetative character of the now ephemeral Salt River reach through the Va Shly'ay Akimel study area. With the exception of two perennially wet segments, this amounted to preserving and enhancing relatively xeric scrub-shrub communities along the majority of the reach. Because of the high percentage of suitable sand and gravel extraction areas, development of alternatives was further constrained. This resulted in an initial matrix of 13 initial alternatives that minimized water use and avoided existing and future sand and gravel extraction areas.

As the process continued and more information became available, two things came clear. First, the local sponsors did not care for alternatives that did not focus upon establishment of native riparian forests of cottonwood and willow. Second, the sponsors were able to secure larger amounts of water for the project. As such, two additional alternatives were added both of which focused upon providing maximal amounts of cottonwood and willow habitat. This resulted in a list of 15 alternatives. These 15 alternatives were further expanded by considering two means of irrigating project features, rill and drip irrigation. It was these resultant 30 alternatives for which HGM scores were developed and the CEA and ICA costs calculated.

Developing RVIs and Performing Tradeoffs

In order to select one alternative as the "preferred," or most effective alternative, it is necessary to compare it to other alternatives. Comparing the alternatives is a way to distinguish the benefits and drawbacks of each plan, as well as, the strengths and weaknesses. The purpose of the comparison step is to identify the important criteria for evaluation and compare the alternatives across those criteria. Ideally, the comparison of alternatives results in a ranking of alternatives, or some determination of the best course of action for the decision-makers. The comparison can be simplified by measuring the alternative designs in the same units, such as ecological units, acres, dollars, or others.

Typically, alternative designs are measured in a combination of dollars, ecological units, acres, water quality changes, noise levels, changed erosion rates, or a host of other tangible or intangible units. Sometimes these comparisons lead to trade-offs. Trade-offs

are made throughout the planning process and screening activities, but they may play a more prominent role as the study team, decision-makers, and other stakeholders move toward selecting the "preferred" alternative. These trade-offs are made regarding both the measures and alternatives under evaluation. Measures and alternative designs can be dropped from further analysis for a variety of reasons including cost ineffectiveness, design inconsistencies, hydrologic issues, and biological unproductiveness.

Trade-offs are considered across and among, all the alternatives. Trade-offs are considered when contrasting outputs are encountered. For example, Alternative 1 may be less costly, but restores fewer wetlands than Alternative 2, a more costly design that restores significantly more wetland acres. Trade-off analysis is a multi-criteria evaluation method commonly used by USACE when it may not be possible (or not desirable) to express all alternative effects in a single metric evaluation. In some cases, more than one evaluation metric can be considered (i.e., HEP, HGM, and costs together) in a trade-offs analysis (Edmunds and Letey 1973). Trade-offs enable planners to account for the entire spectrum of differing (but relevant) criteria when comparing alternatives. Trade-offs can be as simple, or as complex, as necessary to afford the greatest suite of comparisons. In a simple application, trade-offs can frequently rely on professional knowledge and judgment. Planners "trade-off" alternative contributions to objectives based on their own accumulated technical expertise, general experience, and specific knowledge of the study area (including stakeholder views and values). In essence, planners sit down and develop an alternative with "a little more of this" and "a little more of that," where the trade-offs made tend to be of a subjective nature. However, more quantifiable approaches exist to conduct trade-off analyses in a controlled environment.

Simple weighting is an approach to trade-offs that can be used when there are no apparent prominent alternatives among those compared. In HGM, FCI models are selected on the basis of their representation of ongoing critical ecosystem processes, and can be "traded-off" by incorporating a weighting scheme into the calculation of final FCIs. By applying Relative Value Indices (RVIs) to the resultant outputs, wetland function priorities can be characterized, and mathematical "weights" can be applied to the HGM analysis. RVIs can be applied to emphasize, or even decrease, the overall effect of individual FCIs. Using RVIs, mathematical "weights" can be used to prioritize functions. For example, the 11 functions in the HGM model generally fall into three functional groups, water, biogeochemical, or habitat. Recognizing that many of the same variables are used to calculate these functions, there is an obvious link between the functions. For example, it is reasonable to assume that an improvement in function 2, surface water storage, would lead in an improvement in function 8, plant communities, since more water means that plants would grow and improve the vegetation community. RVIs provide an opportunity to acknowledge the limited buffer areas, yet downplay their affect on the analysis so the value of the restoration project is not overshadowed. While the prioritization of functions, and whether or not to weight them with RVIs, is somewhat subjective, the process allows for the flexibility to emphasize particular components of a restoration project when warranted, as long as the choices are documented. Therefore, RVIs can be used in HGM to perform trade-offs among functions.

Reporting the Results of the Analyses

Successful evaluation lies in the planner's ability to discuss the assessment strategies and findings to the public. Reporting simply refers to communicating the methodologies and results of the habitat assessment in a clear and concise manner to the reader. Underlying the HGM process is the concept of "repeatability". To assure that the assessment is reasonable and reliable, the reader should be able to follow the descriptions of approach and applications presented and repeat the analyses just as the planner did. To assure the repeatability aspects of the assessments, the planner should document the evaluation. Usually this is done through an assessment report. Reports typically include five plus chapters: Introduction, Methods, Results, Trade-offs, and Summary/Conclusions. In addition, the report should have a Literature Cited section and an appendix documenting the models used in the assessment. Further reporting of the assessment results can include, but is not limited to, graphics (maps, graphs, tables, etc.) that visually depict the conditions of both Without and With Project, of the study area under evaluation. In HGM, it is important to document the results in terms of functional capacity units (FCU), quality (FCIs), and quantity (acres). In addition, any factors that significantly affected the outcome of the study (e.g., minutes of team meetings, data extrapolations, etc.) should be documented, either in the report itself, or in the appendix to the report.

Software Used In The Va Shly'ay Akimel Ecosystem Restoration Project

EXHGM is a Microsoft Access© 2000 software package developed by ERDC-EL to automate standard HGM calculations. EXHGM's programming architecture is similar to that of the EXHEP package. The EXHGM program should be viewed as a tool that can provide a rational, supportable, focused, and traceable evaluation of wetland functionality, and its application to the decision-making process is unquestionable. However, the user must understand the basic HGM tenets as defined in supporting literature (Brinson 1993; Smith et al. 1995) prior to attempting application of the software. In other words, the user should not expect the EXHGM software to provide the only predictive environmental response to project development scenarios, and should understand the limitations of the methodology's response to predictive evaluations prior to its application.

The EXHGM program was designed to process large amounts of data quickly and efficiently, handling a large number of FCI models simultaneously. Each model can incorporate any number of cover types and partial wetland assessment areas. Each cover type can include a large number of variables, and the user can incorporate as many functions within each model as necessary. These capabilities support the examination of complex studies with large numbers of permutations. The number of permutations, processing speed, and program performances are limited only by the capacity of the user's hardware, where data storage becomes the limiting factor.

The EXHGM program allows the user to evaluate a large number of projected changes (future factors) across numerous years for each alternative design. Each package allows the user to assign future factors to each model for each year considered within the life of the project (i.e., each TY). This capability allows the user to manage forecasts across the long-term planning horizon, in an attempt to better reflect reality through the life of the project. Again, the number of permutations is limited only by the user's computer storage capacity. EXHGM evaluates any FCI-based model. In most instances, a wetland cannot be described using a single PWAA. A standard HGM tool must complete these computations, regardless of whether the model uses a single PWAA or multiple PWAAs. EXHGM can be used to calculate suitability for any single or multiple PWAA model whether the wetlands functionality is based on one or more multi-faceted functions. The two tools are capable of reevaluating HSI and FCI models as the user adapts previously created alternative designs to fit new situations. It is not necessary to reinvent FCI models once a standard evaluation configuration has been created. The software package allows the user to open a previously created configuration and introduce change (e.g., adding field data, future factors, TYs, cover types, acreage quantities, variables, etc.). This capability supports the software's utilization in a wide range of agency activities over the long term. For example, an alternative design developed to evaluate project impacts for a stream restoration study in the past can be adapted to evaluate stream restoration projects throughout the region in the future. By simply altering the cover type composition of a previously developed EXHGM data file, the software can account for regional variations and quickly define functionality impacts. Thus, as projects are funded or evolve, EXHGM can be easily implemented with little effort devoted to modeling "setup."

Introduction to the Cost Analysis Process

Between 1986 and 1987, the Headquarters' Office of the U.S. Army Corps of Engineers provided policy directing USACE Districts to perform a type of cost analysis referred to as Incremental Cost Analysis (ICA) for all feasibility-level studies. The required ICA is, in effect, a combination of both a Cost Effectiveness Analysis (CEA) and Incremental Effectiveness Analysis. Together, the CEA/ICA evaluations combine the environmental outputs of various alternative designs with their associated costs, and systematically compare each alternative on the basis of productivity. Cost effectiveness analyses focus on the identification of the least cost alternatives and the elimination of the economically irrational alternatives (e.g., alternative designs which are inefficient and ineffective). By definition, inefficient alternative designs produce similar environmental returns at greater expense. Ineffective alternative designs result in reduced levels of output for the same or greater costs. The incremental cost analysis is employed to reveal and interpret changes in costs for increasing levels of environmental outputs.

In 1990, USACE issued Engineer Regulation 1105-2-100 (U.S. Army Corps of Engineers 1990) directing planners, economists, and resource managers to conduct CEA/ICA for all

recommended mitigation plans. Later, in 1991, USACE produced Policy Guidance Letter Number 24 that extended the use of cost analysis to projects that restored fish and wildlife habitat resources (U.S. Army Corps of Engineers 1991). In the USACE Engineering Circular 1105-2-210, the incorporation of cost analysis was declared "fundamental" to project formulation and evaluation (U.S. Army Corps of Engineers 1995).

To facilitate the inclusion of these basic economic concepts into the decision making process, USACE published two reports detailing the procedures to complete both incremental and cost-effective analysis (Orth 1994; Robinson et al. 1995). Based on these reports, there were nine steps that should be completed to evaluate alternative designs based on CEA/ICA. These were as follows:

A. Formulate all possible combinations of alternative designs by:
   1. Displaying all outputs and costs.
   2. Identifying filters, which restrict the combination of alternative designs.
   3. Calculating outputs and costs of combinations.
   4. Complete a cost effective analysis by:
   5. Eliminating economically inefficient alternative designs.
   6. Eliminating economically ineffective alternative designs.

B. Develop an incremental cost curve by:
   7. Calculating the average costs.
   8. Recalculating average costs for additional outputs.

C. Complete an incremental cost analysis by:
   9. Calculating incremental costs.
   10. Comparing successive outputs and incremental costs.

In the ICA terminology, an alternative design is considered the With Project condition (i.e., "Build A Dam," "Develop a Wetland," "Restore the Riparian Zone," "Management Plan A," etc.). Under an alternative design, a series of scales (i.e., variations) can be defined which are modifications or derivations of the initial With Project conditions (i.e., "Develop 10 acres of Low Quality Wetlands," "Develop 1,000 acres of High Quality Wetlands," etc.). Often, these scales are based on differences in intensity of similar treatments and can, therefore, can be "lumped" under an alternative design class or category. During the first steps of CEA/ICA, all possible combinations of alternative designs and their scales are formed. As a general rule, intra-scale combinations (i.e., combinations of variations within a single alternative design) are not allowed. These activities would occupy the same space and time.

In most instances, CEA/ICA results are displayed in tables, scatter plots, and/or bar charts. These illustrative products assist decision-makers in the progressive comparisons of alternative design costs, and the increasing levels of environmental outputs. Before a user makes a decision based upon the outputs generated by the CEA/ICA, they must

determine whether cost thresholds exist that limit production of the next level of environmental output (i.e., cost affordability). In addition, factors such as curve anomalies (i.e., abrupt changes in the incremental curve), output targets, and output thresholds can influence the selection of alternative designs.

CHAPTER 3 - Va Shly'ay Akimel Project Results

Va Shly'ay Akimel (Salt River)

Project Description

Location
The Va Shly'ay Akimel study area is located in south central Arizona, in the eastern portion of Maricopa County. The project study area is located entirely within the Lower Salt watershed (USGS Cataloging Unit: 15060106). The Va Shly'ay Akimel Ecosystem Restoration project boundary follows the Salt River from Granite Reef Dam to Price Road (US 101), Figure 3-1. Thirteen project alternatives were developed in the Feasibility Study, F4 Phase.

Purpose
The objective of the study was to develop alternatives that increased native riparian vegetation, increased vegetation connectivity, and stabilized bank sections, where necessary. Figure 3-1 shows the project location identifying key features and sub-area locations used in this report.

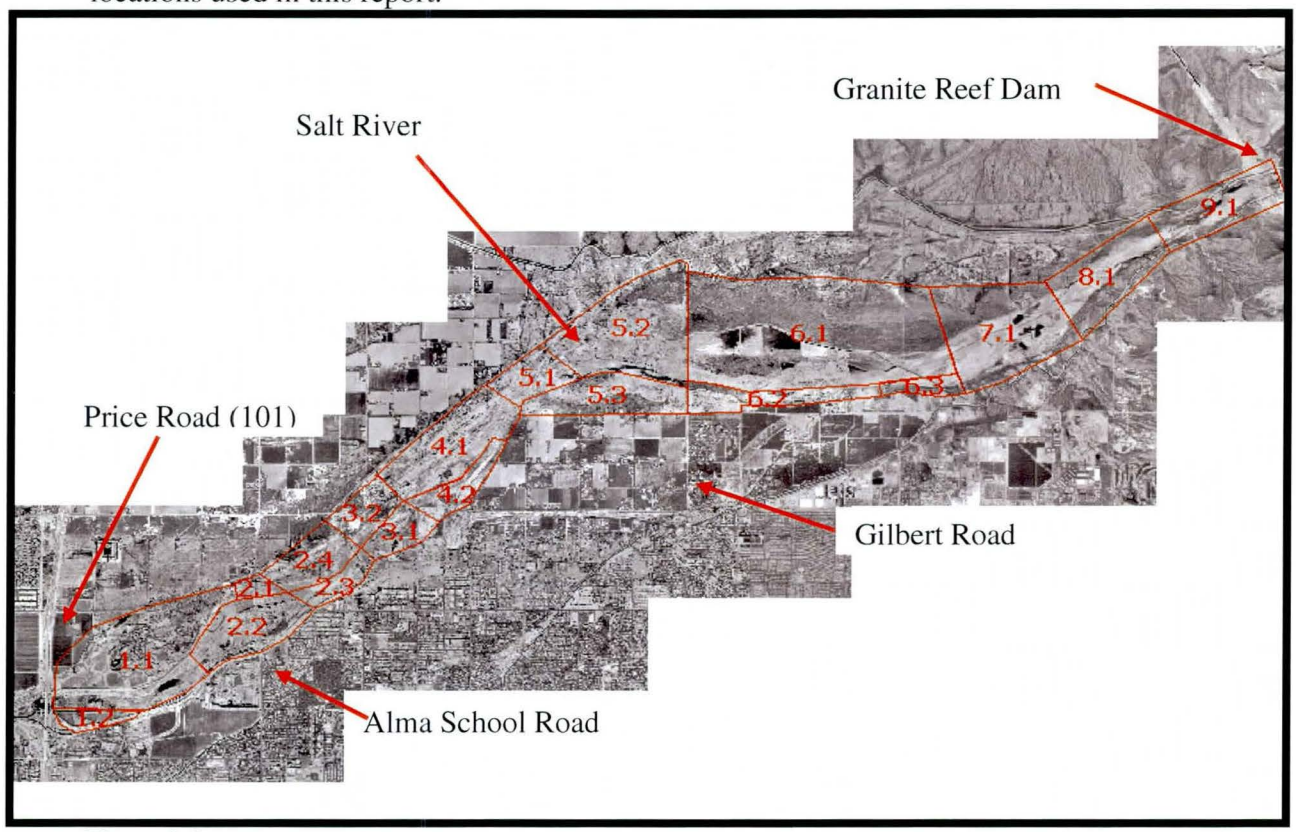

Figure 3-1
General location map for the Salt River Va Shly'ay Akimel Project identifying key features and project sub-areas.

Measures Under Consideration

In order to complete ecosystem restoration on the Va Shly'ay Akimel project, multiple measures will likely need to be implemented. In all, ten measures were considered that when implemented will influence the cover type within a given reach of the project. Alternatives were then formulated using various measures in combination. Not all measures were used in all alternatives. The following provides a brief summary of the measures considered.

Water Sources

Six water sources are available to supply the project facilities: 1) Surface water available for use by the Pima Maricopa Indian Community via existing water sources, 2) groundwater from existing and new wells, 3) storm water, 4) City of Mesa Wastewater Treatment Facility water, and 5) irrigation tailwater. Alternatives rely primarily on surface water and groundwater from the Salt River Pima Maricopa Indian Community (SRPMIC) and effluent from the City of Mesa Wastewater Treatment Facility. According to the Pima Maricopa Indian Community staff, 30,000 acre-ft/yr of water can be allocated to the project. Groundwater is considered a secondary source of water.

Water Distribution System(s)

Infrastructure is needed to deliver water (surface water, groundwater, or wastewater) from the source (irrigation canal, well, or effluent line) to areas where vegetation will be restored. The distribution system does not take into account the irrigation system.

Irrigation Techniques

Surface water from the storm water sources, irrigation canals and ditches will be diverted to various vegetated areas by a network of lined irrigation channels and buried pipes. The size of the channel and pipe will be dependent on site specific conditions such as flow requirements and terrain. Pumps may be needed to distribute water.

Reshaping

Many of the alternatives require surface reshaping. Three types of reshaping categories are proposed for use in this project: 1) Channelization, 2) Surface Reshaping, and 3) Vegetation/Irrigation Reshaping. Channelization is defined as the material moved in the process of constructing the 200 ft wide low flow channel. Surface Reshaping is defined as the material moved to alter significant features such as large mounds, filling quarry pits and reducing the side slopes of the quarry walls. Vegetation Reshaping is defined as minor reshaping required for planting purposes and to ensure that gravity irrigation systems will be feasible. It is assumed that for Vegetation Reshaping, 2 ft of material will be moved per acre of vegetated area. And Irrigation Reshaping is defined as the construction of irrigation ditches needed in the flood irrigation and SBIN irrigation methods (2-3 ft wide and 6 inches deep) and the construction of the drainage ditches (15 ft wide and 3 ft deep).

Vegetation
Five vegetation types were evaluated: 1) Cottonwood/Willow, 2) Mesquite, 3) Wetlands, 4) Sonoran Desert, and 5) River Bottom. In addition to the planting of the vegetation, some reshaping may be necessary to provide the proper landscape to maintain and encourage the future propagation of the vegetation.

River Channelization
Some alternatives require segments of the Salt River to be channelized, off setting the reduction in water conveyance, due to planting of vegetation within the main channel. The river bottom will be excavated to form a low flow channel with a bottom width of 200 ft, 1V:3H side slopes and 4 to 8 ft in depth. The channel will be free to migrate. The excavated material can be used to create benches along the channel, to fill quarry pits and to vary the local topography to encourage vegetation growth and reduce flood damage on proposed vegetation areas. A two hundred foot buffer on both sides of the low flow channel will be incorporated to allow for the migration of the low flow channel. Portions of the low flow channel will be designed with a semi impervious soil substrate to support wetland areas. In some alternatives requiring channelization activities, Sonoran desert vegetation will be planted along the low flow channel to increase stability of the overbank area.

Grade Control Structure
A grade control structure may be needed to protect the Gilbert Road Bridge due to the extensive mining that has occurred downstream of the bridge. Mining operations have altered the channel system, creating a nickpoint, or area where an abrupt change in elevation and slope occurs.

Buried Guide Dikes
The buried guide dikes are used to control lateral migration of the low flow channel and have been included in only Alternative I (CHNL). These structures will be constructed with soil cement and buried perpendicular to the low flow channel alignment.

Bank Stabilization
Several areas require bank stabilization to stabilize the river, reducing erosion, and provide protection for newly established vegetation. Four general bank stabilization measures have been evaluated: 1) riprap, 2) buried groins, 3) endways weirs (wingdams, groins), and 4) soil cement. Application of each stabilization measure depends upon the local hydraulic, and scour and deposition conditions and the proximity to significant areas.

Levee
Although considered by the design team, a levee measure is not recommended near Gilbert Road, to protect the Lehi area, because it already appears to be out of the100 year flood plain. To protect from the 500 Year event, the levee needs to be 15,000 ft long, extending from Reach 6 to Reach 5 (Figure 1) and 6 ft high. If built to Army Corps of Engineer's standards, the levee would require armoring. A levee is not recommended

because there appears to be very little damage for the 100 Year event and only slightly more for the 500 Year event.

Cultural Center
A Cultural Center, intended to provide Community members and visitors with information regarding the historic way of Pima Maricopa Indian Community life, is planned as part of the greater river restoration project. The exact location of the Center has yet to be determined, however, it will be placed relatively close to the river, so that the river and its associated vegetation can be visually highlighted in the area surrounding the Center itself. Materials historically and culturally important to the Indian Community may be planted in the area surrounding the Center, as well as highlighting the native river vegetation. It can be expected that greater infrastructure and resources will be necessary to achieve the expected level of vegetation establishment.

Alternatives Under Evaluation
The thirteen alternatives developed vary with respect to vegetation layout, amount of river channelization, reshaping and method(s) for distributing water. Levees, bank stabilization and water sources (groundwater and/or surface water) were examined. These measures were combined into alternatives that result in varying amounts of a given PWAA being represented within the project reach. Table 3-1 provides a list of all alternatives considered for the Va Shly'ay Akimel ER and is followed by a brief description of each.. An in-depth description of each alternative is available in the F4 document.

Table 3-1
Va Shly'ay Akimel ER-FS alternative list.

Alternative Name	Alternative Letter
LOAD	A
MEAD	B
HIAD	C
MINE	D
VHAD	E
MAX	F
CWAD	G
MSAD	H
CHNL	I
BRAD	J
NODL	K
POCK	L
WET	M
MAX	N
MAX	O

A - LOAD: Xero-Riparian dominated with minimal vegetation establishment.

B - MEAD: Xero-Riparian dominated with moderate vegetation establishment.

C - HIAD: Xero-Riparian dominated with extensive vegetation establishment.

D - MINE: Meso-Riparian dominated with moderate vegetation establishment. Stream channelization, but avoiding sand and gravel mines.

E - VHAD: Meso-Riparian dominated (cottonwood-willow, mesquite and xero-riparian species) with extensive vegetation establishment.

F - MAX: Meso-Riparian dominated with maximum vegetation establishment. Reshaping and channelization activities are also included.

G - CWAD: Cottonwood dominated with a braided channel network.

H - MSAD: Mesquite bosque dominated with a braided channel network.

I - CHNL: Cottonwood dominated with moderate vegetation establishment. Stream channelization is also included.

J - BRAD: Cottonwood dominated with extensive vegetation establishment. Also includes reshaping of selected sand and gravel impacted areas.

K - NODL: Cottonwood dominated with extensive vegetation establishment. No reshaping of sand and gravel mining areas.

L - POCK: Cottonwood and mesquite co-dominated with moderate vegetation establishment. Restoration activities located to provide maximum visibility from surrounding roadways.

M - WET: Hydro-riparian dominated with extensive vegetation establishment.

N – MAX: Meso-Riparain dominated modification of alternative F-MAX.

O – MAX: Meso-Riparian dominated modification of alternative F-MAX.

Baseline Conditions

Baseline Acres and Cover Types

Thirteen existing cover types were identified in the Va Shly'ay Akimel project area, the majority of which could be considered degraded because of a lack of water or because of

anthropogenic activities. Of the 5,870.6 total project acres, Scrub-shrub lands occupy the majority of the project area at 2,057.1 acres. The second most prevalent existing cover type supports sand and gravel mining activities (1,651.6 acres), while the third is considered Desert (961.9 acres). Wetland and hydroriparian cover types do occur but these are, in general, located at the upstream and downstream most reaches of the project area where subflow from Granite Reef Dam or surface discharges from agriculture, wastewater treatment, or urban dry-weather flows enters the system respectively. Existing cottonwood-willow forests only represents 69.5 acres of the project, while riverbottom (largely unvegetated but including emergent marshes) accounts for 334.6 acres. A complete listing of baseline cover types (PWAAS) and their respective acreages is presented in Chapter 2, Table 2-9.

Baseline Variable Values for Each Cover Type

The HGM model was used to assess the baseline conditions for the Va Shly'ay Akimel ER study site. Baseline field data were collected in the spring of 2002 to determine existing conditions for the site. Data for each variable per cover type was recorded, and the means/modes were calculated to generate baseline Functional Capacity Index (FCIs). For detailed information regarding the field data collected by the Biological Team, please refer to the discussion on the collection of variables in Chapter 2 of this document.

Baseline Evaluation

Ten (10) HGM functional formulae from the Arizona Riverine model were used to evaluate the ecosystem benefits in the Va Shly'ay Akimel project area under baseline conditions, as well as for the different alternatives. These functional indices included:

FXN 01: Maintenance of Characteristic dynamics
FXN 02: Dynamic Surface Water Storage/Energy Dissipation
FXN 03: Long Term Surface Water Storage
FXN 04: Dynamic subsurface Water Storage
FXN 05: Nutrient Cycling
FXN 06: Detention of Imported Elements and Compounds
FXN 07: Detention of Particles
FXN 08: Maintain Characteristic Plant Communities
FXN 09: Maintain Spatial Structure of Habitat
FXN 10: Maintain Interspersion and Connectivity

Plots showing the baseline FCI and FCU results are provided in Appendix A, while these data are provided in tabular form in Table 3-2 below.

Table 3-2
Baseline HGM Functional Capacity Indices (FCI) and Functional Capacity Units (FCU) for the Va Shly'ay Akimel ER project.

Function Name	Weighted FCI	FCU
FXN 01: Maintenance of Characteristic dynamics	0.333	821.8
FXN 02: Dynamic Surface Water Storage/Energy Dissipation	0.423	1044.0
FXN 03: Long Term Surface Water Storage	0.048	119.1
FXN 04: Dynamic subsurface Water Storage	0.083	204.1
FXN 05: Nutrient Cycling	0.384	947.3
FXN 06: Detention of Imported Elements and Compounds	0.333	820.8
FXN 07: Detention of Particles	0.311	767.5
FXN 08: Maintain Characteristic Plant Communities	0.602	1484.5
FXN 09: Maintain Spatial Structure of Habitat	0.399	983.4
FXN 10: Maintain Interspersion and Connectivity	0.377	929.7
Total	N/A	8122.2

Inspection of Table 3-2 shows only one weighted FCI value falling within the moderately functional range ($0.5<FCI\leq0.75$) indicating the potential for restoration does exist within the Va Shly'ay Akimel project reach of the Salt River. The lowest overall baseline FCI's are related to long term surface water and dynamic subsurface water storage which reflect the current lack of water resources entering the project area(s). The far right column of Table 3-2 provides the baseline FCU's based upon the FCI scores multiplied by the associated existing partial wetland assessment area acreages (PWAAs).

Future Conditions

Without Project Conditions
Based in the general Without Project trends described earlier in Chapter 2, the Biological Team developed a series of incremental projections to describe future conditions at the study site. Important factors in the projects were the continuing degradation of the river by incision, sand and gravel mining activities, as well as urban development. The team forecast the impacts in terms of acreage losses, as well as capturing the impacts in terms of degrading water quality and vegetation composition and structure scores.

In terms of acres, it was assumed that 5-years after construction (TY 6) 288 acres of existing PWAA would be lost and converted to residential, industrial, and transportation cover types. This includes 50% of the 69.50 acres of the cottonwood willow forest PWAA. Cover type acreage does not vary, except for the remnants of the existing cottonwood-willow forest, until the end of the project (TY 51). Between TY 26 and TY 51, it was assumed that the remaining 30.6 acres of cottonwood-willow forest would become newly developed river bottom areas within the active channel.

Without project FCI results for all 10 functions are presented graphically in Figure 3-2.

As can be seen all functional capacity indices decrease over time for the without project conditions. With the exception of function 01 which does not vary until between TY 6 and TY 26 (Maintenance of Characteristic Dynamics), all other FCI's experience a reduction in value that occurs between TY 1 and TY 6.

Resulting Without Project changes in Average Annual Functional Capacity Units (AAFCUs) are provided graphically in Figure 3-3. In general, the AAFCUs remain constant for the first year, but degrade significantly (-92 AAFCUs) between TY 1 and TY 6. The decline in AAFCUs is then more gradual with a reduction of 11 AAFCUs occurring over the next 18 years (TY 20). By the end of the project's life (TY 51) an additional 4 AAFCUs are lost.

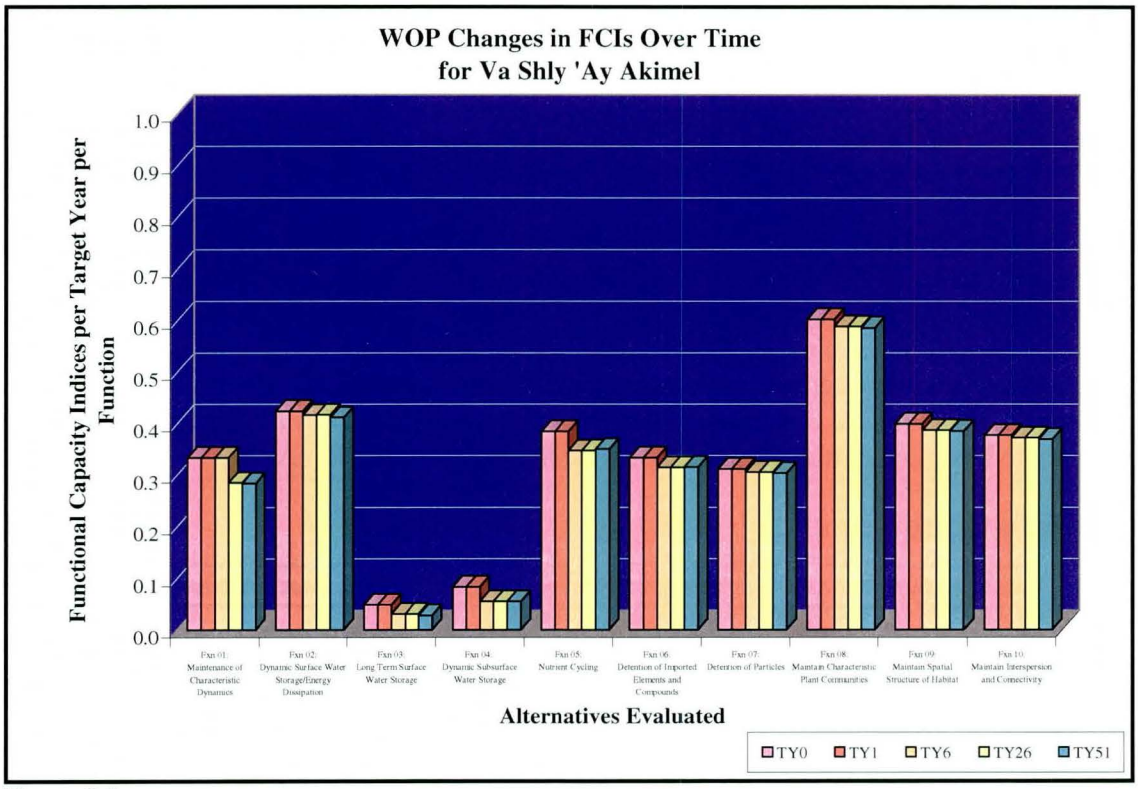

Figure 3-2
Va Shly'ay Akimel without project changes in FCIs over time for all 10 HGM functions evaluated.

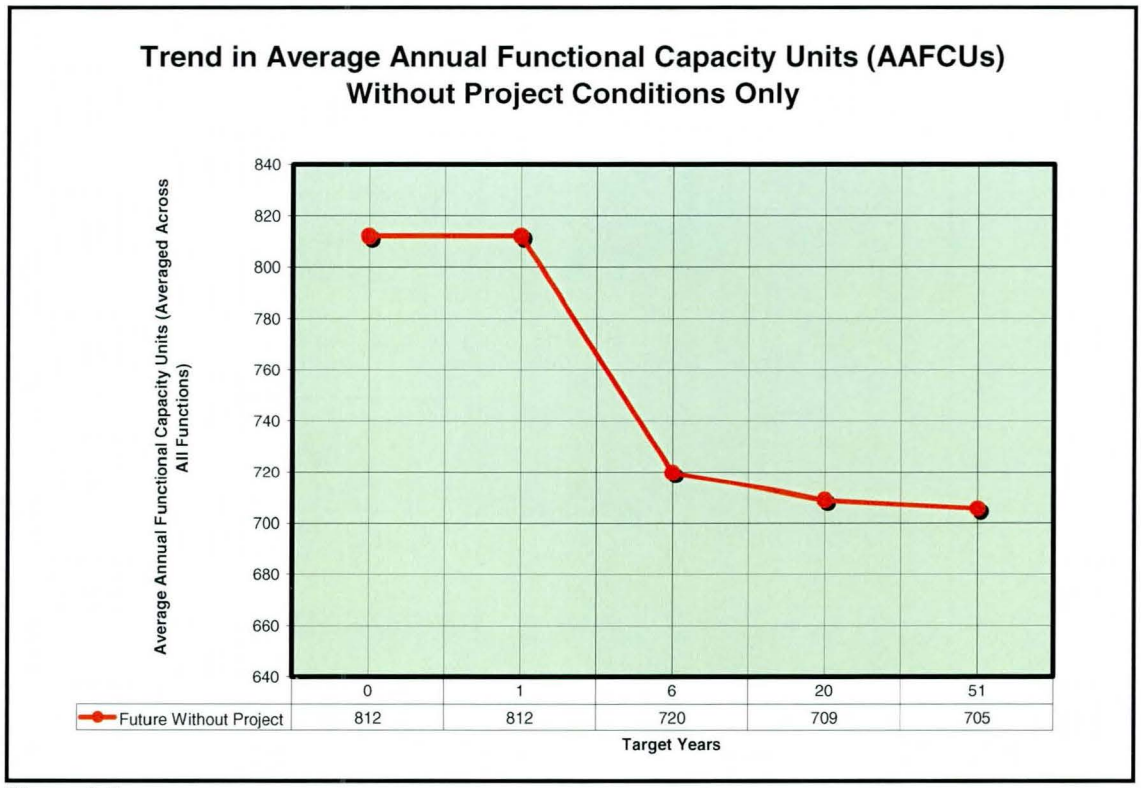

Figure 3-3
Without project Annual Average Functional Capacity Units (AAFCU) summary plot.

With Project Conditions
With the general trends of the Without Project condition in mind, the E-Team developed acreage and variable projections for the 15 alternatives presented above. Further these alternatives, when possible, were formulated with the intent of meeting as many of the goals and objectives developed and discussed earlier. As a general rule, the E-Team developed alternatives that varied with respect to the character and level of vegetation restoration, and either did or did not require specific engineering issues to be addressed (Table 3-3).

Vegetation character included Xeric-, Meso-, and Hydro-riparian communities in addition to those in which either Cottonwood or mesquite dominate. The level of vegetation restoration was defined by a range that includes minimal, moderate and extreme. The alternative MAX (F, N, & O) involves the maximum level of vegetation restoration, while LOAD (A) requires a minimal level. The remaining 11 alternatives require a moderate level of vegetation restoration.

Engineering considerations were necessary for 8 of the thirteen alternatives. Such considerations include the creation of channelized streams segments, reshaping of the channel invert, construction of braided channel networks, and sight/visibility corridors adjacent to surrounding roadways.

Table 3-3
Va Shly'ay Akimel ER-FS with project alternative conditions.

Vegetation Proposed	Level of Vegetation Restoration	Specific Engineering Issues	Alternative Code
Xero-Riparian Dominate	Minimal	None	A-LOAD
	Moderate	None	B-MEAD
	Extensive	None	C-HIAD
Meso-Riparian Dominate (Cottonwood, Mesquite & Xero-Riparian)	Moderate	Channelized Stream (Avoiding Mine)	D-MINE
	Extensive	None	E-VHAD
	Maximum	Reshaping and Channelized Stream	F-MAX
Cottonwood Dominate	Extensive	Braided Channel Network	G-CWAD
Mesquite Dominate	Extensive	Braided Channel Network	H-MSAD
Cottonwood Dominate	Moderate	Channelized Stream	I-CHNL
	Extensive	Reshaping of Sand & Gravel	J-BRAD
	Extensive	NO Reshaping of Sand & Gravel	K-NODL
Cottonwood & Mesquite Dominate	Moderate	High Visibility from Roads	L-POCK
Hydro-Riparian Dominate	Extensive	None	M-WET
Meso-Riparian Dominant	Maximum	Reshaping and Channelized Stream	N-MAX
Meso-Riparian Dominant	Maximum	Reshaping and Channelized Stream	O-MAX

Evaluation of Alternatives

Overall Review of the HGM Results

The overall HGM gains and losses in AAFCUs per alternative are summarized in Table 3-4. Inspection indicates only three alternatives exceed the performance target of 915.

Table 3-4
Net AAFCUs for each HGM model per alternative for the Va Shly'ay Akimel ER-FS.

Va Shly Ay Alternatives					NET AAFCUs									
					WATER				BIOGEOCHEM			HABITAT		
Vegetation Proposed	Level of Vegetation Restoration	Specific Engineering Issues	Alternative Code	Average Net AAFCUs	FXN 1: CHANNELDYN	FXN 2: WATSTORENR	FXN 3: WATSTORLNG	FXN 4: WATSTORSUB	FXN 5: NUTRIENT	FXN 6: ELEMENTS	FXN 7: DETPARTICL	FXN 8: PLANTS	FXN 9: HABSTRUCT	FXN 10: INTERSPERS
Xero-Riparian Dominate	Minimal	None	A-LOAD	373	400	407	311	72	324	275	385	569	534	454
	Moderate	None	B-MEAD	594	561	623	564	240	422	370	621	808	840	887
	Extensive	None	C-HIAD	771	628	817	792	300	591	466	812	1015	1065	1226
Meso-Riparian Dominate (Cottonwood, Mesquite & Xero-Riparian)	Moderate	Channelized Stream (Avoiding Mine)	D-MINE	598	425	634	611	383	520	355	622	727	755	950
	Extensive	None	E-VHAD	926	763	987	883	396	690	567	953	1225	1267	1525
	Maximum	Reshaping and Channelized Stream	F-MAX	1035	680	1129	1155	694	852	587	1102	1248	1377	1521
Cottonwood Dominate	Extensive	Braided Channel Network	G-CWAD	943	682	1020	979	552	750	554	991	1177	1257	1466
Mesquite Dominate	Extensive	Braided Channel Network	H-MSAD	850	674	905	939	535	592	462	957	1040	1147	1249
Cottonwood Dominate	Moderate	Channelized Stream	I-CHNL	675	420	816	732	589	601	409	663	752	766	1006
	Extensive	Reshaping of Sand & Gravel	J-BRAD	872	591	948	902	640	717	508	901	1044	1131	1343
	Extensive	NO Reshaping of Sand & Gravel	K-NODL	627	486	755	761	619	572	405	715	527	619	814
Cottonwood & Mesquite Dominate	Moderate	High Visibility from Roads	L-POCK	758	516	884	744	693	671	477	751	920	947	977
Hydro-Riparian Dominate	Extensive	None	M-WET	829	547	944	862	777	667	477	830	953	1024	1211
Meso-Riparian Dominate	Maximum	Modification of MAX (Alternative F)	N-MAX	913	599	1023	891	652	812	565	912	1127	1178	1370
Meso-Riparian Dominate	Maximum	Modification of N-MAX (Alternative N)	O-MAX	963	627	1084	951	657	851	590	976	1192	1242	1455
			Performance Targets	915	689	1324	234	194	1152	821	1157	1617	1040	926

In general, the alternative requiring moderate or minimum levels of vegetation restoration resulted in the least amount of Net AAFCUs, while those requiring maximum or extensive levels resulted in the highest amount. Interestingly, the need to address specific engineering issues did not appear to correlate well with the amount of AAFCUs produced by a given alternative.

When considered by functional group, e.g. Water-related, Biogeochemically-related, or Habitat-related, Performance Target Net AAFCUs are met or exceeded by four of the 10 functions. All 15 alternatives exceed the performance target value for FXN 3: WATSTORLNG, while 14 alternatives satisfy target values for FXN 4: WATSTORSUB. None of the alternatives exceeded the performance target value for FXN 1: CHANNELDYN, FXN 2: WATSTORENR, nor were they by any of the biogeochemical functions, (NUTRIENTS, FXN 5, ELEMENTS, FXN 6, and DETPARTICL, FXN 7). Two of the habitat related functions, 9 (HABSTRUCT) and 10 (INTERSPERS), met performance targets in 9 and 12 of the alternatives respectively. Detailed information regarding these results can be found in the Appendix to this report.

Top Four Biological Winners Using HGM

As previously mentioned inspection of Table 3-4 above indicates that only three alternatives E - VHAD, F - MAX, and G - CWAD exceed the targeted net AAFCUs. F - MAX was subsequently reformulated into three alternatives F-MAX, N-MAX and O-MAX. O-MAX turned out to be the sponsors preferred alternative. These winners are briefly described below:

#1	O - MAX	Meso-Riparian dominated with maximum vegetation establishment. Minimal reshaping and channelization activities are also included. Net AAFCUs produced = 963
#2	F - MAX	Meso-Riparian dominated with maximum vegetation establishment. Reshaping and channelization activities are also included. Net AAFCUs produced = 1035
#3	G - CWAD	Cottonwood dominated with a braided channel network. Net AAFCUs produced = 943
#4	E - VHAD	Meso-Riparian dominated (cottonwood-willow, mesquite and xero-riparian species) with extensive vegetation establishment. Net AAFCUs produced = 926
		Performance Target = 915 AAFCUs

Individual HGM Model Results

Creating wetland and riverine riparian habitat under these winning scenarios, even though the quality of these areas were less than optimal for the HGM functions (i.e., $0 < FCIs \leq 1.0$

by TY51), nevertheless resulted in favorable returns on an AAFCU basis for all four of the proposed winning alternatives. With respect to the FCI scores at TY51, the flowing summations can be made on a model-by-model basis.

Function 1: Maintenance of Characteristic dynamics
Less than optimum (FCI = 1.0), the FCI values for the four top finishers ranged from 0.37 (E - VHAD) to 0.38 (O-MAX, F-MAX, and G-CWAD). The baseline results indicated the FCI for TY 51 was 0.28, hence improvement in this model is seen over baseline conditions for all three alternatives. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 689
AAFCU O-MAX = 627
AAFCU F-MAX = 680
AAFCU G-CWAD = 682
AAFCU E-VHAD = 763

Function 2: Dynamic Surface Water Storage/Energy Dissipation
FCI values for the four top finishers ranged from 0.50 in E-VHAD to a high of 0.59 for alternatives O-MAX and F-MAX. G-CWAD had an intermediate value of 0.55. Only O-MAX and F-MAX resulted in an improved FCI score when compared to the baseline condition at TY 51 for Function 2 (0.57). A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 1324
AAFCU O-MAX = 1084
AAFCU F-MAX = 1129
AAFCU G-CWAD = 1020
AAFCU E-VHAD = 987

Function 3: Long Term Surface Water Storage
The performance target FCI, (0.09) for Function 3 was exceeded by the top four biological alternatives. At TY 51 the FCI for long term surface water storage was 0.29 and 0.35 for O-MAX and F-MAX respectively, 0.29 for G-CWAD, and 0.25 for E-VHAD. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 234
AAFCU O-MAX = 951
AAFCU F-MAX = 1155
AAFCU G-CWAD = 979
AAFCU E-VHAD = 883

Function 4: Dynamic Subsurface Water Storage
The final FCI target value for Function 4 (0.08) was exceeded by all four top biological winners. O-MAX and F-MAX were almost three times the target value at 0.22 and 0.23 respectively, while G-CWAD was 0.19. E-VHAD had the lowest TY51 FCI value at 0.14. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 194
AAFCU O-MAX = 657
AAFCU F-MAX = 694
AAFCU G-CWAD = 552
AAFCU E-VHAD = 396

Function 5: Nutrient Cycling
The performance target FCI value at TY 51 was exceeded by O-MAX, F-MAX, and CWAD. In such cases these improvements were slight, 0.07 increases for O-MAX and F-MAX, and 0.01 increase for G-CWAD over the target FCI for this function which was 0.50. The fourth top biological alternative E-VHAD does not achieve the performance target value at 0.44. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners:

AAFCU Performance Target = 1152
AAFCU O-MAX = 851
AAFCU F-MAX = 852
AAFCU G-CWAD = 750
AAFCU E-VHAD = 690

Function 6: Detention of Imported Elements and Compounds
All four top biological winners meet or exceed the performance target FCI value (0.33) for Function 6. The Alternatives O-MAX and F-MAX are highest at 0.39, while G-CWAD and E-VHAD were 0.37 and 0.34 respectively. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners:

AAFCU Performance Target = 821
AAFCU O-MAX = 590
AAFCU F-MAX = 587
AAFCU G-CWAD = 554
AAFCU E-VHAD = 567

Function 7: Detention of Particles
Only one of the top four biologically winning alternatives, F-MAX (0.52), meets the performance target established for the Function 7 of 0.50 at TY 51. O-MAX had a value of 0.49, while G-CWAD had a value of 0.47, and E-VHAD had a value of 0.43. A summary of the TY 51 performance target AAFCU and the AAFCU values for the top four biological winners are provided below:

AAFCU Performance Target = 1157
AAFCU O-MAX = 976
AAFCU F-MAX = 1102
AAFCU G-CWAD = 991
AAFCU E-VHAD = 953

Function 8: Maintain Characteristic Plant Communities
The performance FCI target value at TY 51 for Function 8 was achieved by three of the four top winning biological alternatives, O-MAX (0.76), F-MAX (0.79) and G-CWAD (0.74), while the fourth best biological winner E-VHAD equaled it at 0.70. All of these alternatives fall within the moderately functioning range of FCI values. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners are now provided:

AAFCU Performance Target = 1617
AAFCU O-MAX = 1192
AAFCU F-MAX = 1248
AAFCU G-CWAD = 1177
AAFCU E-VHAD = 1225

Function 9: Maintain Spatial Structure of Habitat
The top four biologically winning alternatives exceed the target FCI TY 51 value for Function 9 (Target TY 51 FCI = 0.45) and all fall within the moderately functioning range. The final FCI TY 51 values for the alternatives were 0.64, 0.69, 0.63, and 0.60 for the alternatives O-MAX, F-MAX, G-CWAD, and E-VHAD respectively. A summary of the TY 51 performance target AAFCU and the AAFCU values for the top four biological winners are shown below:

AAFCU Performance Target = 1040
AAFCU O-MAX = 1242
AAFCU F-MAX = 1377
AAFCU G-CWAD = 1257
AAFCU E-VHAD = 1267

Function 10: Maintain Interspersion and Connectivity
The final performance target value for Function 10 was 0.40. This was exceeded by all three of the top biological winners. O-MAX and F-MAX produced final TY 51 FCI values of 0.68 and 0.70 respectively. G-CWAD had a final TY 51 FCI score of 0.67 for Function 10, while E-VHAD was 0.64. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners are now provided:

AAFCU Performance Target = 926
AAFCU O-MAX = 1455
AAFCU F-MAX = 1521

AAFCU G-CWAD = 1466
AAFCU E -VHAD = 1525

Cost Analysis

Project Costs
Two techniques were used to determine the most cost effective alternatives. The first method compared alternatives with respect to their cost effectiveness and is termed the Cost Effectiveness Analysis or CEA. Using this method, alternatives that produced increased levels of output, measured as AAFCUs, for the same or lesser costs were considered "effective" solutions and were retained. Those alternatives that provided lesser return for higher associated cost were dropped from consideration. The "effective" solutions were then assessed on the basis of efficiency in which "efficient" alternatives where those that produced similar levels of AAFCUs at the least expense. In order to establish a common point in time for alternative comparisons, the AAFCUs developed from the HGM analysis were modified. The reader is encouraged to refer to Section 5.7 of the Alternative Formulation Briefing Report for a full explanation.

The second technique involved conducting an Incremental Cost Analysis (ICA) using those alternatives that were deemed "efficient". In short, the ICA explores the costs associated with a given incremental increase in output of a given alternative. The results of this two-part analysis identified alternatives that are both cost and incrementally effective. Annualized costs and outputs for all alternatives, as well as the results of the CEA and ICA evaluations are discussed in the Cost Appendix to the main F4 Report.

Top Three Cost Effective Solutions Based On HGM Results

The cost analysis indicates that the top three Cost Effective Solutions include alternatives A2 - LOAD, B2 - MEAD, and L2 - POCK (Table 3-5). Alternative A2 - LOAD produces 389 AAFCUs with an average annual cost of $1,621,000. Alternative B2 - MEAD was the next most cost effective solution producing 619 AAFCUs for an average annual cost of $5,355,000. Alternative L2 - POCK was the third most cost effective solution providing 792 AAFCUs for an average annual cost of $7,570,000. The average annual cost per average annual functional capacity unit for the top three most cost effective solutions are provided in Table 3-5 below. Three of the top four biological winners are included in Table 3-5 for comparison; the least costly being two-times the cost of the least expensive alternative.

Table 3-5. The top three cost effective solutions for the Va Shly'ay Akimel restoration study. Note: in $1,000s.

Alternative	AAFCU*	AAC/AAFCU
1) A2 (LOAD)	389	$4.20
2) B2 (MEAD)	619	$8.60
3) L2 (POCK)	792	$9.60

*Note: AAFCU's adjusted for cost analysis time-frame.

Top Three Incrementally Effective Solutions Based On HGM Results

Results of the ICA indicate that the top three incrementally cost effective solutions include alternatives A2 - LOAD, O2 - MAX, and F2 - MAX (Table 3-6). Alternative A2 - LOAD is again included as an ICA alternative although the AAFCU is well below the project goals. The second place ICA alternative, O2 - MAX does however meet the project biological goals with an AAFCU of 1,006. The average annual cost for alternative O2 is $9,158,000. The third most incrementally cost effective alternative was F2 which produced 1,084 AAFCUs for an average annual cost of $15,409,000. Table 3-8 provides a summary of the top three ICA alternatives including their respective AAFCUs, incremental AA Cost, and incremental AAC/AAFCU.

Table 3-6. The top three ICA solutions for the Va Shly'ay Akimel restoration study. Note: in $1,000s.

Alternative	AAFCU*	Incremental AA Cost	Incremental AAC/AAFCU
1) A2 (LOAD)	389	$1,621	$4.20
2) O2 (MAX)	1006	$7,537	$12.20
3) F2 (MAX)	1084	$15,409	$80.50

*Note: AAFCU's adjusted for cost analysis time-frame.

CHAPTER 4 - Tradeoffs

During the HGM process alternatives are compared based upon the model outcomes with respect to wetland functions achieved, plant communities present, and the overall species mixture of the proposed system. The model itself is based upon functional groups within which many variables can be measured. Other variables and hence functions can not and must be estimated. Using these data as a basis, the alternatives are formulated, and the resulting output collected, ranked, and compared. Often times, such comparisons rely upon expert opinion and documentation to make the final selection.

The Va Shly'ay Akimel Environmental Restoration Trade-offs Process

During the Va Shyl'ay Akimel environmental restoration HGM process, FCI models were chosen to emphasize the importance of critical wetland processes and functions. In all only four "priority" functions were selected and of those two focused upon the "water" functional group and two focused upon the "habitat" functional groups. No biogeochemical functions were considered as a "priority" because the Team felt that these functions could not be restored without restoring the overall hydrology to the contributing watershed. Conversely, those functions that were considered as "priority" functions were those that the Team felt, at least on an appropriate scale, could realistically be achieved. Those priority functions included: Maintenance of Characteristic Dynamics, e.g. appropriate energy can be supplied to sustain the project feature over the long-term; Long-Term Subsurface Water Storage, e.g. creation and maintenance of perched groundwater area(s) or long-term surface irrigation will be provided; Maintain Characteristic Plant Communities, e.g.. sufficient energy will be input over the long-term in the form of operation and maintenance to reduce invasive/exotic plants and to promote native plant communities; and Maintenance of Spatial Structure, e.g. there would be an operation and maintenance commitment to ensure the original habitat and ecosystem mosaic is sustained for the life of the project. Although the above listed functions were considered as a priority, the HGM analysis considered all eleven.

If desirable, the influence of one function over that of another in an HGM model can be altered through the use of a relative value index or RVI. For example, the Team felt that Function 4, Detention of Imported Elements and Compounds would not be improved because of a lack of incoming materials due to the ephemeral nature of the project reach. To downplay the importance of Function 4, an RVI score could be assigned to weight the outcome of Function 4 to be of less importance than the other functions. Along the same lines, the priority functions could be assigned RVI values that weight their outcomes to be more important.

Although the Team considered the use of the RVI Trade-Offs process, it was not implemented. The Team instead acknowledged that there were assumptions made about all functions and that many functions were interdependent. The interdependency was such that increasing the importance of one, similarly increased the importance of others that were related, e.g. increasing the importance of water in the root-zone, likely resulted in increased plant community fitness and spatial structure.

As stated, the Va Shly'ay Akimel project did not utilize a formal tradeoff process with RVIs. Instead, it relied upon the weighting done by prioritizing the functions which were constructed using weighted variables. Table 4-1 provides the reader with a summary of the top three Cost Effective Analysis, Incremental Cost Analysis, and HGM rankings.

Table 4-1. The Va Shly'ay Akimel Environmental Restoration Study top three Alternatives based upon the CEA, ICA, and HGM analyses.

Rank*	CEA	ICA	HGM
1st	A2 LOAD	A2 LOAD	F1 MAX
2nd	B2 MEAD	O2 MAX	O1 MAX
3rd	L2 POCK	F2 MAX	G1 CWAD

* The ranking of alternatives for the Va Shyl'ay Akimel Environmental RS does not consider RVIs, due to the decision not to conduct trade-offs.

CHAPTER 5 - Summary and Conclusions

Overall Results Summarized

Based on the HGM assessment, the District can expect the proposed ecosystem restoration efforts to increase in ecosystem productivity and associated returns to riparian communities. The primary goal of this study is ecosystem restoration. The ecosystem restoration goal consists of hydraulic, vegetation, then eventually species restoration. Given the results documented in the previous chapters of this report, the District can reasonably assume that this goal will be met, since ecosystem function and restored communities are expected to increase in both quality and quantity over the life of the project.

Summary of Plans Under Consideration

The Biological Plan

This section provides a short summary of each of the top three biological plans based on the HGM analysis. Note that sub-alternatives 1 and 2 (denoting irrigation methods) do not differ with regard to biological outcome and therefore are not discussed separately. The top three alternatives from first to third were: alternative F, alternative O, and alternative G. These alternatives produce net AAFCU gains of 1035, 963, and 943 respectively (Table 5-1). Final FCI gains and habitat acres gained are shown in Table 5-1.

Table 5-1. Net AAFCU gains, final FCI scores, and gains in habitat acres for the top three biological alternatives Va Shly'ay Akimel restoration study.

	Alternative		
	F	O	G
Net AAFCU	1035	963	943
Final FCI score	0.52	0.52	0.48
Habitat Gain (acres)	447	442	457

Figures 5-1 and 5-2 show net AAFCU gains per function and final FCI's per function for the top three biological alternatives and performance targets. The red line across the graph represents the average net AAFCU (Fig. 5-1) and FCI (Fig. 5-2) for all 30 alternatives. From the red line on the graph it can be seen that the top three biological alternatives exceed the average net AAFCU and FCI for many of the functions except for CHANNNELDYN (channel dynamics) and those functions dependent upon channel

dynamics such as WATSTORLNG (water storage) WATSTORSUB (subsurface water storage) and ELEMENTS (elements).

Increases in the amount of restored and preserved vegetation communities are shown in Figure 5-3. Most existing acreage is in the scrub shrub vegetation community type, while all three alternatives create significant acreage of cottonwood vegetation community, a community type with the highest biological value.

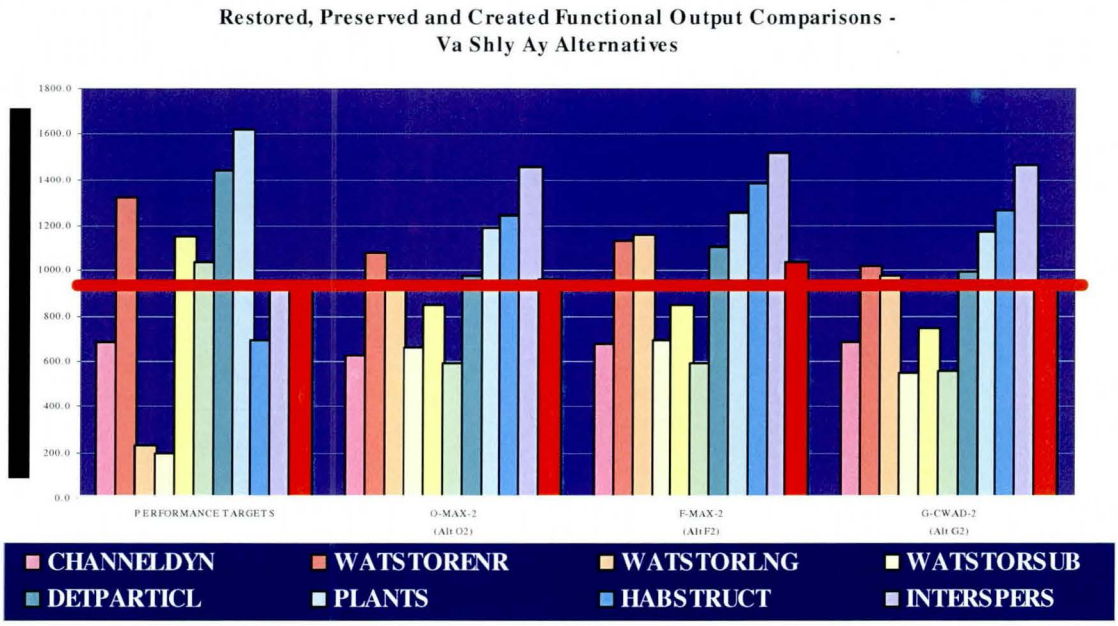

Figure 5-1. AAFCUs per function for performance targets and top three biological alternatives for the Va Shly'ay Akimel restoration study.

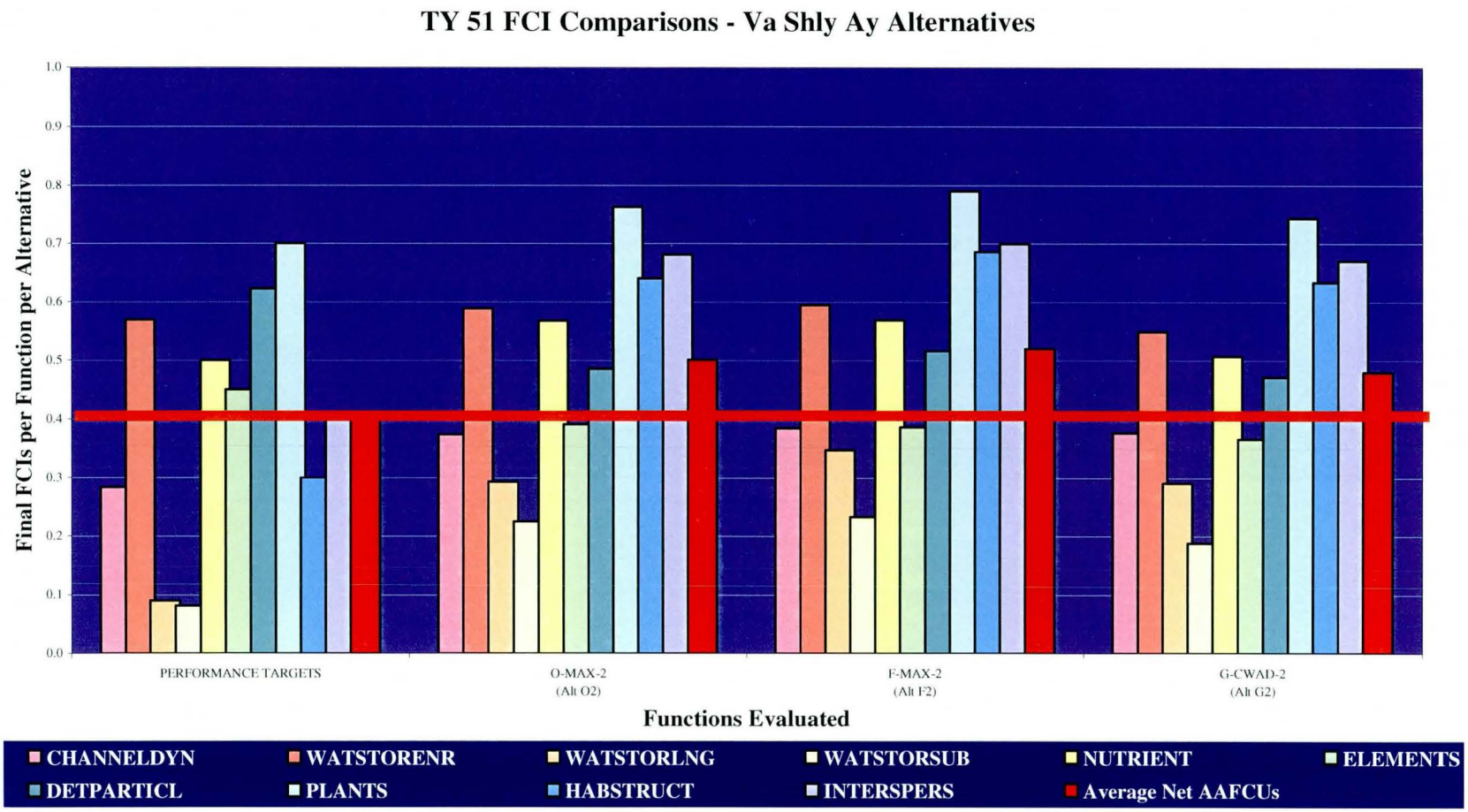

Figure 5-2. Final FCI's per function for performance targets and the top three biological alternatives for the Va Shly'ay Akimel restoration study.

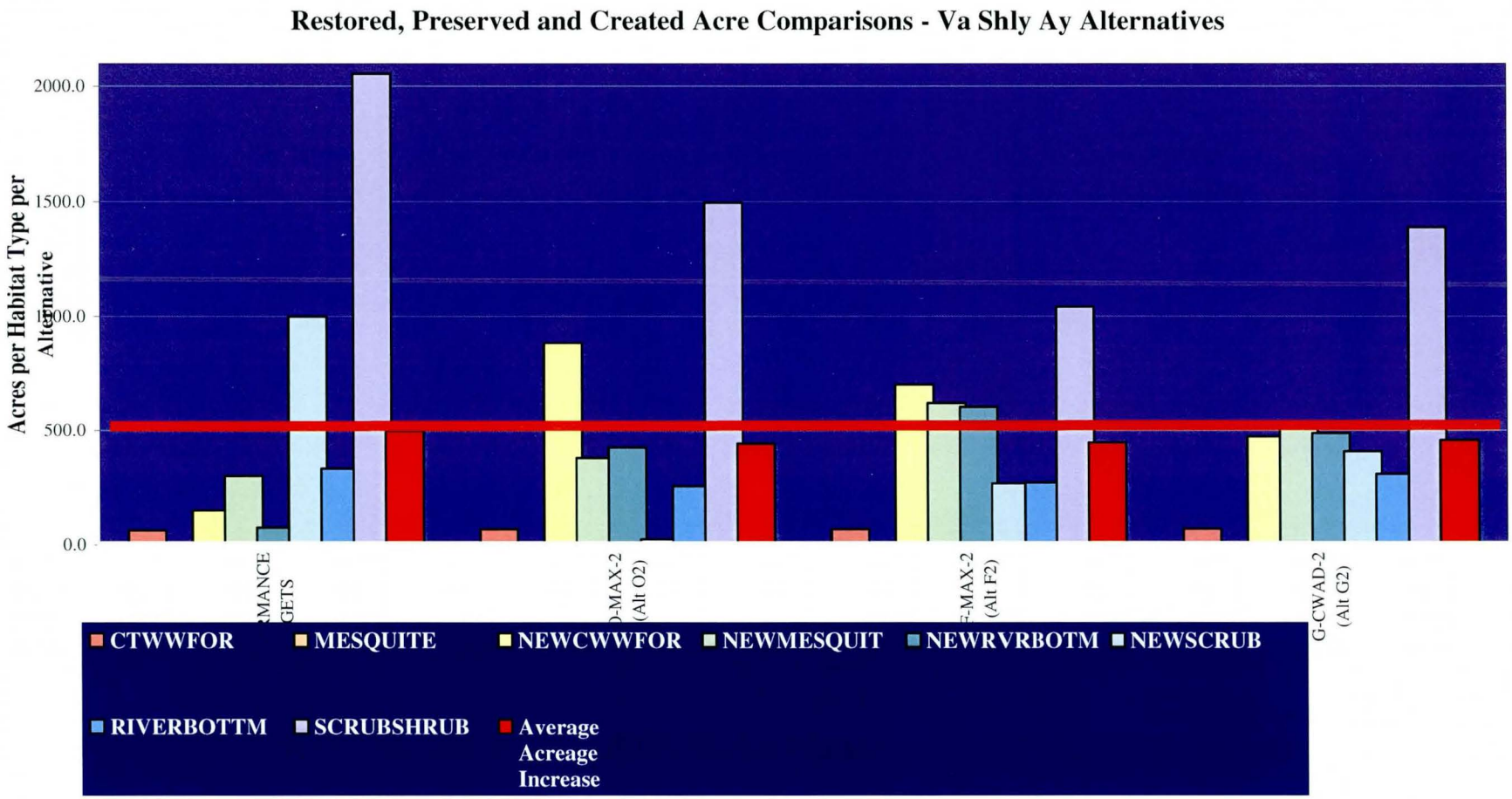

Figure 5-3. Acres per habitat type for performance targets and the top three biological alternatives for the Va Shly'ay Akimel restoration study.

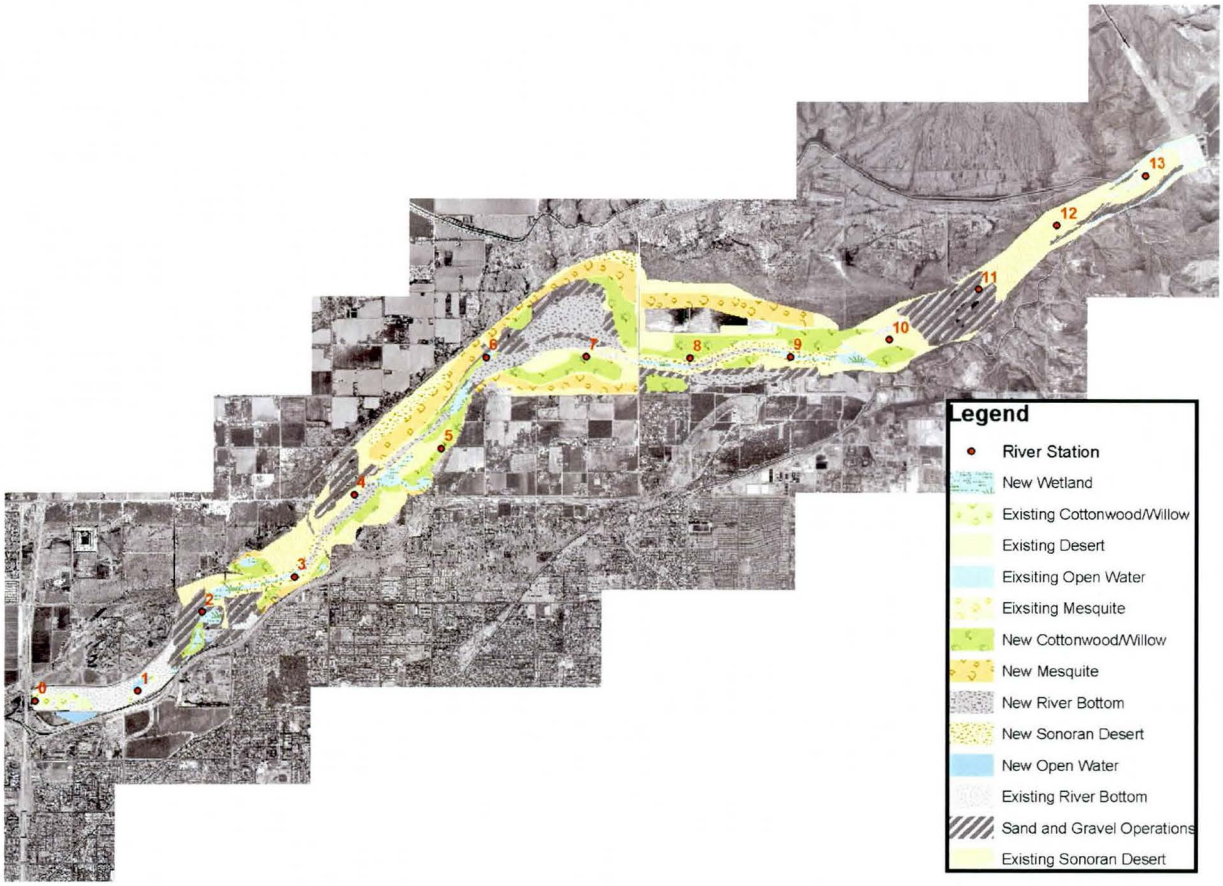

Figure 5-4. Diagram of alternative F, Va Shly'ay Akimel restoration study.

Alternative F

Alternative F creates a low flow channel from the Hennessey Drain to Gilbert Road and from Country Club Road downstream to Alma School Road. (Fig. 5-4) This channel would support Sonoran desert scrub shrub and wetlands. However, cottonwood/willow would be the dominant vegetation type with sufficient acreage of mesquite. Improvements by project reach including areas of bank stabilization are detailed in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, and gains in habitat area for this alternative and others are given in Table 5-1.

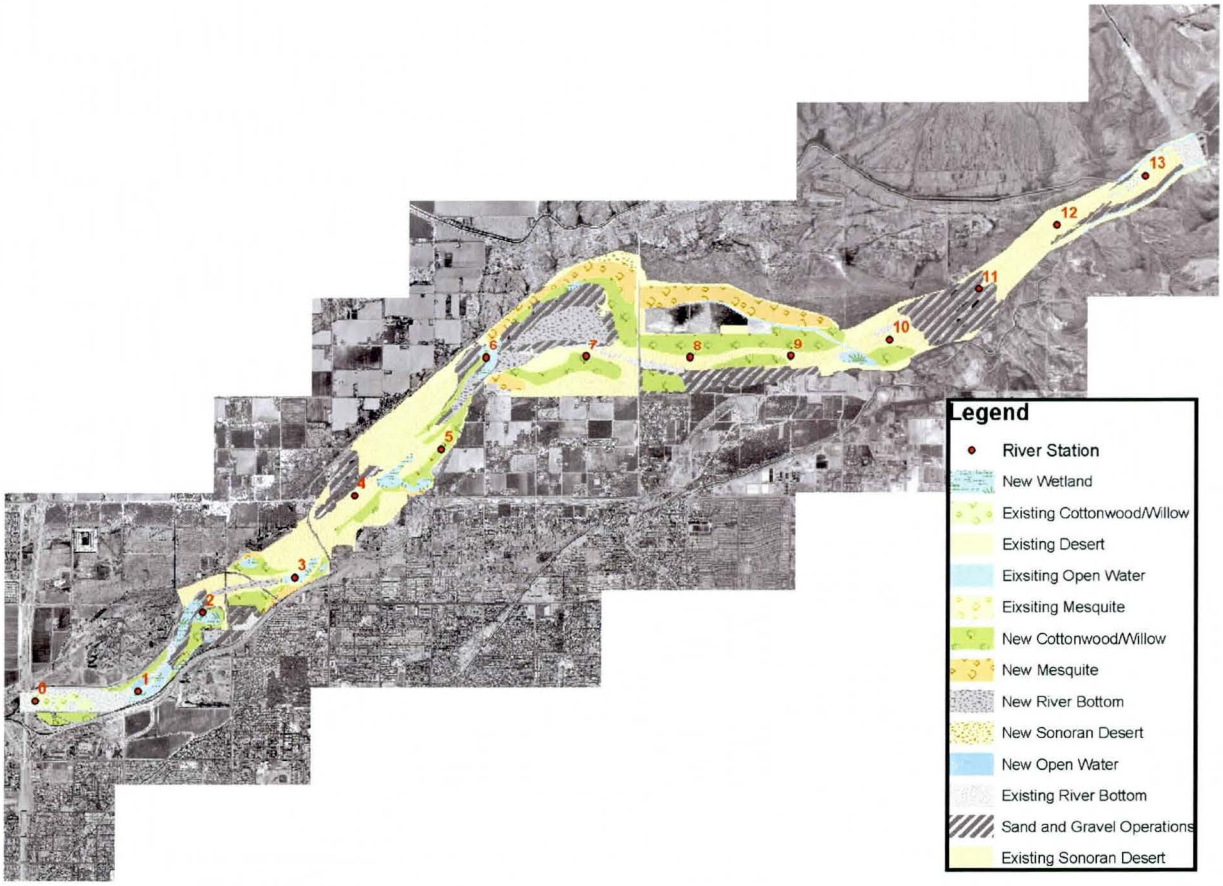

Figure 5-5. Diagram of alternative O, Va Shly'ay Akimel restoration study.

Alternative O

Alternative O creates a low flow channel from the Hennessey Drain to Gilbert Road and from Country Club Road downstream to Alma School Road. (Fig. 5-5) This channel would support Sonoran desert scrub shrub and wetlands. The major difference between Alternative O and Alternative F is the creation of additional cottonwood/willow habitat in the downstream reaches of the project. This alternative is a sponsor initiated alternative and did not appear in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, and gains in habitat area for this alternative and others are given in Table 5-1.

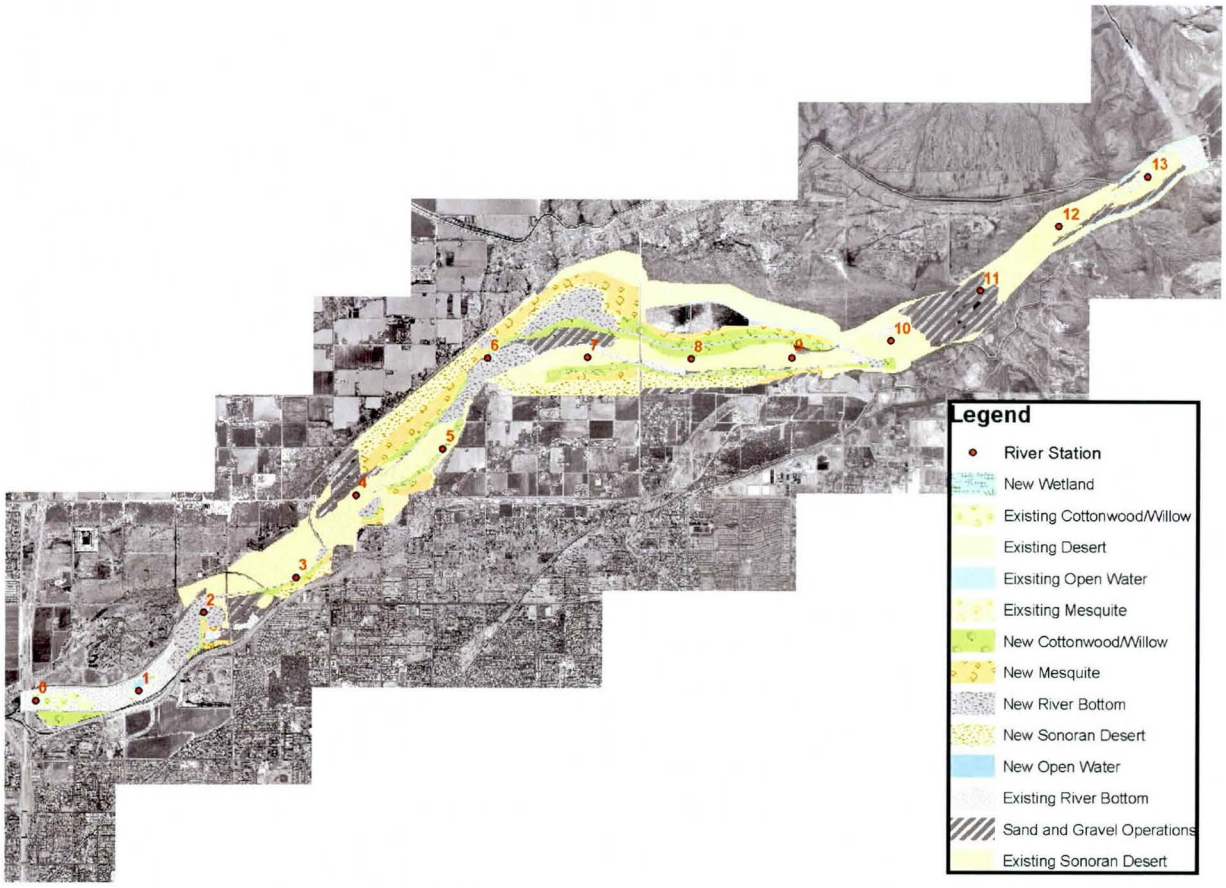

Figure 5-6. Diagram of alternative G, Va Shly'ay Akimel restoration study.

Alternative G

Alternative G is similar to alternative F. However, is does not have a low flow channel and some stands of cottonwood/willow are replaced with more xeric vegetation especially mesquite to reduce water demand (Fig. 5-6). Improvements by project reach including areas of bank stabilization are detailed in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, and gains in habitat area for this alternative and others are given in Table 5-1.

The Incremental Plan

This section provides a short summary of each of the top three plans based on an incremental cost analysis (ICA). Note that sub-alternatives 1 and 2 provide different ICA results due to differing installation and maintenance costs associated with the specific irrigation system. The top three alternatives from first to third were: alternative A2, alternative O2, and alternative F2. Cost per AAFCU ranges from $4.00 for alternative A2 to $15.00 for alternative F2. These alternatives produce net AAFCU gains ranging from 373 for alternative A2, to 1035 for alternative F2 (Table 5-2). Final FCI gains and habitat acres gained are shown in Table 5-2.

Table 5-2. Net AAFCU gains, final FCI scores, gains in habitat acres, average annual cost, and cost per AAFCU for the top three ICA alternatives for the Va Shly'ay Akimel restoration study.

	Alternative		
	A2	O2	F2
Net AAFCU	373	963	1035
Final FCI score	0.36	0.52	0.52
Habitat Gain (acres)	389	442	447
Average annual cost	$1621	$9158	$15409
Cost per AAFCU	$4.00	$10.00	$15.00

Figures 5-7 and 5-8 show net AAFCU gains per function and final FCI's per function for the top three ICA alternatives and performance targets. The red line across the graph represents the average net AAFCU (Fig. 5-4) and FCI (Fig. 5-5) for all 30 alternatives. From the red line on the graph it can be seen that of the top three ICA alternatives, alternative O2 and F2 exceed the average net AAFCU and FCI for many of the functions except for CHANNNELDYN (channel dynamics) and those functions dependent upon channel dynamics such as WATSTORLNG (water storage) WATSTORSUB (subsurface water storage) and ELEMENTS (elements). Alternative A2 which was the ICA winner had the lowest AAFCU and FCI gain. This alternative had below average AAFCU gain in all functions. This due to the only restoring scrub shrub habitat in this alternative.

Increases in the amount of restored and preserved vegetation communities are shown in Figure 5-9. Most existing acreage is in scrub shrub vegetation community type. Alternatives O2 and F2 create significant acreage of cottonwood vegetation community, a community type with the highest biological value. Habitat gain is lowest for alternative A2 because of minimal inputs in the restoration effort.

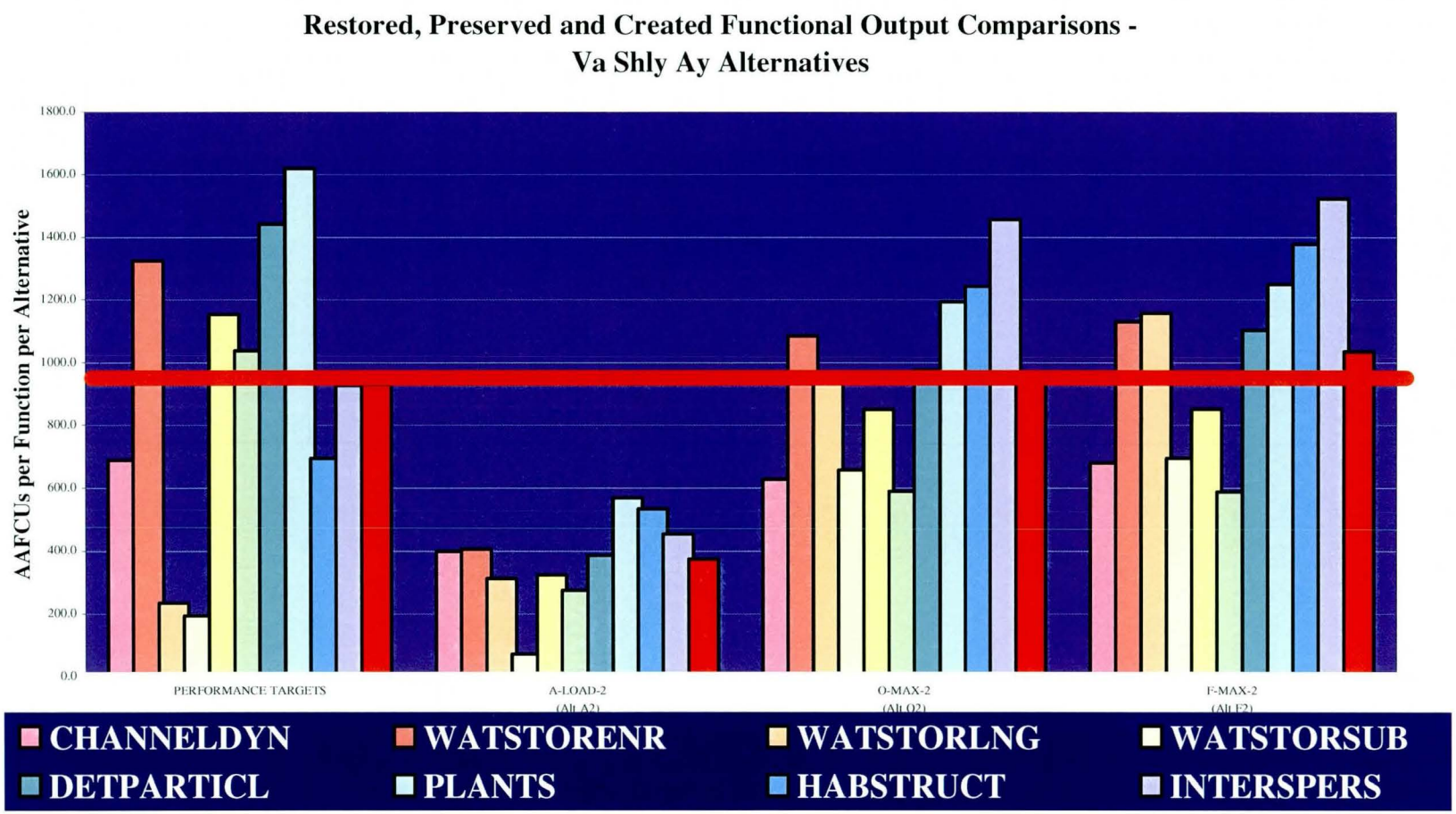

Figure 5-7. AAFCUs per function for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study.

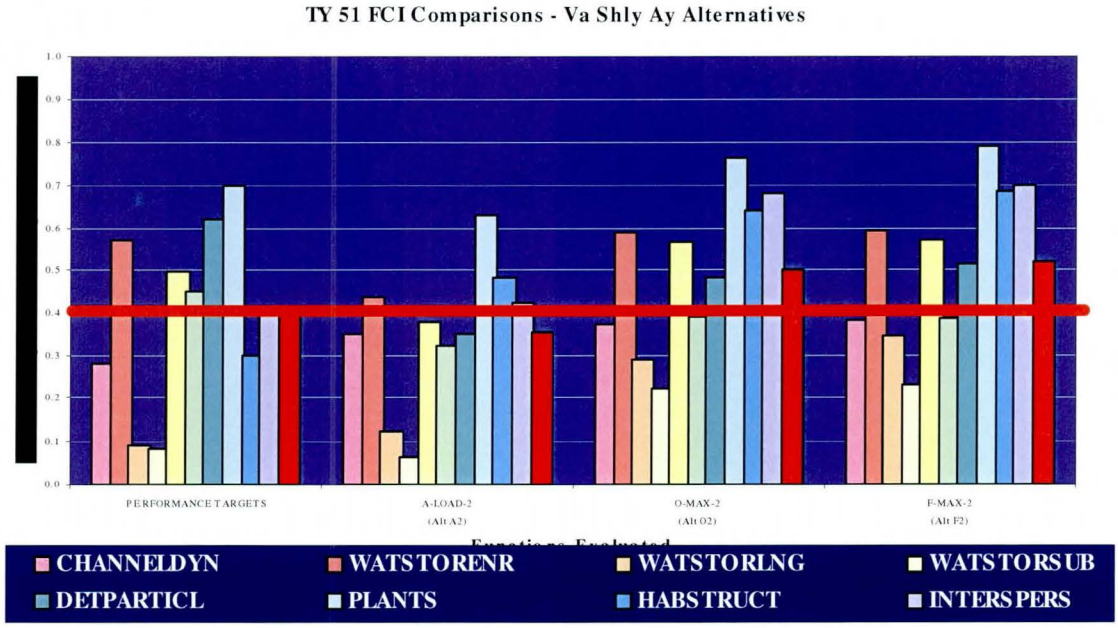

Figure 5-8. Final FCI's per function for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study.

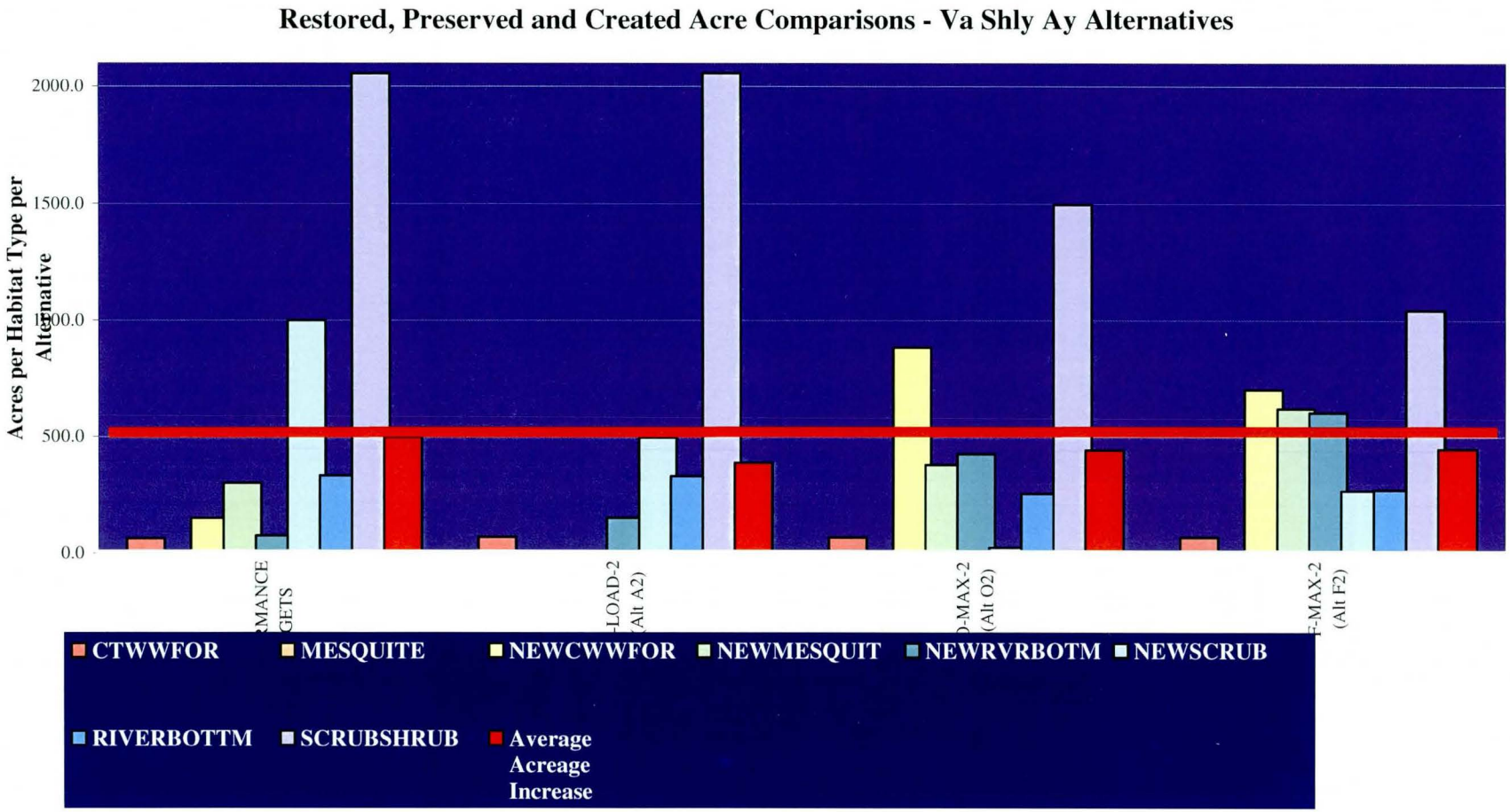

Figure 5-9. Acres per habitat type for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study.

Alternative A2

Alternative A provides a vegetative community that obligates the least amount of water. Sonoran desert scrub shrub, adapted to survive of relatively little rainfall, is the only vegetation type planned. No structural features are planned for this alternative. Improvements by project reach are detailed in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, gains in habitat area annual cost and cost per AAFCU for this alternative are given in Table 5-2.

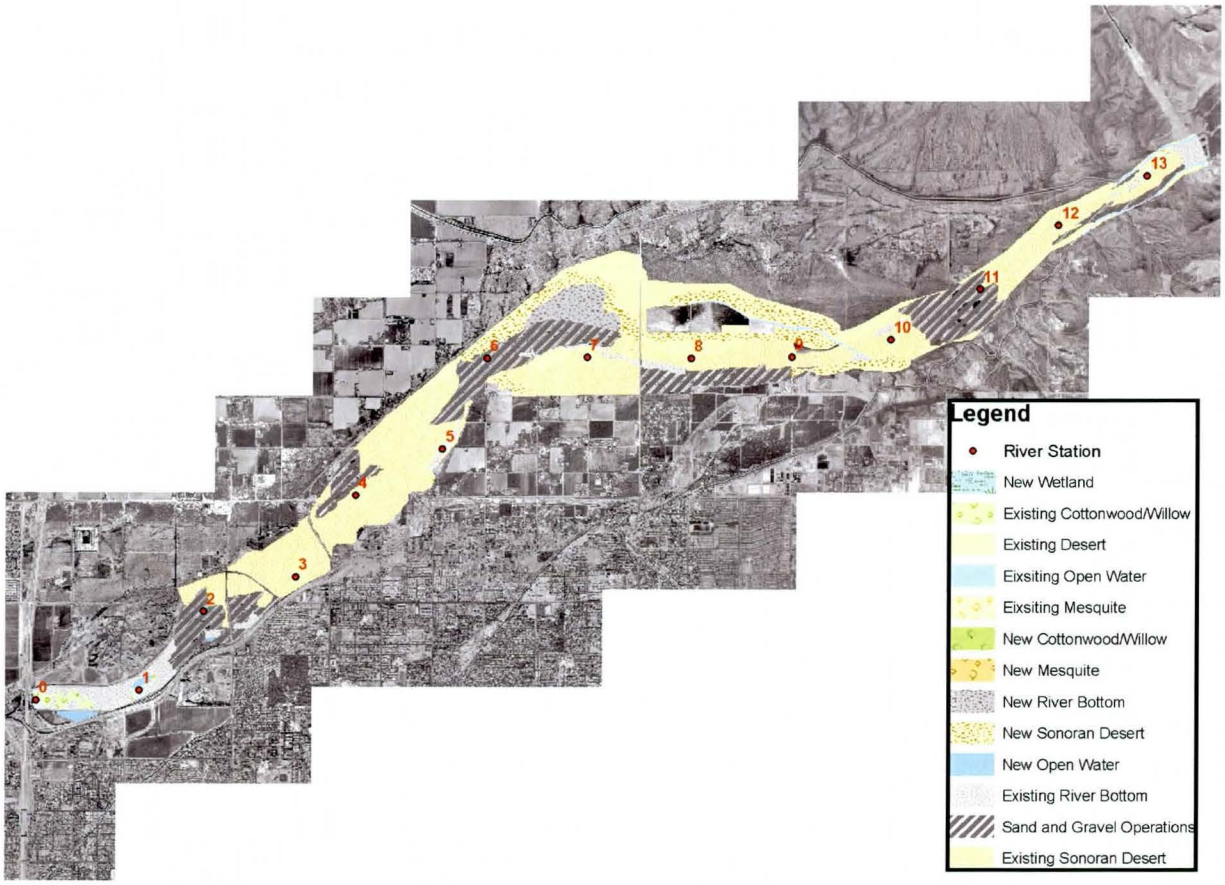

Figure 5-10. Diagram of alternative A, Va Shly'ay Akimel restoration study.

Alternative O2

A brief discussion and diagram (Fig. 5-5) of this alternative was presented in the previous section, The Biological Plan.

Alternative F2
A brief discussion and diagram (Fig. 5-4) of this alternative was presented in the previous section, The Biological Plan.

The Recommended Plan

Based on the HGM and ICA analyses, alternative O2 is the recommended plan. Alternative O2 is also the sponsor's preferred alternative. Alternative O2 ranked as the second biological alternative and the second ICA alternative. The sponsor's strong preferences for this alternative, combined with the high HGM and ICA rankings made O2 the recommended plan.

Net AAFCU gains, FCI scores, habitat gains, annual costs and costs per AAFCU compared to other leading alternatives have been discussed earlier (see The Biological Plan and The Incremental Plan).

Objectives Met

With respect to the goals of this restoration study, the alternative that meets the most objectives in a cost effective and efficient manner can be expected to achieve the ecosystem restoration goals, resulting in the most successful and desirable scenario of a restored ecosystem for a reasonable cost. The recommended plan (alternative O2) provides large gains in several biologically important habitat types. The amount of restored cottonwood vegetation type exceeds performance targets by 733 acres, restored river bottom exceeds targets by 350 acres and the amount of mesquite exceeds targets by 80 acres. Performance targets were not met for scrub shrub however this was considered an acceptable condition due to the low biological value of scrub shrub and the high value of cottonwood, river bottom, and mesquite.

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Glossary

Alternative
In HGM analyses, this is the "With Project" condition commonly used in restoration studies. An Alternative can be composed of numerous activities, measures, and/or options. Some examples of Alternatives include:

Alternative 1: Plant food plots, increase wetland acreage by 10 percent, install 10 goose nest boxes, and build a fence around the entire site.

Alternative 2: Build a dam, inundate 10 acres of riparian corridor, build 50 miles of supporting levee, and remove all wetlands in the levee zone.

Alternative 3: Reduce the grazing activities on the site by 50 percent, replant grasslands (10 acres), install a passive irrigation system, build 10 escape cover stands, use 5 miles of willow fascines along the stream bank for stabilization purposes.

Average Annual Functional Capacity Units (AAFCUs)
A quantitative result of annualizing Functional Capacity Unit (FCU) gains or losses across all years in the period of analysis.
AAFCUs = Cumulative FCUs ÷ Number of years in the life of the project, where:
Cumulative FCUs = Sum $(T_2 - T_1)[((A_1 F_1 + A_2 F_2) / 3) + ((A_2 F_1 + A_1 F_2) / 6)]$
and where:

T_1 = First Target Year time interval
T_2 = Second Target Year time interval
A_1 = Area of available wetland assessment area at beginning of T_1
A_2 = Area of available wetland assessment area at end of T_2
F_1 = FCI at beginning of T_1
F_2 = FCI at end of T_2

Baseline Condition
In the habitat assessment and planning analyses, baseline is the point in time before proposed changes, and is synonymous with Target Year (TY = 0).

Compensation
Also referred to as mitigation, in terms of wildlife habitat value loss, functional capacity loss, or environmental impacts, these are the methods or actions by which the inflicting agency or group offsets the unavoidable loss, of or damage to, these resources due to the proposed action.

Cost Effectiveness Analysis (CEA)
An economic analysis completed to determine the least-cost, economically rational, alternatives. Economically rational alternatives are, by definition, both the efficient and effective alternatives. The results of a cost effectiveness analysis are often displayed in tables, bar charts, and scatter plots.

Cover Type
A homogenous zone of similar vegetative species, geographic similarities, and physical conditions that make the area unique. In general, cover types are defined on the basis of species recognition and dependence.

Delimiting Situations
Occur when project manager's attempt to narrow the array of alternatives to a series of alternatives that meet certain restraining criteria. The project manager can eliminate the evaluation of costly alternatives and unproductive alternatives in cost analyses. For example, the project manager can declare an upper limit of costs—any alternative with a budget higher than this limit will be removed from further consideration. In this manner, project managers can limit the cost evaluation to alternatives that can be completed under the project's budget. Further, project managers can provide a minimum environmental productivity level. The cost analyses will "weed out" those alternatives that do not produce at least the minimal environmental output.

Dependent Alternatives
As a general rule, Dependent Alternatives cannot be implemented alone. Dependent Alternatives must be implemented in combination with their Independent Alternative to be successful. Dependent situations occur when the success of alternatives is contingent upon the presence of specific conditions (i.e., other alternatives) in the project. Often these situations arise when environmental, economic, and/or management factors reinforce one another to produce favorable outcomes. For example, the construction of a series of food plots on a high desert bench will require the installation of an irrigation system, or a channel/culvert system, connected to the nearest water source. The project manager will identify the food plot alternative as "dependent" upon either the irrigation system alternative, or the channel/culvert system alternative, on the basis of operation and management dependability.

Ecosystem
An ecosystem is a biotic community, together with its physical environment, considered as an integrated unit. Implied within this definition is the concept of a structural and functional whole, unified through life processes. Ecosystems are hierarchical, and can be viewed as nested sets of open systems in which physical, chemical, and biological processes form interactive subsystems. Some ecosystems are microscopic, and the largest comprises the biosphere. Ecosystem restoration can be directed at different-sized ecosystems within the nested set, and many encompass multi states, more localized watersheds or a smaller complex of aquatic habitat.

Effective Alternatives
When comparing alternatives, these alternatives produce increased levels of outputs (AAHUs from HEP or AAFCUs from HGM) for the same or lesser costs.

Efficient Alternatives
When comparing alternatives, these alternatives produced similar levels of output (AAHUs from HEP or AAFCUs from HGM) at a lesser expense.

Existing Condition
Also referred to as the Baseline Condition, the Existing Condition is the point in time before proposed changes, and is designated as Target Year TY = 0 in the analysis.

Field Data
In HGM, this information is collected on various parameters (i.e., variables) in the field, and from aerial photos, following defined, well-documented methodology. An example is the measurement of percent herbaceous cover, over 10 quadrats, within a riparian forest cover type. The values recorded are each considered "field data." Means of variables are applied to derive functional capacity indices.

Functional Capacity Index Model (FCI)
In the HGM, an FCI Model is a quantitative estimate of functional capacity for a wetland. The ideal goal of an FCI model is to quantify and produce an index that reflects functional capacity at the site. The results of an FCI analysis can be quantified on the basis of a standard 0-1.0 scale, where 0.00 represents low functional capacity for the wetland, and 1.0 represents high functional capacity for the wetland. An FCI model can be defined in words, or mathematical equations, that clearly describe the rules and assumptions necessary to combine functional capacity indices in a meaningful manner for the wetland.
For example:

$$FCI = (VSI\ V_1 * VSI\ V_2) / 4,$$

where:

$VSI\ V_1$ is the Variable Subindex (VSI) for

variable 1;

$VSI\ V_2$ is the VSI for variable 2

Functional Capacity Units (FCUs)
A quantitative environmental assessment value considered the biological currency in HGM. Functional Capacity Units are calculated by multiplying the area of available wetland (quantity) by the quality of the wetland based on functionality. Quality is determined by measuring limiting factors describing wetland function, and is represented by values derived from Functional Capacity Indices (FCIs). FCU = AREA X FCI.

Changes in FCUs represent potential impacts or improvements of proposed actions.

Future Factor (FF)
A unit of quality change, used to define the anticipated changes in mean field data, by target year, on a variable-per cover type basis, rather than on a species-by-species basis. FF values are multiplicative factors (1.0, 1.5, 0.5, etc.), directly multiplied against the mean baseline condition, to allow project managers an opportunity to forecast changes over time on the site or project. For example, if the project manager anticipates a 50 percent increase in height of grass in the grassland cover type between TY_0 and TY_1, the baseline FF = 1.0, and the increase is an additional FF = 0.5, thus the overall FF = 1.0 + 0.5 = 1.5. In most instances, FFs less than 1.0 represent decreases in quality at the site, and FFs greater than 1.0 represent increases in quality at the site. Of course, this change is dependent upon the relationship between the species, the function, the cover type or PWAA, and the suitability index/functional capacity index for the model.

Guild A group of functionally similar species with comparable habitat requirements whose members interact strongly with one another, but weakly with the remainder of the community. Often a species HSI model is selected to represent changes (impacts) to a guild.

Increment
In cost analyses, this term represents the change in cost divided, by the change in outputs between those solutions that survive the cost effectiveness filtration of alternatives. An increment then, is used to answer the question: "Is it worth it to take the next leap in cost?" Increments are displayed in bar charts and tabular reports.

Incremental Cost Analysis (ICA)
An economic analysis is completed to reveal and interpret changes in costs for increasing levels of outputs (e.g., AAHUs from HEP or AAFCUs from HGM). The results of an incremental cost analysis are often displayed in bar charts and tables.

Independent Alternatives
These alternatives can be implemented alone or in concert with their dependent alternatives.

Ineffective Alternatives
When comparing alternatives, these alternatives produce **reduced** levels of output (AAFCUs from HGM) for the same or greater costs.

Inefficient Alternatives When comparing alternatives, these alternatives produced **similar** levels of output (AAFCUs from HGM) at a greater expense.

Limiting Factor
A variable whose presence/absence directly restrains the existence of a species or community in a habitat. A deficiency of the limiting factor can reduce the quality of the

habitat for the species or community, while an abundance of the limiting factor can indicate an optimum quality of habitat for the same species or community.

Limits
See "Delimiting Situations."

Measure
The act of physically sampling variables such as height, distance, and percent and the methodology followed to gather variable information (i.e., see "Method" below). In some economic terms, a "measure" is considered a hierarchy of alternatives that can be subdivided further into scales or increments.

Method
In HGM applications, this is the mode/protocol followed to collect and gather field data. It is important to document the relevant criteria limiting the collection methodology. For example, the time of data collection, the type of techniques used, and the details of gathering this data should be documented as much as possible. An example of a method would be:
Between March and April, run five random 50-m transects through the relevant cover types. Every 10-m along the transect, place a 10-m2 quadrat on the right side of the transect tape and record the percent herbaceous cover within the quadrat. Average the results per transect.

Non-Additive Situations
These situations occur when the combination of alternatives results in non-cumulative outputs or costs. Often this condition arises when environmental, economic and/or management factors contradict summative outcomes. For example, if the implementation of two separate alternatives can save on mobilization and demobilization costs, the project manager can reduce the overall combined cost to reflect this savings. The solution is considered "non-additive." This information is included in the cost analyses.

Non-Combinable Situations
These situations occur when mutually exclusive alternatives exist in the project. Often this condition arises when environmental, economic and/or management factors contradict combinable outcomes. For example, the alternative "construction of a new highway through the Florida Everglades" will conflict with the alternative "preservation and enhancement of the existing wetlands, precluding any development." If the only alternatives are to provide protection to the wetlands, or build the highway, these two alternatives are deemed "non-combinable" on the basis of environmental incompatibility. This information is included in the cost analysis evaluations.

Partial Wetland Assessment Area (PWAA)
A homogenous zone of similar vegetative species, geographic similarities and physical conditions that make the area unique. In general, PWAAs are defined on the basis of species recognition and dependence, soils types and topography.

Plans of Interest
These situations occur when an outside qualitative factor directly influences the decision to implement an alternative, regardless of its environmental productivity or cost effectiveness. Several factors (i.e., political importance, aesthetic implications, environmental significance, community support, etc.) can compel decision-makers to evaluate alternatives that would have been eliminated under normal situations because of their ineffectiveness. For example, a "green belt" solution replacing a concrete channel through a business district might not be cost effective, or environmentally productive, but the co-sponsor (i.e., the local business association) can insist this alternative be evaluated as part of the project. This alternative is now considered a "Plan of Interest" alternative in cost analyses.

Project Manager
Any biologist, economist, hydrologist, engineer, decision maker, resource project manager, planner, environmental resource specialist, limnologist, etc., who is responsible for managing a study, program, or facility.

Relative Value Index Is a value that is used to adjust AAFCUs to accommodate social, economic, ecological, and political considerations? Judging criteria for relative values are defined by the decision-making team. Relative weights are calculated for each criterion, and then each evaluation model is rated against each criterion.
RVI = relative weight * value assigned to each evaluation model.

Relative Area
In HGM, the relative area is a mathematical process used to "weight" the various applicable cover types on the basis of quantity. To derive the relative area of a model's cover type, the following equation can be utilized:

Relative Area = Cover Type Area / Total Area

where:

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

Scale (1)
In some geographical methodologies, the scale is the defined size of the image in terms of miles per inch, feet per inch, or pixels per acres; (2) scale can also refer to variations of the alternative in some cost analysis software packages.

Single Formula Model
Is an FCI model in HGM that is based on the existence of a single wetland function requirement and a single formula is used to depict the functional capacity.

Site

The location upon which the project manager will take action, evaluate alternatives and focus cost analysis.

Solutions
In cost analysis, this is the alternative (see definition above.)

Spreadsheet
A type of computer file or page that allows the organization of data (alpha-numeric information) in a tabular format. Spreadsheets are often used to complete accounting/economic exercises.

Target Year (TY)
A unit of time measurement used in HEP, that allows the project manager to anticipate and direct significant changes (in area or quality) within the project (or site). As a rule, the baseline TY is always TY = 0, where the baseline year is defined as a point in time before proposed changes would be implemented. As a second rule, there must always be a TY = 1, and a TY = X_2. TY_1 is the first year land- and water-use conditions are expected to deviate from baseline conditions. TY_{X2} designates the ending target year. A new target year must be assigned for each year the project manager intends to develop or evaluate change within the site or project. The habitat conditions (quality and quantity) described for each TY are the expected conditions at the end of that year. It is important to maintain the same target years in both the environmental and economic analyses.

Trade-offs
Are used to adjust the AAFCUs by considering human values. There are no right or proper answers, only acceptable ones. If trade-offs are used, outputs are no longer directly related to optimum habitat.

Variable
A measurable parameter that can be quantitatively described, with some degree of repeatability, using standard field sampling and mapping techniques. Often, the variable is a limiting factor for a species (or community), used in the development of SI curves and measured in the field (or from aerial photos) by personnel, to fulfill the requirements of field data collection in a HGM application. Some examples of variables include height of grass, percent canopy cover, distance to water, number of snags in 0.4 hectare, or average annual water temperature.

Variable Subindex (VSI)
In HGM, a VSI is a mathematical equation that reflects a wetland function's sensitivity to a change in a limiting factor (i.e., variable) within the PWAA. In HGM, VSIs are depicted using scatter plots and bar charts (i.e., functional capacity curves). The VSI value (Y-axis) ranges on a scale from 0.0 to 1.0, where a VSI = 0.0 represents a variable that is extremely limiting and a VSI = 1.0 represents a variable in abundance (not

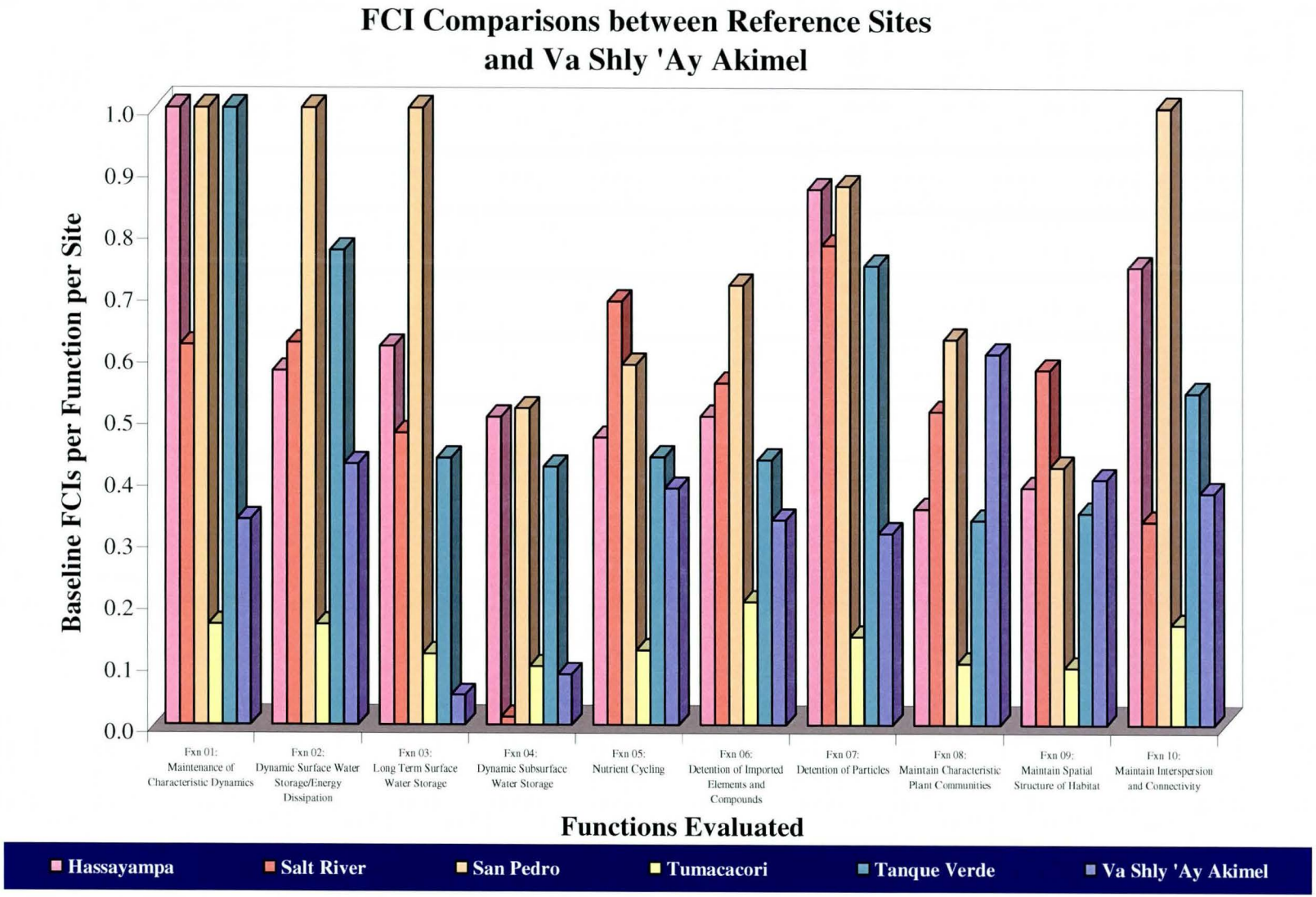
limiting) for the wetland.

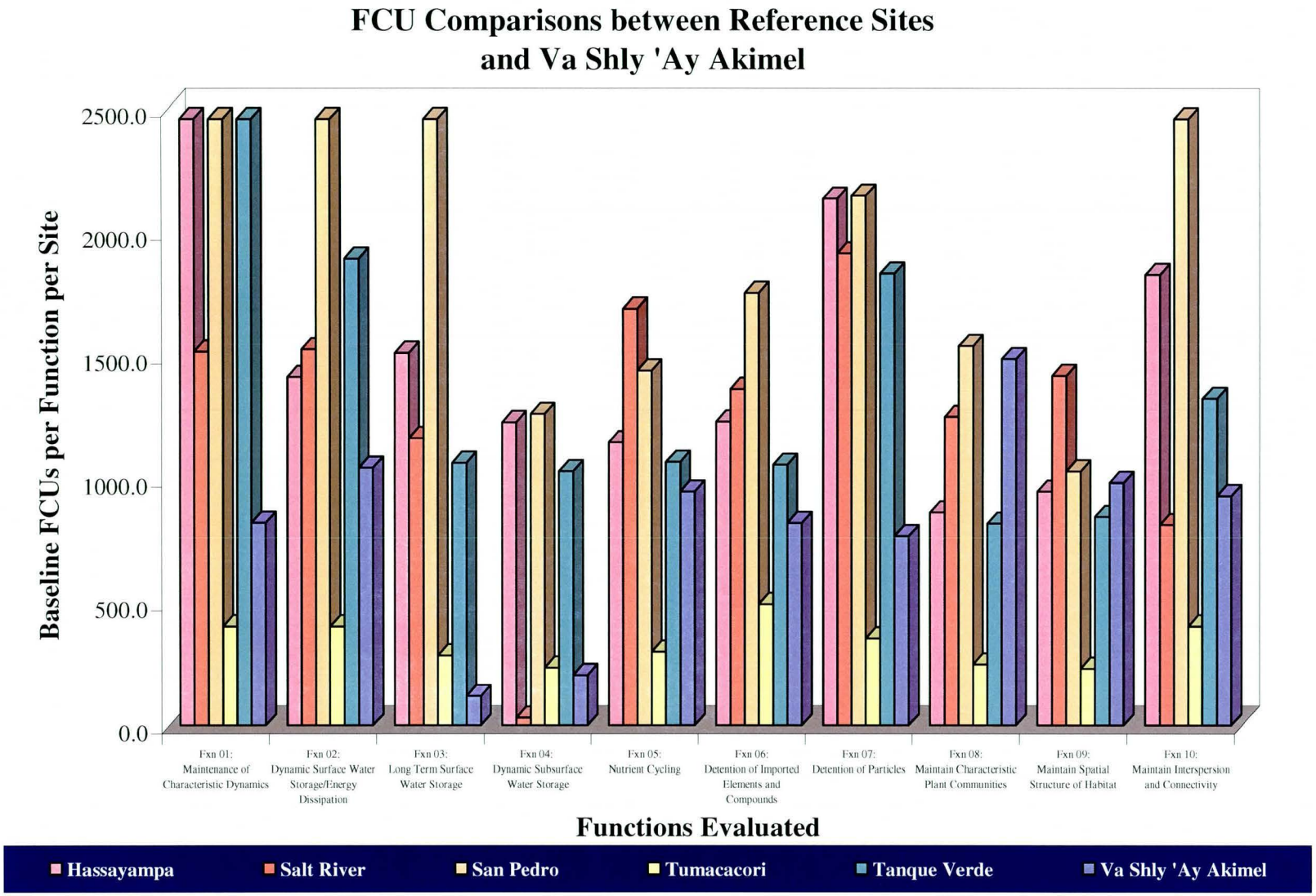
With Project Condition
Also referred to as the alternative, this is the condition of the site after an alternative is implemented.

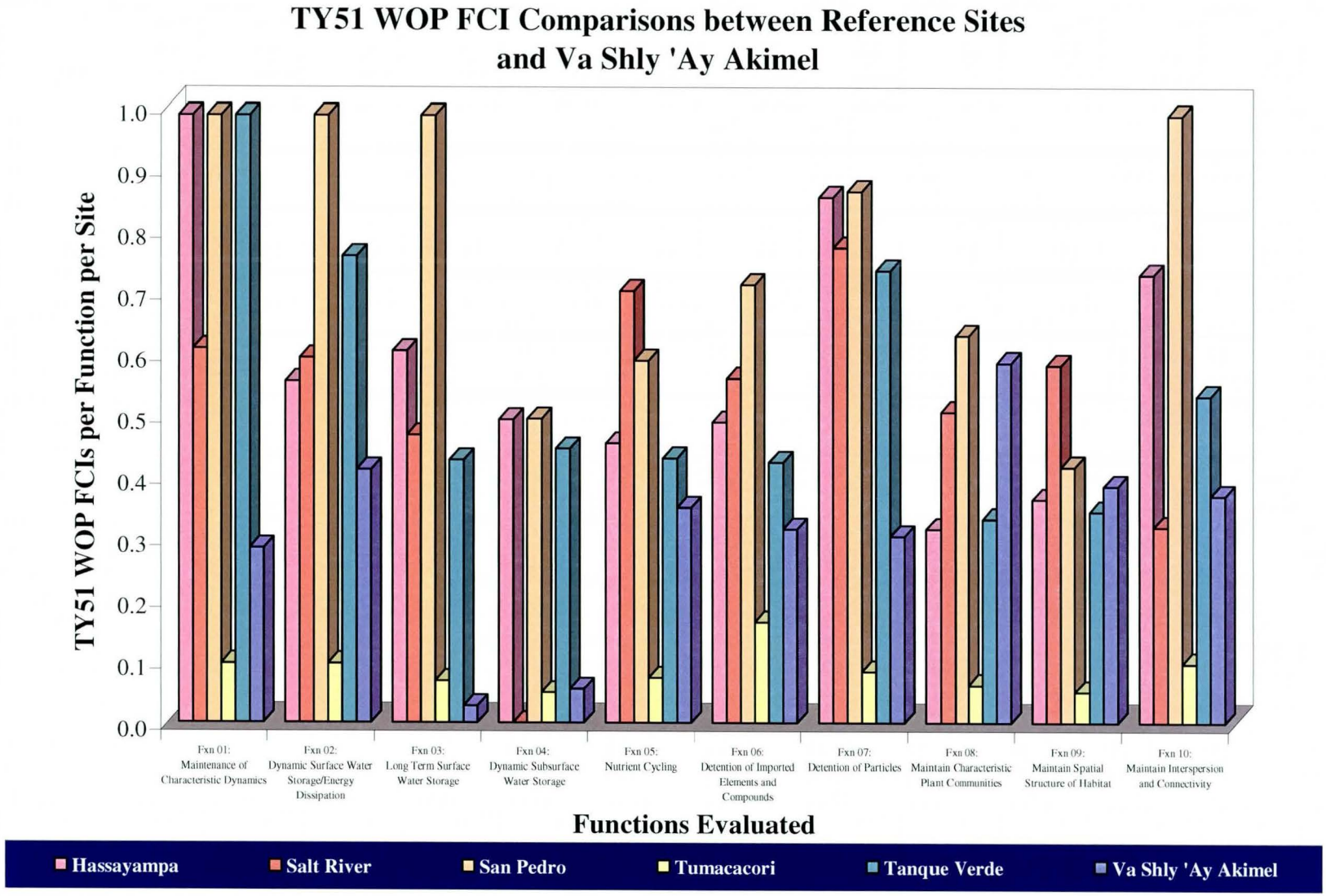
Without Project Condition
Sometimes referred to as the Baseline condition, or the Existing condition, this is the expected condition of the site without implementation of an alternative; referred to as the "No Action" condition in planning studies. The habitat conditions at TY 0 always refer to the pre-existing conditions.

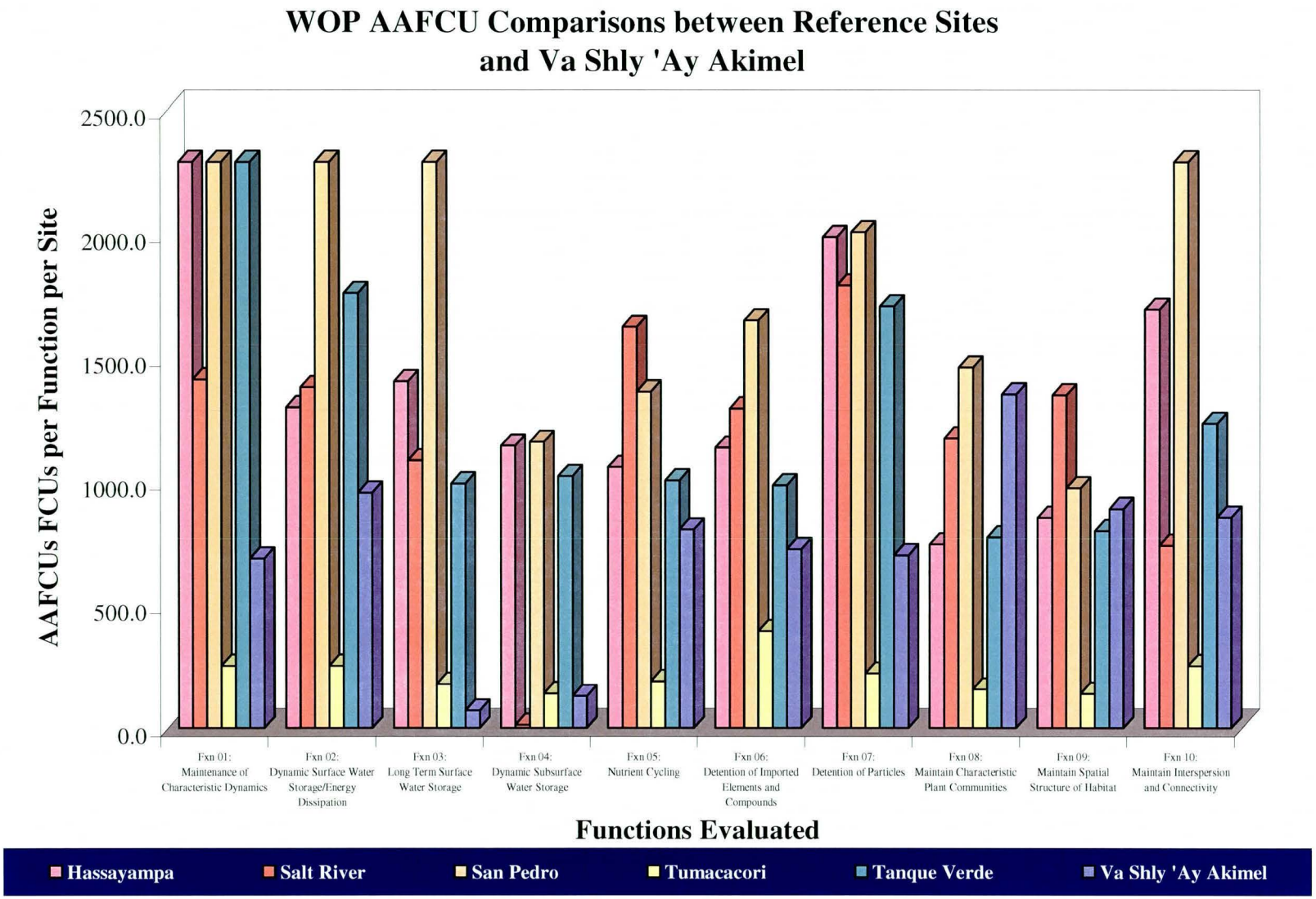
Va Shly'ay Akimel HGM Appendices

Appendix A – Va Shly'ay Akimel Versus Reference Sites Baseline FCIs & TY 51 WOP FCUs & AAFCUs

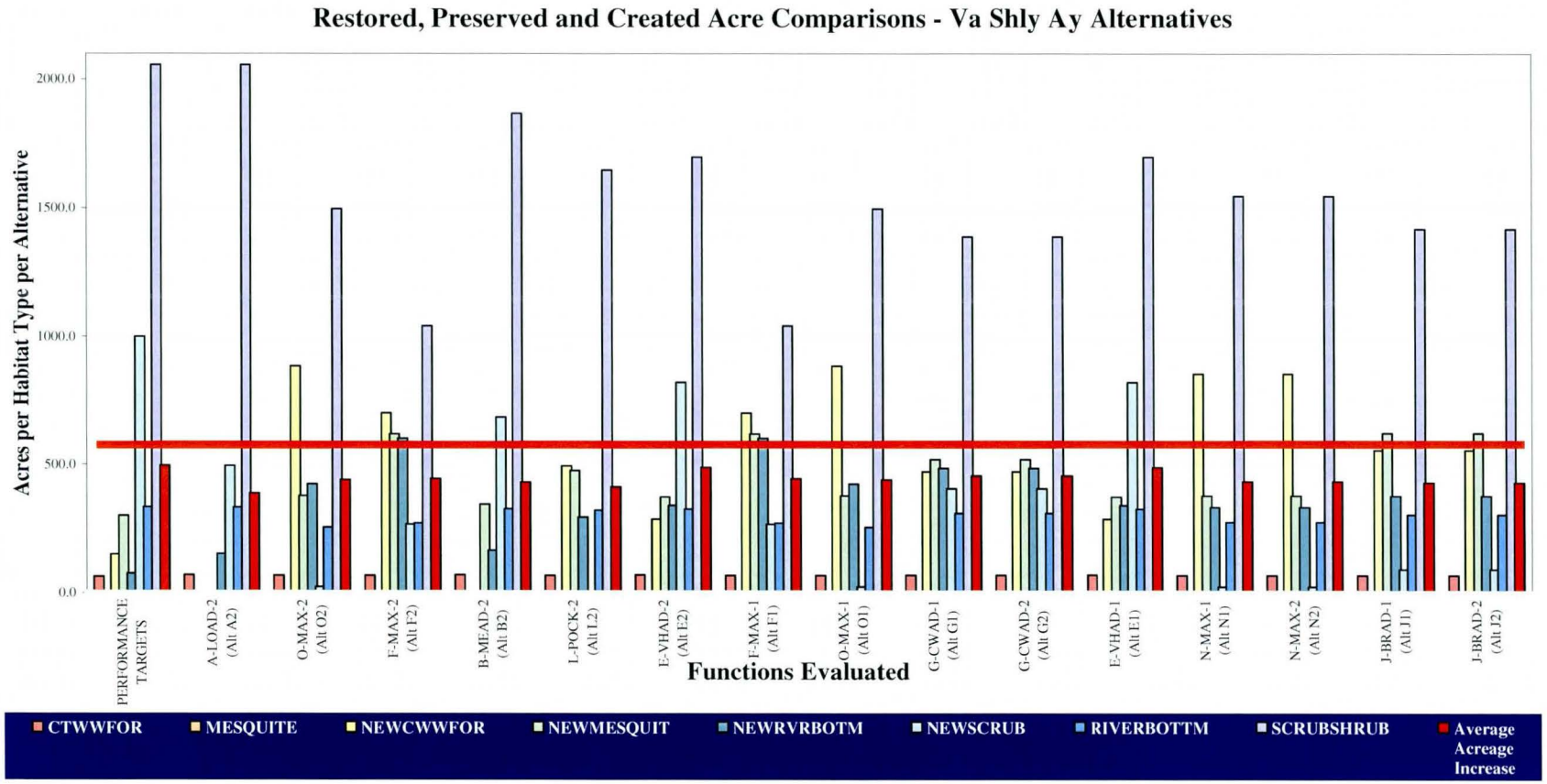

FCI Comparisons between Reference Sites and Va Shly 'Ay Akimel
Baseline FCIs per Function per Site
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functions Evaluated
Hassayampa
Salt River
San Pedro
Tumacacori
Tanque Verde
Va Shly 'Ay Akimel


FCU Comparisons between Reference Sites and Va Shly 'Ay Akimel
Baseline FCUs per Function per Site
2500.0
2000.0
1500.0
1000.0
500.0
0.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functions Evaluated
Hassayampa
Salt River
San Pedro
Tumacacori
Tanque Verde
Va Shly 'Ay Akimel

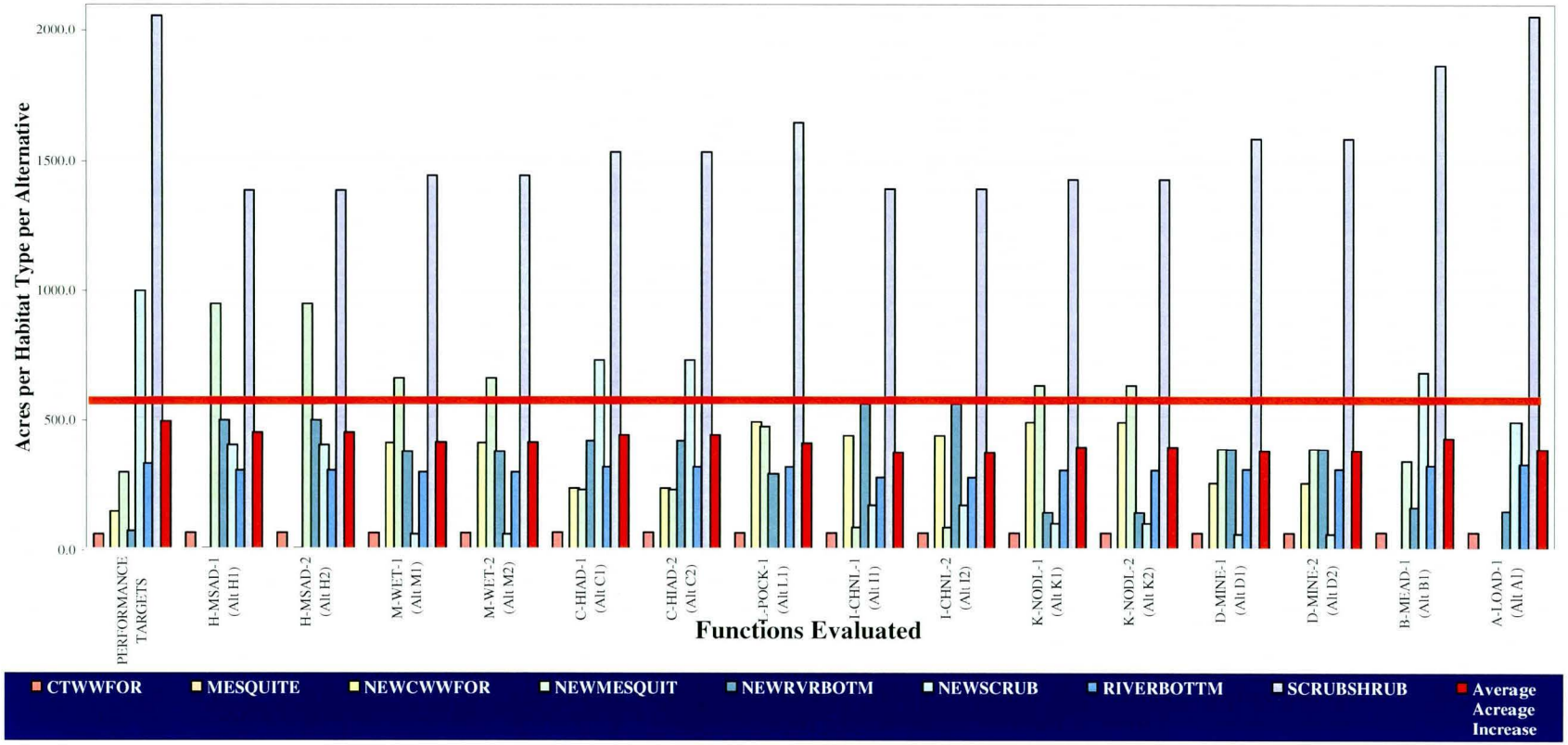

TY51 WOP FCI Comparisons between Reference Sites and Va Shly 'Ay Akimel
TY51 WOP FCIs per Function per Site
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functions Evaluated
Hassayampa
Salt River
San Pedro
Tumacacori
Tanque Verde
Va Shly 'Ay Akimel


WOP AAFCU Comparisons between Reference Sites and Va Shly 'Ay Akimel
AAFCUs FCUs per Function per Site
2500.0
2000.0
1500.0
1000.0
500.0
0.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functions Evaluated
Hassayampa
Salt River
San Pedro
Tumacacori
Tanque Verde
Va Shly 'Ay Akimel

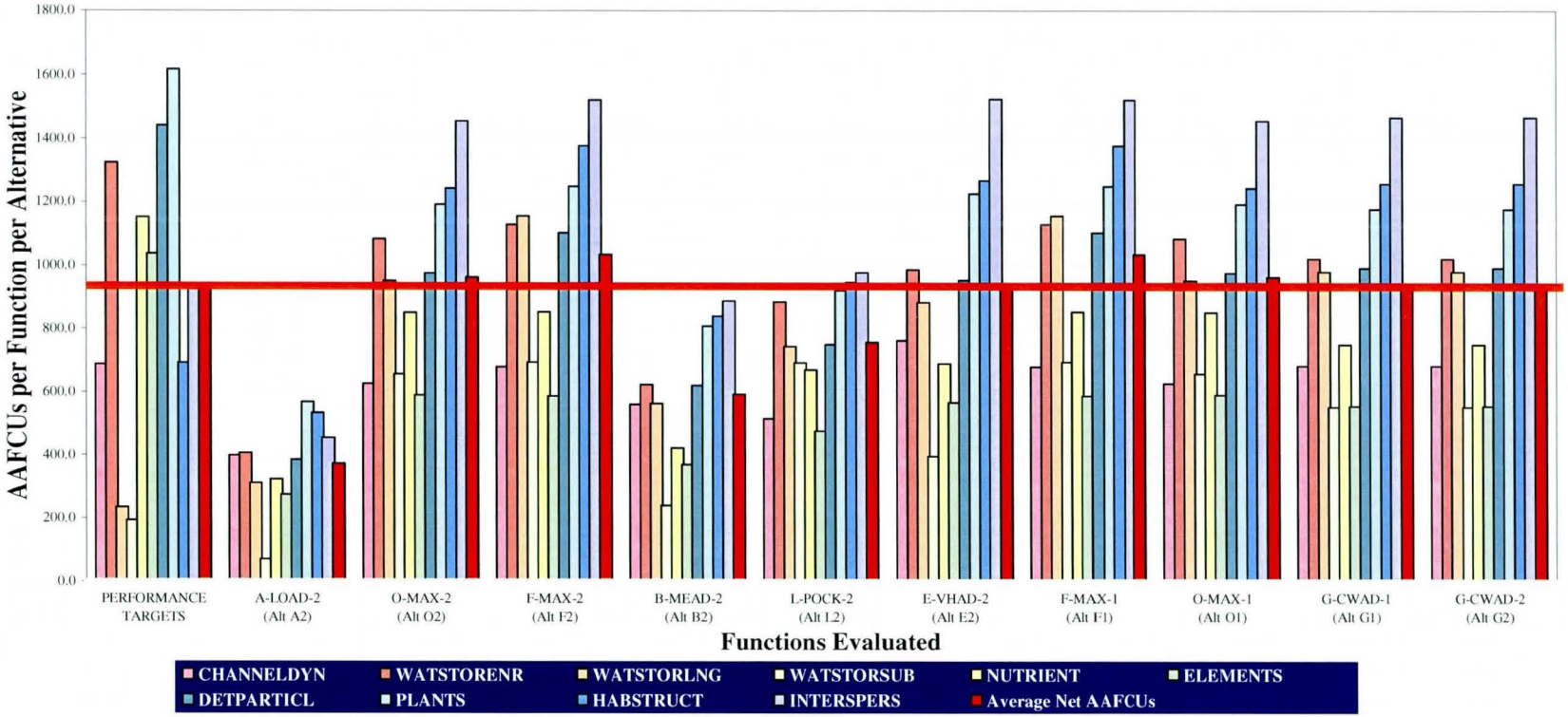
Appendix B – Va Shly'ay Akimel Performance Targets


Restored, Preserved and Created Acre Comparisons - Va Shly Ay Alternatives
Acres per Habitat Type per Alternative
2000.0
1500.0
1000.0
500.0
0.0
PERFORMANCE TARGETS
A-LOAD-2 (Alt A2)
O-MAX-2 (Alt O2)
F-MAX-2 (Alt F2)
B-MEAD-2 (Alt B2)
L-POCK-2 (Alt L2)
E-VHAD-2 (Alt E2)
F-MAX-1 (Alt F1)
O-MAX-1 (Alt O1)
G-CWAD-1 (Alt G1)
G-CWAD-2 (Alt G2)
E-VHAD-1 (Alt E1)
N-MAX-1 (Alt N1)
N-MAX-2 (Alt N2)
J-BRAD-1 (Alt J1)
J-BRAD-2 (Alt J2)
Functions Evaluated
CTWWFOR
MESQUITE
NEWCWWFOR
NEWMESQUIT
NEWRVRBOTM
NEWSCRUB
RIVERBOTTM
SCRUBSHRUB
Average Acreage Increase

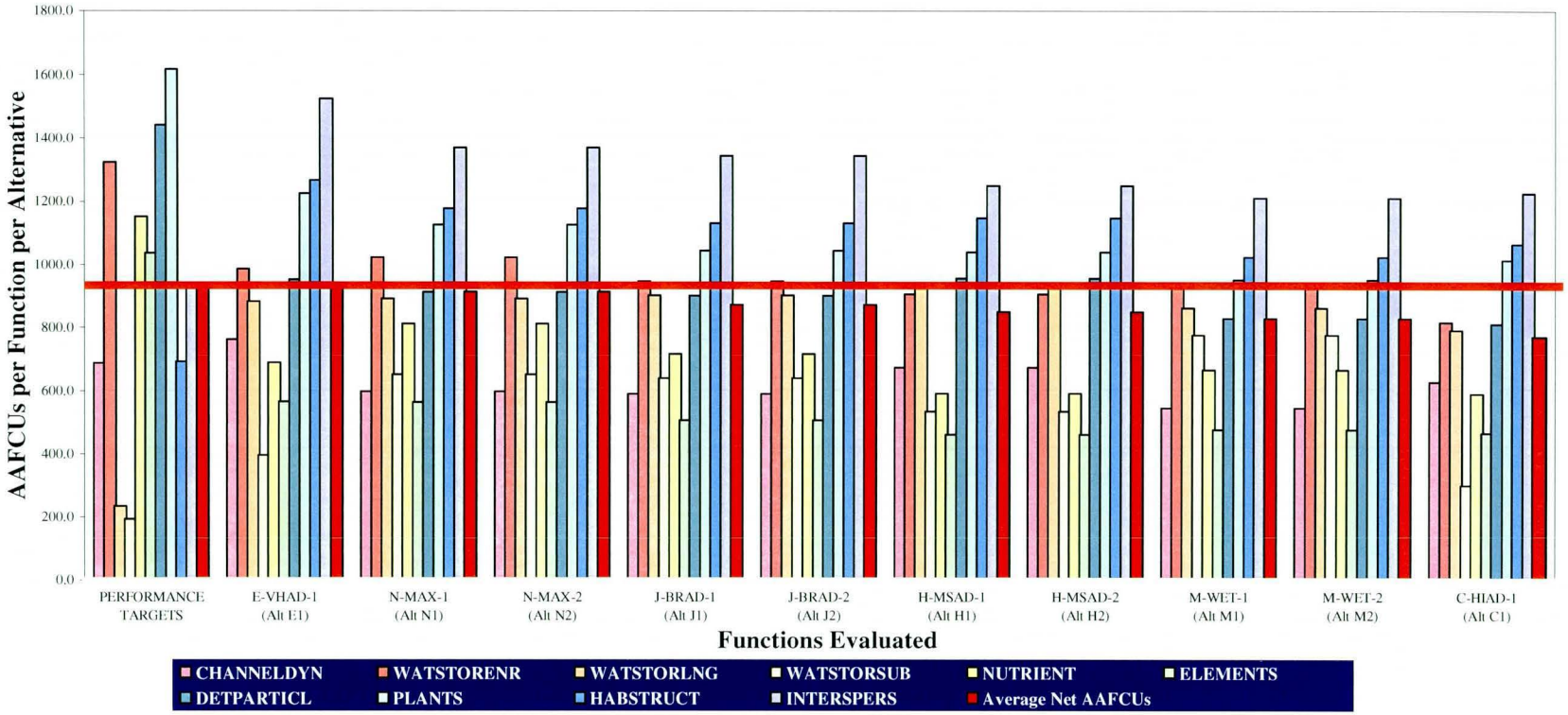
Restored, Preserved and Created Acre Comparisons - Va Shly Ay Alternatives



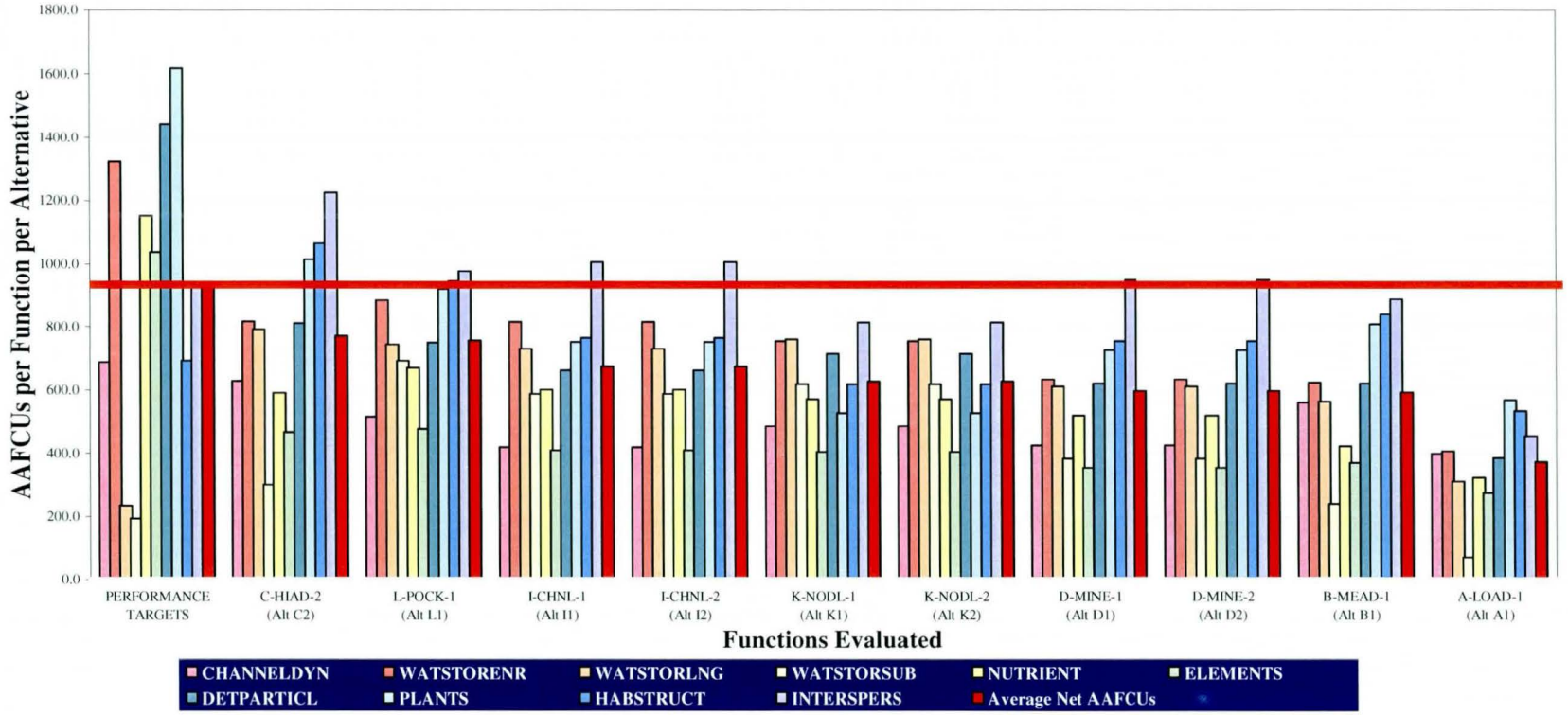
Restored, Preserved and Created Functional Output Comparisons - Va Shly Ay Alternatives

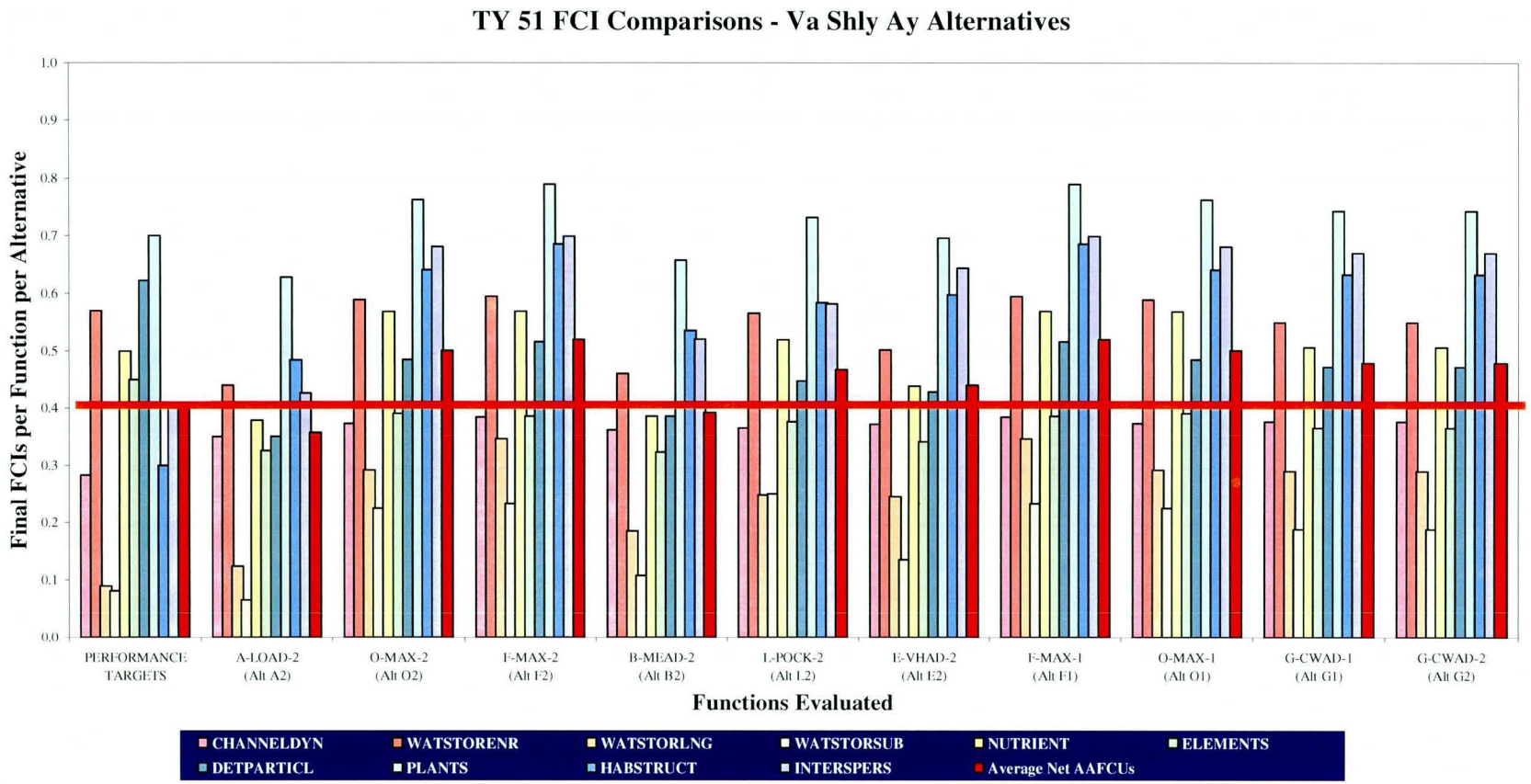


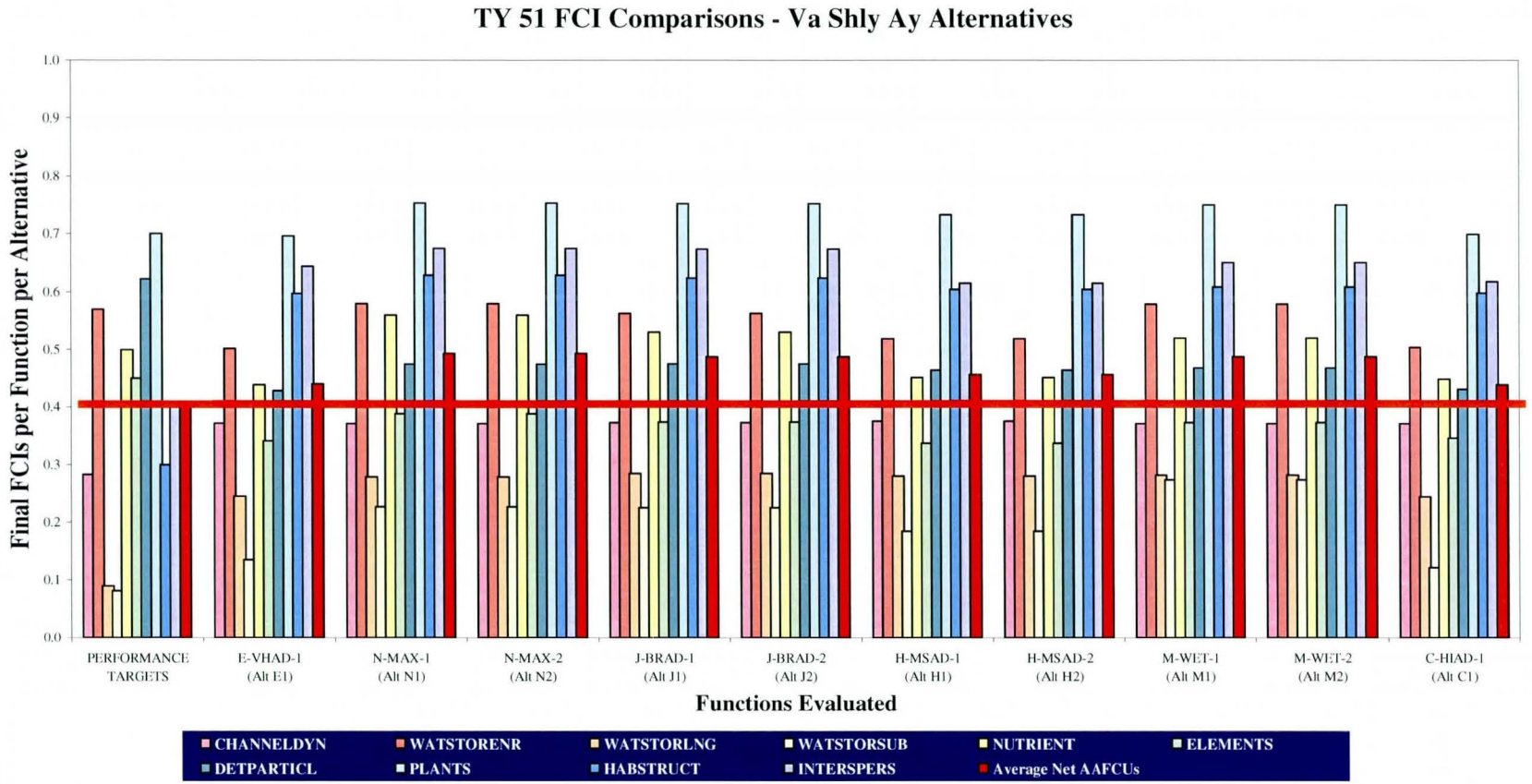
Restored, Preserved and Created Functional Output Comparisons - Va Shly Ay Alternatives

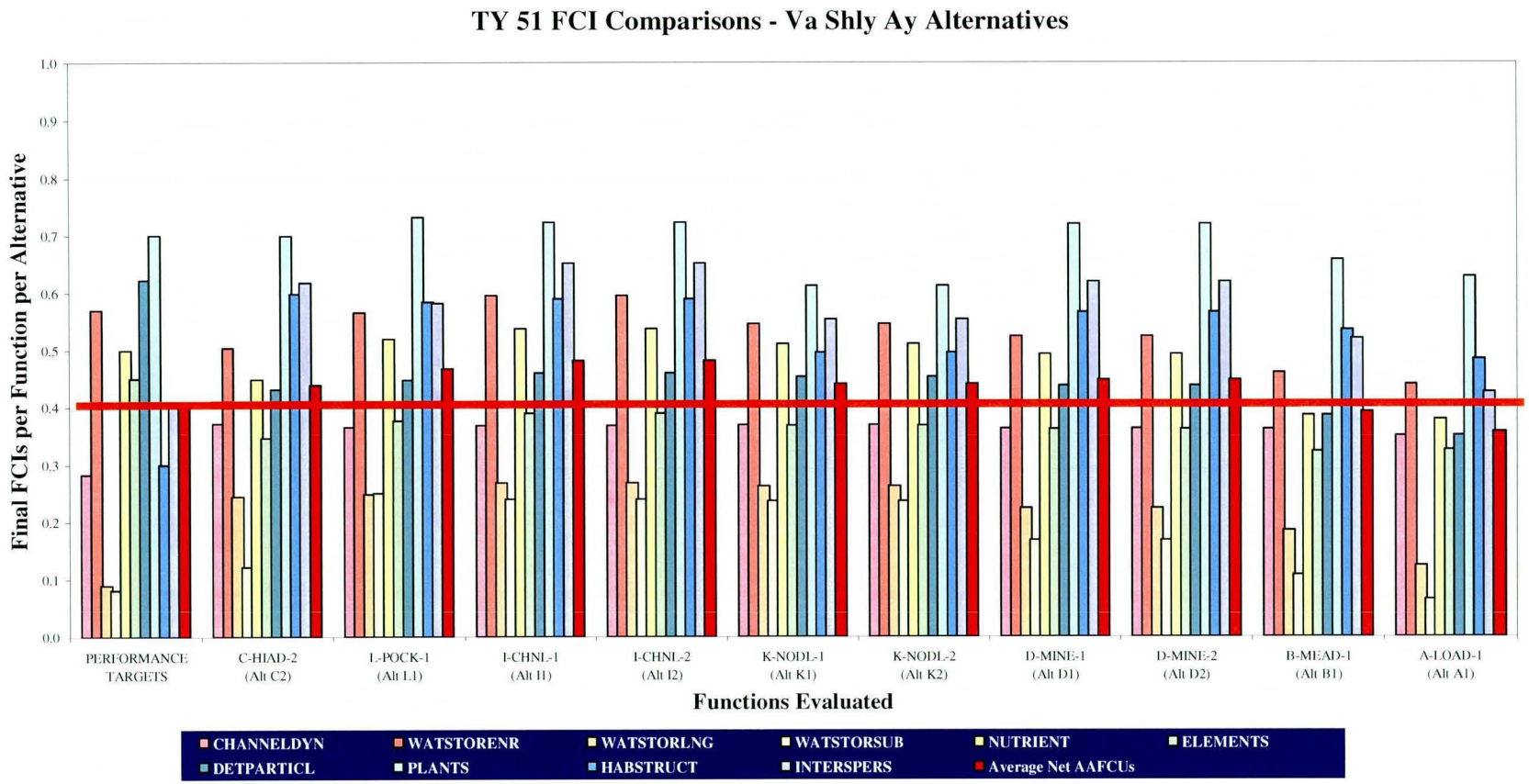


Restored, Preserved and Created Functional Output Comparisons - Va Shly Ay Alternatives

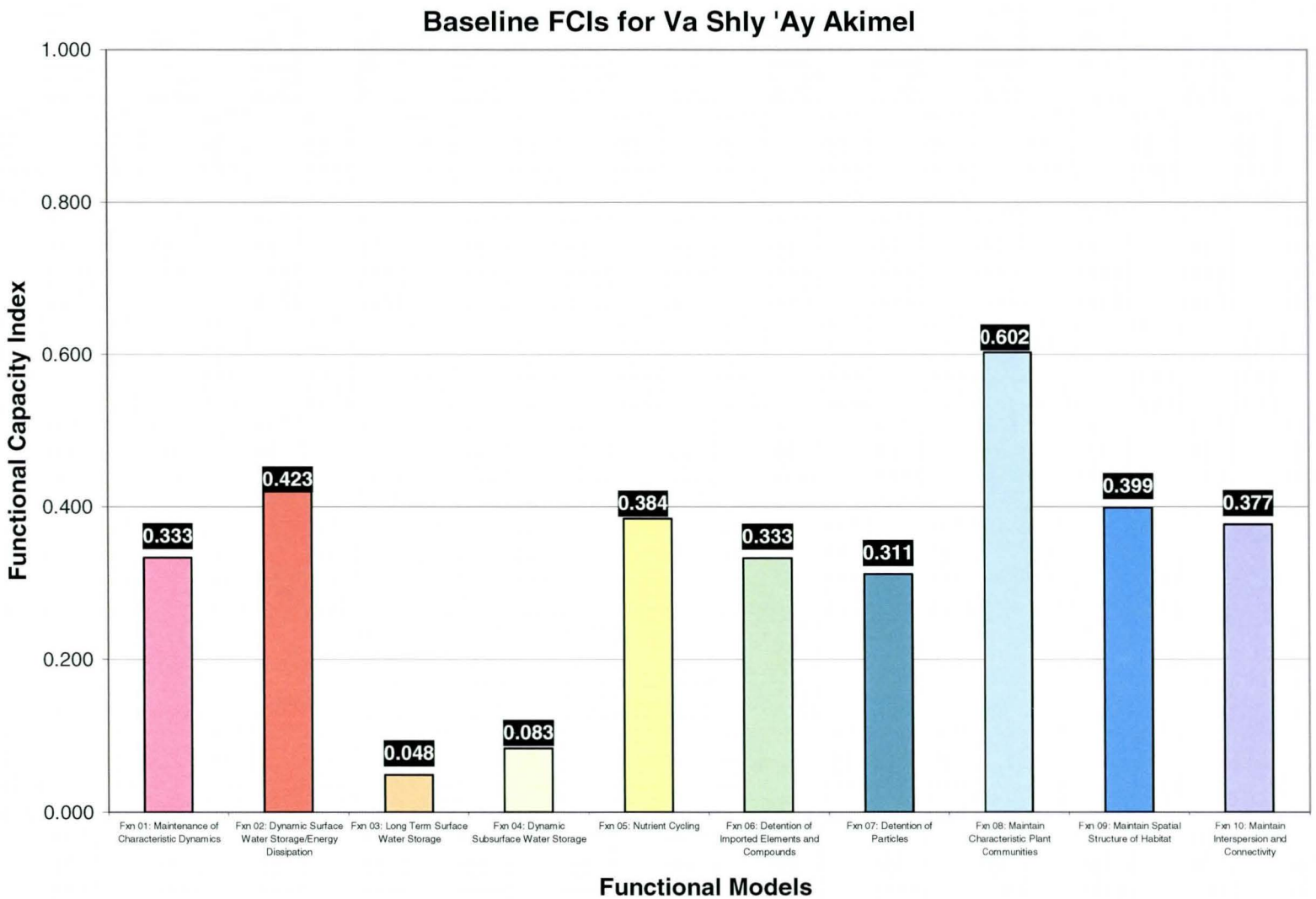


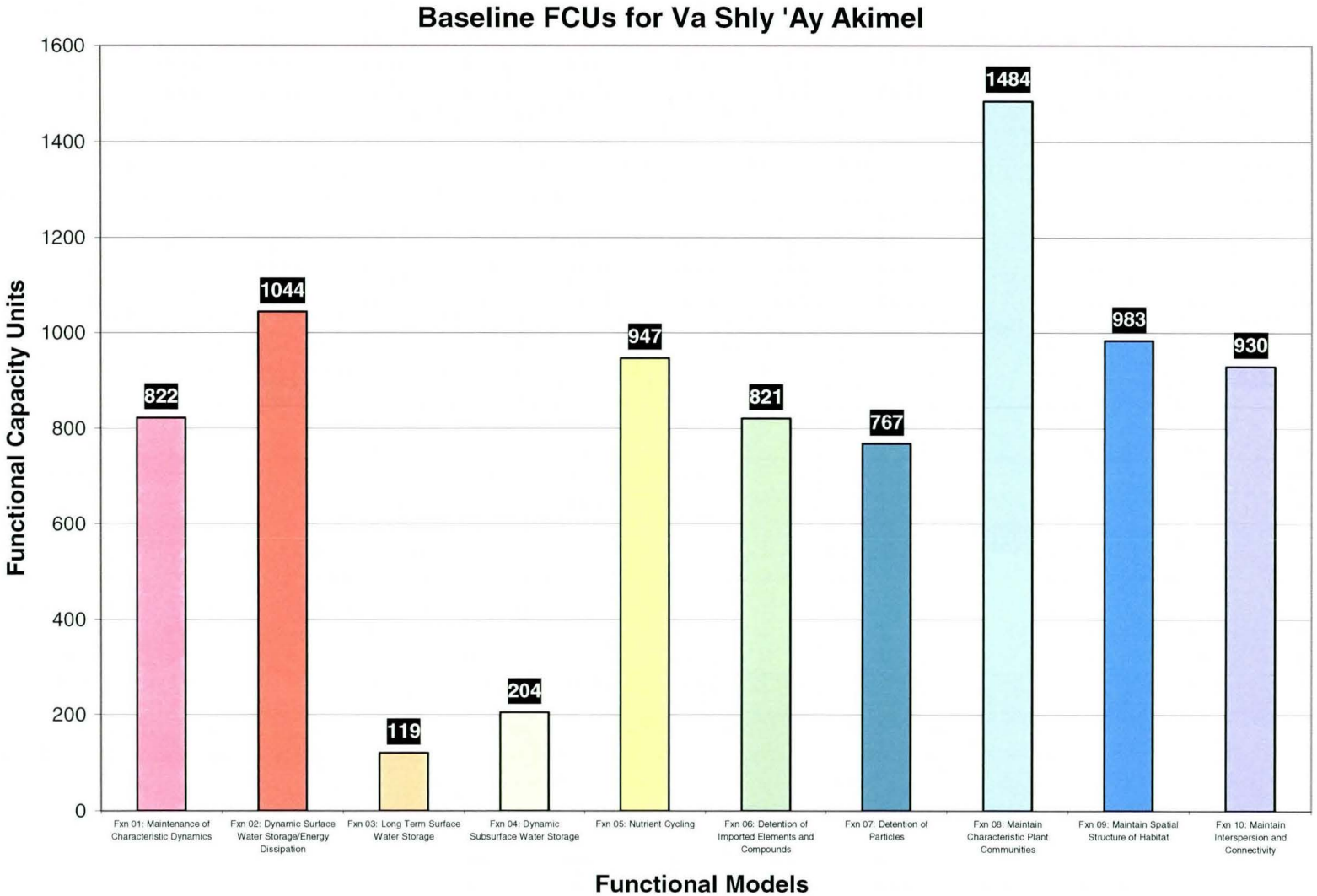

TY 51 FCI Comparisons - Va Shly Ay Alternatives
Final FCIs per Function per Alternative
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PERFORMANCE TARGETS
A-LOAD-2 (Alt A2)
O-MAX-2 (Alt O2)
F-MAX-2 (Alt F2)
B-MEAD-2 (Alt B2)
L-POCK-2 (Alt L2)
E-VHAD-2 (Alt E2)
F-MAX-1 (Alt F1)
O-MAX-1 (Alt O1)
G-CWAD-1 (Alt G1)
G-CWAD-2 (Alt G2)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORLNG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

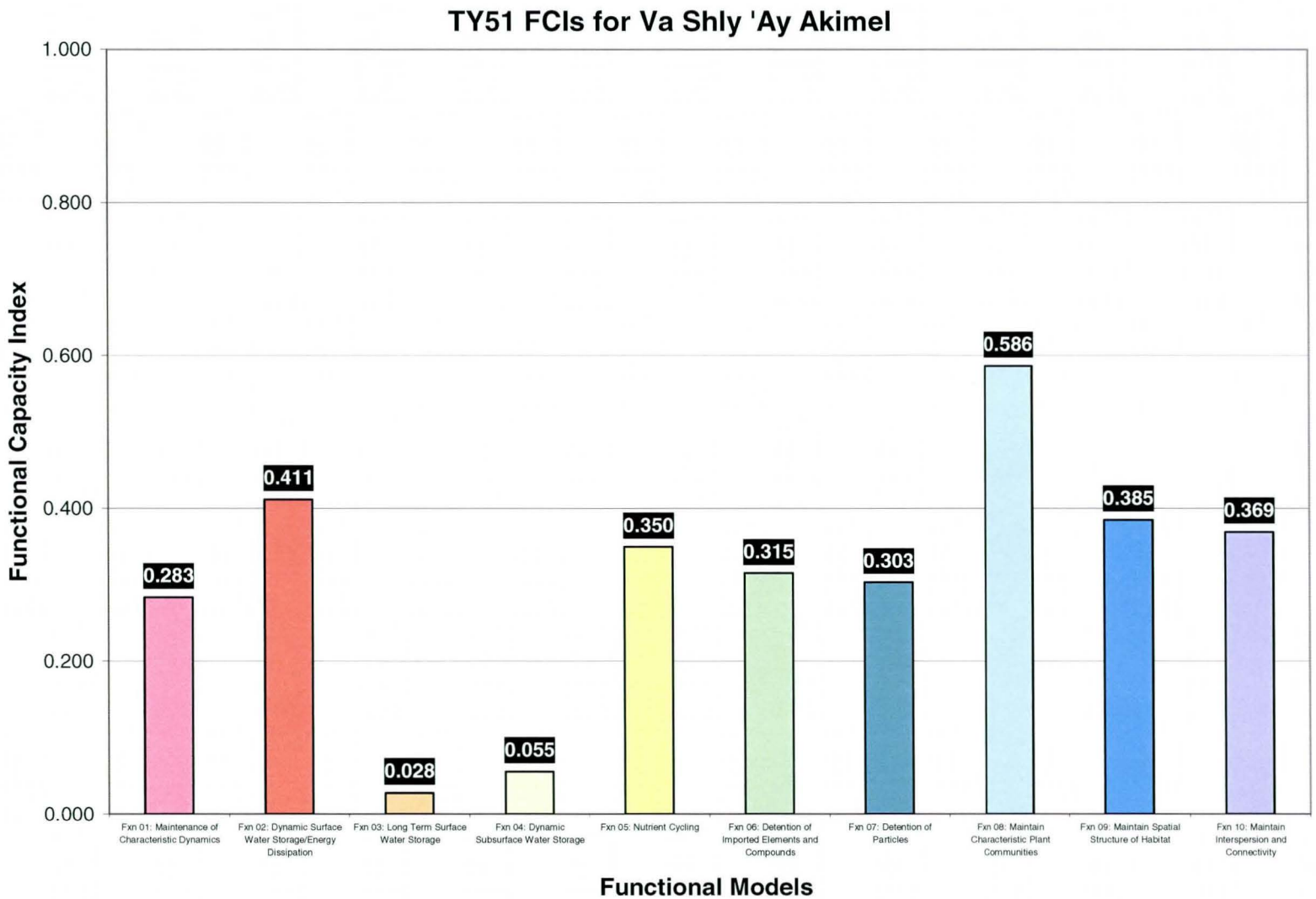

TY 51 FCI Comparisons - Va Shly Ay Alternatives
Final FCIs per Function per Alternative
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PERFORMANCE TARGETS
E-VHAD-1 (Alt E1)
N-MAX-1 (Alt N1)
N-MAX-2 (Alt N2)
J-BRAD-1 (Alt J1)
J-BRAD-2 (Alt J2)
H-MSAD-1 (Alt H1)
H-MSAD-2 (Alt H2)
M-WET-1 (Alt M1)
M-WET-2 (Alt M2)
C-HIAD-1 (Alt C1)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORLNG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

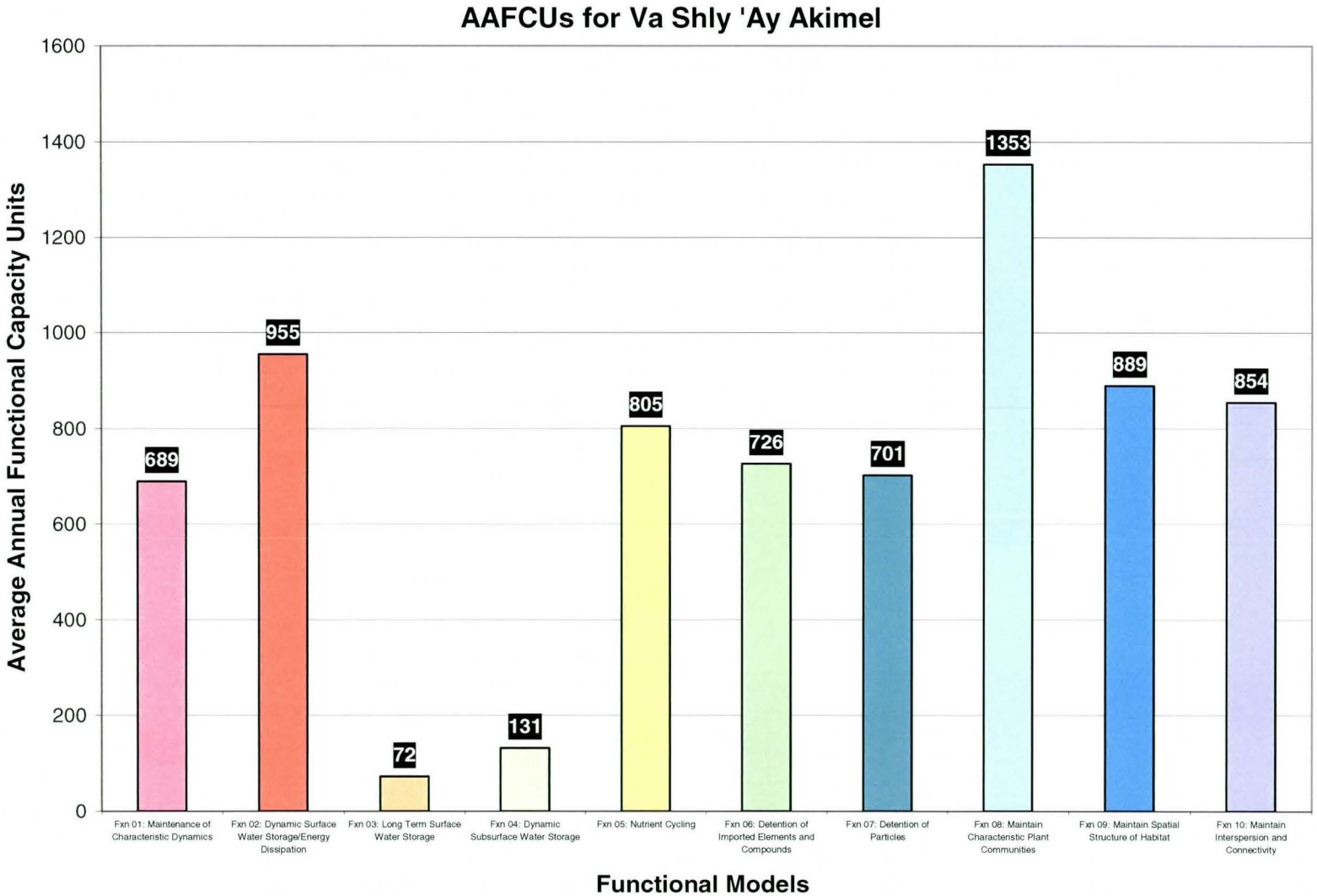

TY 51 FCI Comparisons - Va Shly Ay Alternatives
Final FCIs per Function per Alternative
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PERFORMANCE TARGETS
C-HIAD-2 (Alt C2)
L-POCK-1 (Alt L1)
I-CHNL-1 (Alt I1)
I-CHNL-2 (Alt I2)
K-NODL-1 (Alt K1)
K-NODL-2 (Alt K2)
D-MINE-1 (Alt D1)
D-MINE-2 (Alt D2)
B-MEAD-1 (Alt B1)
A-LOAD-1 (Alt A1)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORLNG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

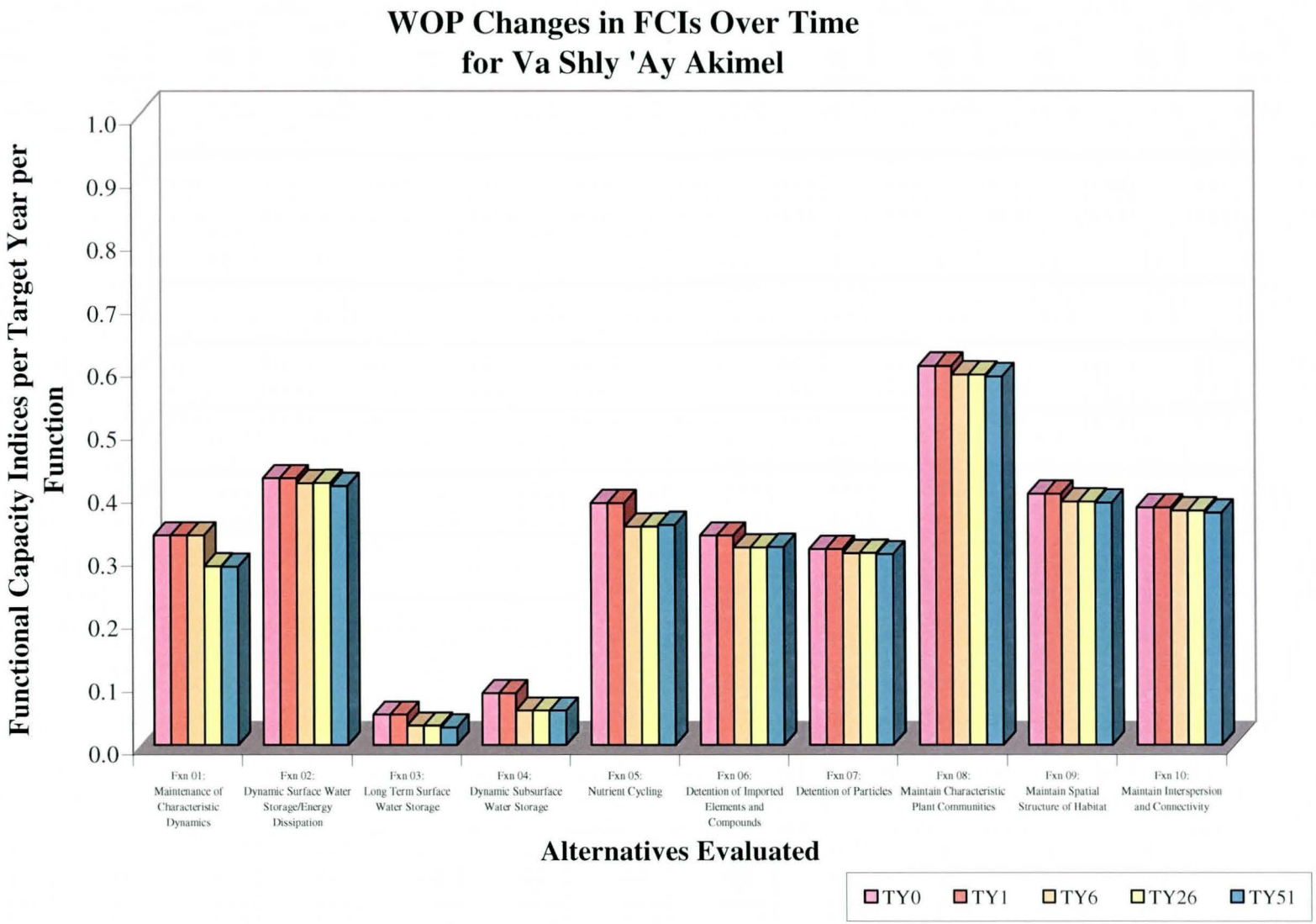
Appendix C – Va Shly'ay Akimel Without Project Results

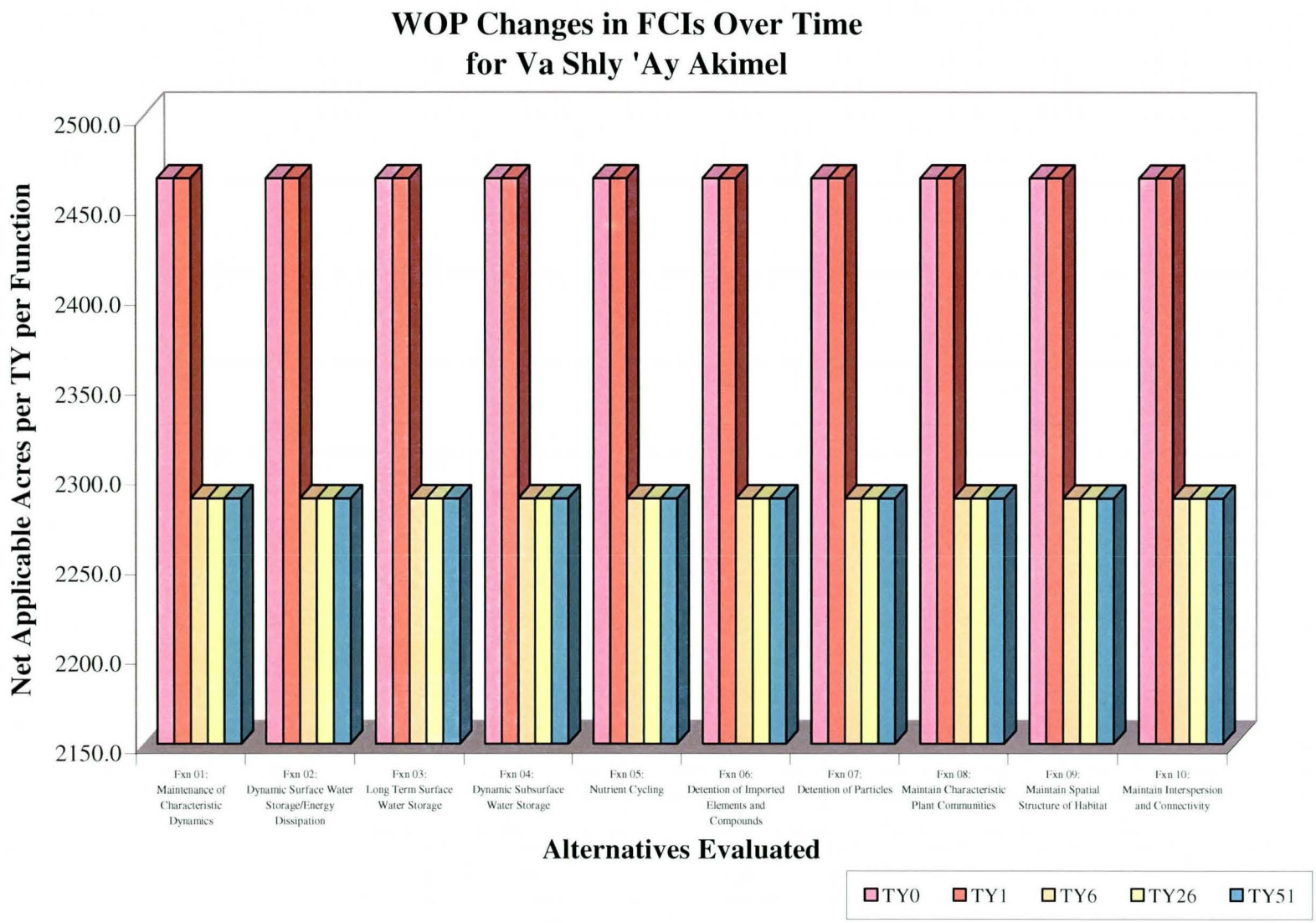

Baseline FCIs for Va Shly 'Ay Akimel
Functional Capacity Index
1.000
0.800
0.600
0.400
0.200
0.000
0.333
0.423
0.048
0.083
0.384
0.333
0.311
0.602
0.399
0.377
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models


Baseline FCUs for Va Shly 'Ay Akimel
Functional Capacity Units
1600
1400
1200
1000
800
600
400
200
0
822
1044
119
204
947
821
767
1484
983
930
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models

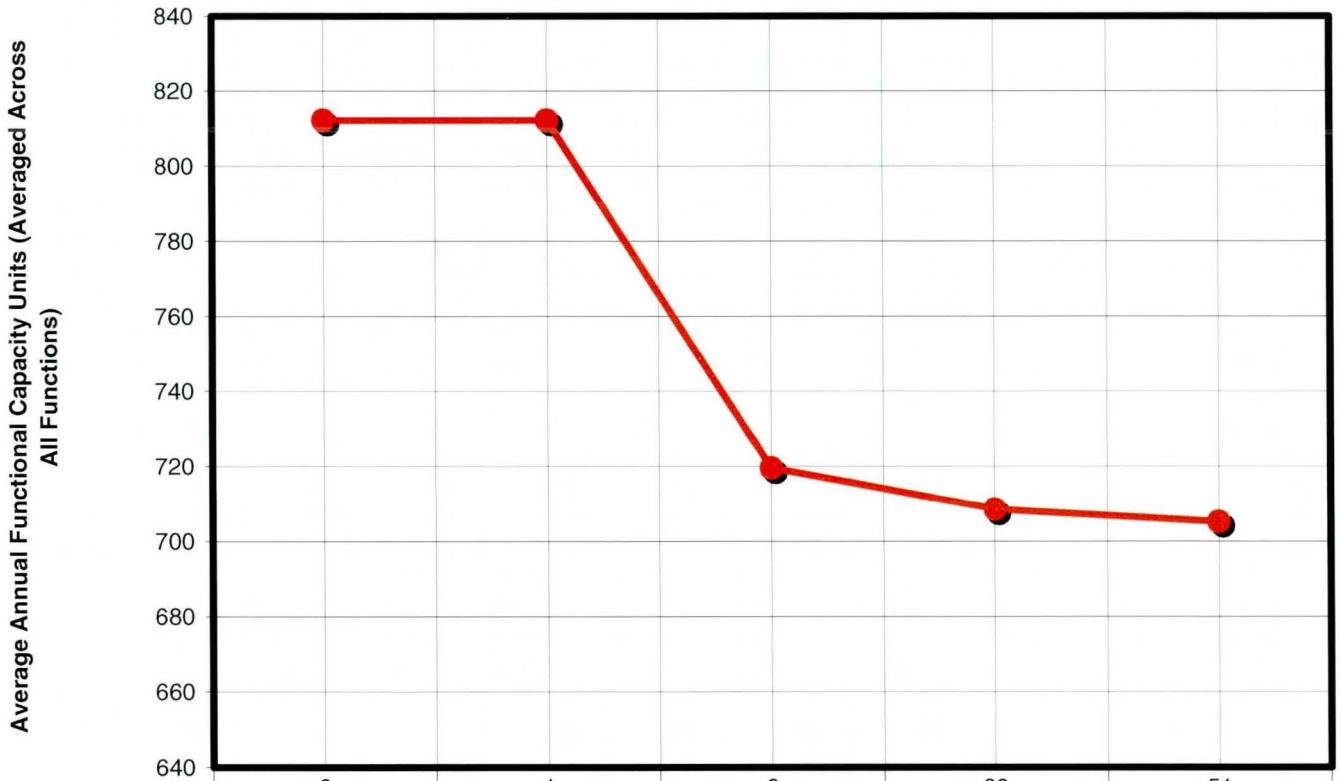

TY51 FCIs for Va Shly 'Ay Akimel
Functional Capacity Index
1.000
0.800
0.600
0.400
0.200
0.000
0.283
0.411
0.028
0.055
0.350
0.315
0.303
0.586
0.385
0.369
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models


AAFCUs for Va Shly 'Ay Akimel
Average Annual Functional Capacity Units
1600
1400
1200
1000
800
600
400
200
0
689
955
72
131
805
726
701
1353
889
854
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models


WOP Changes in FCIs Over Time
for Va Shly 'Ay Akimel
Functional Capacity Indices per Target Year per Function
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Alternatives Evaluated
TY0
TY1
TY6
TY26
TY51


WOP Changes in FCIs Over Time
for Va Shly 'Ay Akimel
Net Applicable Acres per TY per Function
2500.0
2450.0
2400.0
2350.0
2300.0
2250.0
2200.0
2150.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Alternatives Evaluated
TY0
TY1
TY6
TY26
TY51

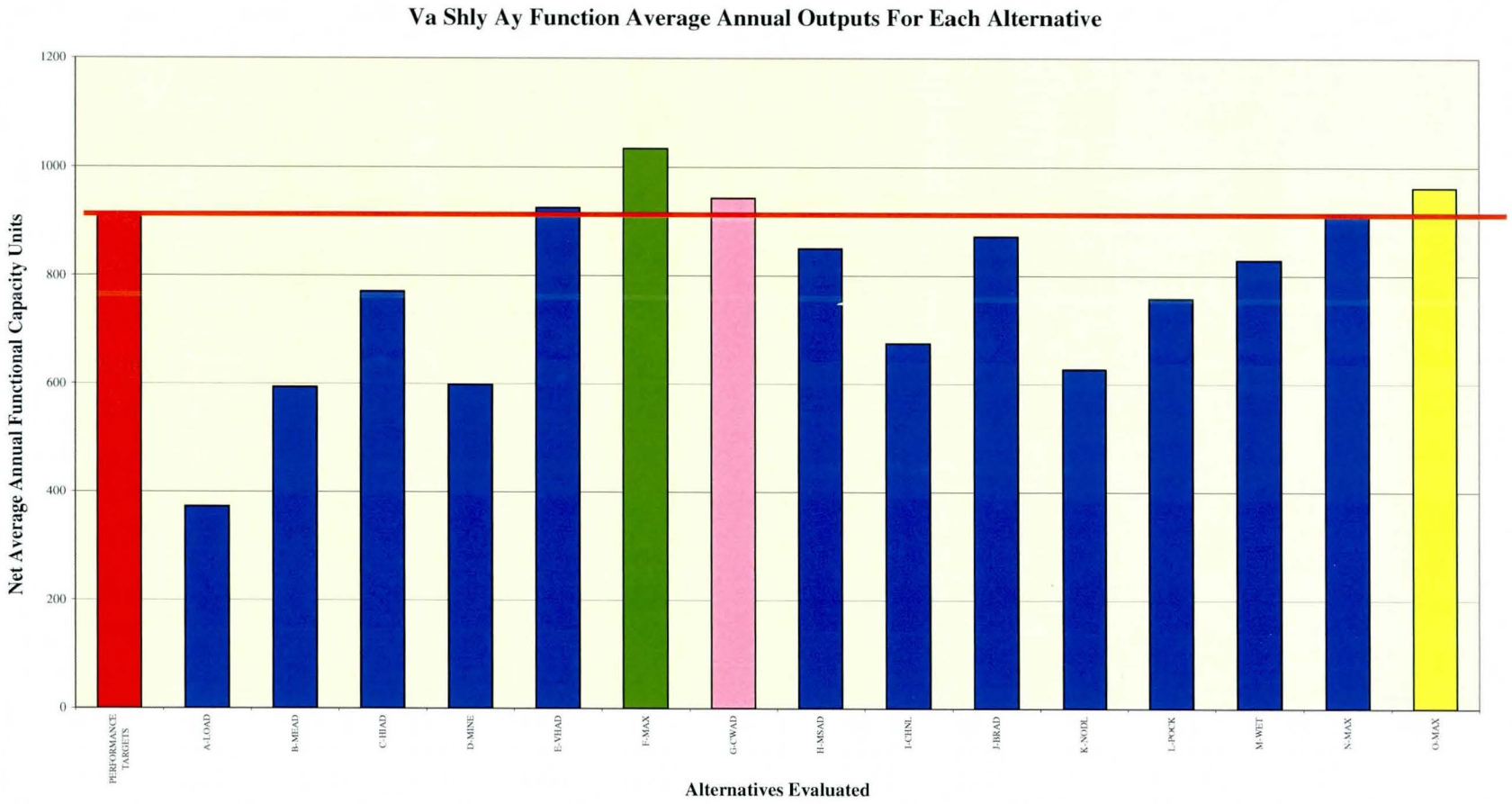
Trend in Average Annual Functional Capacity Units (AAFCUs) Without Project Conditions Only



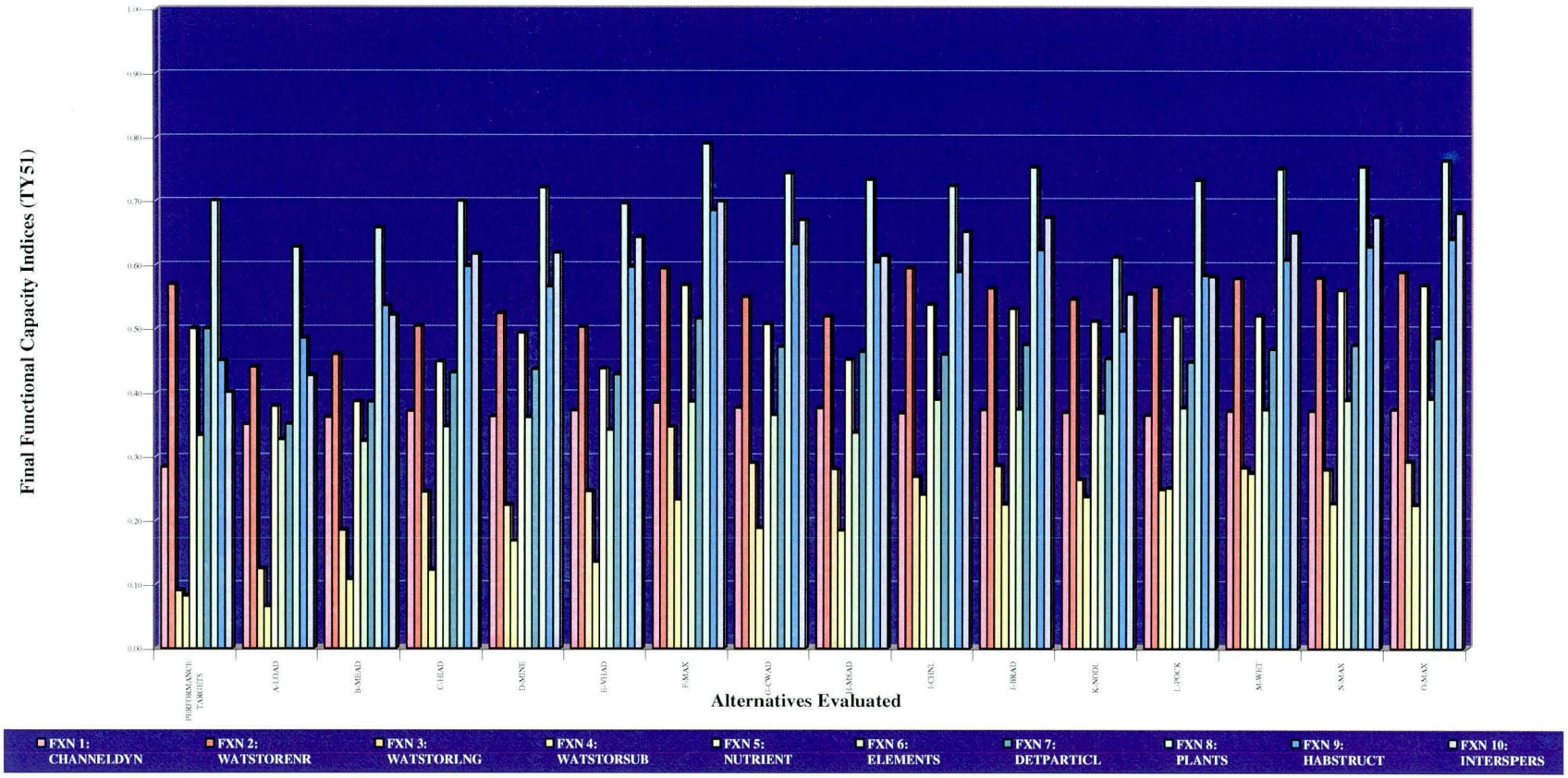
	0	1	6	20	51
Future Without Project	812	812	720	709	705

Target Years

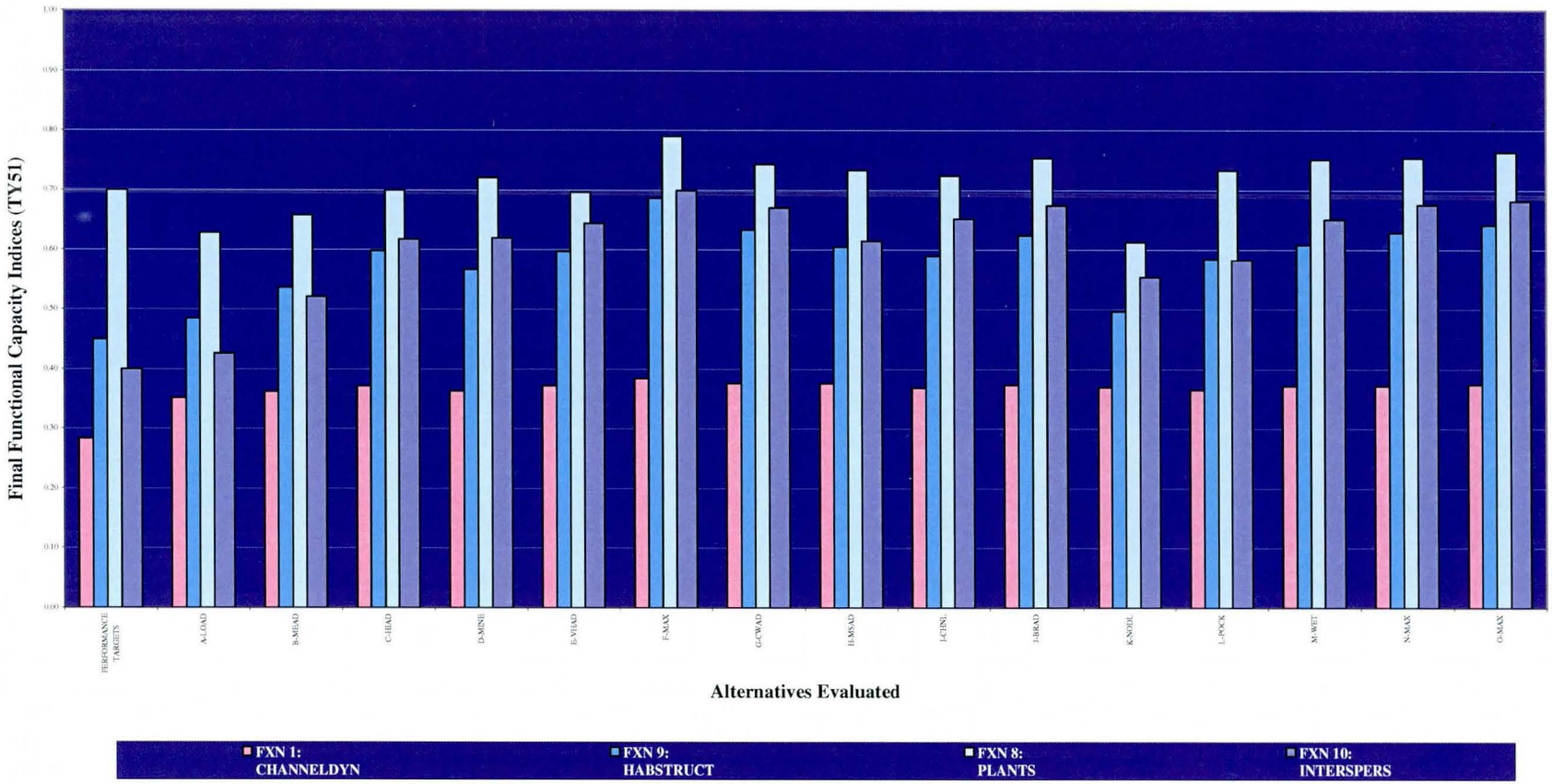
Appendix D – Va Shly'ay Akimel With Project Results


Va Shly Ay Function Average Annual Outputs For Each Alternative
Net Average Annual Functional Capacity Units
1200
1000
800
600
400
200
0
PERFORMANCE TARGETS
A-LOAD
B-MEAD
C-HIAD
D-MINE
E-VHAD
F-MAX
G-CWAD
H-MSAD
I-CHSL
J-HRAD
K-NODL
L-POCK
M-WET
N-MAX
O-MAX
Alternatives Evaluated

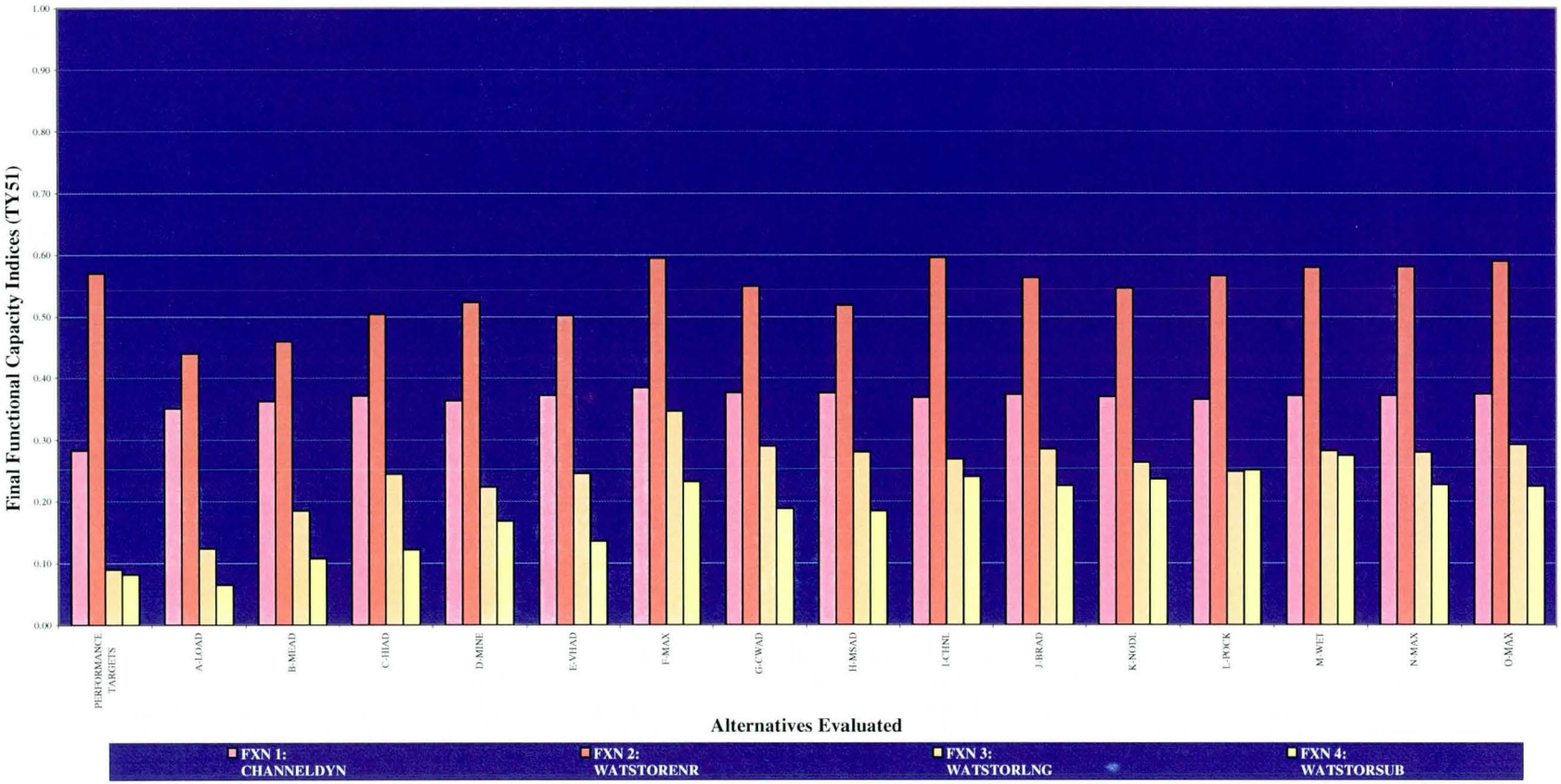
Va Shly Ay Functional Capacity Indices per Function For Each Alternative



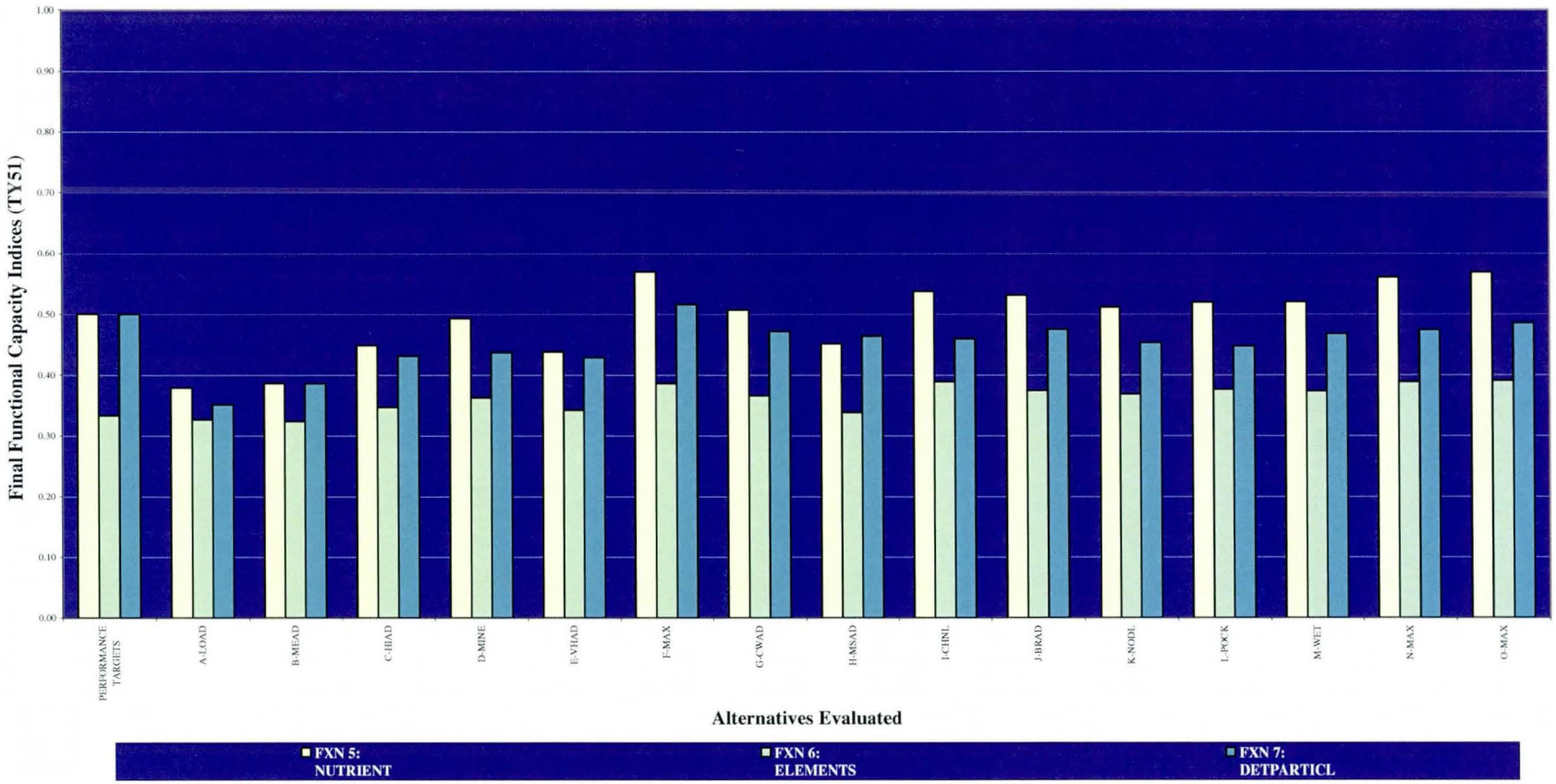
Va Shly Ay Functional Capacity Indices per Target Function For Each Alternative



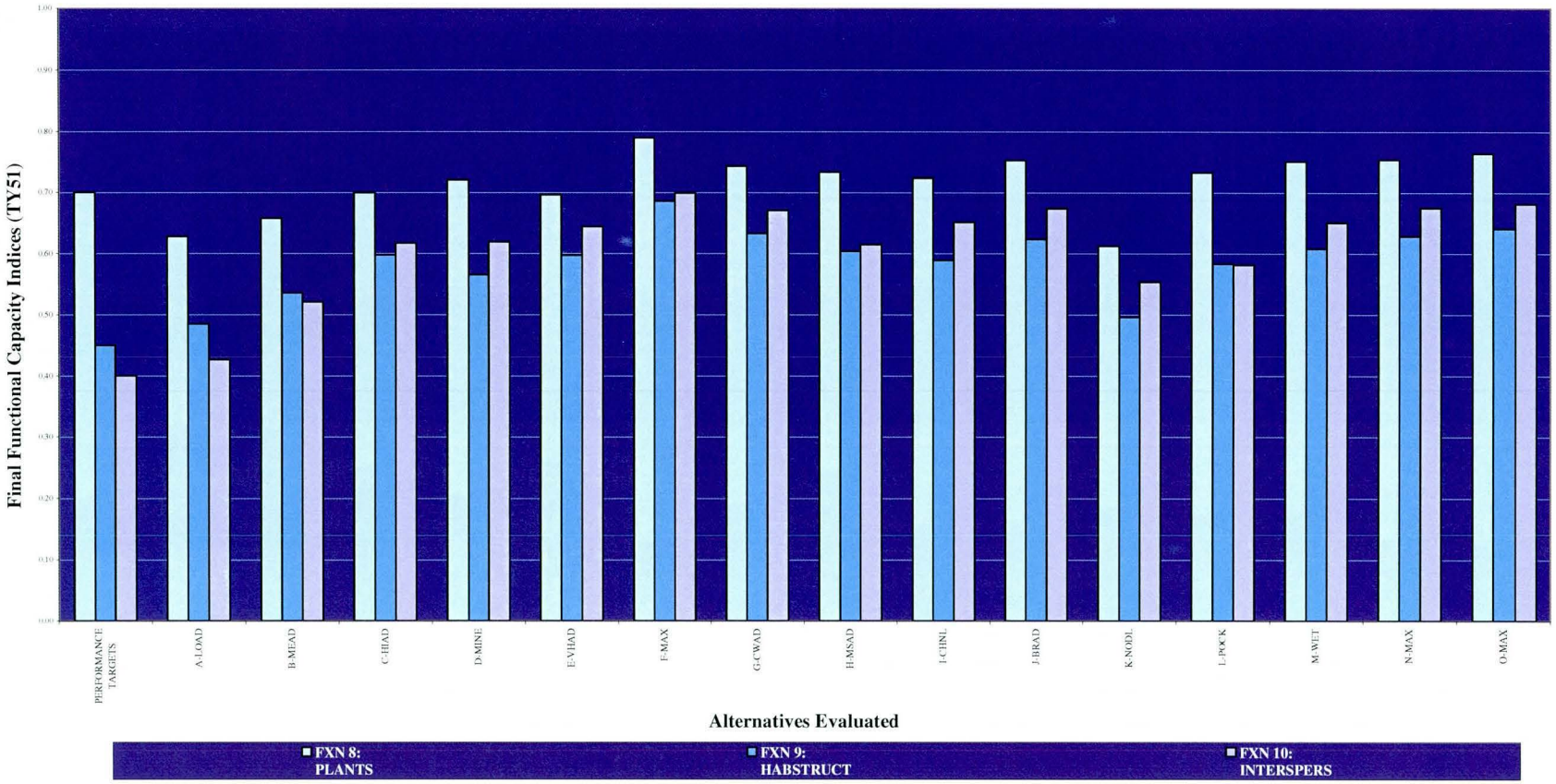
Va Shly Ay Functional Capacity Indices per Water Function For Each Alternative

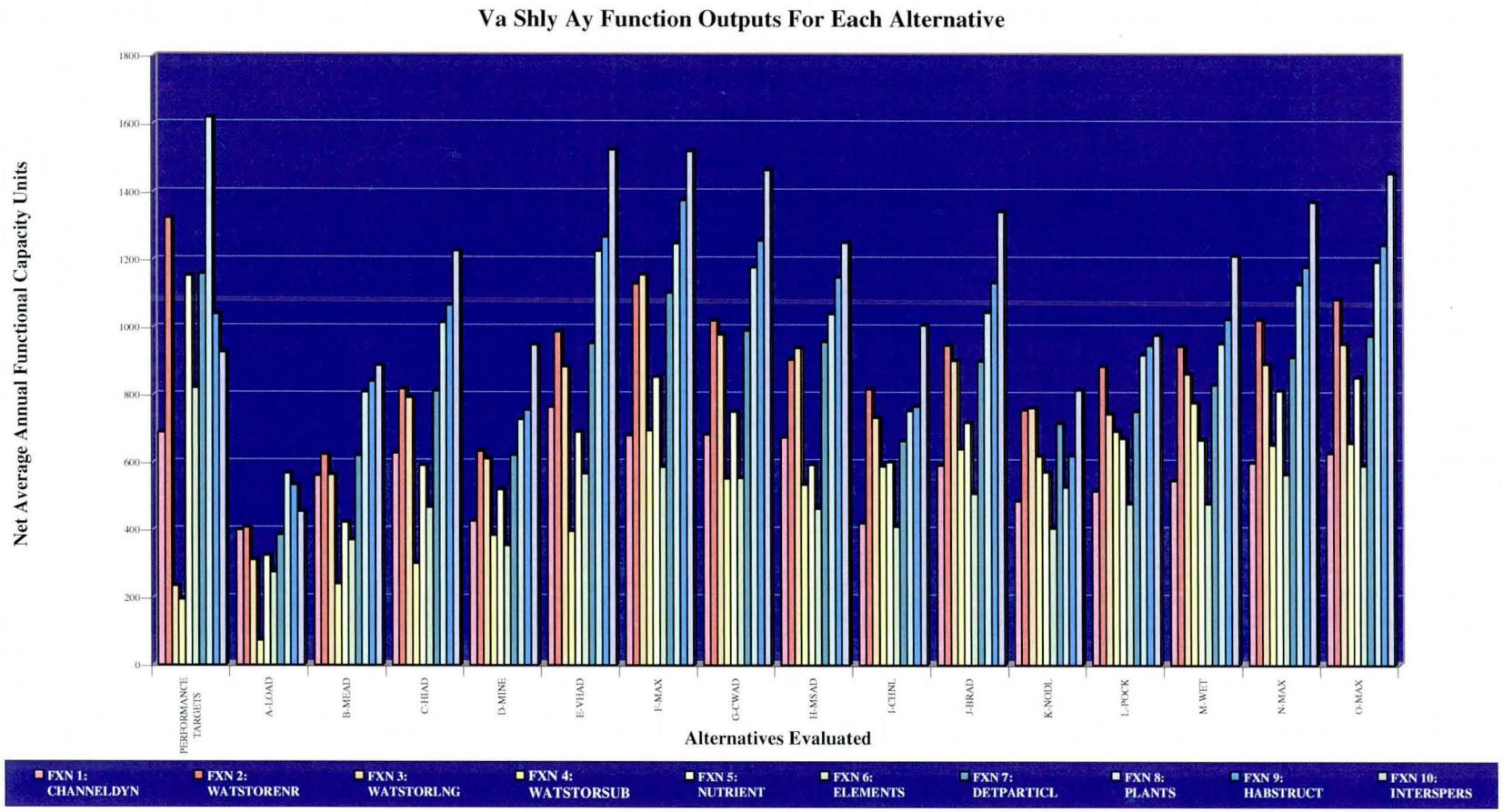


Va Shly Ay Functional Capacity Indices per Biogeochemical Function For Each Alternative

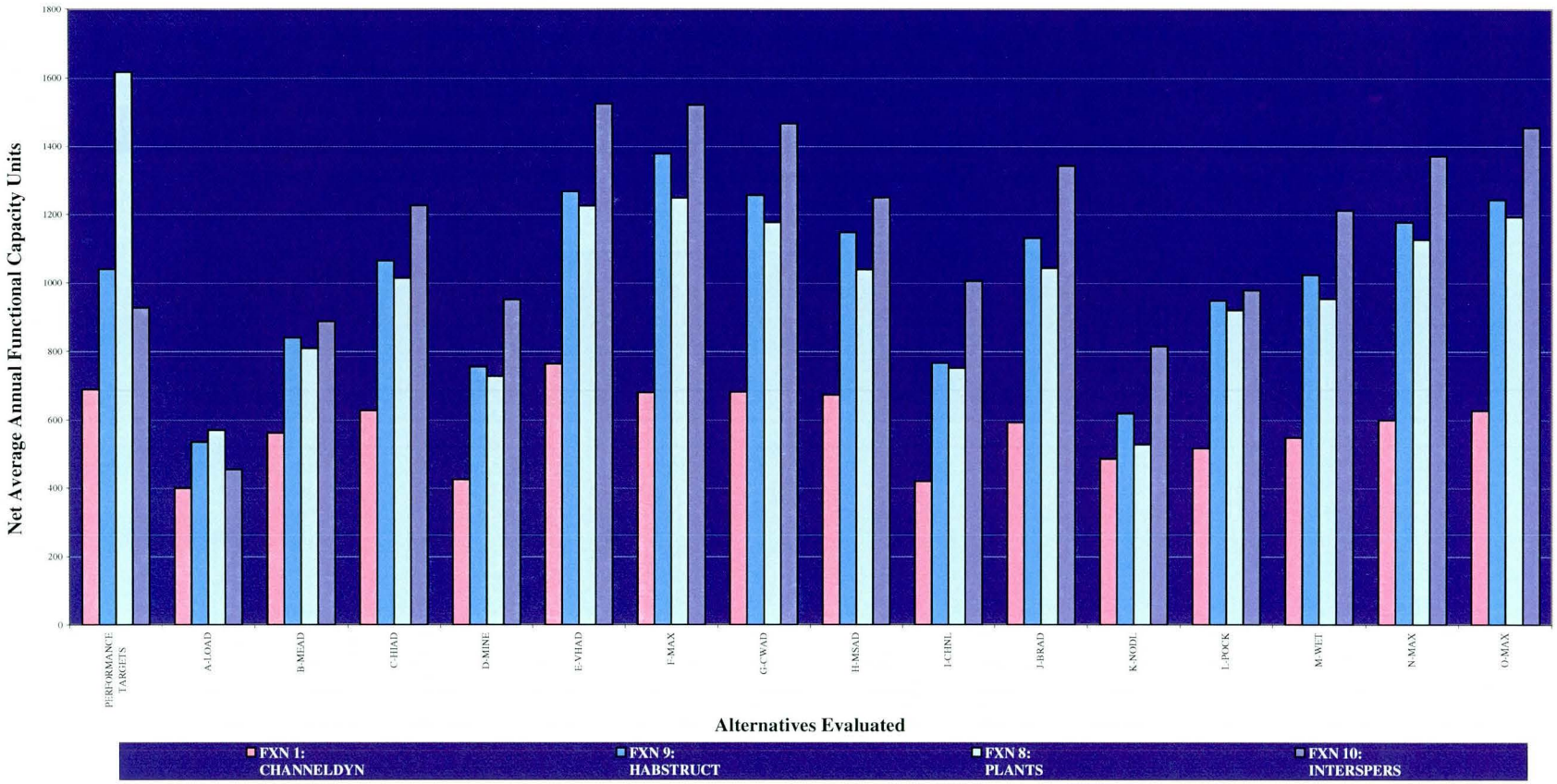


Va Shly Ay Functional Capacity Indices per Habitat Function For Each Alternative

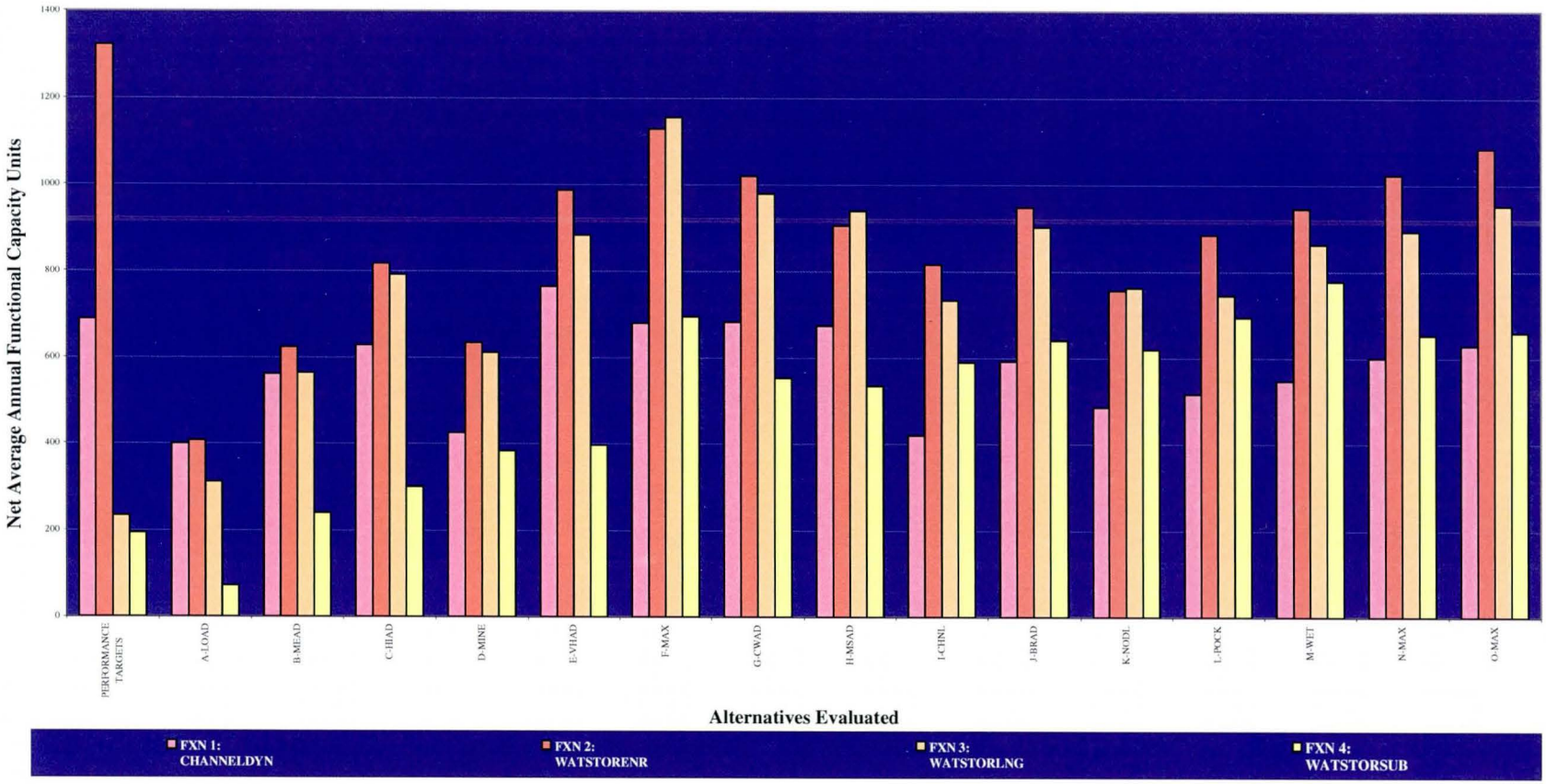



Va Shly Ay Function Outputs For Each Alternative
Net Average Annual Functional Capacity Units
1800
1600
1400
1200
1000
800
600
400
200
0
PERFORMANCE TARGETS
A-LOAD
B-MEAD
C-HIAD
D-MINE
E-VHAD
F-MAX
G-CWAD
H-MSAD
I-CHNL
J-BRAD
K-NODL
L-POCK
M-WET
N-MAX
O-MAX
Alternatives Evaluated
FXN 1: CHANNELDYN
FXN 2: WATSTORENR
FXN 3: WATSTORLNG
FXN 4: WATSTORSUB
FXN 5: NUTRIENT
FXN 6: ELEMENTS
FXN 7: DETPARTICL
FXN 8: PLANTS
FXN 9: HABSTRUCT
FXN 10: INTERSPERS

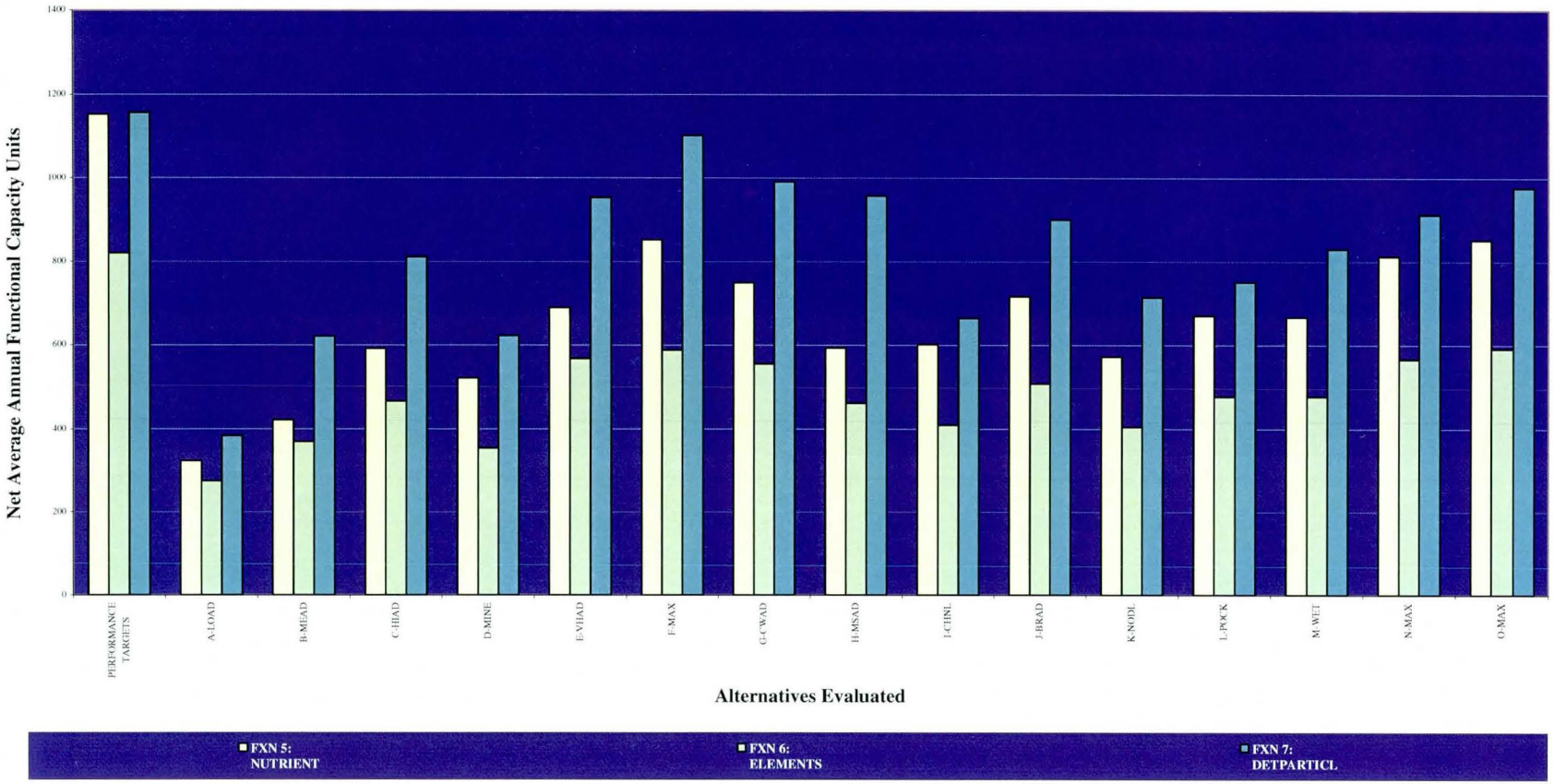
Va Shly Ay Function Outputs (Target Functions Only) For Each Alternative



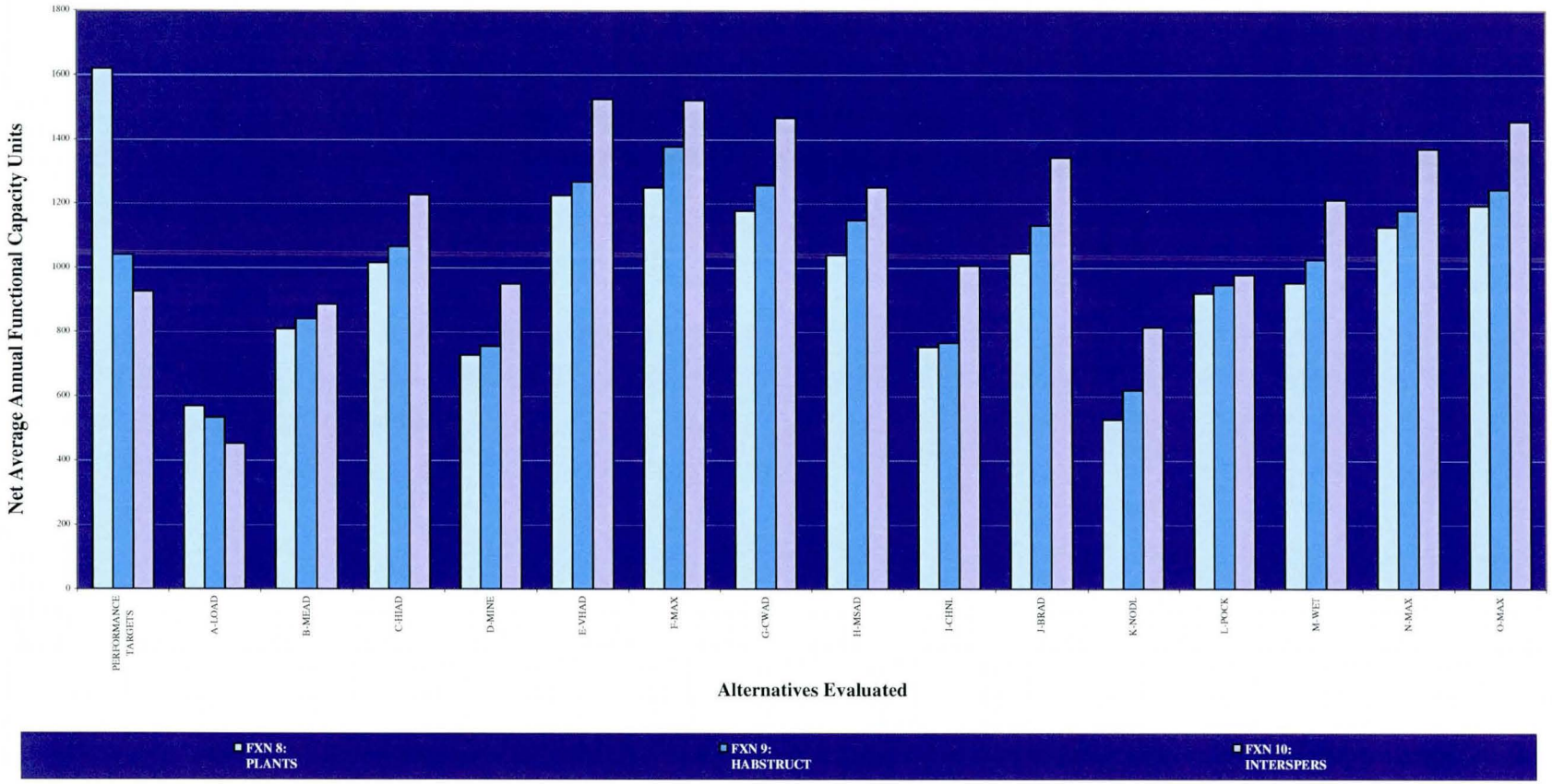
Va Shly Ay Function Outputs (Water Functions Only) For Each Alternative



Va Shly Ay Function Outputs (Biogeochemical Functions Only) For Each Alternative



Va Shly Ay Function Outputs (Habitat Functions Only) For Each Alternative



APPENDIX

J

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

ECONOMICS

Va Shly' ay Akimel Feasibility Study
Economic Appendix

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PURPOSE

The following presents an economic evaluation of the benefits and costs associated with riparian habitat restoration, flood control and recreation opportunities along the Salt River in the Salt River Pima-Maricopa Indian Community, adjacent to the City of Mesa in Maricopa County Arizona.

METHODOLOGY

Methodology employed for this economic analysis is in accordance with current principles and guidelines and standard economic practices, as contained in *Engineering Regulation 1105-2-100 – Planning Guidance Notebook (April 2000)*. Evaluation of environmental restoration alternatives has been completed in conformance with *IWR Report #95-R-1 -- Evaluation of Environmental Investments: Procedures Manual (May 1995)*. Benefits and costs are computed at October 2003 price levels utilizing the current Federal Discount rate of 5 5/8 percent. The period of analysis is 50 years. The Base Year for economic computations is 2011.

STUDY AREA

Location

The study area is located along the Salt River in the Salt River Pima-Maricopa Indian Community ("SRP-MIC"), adjacent to the City of Mesa in Maricopa County, Arizona. The Study Area is approximately 18 miles east of the City of Phoenix. The upstream limit of the study area is Granite Reef Dam, and the downstream limit is the Pima Freeway (US 101). **Figure 1** shows the location of the Va Shly' ay Akimel ("VSA") study area.

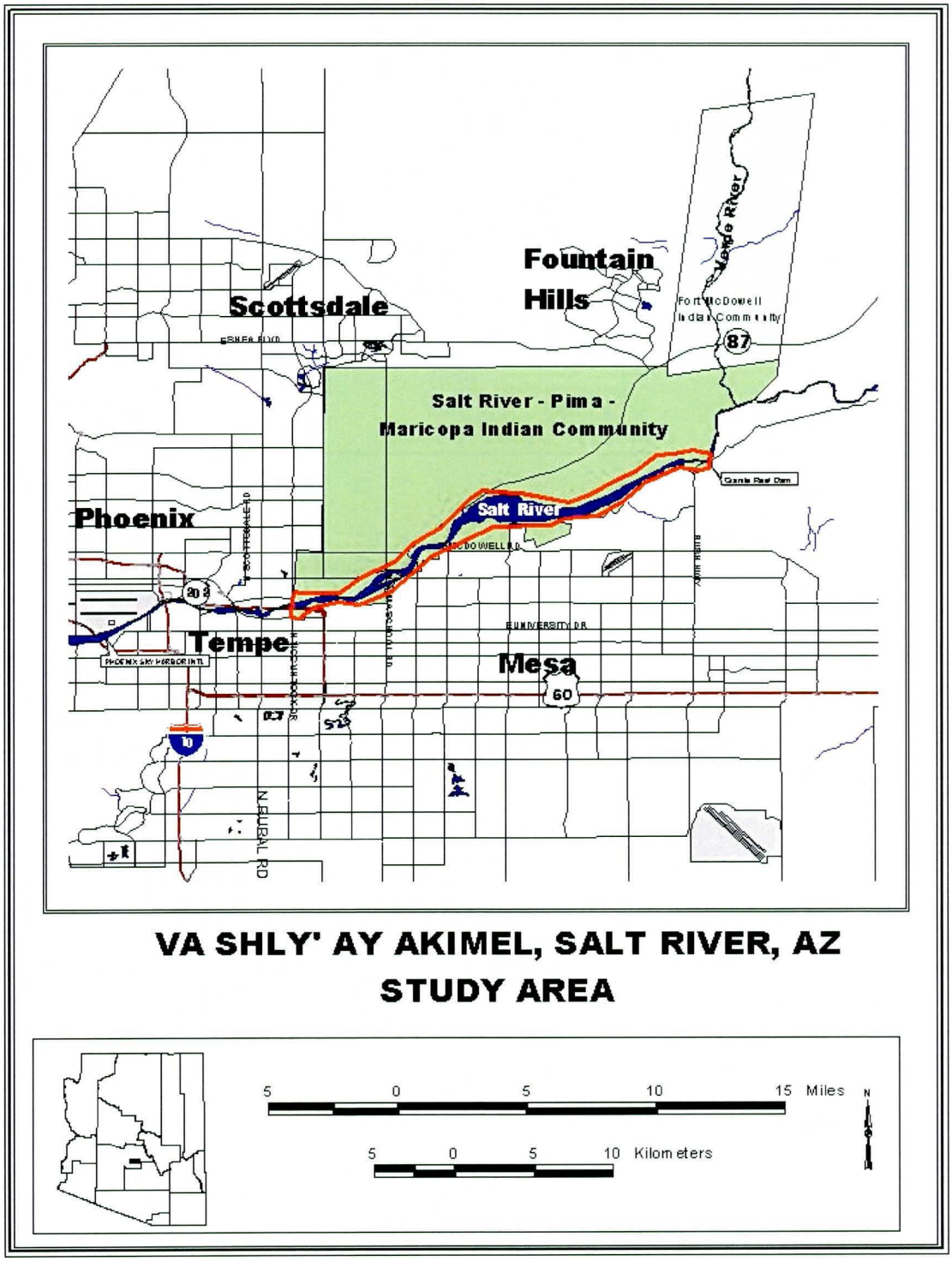
Problems & Opportunities

Environmental Resources

In pre-settlement times (prior to 1900) the Salt River was one of the few perennially-watered riparian areas of the Arizona Sonoran Desert, with highly productive cottonwood, willow, and mesquite habitats. These areas were rich in habitat diversity, supporting a wide variety of wildlife species. As the lower Salt River valley became developed, riparian habitat degraded significantly. The once perennial Salt River has now been transformed into a dry riverbed virtually devoid of habitat. Native plant species and wildlife habitat have been eliminated along the Salt River and adjacent overbank areas due to upstream water resources development, increased depths to groundwater beneath the river channel, changes in the natural flood regime, and land use changes, e.g., landfills and sand and gravel mining.

There is an opportunity to restore the environment through the creation of wetland, mesquite bosque, and cottonwood-willow habitat throughout the study area. Constructed wetlands could be created with water supplied from groundwater and surface water sources, including the Salt River Project, surface water from canals, reclaimed water, groundwater wells and storm drains. Potential locations include areas adjacent to storm drains and gravel mining pits. Mesquite trees could be established at higher elevations from the river bottom, including terraces and overbank areas. Cottonwood-Willow corridors could be created along the perimeters of open water areas, such as constructed wetlands and streams within the river bottom.

FIGURE 1
Va Shly' ay Akimel Study Area



Flooding

Based upon hydrologic and hydraulic analyses completed for this feasibility study, flooding problems in the study area are limited. There are primarily two developed areas subject to flooding during major storm events. The first overflow area extends south of the Salt River and is generally bounded by Lehi Road on the east, Harris Street on the west, and McDowell Road on the south. This area is rural and comprised primarily of residential properties east of Gilbert Road and agricultural properties west of Gilbert Road. The other area subject to potential flooding is also located on the south side of the Salt River, west of Mesa Drive and north of McKellips Road. This area includes more dense development, including mobile homes as well as some commercial and industrial properties. Even for most of these two areas, the probability of flooding in any given year is generally less than one percent.

Although expected annual flood damages for the Study Area appear to be minimal, it is possible that there could be opportunities for small-scale improvements to provide additional protection to these two reaches.

Recreation

Tremendous historical and projected population growth in the Phoenix metropolitan area has increased the demand for recreation facilities in the study area. As additional development occurs along the study area, including the conversion of vacant and agricultural lands to residential and commercial uses, development of new recreation facilities will also be essential. As part of a restoration project for VSA, there is an opportunity to provide complimentary passive recreation facilities, such as multiuse trails for hiking, biking and horseback riding, comfort stations, signage, and environmental education/interpretive centers. The study area location would be ideal for linking recreation facilities with existing and planned facilities downstream at Tempe Town Lake and Rio Salado. Additional linkages could be established with the Tonto National Forest and the Canal Trail System.

Population

The study area is located in Maricopa County and extends through the Salt River Pima-Maricopa Indian Community (SRP-MIC) and adjacent city of Mesa. As of the year 2000, Maricopa County had a population of 3.07 million. From 1995 to 2000, County population grew by over 543,000, representing an average annual growth rate of nearly four percent.

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

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

The SRP-MIC is home to the Onk Akimel Au-Authm (Pima) and Xalchidom Pii-pash (Maricopa) Indians, descendants of the Hohokam Indians. The Community covers an area of nearly 84 square miles and shares

boundaries with the cities of Mesa, Tempe, Scottsdale, Fountain Hills and metropolitan Phoenix. The population of the SRP-MIC was 6,405 as of 2000, according to the US Census. From 1990 to 2000, population increased by 1,553, or an average annual rate of about 2.8 percent. Thus, the combined population of the communities adjacent to the study area (Mesa and SRP-MIC) exceeds 400,000.

Population Projections

The following table displays population estimates and growth projections for Maricopa County and the City of Mesa municipal planning area, obtained from the Maricopa County Association of Governments (MAG) and US Census websites. Strong growth is projected for the County through year 2050, although the rates of growth will be substantially lower than those experienced the past decade. The Arizona Department of Economic Security projects that population within the Phoenix metropolitan area will total over 7.26 million by the year 2050. Growth rates for the region are anticipated to be more than double the national average throughout the period of analysis.

Mesa's population is anticipated to grow significantly over the next decade. However, growth rates are anticipated to drop sharply after 2010.

Table 1
Projected Population & Annual Growth Rate (AGR)
Maricopa County and the City of Mesa Municipal Planning Area

Year	Maricopa County	AGR	Mesa MPA*	AGR
2000	3,072,000		425,000	
2010	3,710,000	2.0	541,000	2.4
2020	4,516,000	2.0	594,000	0.9
2050	7,265,000	1.6	665,000	0.4

Source: US Census and Arizona Department of Economic Security
** Mesa MPA includes some Maricopa County lands within the City's sphere of influence.*

SRP-MIC projects that population within the Community will increase by approximately 1,500 every decade, reaching nearly about 9,500 by 2020 and over 12,600 by 2040.

An examination of the census tracts within a cross section of about two to three miles south of the Salt River from Granite Reef Dam to the downstream limit of the study area indicates that the area is heavily populated with about 70,000 residents and over 28,000 dwelling units.

According to information furnished by the City, over ten square miles of the City's corporate limits lie within a one-mile distance of the Salt River. Within this area, there is a population of nearly 26,700 residents – up from about 23,900 in 1990. The rate of population growth in this area lagged that of the City as a whole over the past decade. The Maricopa County Association of Governments projects that the population of this area will reach about 32,400 by the year 2020 (representing an average annual growth rate of about one percent). Most of this growth is anticipated to take place in the area between Gilbert Road and Greenfield Road, north of McDowell Road.

The City of Mesa estimates that there are only about 350 residents of the SRP-MIC that reside within a one-

mile distance of the River along the Study area. The population in this area has remained fairly constant over the past couple of decades. Future population growth in this area may be impacted by the planned construction of the Red Mountain Freeway along the southern edge of the Community.

Land Use

City of Mesa

The City of Mesa's general plan shows various existing land uses on the south side of the Salt River. Agriculture and recreation/open space uses are present between Alma School Road and the downstream limit of the study area, as well as upstream between Val Vista Drive and Highly Road. There are some industrial land uses at the upstream end of the study area, east of Highly Road as well as surrounding the Falcon Field airport between Greenfield Road and Highly Road. Most of the remaining lands are rural and large lot residential north of University Drive. There are many commercial establishments and more high-density residential uses in the east/west corridor south of University Drive and north of Baseline Road.

The City's land use plan shows that much of the existing open space and rural lands south of the Salt River will be converted to industrial and residential uses.

The City has provided a detailed breakdown of City land uses within a one-mile radius of the Salt River throughout the Study Reach. According to this information, the largest categories represented are industrial (about 14 percent of the land area) and rural (about 20 percent of the land area). However, there are also large tracts of land that are currently vacant or agricultural (each representing about 12 percent of the land area).

The stretch of Study Area extending from Granite Reef Dam to Val Vista Drive is primarily vacant or in industrial uses. According to the City's 1996 General Plan, this area will develop with industrial land uses.

The area between Val Vista Drive and Mesa Drive is mostly agricultural and rural. This area is known as the Lehi area within the City of Mesa. According to the City, land uses are expected to remain the same within this area for the foreseeable future.

The downstream stretch from Mesa Drive through the Pima Freeway is mostly medium to medium-high density residential, with some industrial uses adjacent to the riverbed (e.g., rock and gravel operations). The area is primarily built out; so future development will be limited. There was a possibility that a multi-use sports facility for the Arizona Cardinals National Football League team would be built in this area, which would have resulted in substantial changes in existing land uses, particularly in the commercial category. However, Mesa residents rejected the proposal on a recent ballot measure.

SRP-MIC

Land north of the Salt River is primarily owned by SRP-MIC, although the reservation also includes some lands (about 900 acres) south of the river as well. Most of the Community's land area is comprised of open space and agricultural lands, including a variety of crops such as cotton, watermelon, and honeydew. There is a commercial corridor along the Community's border with the City of Scottsdale along Pima Road, which includes a 140-acre retail center.

Community zoning within a one-mile radius of the study reach shows that over 82 percent of the land is currently designated for agriculture, natural resources and open spaces. The remaining lands are designated primarily for industrial and commercial uses. Most of the planned commercial and industrial development will

take place west of Gilbert Road adjacent to the Salt River. East of Gilbert Road, land uses are planned to remain agricultural and rural in nature.

SRP-MIC property includes a large tract south of the Salt River from Gilbert Road to Mesa Drive. This property is currently being used for agricultural purposes. This area will remain primarily agricultural and rural, with the exception of some planned commercial development along Gilbert and McDowell Roads.

The SRP-MIC lands north of the Salt River downstream of Mesa Drive could see an increase in residential development as well as some commercial development along freeway corridors.

Housing Unit Projections

According to the US Census and MAG, the ratio of persons per housing unit in the City is about 2.7. Mesa's Draft General Plan (*Mesa 2025 – A Shared Vision*, October 2001) shows a similar ratio projected at buildout. Table 2 shows the number of additional housing units that would need to be built to accommodate the anticipated population increases.

Table 2
Projected Housing Unit Growth
City of Mesa

	City of Mesa	
Period	Population Inc.	HU Inc.
2000-2010	116,000	43,000
2010-2020	53,000	19,600
2020-2050	71,000	26,300
Total	240,000	88,900

Table 2 shows that roughly 89,000 new housing units would be needed in the city by the year 2050 to accommodate projected future population increases.

An analysis of Mesa's Draft General Plan indicates an average density for residential lands of about five dwelling units per acre, based upon existing land use plans. At this density ratio, about 17,780 acres of residential lands would need to be developed to accommodate future population increases through 2050. The ratio of commercial, industrial and public land uses relative to residential land uses is about 58%, which would correspond with a required additional 10,300 acres of non-residential development. Mesa's Draft General Plan indicates that about 23% of the City's 172 square mile planning area (or over 25,000 acres) is currently undeveloped. Hence, it is likely that the City will be built out before the end of the period of analysis.

Employment & Economy

According to Arizona Department of Commerce, the primary employment sectors in the City of Mesa are services and retail trade. Manufacturing, and construction are also major employment sectors.

Table 3 Mesa Employment by Industry	
Services	35%
Trade	28%
Manufacturing	13%
Finance, Insur., & Real Estate	9%
Construction	9%
Transport., Comm. & Utilities	6%

Source: Arizona Dept. of Economic Security

The five largest private and public employers are as follows:

Table 4 City of Mesa Largest Employers	
Private	**Public**
Boeing	Mesa Public School System
Motorola	Banner Health System
TRW Safety Systems	City of Mesa
AT&T	Mesa Community College
Empire Southwest Machinery	Salt River Project

Growth in Phoenix MSA population has been due primarily to net migration into the area. Factors contributing to this inmigration include diverse job availability, climate, quality of life, low cost of living, and a strong, diversified industrial base. Inmigration and high graduation levels from Arizona State University have provided local employers with a quality labor force.

The substantial growth in employment opportunities has helped maintain low unemployment rates in the greater Phoenix area in recent years. For example, unemployment rates in the Phoenix-Mesa Metropolitan Area (4.1 percent as of December 2003) have remained below the state (5.0 percent) and the national rates (5.7 percent).

WITHOUT PROJECT CONDITIONS

Without Project Conditions are those conditions projected to prevail over the 50-year period of analysis in the absence of any management measures designed to address the problems and opportunities outlined earlier in this report. They serve as the basis for comparison to determine the benefits of proposed management measures. Hence, without-project conditions must first be calculated in order to ascertain the potential benefits that may result from implementing alternatives.

Environmental Resources

Due to dams and diversions, perennial flows on the Salt River have ceased. This has caused detrimental environmental impacts to natural wildlife habitat and riparian communities along the Salt River. The elimination of natural base flows reduced Salt River flows to summer or fall rainfall-related flood events. The ground water table beneath the river dropped. The soil moisture in the riverbed was virtually eliminated, and the native cottonwoods, willows and riparian ecosystem rapidly died out. Most areas of the Salt River are barren today. The few existing riparian communities in the Study Area are currently supported by wastewater effluent, sporadic flood releases from upstream and local storm-water runoff. Only disturbed riparian vegetation occurs on sandbars and terraces. The vegetation is primarily salt cedar (tamarisk) and desert broom with scattered cottonwood, seep willow and rabbit brush. As wildlife depend on vegetation for food and/or cover, the lack of vegetation in the study area makes the area generally unsuitable as wildlife habitat. Only small birds, small mammals and reptiles tolerant of very disturbed conditions inhabit the study area.

Hydrogeomorphic Model Description

The value of the limited amount of habitat existing in the Study Area has been assessed using a Hydrogeomorphic Modeling (HGM) process. HGM is an evaluation methodology in which the environmental impacts of projects are measured in ecological, rather than monetary terms. As a result, it is not possible to perform a direct benefit/cost analysis. Rather, the focus of HGM analysis, as well as other non-monetary evaluation techniques, is to determine the most cost-effective way to provide an array of environmental outputs. This is typically completed through an incremental cost analysis in which the marginal cost of providing additional environmental outputs is determined.

The U.S. Army Engineer Waterways Experiment Station has developed HGM for the purpose of assessing wetland functions. Wetland functions are a result of the interaction between the structural components of wetlands, such as soil, plants and animals, and the physical, chemical and biological processes that occur in wetlands. The assessment phase of the procedure is to measure the ability of a wetland to perform functions, in terms of its functional capacity. The functional capacity of a wetland is determined using a functional capacity index (FCI).

In HGM, an FCI model is a quantitative estimate of the functional capacity for a wetland. The ideal goal of an FCI model is to quantify and produce an index that reflects the functional capacity at the subject site. The results of an FCI analysis can be quantified on the basis of a standard zero to one scale, where 0.00 represents the lowest functional capacity for the wetland, and 1.0 represents the highest function capacity for the wetland. The FCI model can be defined in words or mathematical equations that clearly describe the rules and assumptions necessary to combine functional capacity indices.

Functional Capacity Units (FCU's) are a quantitative environmental value, considered to be the biological currency in the HGM methodology. FCUs are calculated by multiplying the area of available wetland (quantity) by the quality of the wetland based on functionality, which is represented by values derived from the FCIs. FCU = Area times FCI. Changes in FCUs represent potential impacts or improvements of proposed actions.

HGM Results – Without Project Conditions

Ten FCI functions have been developed specifically for the desert southwest ecosystem along the Salt River to assess the environmental conditions in the Study Area. These functions have been applied to the existing areas of habitat throughout the Study Area to derive estimates of FCUs, both for existing and future without project conditions.

The first four functions (F1-F4) are water-related variables, such as surface and subsurface water storage and channel dynamics. The next three (F5-F7) are biochemical-related variables, such as the presence of required nutrients. Finally, the last three variables (F8-F10) are habitat-related variables, such as the quantity, type and locations of vegetation. Table 5 below summarizes the results. Note that FCUs for each function have been estimated for Target Years 1, 6, 26, and 51 (Target Year 1 being equivalent to the first year of construction). These projected values were then converted into average annual FCUs (AAFCUs) for each function. The total combined AAFCU representative of without project conditions was derived by simply averaging the AAFCU values for each of the ten functions (i.e., no weighting was applied to the different functions, and each was therefore assigned equal importance in terms of measuring the without project condition habitat value).

Table 5
Va Shly Ay Akimel Study Area
Without Project AAFCUs

	T1	T6	T26	T51	AAFCUs
F1	822	762	650	648	689
F2	1,044	951	951	940	955
F3	119	70	70	63	72
F4	204	125	125	125	131
F5	947	793	794	800	805
F6	821	718	718	720	726
F7	767	697	698	693	701
F8	1,484	1,345	1,345	1,339	1353
F9	983	883	883	880	889
F10	930	851	851	844	854
Avg	812	720	709	705	**718**

As shown in Table 5, habitat value is projected to decline considerably (by about eleven percent) through target year 6. Subsequently, habitat values are projected to level off, both in terms of habitat acreages and functional index values. AAFCUs for without project conditions total 718. This is the value that will be the basis for comparison when assessing the potential benefits of proposed restoration alternatives.

Flooding Problems

The Salt River Project maintains four dams on the Salt River, as well as two on the Verde River. Granite Reef Diversion Dam is located about five miles downstream of the confluence of the Salt and Verde Rivers. At this dam site, all water is taken from the Salt River and diverted into the Arizona and South Canals, which deliver drinking and irrigation water to the greater Phoenix area. During significant flood events, the Salt River Project is forced to release water over Granite Reef Dam into the normally dry Salt River.

Historical Flood Damages

The highest release since the construction of the Salt and Verde River dams occurred in February 1980, when 178,000 cubic feet per second was released because of heavy rains and rapid snowmelt in the watersheds. All bridges were forced to close during that flood except the Central Avenue Bridge in the City of Phoenix. Subsequently, most of the remaining bridges crossing the Salt River have been rebuilt to withstand flow rates of 200,000 cfs and greater.

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

Information regarding damage estimates specific to the study reach was not available. However, current hydrologic data for the Salt River through the Study Area shows that peak discharges for the 100-year event are approximately 172,000 cubic feet per second (cfs). Current hydraulic analysis indicates that there are very few structures in the100-year floodplain. Therefore, it is likely that damages throughout the Study Area reach were limited during these storms.

Floodplain Boundaries & Reach Definitions

Before determining potential damages within the floodplain, an inventory of structures susceptible to damage and estimates of the value of these structures must first be developed. **Figure 2** shows the Base Year floodplain boundaries. As shown on Figure 2, the floodplain is primarily confined within the channel, with the exception of two "breakout" areas (labeled "1" and "2" on Figure 2). Breakout Area 1 extends south of the Salt River and is generally bounded by Lehi Road on the east, Harris Street on the west, and McDowell Road on the south. This area is rural and comprised primarily of residential properties east of Gilbert Road and agricultural properties west of Gilbert Road. The other area subject to potential flooding (Breakout Area 2) is also located on the south side of the Salt River, west of Mesa Drive and north of McKellips Road. This area includes more dense development, including mobile homes as well as some commercial and industrial properties. Even for most of these two areas, the probability of flooding in any given year is generally less than one percent.

The floodplain has been further segmented into sub areas, or Reaches, for analysis purposes. Critical factors used to determine reach boundaries include: discharge/frequency characteristics, overflow spatial characteristics, and economic activity. **Figure 3** shows floodplain reach Boundaries. **Table 6** below provides a summary of reach characteristics, including approximate upstream and downstream boundaries.

Table 6
Va Shly Ay Akimel Study Area
Floodplain Reach Definitions

Reach Name	Upstream Limit	Downstream Limit	Notes
1	~ Longmore Road	Pima Freeway	No damages in this reach
2	~ Country Club Drive	~ Longmore Road	Upstream end of this reach contains downstream portion of downstream breakout area. Primarily commercial/industrial area surrounding McKellips & Country Club
3	~ Mesa Drive	~ Country Club Drive	Contains upstream portion of downstream breakout. Primarily mobile homes, with some commercial structures.
4&5	~ Stapley Drive	~ Mesa Drive	No damages in these reaches
6	~ 32nd St.	~ Stapley Drive	Upstream breakout area. West of Gilbert Road is SRPMIC property, primarily agricultural. East of Gilbert Road is mostly residential.
7-10	Granite Reef Dam	~ Stapley Drive	No damages in these reaches

FIGURE 2

Va Shly Ay Akimel Study Area - Base Year Floodplain Delineations

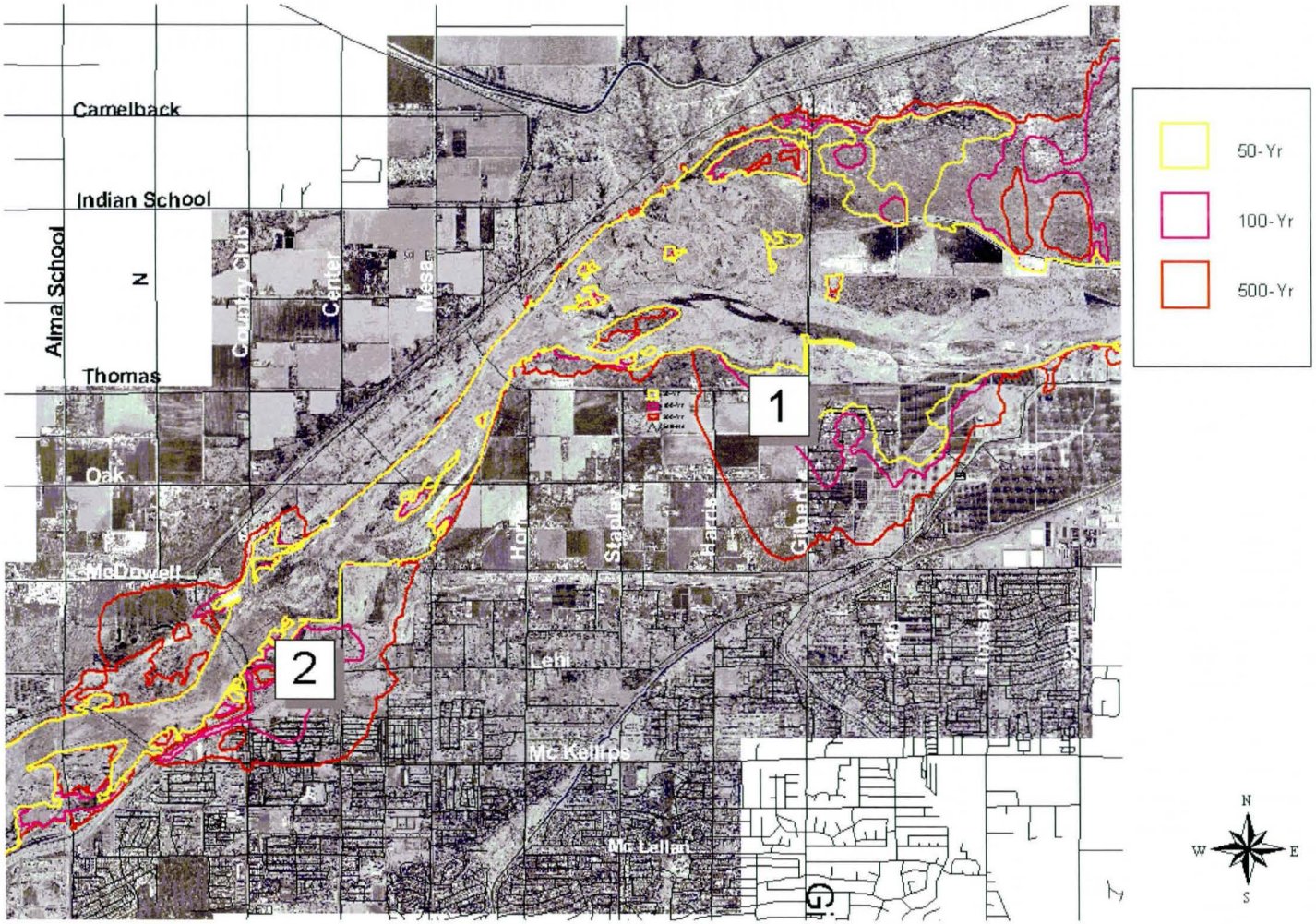
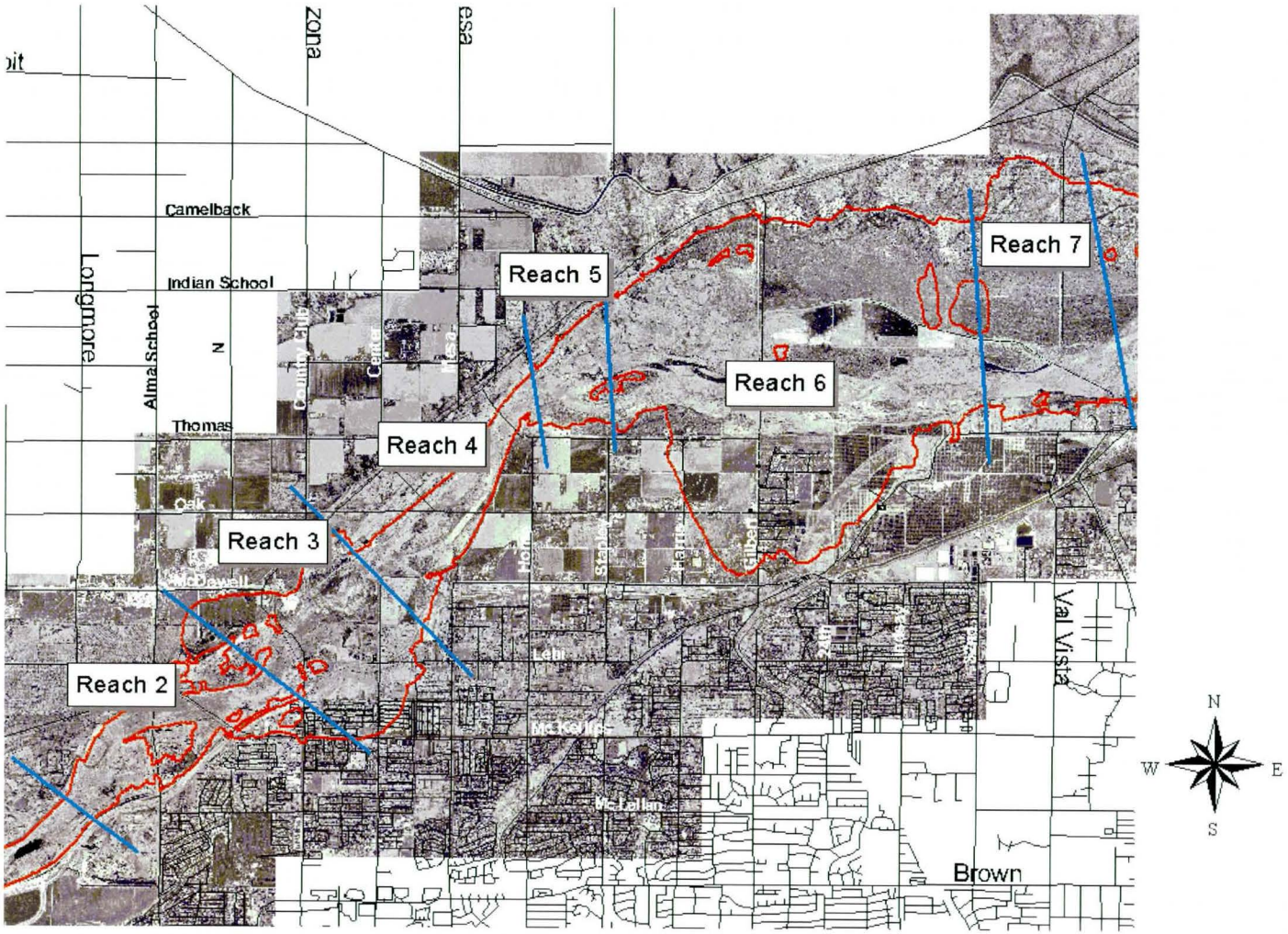


FIGURE 3

Va Shly Akimel Study Area
Reach Delineations



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

Number of Structures

The number of structures in the 100-year and 500-year floodplains was determined based upon an analysis of aerial photography, parcel maps, real estate assessor's data and a site survey. **Tables 7 and 8** which follow show the number of structures by reach, floodplain and structure type.

Table 7
Va Shly Akimel 100 & 500-Year Floodplains
Number of Structures

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

Table 7 shows that there are approximately 883 structures in the Va Shly Ay Akimel floodplain. Of this total, nearly 90 percent are residential (sfr/mh). Roughly 236 structures are located within the 100-year floodplain boundaries (about 27 percent of the structures in the 500-year floodplain).

Table 8
Va Shly Ay Akimel 500-Year Floodplain
Number of Structures by Reach

Location	Number of Structures
Reaches 2&3	718
Reach 6	165
Total	883

As indicated in Table 8, most floodplain structures are located in the downstream breakout area (Reaches 2 & 3). Most of these structures are residential, primarily mobile homes.

Value of Structures & Contents

Depreciated structure replacement values were calculated as follows:

1) Square footage for each structure was obtained from real estate assessor's data.
2) Structure construction type and condition were noted during a field survey.
3) Appropriate Marshall & Swift Valuation Service multipliers were determined for each structure based upon its condition, classification and construction type. These multipliers were applied to square footage estimates to derive depreciated structure replacement values.
4) Values were adjusted to reflect local building costs for the Maricopa County area using Marshall & Swift locality multipliers.

Content values were estimated as a percentage of depreciated structure value for each structure. Content ratios by structure type were based upon values derived for several recent Los Angeles District Feasibility Studies. The study areas for all of these projects were located in the Southwestern U.S. Ratios were developed based upon a statistical analysis of content surveys mailed to local residents. The content ratios by structure type used for this study are as follows:

- Residential 50%
- Commercial 140%
- Industrial 171%
- Office 80%
- Public 33%

Tables 9 and 10 provide a summary of floodplain structure and content values, respectively, by structure category and reach. Note that industrial and public percentages do not exactly match the percentages shown above due to rounding of the structure/content values to the nearest $100,000. Content ratios applied to office and commercial structures were 80% and 140%, respectively. The two categories were grouped in Table 9, so the combined values represent structures from both categories (120% ratio).

Table 9
Va Shly Ay Akimel 500-Year Floodplain
Value of Structures & Contents By Structure Type (In $Millions)

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

Table 10
Va Shly Ay Akimel 500-Year Floodplain
Value of Structures & Contents By Reach (In $Millions)

Location	Struct Val	Cont Val	Total
Reaches 2&3	26.6	21.4	48.0
Reach 6	16.6	9.1	25.7
Total	43.2	30.5	73.7

As displayed on Tables 9 and 10, the total estimated value of property in the floodplain is about $73.7 million. Residential properties account for about 66 percent of this total, even though they represent about 90% of the total number of structures. This is attributable to the relatively low value of the residential properties (primarily mobile homes) relative to commercial and industrial structures. As would be expected, most of the floodplain property value is located in the downstream reaches which contain most of the structures.

Without Project Structure & Content Damages

Overview of Methodology

A risk-based analysis (RBA) procedure has been used to evaluate without project flood damages in the study area. Guidance for conducting RBA is included in Corps Engineering Regulation 1105-2-101, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability and Economics in Flood Damage Reduction Studies (1 March 1996).*

The guidance specifies that the derivation of expected annual flood damage must take into account the uncertainty in hydrologic, hydraulic and economic factors. Risk and uncertainty are intrinsic in water resource planning and design. They arise from measurement errors and the inherent variability of complex physical, social and economic situations. Best estimates of key variables, factors, parameters and data components are developed, but are often based on short periods of record, small sample sizes, measurements subject to error, and innate residual variability in estimating methods. RBA explicitly analytically incorporates these uncertainties by defining key variables in terms of probability distributions, rather than single-point estimates. The focus of RBA is to concentrate on the uncertainties of variables having the largest impact on study conclusions.

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

1) Discharge/Probability: For a flood or storm event with a given probability of occurrence, there is uncertainty regarding what the resulting discharge will be at a specific location along the stream or river. The reliability of discharge/probability estimates is directly linked to the historical record of stream gauge data available. In cases where records are small or incomplete, the associated uncertainty increases. To address this uncertainty, an analytical or graphical method is typically used to determine statistical distributions of discharge for a range of probabilities at locations throughout the floodplain.

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

2) Stage/Discharge: For a given discharge, there is uncertainty regarding what the resulting water surface elevation will be at a given location. Factors contributing to this uncertainty include bed forms, water temperatures, debris or other obstructions, unsteady flow effects, variation in hydraulic roughness with season, sediment transport, channel scour or deposition, changes in channel shape during or as a result of flood events, as well as other factors. To address this uncertainty, standard deviation estimates are developed for stages associated with a range of discharges at locations throughout the floodplain.

   For this study, the standard deviations of error for stages associated with a range of discharges were provided for each reach by Engineering Division. The error values generally increase in value from about 0.1 feet for the 5-year flood event up to about 0.7 feet for 100-year to 500-year flood events.

3) Geotechnical Features: When there are improvements such as levees along a river or stream, there is uncertainty regarding how effective they will be in containing a given flood event. Specifically, there is uncertainty regarding what combination of discharge and stage will result in levee failure. To address this uncertainty, probable failure and non-failure points (elevations) for levees are determined at various locations along the levee's length.

   There are not any existing levees along the Salt River in the Va Shly ay Akimel study area.

4) Structure Elevation: A structure's susceptibility to being inundated is a function of its location within the floodplain and its elevation. There are two sources of potential error in determining elevation. The first is the topographic ground elevation of the structure. This uncertainty is a function of the data source used to derive the elevation estimate. For example, there is greater potential error associated with elevation estimates derived from examining a 5-foot contour

topographic map than a 2-foot aerial survey contour map. The other source of uncertainty is associated with estimates of first floor elevations above ground level (or foundation height). This variable is key, as a structure built on fill or with a large crawl space, for example, may sustain only minor or no damages, even though the surrounding ground is underwater. First floor elevation estimate errors also vary with the methods used to derive them, ranging from best-guess estimates from windshield surveys to professional surveys. Statistical uncertainty in elevation is typically determined by referencing the standard deviation estimates contained in Corp Engineering Manual 1110-2-1619 – *Risk Based Analysis for Flood Damage Reduction Studies (1 August 1996).* This publication presents standard deviation estimates for a wide range of measurement methods.

For this study, ground elevations for each structure were derived from a 10-foot interval digital elevation model in GIS format (which was used in turn to generate 4-foot contour interval shape files). First floor elevations above ground level were estimated during a field survey. Based upon the Engineering Manual cited above, the error associated with first floor elevation estimates is assumed to be normal, with a mean of 0 and a standard deviation of 2.94 feet.

5) Structure Values: Structure values have been determined based upon Marshall & Swift multiplication factors applied to square footage estimates. Square footage estimates were primarily obtained from real estate assessor's data and are determined to be accurate. The primary source of potential error results from misclassification of a given structure in terms of its construction quality and condition. The errors associated with structure value estimates are assumed to be normal, with a mean of 0 and standard deviations ranging from 10 to 21 percent (depending on structure type), based upon upper and lower ranges of M&S factors.

6) Inundation Depth/Percent Damage: There is considerable uncertainty regarding the percentage of damage to structures and contents given a certain level of flooding. The National Flood Insurance Program of FEMA collects damage data following flood disasters and publishes depth/damage functions. These functions are used to derive estimates of damages to non-residential structures. For residential structures, depth-damage functions and associated standard error estimates have been developed by the Institute for Water Resources based upon a statistical analysis of actual flood damages that have occurred throughout the United States. Damage percentages for both structures and contents are based upon corresponding structure values. These functions were used for this analysis.

The Corps of Engineers Hydrologic Engineering Center has developed software specifically designed for conducting RBA, referred to as the HEC-FDA Program (Version 1.2 used for this analysis). This program applies a Monte Carlo simulation process, whereby the expected value of damages is determined explicitly through a numerical integration technique accounting for uncertainty in the basic parameters described above. Data requirements for the program include:

- Structure data, including structure I.D., category (sfr, mfr, etc.), stream location, ground and/or first floor elevation, structure value and content value. This data was developed in a Microsoft Excel spreadsheet and imported into the HEC-FDA program.
- Hydrologic and hydraulic data, including water surface profiles, frequency/discharge relationships, and stage/discharge relationships. For this study, water surface profiles were developed using the HEC-RAZ program. These functions were imported into the HEC-FDA program.
- Depth/Damage functions. Functions for residential and non-residential structures were obtained from the Institute for Water Resources and FEMA's National Flood Insurance Program.
- Risk & Uncertainty Parameters, as described in detail previously, were also entered into the program.

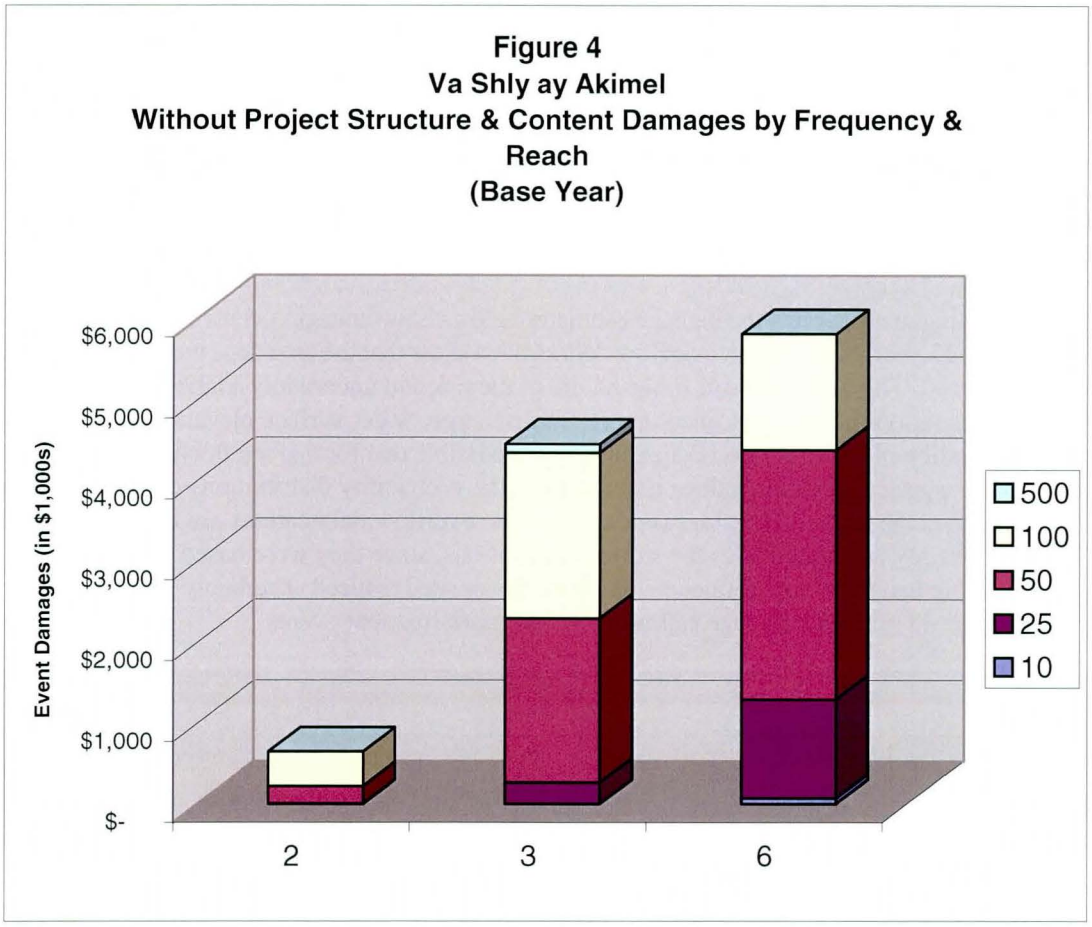
Results – Base Year (2011)

Without project damages by event for Base Year conditions, as calculated by the HEC-FDA program, are shown in **Tables 11** and on **Figure 4.** The non-damaging event is approximately the 10-year event. However, most reaches do not incur damages until less frequent events. Damages calculated for the 25-year event are approximately $1.56 million. Damages increase significantly for the 50-year and 100-year events, with only a marginal increase for the 500-year event.

One important thing to note is that the damage estimates below show damages occurring for flood events such as the 10-year or 25-year, even though overflow delineations show that the area does not sustain flooding until less frequent events. This is attributable to the nature of the risk and uncertainty analysis. The R&U analysis takes into consideration the inherent uncertainties in discharge, water surface elevation, and the estimated topographic elevation of the structure. For example, it is possible that for a given flood frequency, discharge values and water surface elevation values derived from the probability distributions could be substantially higher than the average or median values (upon which the overflow delineations are based). Also, there is significant uncertainty associated with the structure elevations, since they were based upon 10-foot contour maps. It is possible that with more refined mapping and associated reduced uncertainty in structure elevations, the simulation would not yield damage estimates for the more-frequent events.

Table 11
Va Shly ay Akimel
Without Project Damages By Reach & Event (Base Year – 2011)
(in $1,000s)

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



Expected annual damages by reach and structure type for Base Year conditions are shown on Table 12. Damages to residential structures and contents (sfr/mh) represent about 74% of total damages. Most damages occur in Reach 6 (the upstream breakout area), even though there are many more structures located in Reaches 2 & 3. This is due to the higher probabilities of flooding in the upstream reach. In addition, the residential structures in Reaches 2 & 3 are mostly mobile homes, which have a lower value than the single-family residences located in the upstream reach.

Table 12
Va Shly ay Akimel
Without Project Expected Annual Damages – Base Year
(in $1,000s)

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

Results – Future Conditions (2060)

Hydrologic and hydraulic analyses were conducted for future without project conditions to determine the impacts of processes such as sedimentation and channel degradation and the resulting impacts on potential

flooding. Updated water surface profiles and stage/discharge uncertainty data were used to recomputed expected annual damages under future conditions. Table 13 summarizes the results.

Table 13
Va Shly ay Akimel
Without Project Expected Annual Damages – Future Conditions (2060)
(in $1,000s)

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

Without project expected annual damages actually decrease from about $317,000 under Base Year conditions to about $92,000 under future conditions (a drop of over 71 percent). The most dramatic decline was in Reach 6, which shows a damage reduction of about 87% relative to Base Year conditions. Water surface elevations are generally lower throughout the Study Area under future conditions (refer to Hydraulic appendix for details). This is depicted in **Figure 5**.

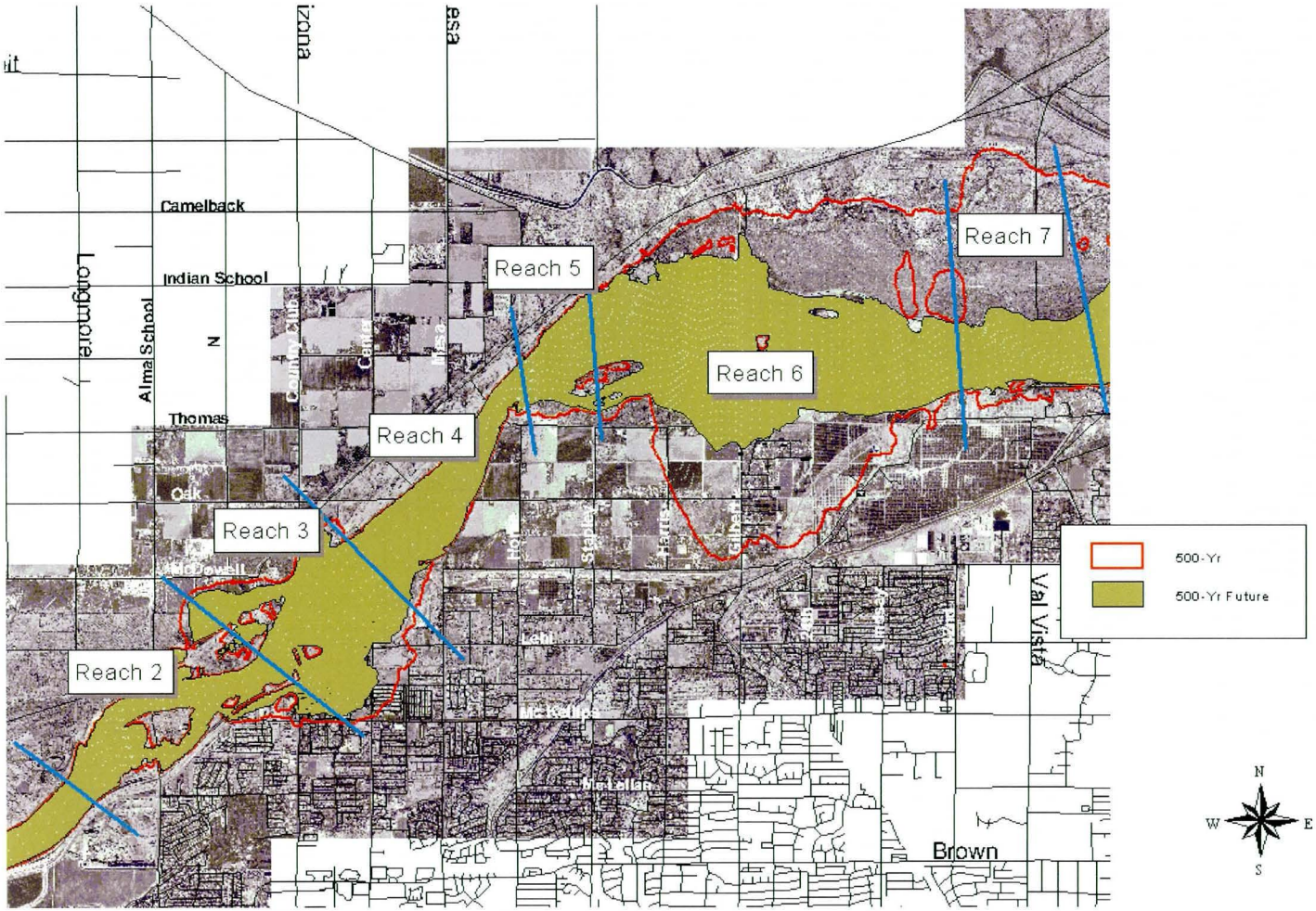
Equivalent annual damages were computed based upon forecast annual damages using a discount rate of 5 5/8% (see Table 14). As shown below, equivalent annual damages total about $251,000, with over 71% of damages associated with residential structures, and over 57% located within Reach 6.

Table 14
Va Shly ay Akimel
Without Project Equivalent Annual Damages (50 Yrs, 5 5/8%)
(in $1,000s)

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

Figure 5

Va Shly ay Akimel - Base Year vs. Future Conditions 500-Year Floodplain



Without Project Emergency & Cleanup Costs

Cleanup, Debris Removal & Public Infrastructure Repairs

Emergency costs are defined as those expenses resulting from a flood that would not otherwise be incurred. Emergency costs include such items as emergency protective measures, post-flood cleanup and debris removal, utility repairs, and evacuation, reoccupation and temporary housing costs for floodplain residents.

Emergency costs related to public infrastructure repairs, debris removal and post-flood cleanup have been calculated by applying an average per acre cost to the number of developed acres inundated by flood event. Based upon several recent Los Angeles District studies, per acre costs for these items may range from $1,250 to $7,500 per acre1. In accordance with this range, $5,000 per acre has been assumed for this analysis.

Per acre costs are applied to floodplain acreage with existing development. Floodway, undeveloped and agricultural acreage are not included (agricultural cleanup costs are calculated separately and included under Agricultural Damages). ArcView GIS software was utilized to determine acreage by flood event that would require cleanup, public repairs and debris removal. Table 15 displays without project cleanup related costs by frequency, while Table 16 displays expected annual costs by reach.

Table 15
Va Shly ay Akimel
Without Project Cleanup Costs
(in $1,000s)

Event	Acres	Costs
20	0	$ 0
50	100	$ 500
100	295	$ 1,475
500	845	$ 4,225
Expected Annual Damages		**$ 44.5**

Table 16
Va Shly ay Akimel
Without Project Expected Annual Cleanup Costs
By Reach (in $1,000s)

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

Temporary Evacuation, Relocation and Housing Assistance Costs

FEMA provides grants to assist individuals and families to find suitable housing when they are displaced in cases of federally declared disasters. The program assures that people have a safe place to live until their homes can be repaired. This assistance is directly attributable to the disaster and being an expenditure that

1 *Lower Mission Creek, Santa Barbara County, CA and Rio de Flag, Coconino County, AZ Feasibility Studies, LA District.*

would not be undertaken except for the disaster falls under the emergency cost guidance of ER 1105-2-100. Therefore, the funds expended by FEMA for temporary housing assistance in the event of flooding are NED flood damages.

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

To estimate temporary housing costs by flood event for this study, the number of houses and mobile homes inundated by frequency was ascertained through an analysis of HEC-FDA output files, and the per housing unit claim of $1,500 was applied. Table 17 shows the results.

Table 17
Va Shly ay Akimel
Without Project Temporary Housing Costs
(in $1,000s)

Event	Structures	Costs
20	0	$ 0
50	20	$ 30
100	203	$ 305
200	515	$ 773
500	787	$ 1,181
Expected Annual Damages		**$ 8.9**

Table 18 shows expected annual without project temporary housing costs by reach.

Table 18
Va Shly ay Akimel
Without Project Expected Annual Temporary Housing Costs
By Reach (in $1,000s)

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

Without Project Agricultural Damages

Reach 6 contains agricultural croplands susceptible to flood damages. The following table shows agricultural land area by floodplain and crop type. Please refer to attached Addendum 1 for a detailed description of the agricultural crop damage analysis. Addendum 2 documents the supporting hydrologic and hydraulic analysis used to derive agricultural flood damage estimates.

Table 19 Va Shly Ay Akimel Estimate of Floodplain Crop Acreages (Reach 6)				
	Number of Acres Enclosed within Floodplain Demarcation Line			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

For each of the crop types listed above, monthly crop budgets were developed to determine potential direct production losses based upon the stage of production when a potential flood event could occur. According to information furnished by Engineering Division, it is highly probable that any major flood event would occur during the months of January through March. This is a critical factor when determining potential flood damages. For example, alfalfa hay is typically harvested in mid-April, so cumulative production expenses by the end of March are relatively high. For cotton, however, land preparation activities are typically not completed until mid-March, so cumulative production expenses during the months most likely to experience flooding are minimal.

Tables 20 shows expected annual flood damages based upon direct production losses, not taking into consideration seasonal flood probabilities or potential inundation durations. Table 21 factors in the monthly probabilities of major flood events. Also, although duration data was not available, damages presented in Table 21 were derived by taking an average of potential damages for inundation durations ranging from less than one day to more than one week.

Table 20 Va Shly ay Akimel Estimate of Crop Prod. Losses by Flood Event (Reach 6) Not Discounted for Seasonal Flood Probabilities or Duration Impacts					
Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$4,700	$1,900	$314,400	0.0	$320,900
100	$13,400	$5,300	$409,300	0.0	$428,000
200	$47,200	$18,800	$528,800	$13,600	$608,400
500	$50,600	$20,100	$618,900	$121,300	$810,900
EAD	$500	$200	$11,400	$400	$12,500

Table 21 Va Shly ay Akimel Estimate of Crop Prod. Losses by Flood Event (Reach 6) Adjusted for Seasonal Flood Probabilities & Potential Duration Impacts					
Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$200	$700	$39,300	0.0	$40,200
100	$500	$2,000	$51,200	0.0	$53,700
200	$2,100	$7,100	$66,200	$3,400	$78,800
500	$2,300	$7,600	$77,400	$30,300	$117,600
EAD	$20	$70	$1,430	$90	$1,600

As shown on Table 21, expected annual direct production losses are minimal when reflecting the low probability of inundation, the seasonal nature of flooding, and a range of potential durations. In addition, the damages to the orchards could actually be lower than the values shown above if the durations were short. For purposes of this analysis and based upon the information available, it is assumed that without project expected annual damages equal $1,600.

These losses do not account for potential income/revenue losses. In order to accurately assess revenue impacts, it would be necessary to analyze the potential for replanting, as well as whether or not the replanting would result in reduced yield. Due to the limited flooding impacts to agricultural areas, this additional analysis was not conducted. However, estimates were developed of the maximum expected annual losses for each crop under the assumption that flood events occurred after all production expenses were incurred, but before any of the harvest could be sold. This value is simply the gross revenue loss assuming a complete loss of the harvest. As shown in the Addendum, even using these values, expected annual damages only total $3,100. Since the harvest times vary for the crops, and the probability that flooding would occur at such a time as to result in complete loss of any of the crops harvested is very low, it was not deemed appropriate to base damage estimates on this value. Rather, damages are based upon direct production losses, although this underestimates potential agricultural losses to a small extent.

In addition to direct production losses, flooding of agricultural areas would also require cleanup. Cleanup costs per acre can vary significantly, depending on the stage of production cycle, duration and timing of the flood event. For purposes of this analysis, cleanup costs were derived by applying a cost per acre of $1,000 to the acreage estimates shown in Table 19. Resulting average annual agricultural cleanup costs total $5,700.

Adding estimated average annual direction production losses to agricultural cleanup costs results in total average annual agricultural damages of $7,300.

Without Project Flood Damage Analysis Summary

Without project flood damages are summarized on Table 22.

Table 22
Va Shly ay Akimel
Without Project Equivalent Annual Damages
(in $1,000s)

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

** Including Direct Production Losses & Cleanup*

Total without project equivalent annual damages total approximately $312,000. About 62 percent of total damages are concentrated in Reach 6. This reach contains fewer structures than the downstream breakout area. However, this area has a higher probability of flooding, and the floodplain boundaries for the 50 through 500-year floods are significantly larger. As a result, structure/content and cleanup damages are higher in this area. Temporary housing costs are higher in the downstream breakout area due to the much greater number of structures, which is the basis for these cost estimates.

Recreation

As demonstrated earlier in this report, the City of Mesa, as well as the entire Phoenix metropolitan area has experienced rapid population growth. As the Phoenix MSA population has now expanded to over three million people, so has the demand for both passive and active recreation opportunities. Envisioned recreational opportunities coinciding with habitat restoration projects for the study area consist primarily of passive recreation, such as bird watching, walking, jogging, hiking, bike riding, horse-back riding, picnicking, and other passive uses of open space.

Existing Recreation Resources in Market Area

Based upon conversations with representatives from the City of Mesa, SRP-MIC, the Arizona Game and Fish Department and other agencies, the proposed habitat and recreation features would attract visitors throughout the Phoenix metropolitan area, particularly the East Valley (Scottsdale, Tempe, Mesa, Gilbert, Chandler and Apache Junction). The greater Phoenix area does not currently have any significant riparian habitat areas with supporting recreation facilities. The major existing parks in the area consist primarily of desert mountain preserves, which do not contain the types of habitat that could be supported in the study area. For purposes of this analysis, the market area will be defined as the greater Phoenix metropolitan area, which would include Maricopa and Pinal Counties, and the SRP-MIC, although it is likely that many visitors would be drawn from even greater distances.

The following presents the primary recreation areas in the greater Phoenix area. This does not include the area's numerous golf courses and man-made lakes.

National Trails Systems

- North Mountain Trail: Nine miles of trails located in Northwest Phoenix.
- South Mountain Trail: Fourteen miles of desert trails in the center of South Mountain Park, providing for hiking and horseback riding.
- Sun Circle Trail: Includes 110 miles of urban to open desert trails forming a loop around the Phoenix Valley for hiking and bicycling.
- Squaw Peak Trail: 1.2 miles of urban wilderness area.

State Parks

- Painted Rocks State Park: 140 acre historical park located 15 miles west of Gila Bend.
- Lost Dutchman State Park: 300 acres of desert park on the Apache Trail located near the Maricopa/Pinal County border. Includes 35 campsites, picnic facilities, and restrooms.

BLM Lands

- Greenbelt Resource Conservation Area located south of Buckeye -- includes hunting and hiking.

State Game & Fish Department

- Usery Mountain Shooting Range: 1,092 acres located northeast of Mesa
- Black Canyon Shooting Range: 1,290 acres located 20 miles north of Phoenix.
- Base and Meridian: 173 acres of wildlife habitat located three miles south of Cashion.
- Gila River Wildlife Area: 6,896 acres of wildlife habitat extending from Avondale to the Gillespie Dam.

Major Water Bodies

- Apache Lake Marina: Located approx. 35 miles east of Phoenix in Maricopa and Gila County.
- Bartlett Lake: Maricopa County (approx. 45 miles northeast of Mesa).
- Canyon Lake: Maricopa County (approx. 30 miles east of Phoenix).

- Saguaro Lake: Maricopa County (approx. 25 miles east of Phoenix).

Maricopa County

- McDowell Mountain Park: One of Maricopa County's largest parks, covering 21,099 acres, with camping, trails, and a nature center.
- Santan Mountains Area: 10,118 acres, currently with no recreation improvements. Phase I development will establish picnic areas, camping, a trailhead, and utilities.
- Usery Mountain Recreation Area: 3,648 acres, including campgrounds, a day-use area, picnic sites with grills, tables, ramadas and water fountains, hiking, mountain biking and horseback riding. A horse staging area is available with picnic areas and hitching posts.
- Estrella Regional Park: 18,000 acres located three miles south of Goodyear.
- Maricopa County Flood Control District Reach 6 Floodway Trail: Two-mile stabilized granite trail from Princess Park to Broadway Rd. along the RWCD canal in Mesa.

Major Municipal Parks & Other Recreation Areas

Red Mountain District Park	Fitch Park
Papago Park	South Mountain Park
Salt River Project Canal Banks (Trails)	Echo Canyon Recreation Area
Phoenix Mountain Preserve	

Red Mountain Park is one of the largest recreation areas listed above which is nearby the study area. Red Mountain Park is the only regional park in the City of Mesa. The park consists of 1,146 acres and is located between Power and Ellsworth Road, just north of McDowell and spans just south of Brown. At this time the majority of the park (1,028 acres) is undeveloped open space, which serves as a tribute to the beautiful Arizona Sonoran Desert. The park amenities include: six lit soccer fields, two lit basketball courts, four lit concrete volleyball courts, picnic areas, ramadas, a playground, walking trails, an artificial riparian habitat area and an urban fishing lake. The lake is also a Department of Water Resources recharge facility that utilizes three wells that permit water from the lake to enter the wells and thereby recharge the underground water aquifer. The City of Mesa estimates the annual visitation at Red Mountain Park at over five million.

South Mountain Park and Papago Park are two of the largest recreation areas in the greater Phoenix Metropolitan Area. South Mountain Park is located about three miles south of the Salt River and extends from about 48th Street on the east to 43rd Avenue on the west -- a distance of over 10 miles. The park encompasses about 17,000 acres of desert mountain landscape and is the largest municipal park in the U.S. It is bounded on the north by Baseline Road and on the south by Chandler Boulevard, and is over three miles wide in some places. It contains an activity complex, hiking and riding trails (extending over 40 miles), an interpretive center, lookouts, ramadas, picnic areas and restrooms. According to the *Sonoran Preserve Master Plan*, annual park visitation during the 1990s exceeded 3 million.

Papago Park is located just north of the Salt River in eastern Phoenix and western Tempe. It includes about 1,400 acres bounded on the north by Oak Street, on the south by State Highway 202, on the west by 52nd Street and on the east by 68th Street. The park includes: rock formations dating back 15 million years, ramadas, picnic facilities, three fish ponds stocked with rainbow trout and channel catfish, a baseball stadium, a softball complex, volleyball courts, the Phoenix Zoo, botanical gardens, a state historical museum, two golf courses, an archery shooting range, nature trails and restrooms. Annual visitation at this park exceeds 2 million.

In addition to South Mountain Park, Phoenix Mountain Preserve is the other major mountain preserve area in greater Phoenix. Located in the northeastern section of Phoenix, the Phoenix Mountains are a combination of

regional parks and preserves. The regional parks represent the partially developed areas while the preserves represent the areas which are completely undeveloped except for trails. There are about 1,800 acres of regional parks embedded within the preserves, including the North Mountain, Squaw Peak, and Shaw Butte recreation areas. These parks include an extensive trails system, picnic areas and restrooms. North Mountain recreation area also features basketball and volleyball facilities and a playground. The combined visitation at North Mountain and Squaw Peak Recreation Areas has totaled approximately 1.5 million in recent years.

Existing Recreation Resources in Study Area

Recreation along the Salt River corridor is highly dependent upon the availability of surface water and riparian habitat, both of which are dependent upon the supply and availability of ground water. The Salt River through the SRP-MIC and the City of Mesa consists of dry river bottom. As a result, virtually no recreation activities take place. The only improved recreation area is Riverview Park, which is adjacent to the Salt River at the west end of the Study Area. The Park contains 51 acres within its boundaries, and includes baseball and softball fields, basketball and volleyball courts, picnic facilities, ramadas and a three-acre urban fishing lake. Riverview Golf Course (a 9-hole course) is adjacent to the park. Annual attendance is estimated at approximately one million.

Some of the other park facilities in the City of Mesa include:

Park/Facility	Annual Visitation	Features
Quail Run Park	432,000	38 acre park with 4 lit soccer fields, 4 lit 90ft baseball fields, a playground, picnic facilities, ramadas, and a fenced dog area
Hohokam Park	2,024,000	37 acres, with professional level baseball stadium with 14,000 seating and training facilities, 2 lit and 2 unlit soccer fields.
Gene Autry Park	670,000	Professional level spring training complex with 3 lit baseball fields and clubhouse, 16-court tennis center with 4 volleyball courts, a playground, and picnic facilities.
Park of the Canals	125,000	This is a historically significant park with ancient Hohokam canals and dwellings, public rest rooms, picnic facilities, playground, and botanical garden.
Fitch Park	2,755,000	4 lit baseball fields, 4 lit reservable racquetball courts, 4 lit basketball courts, 2 playgrounds, picnic facilities, reservable ramadas, rest rooms,
Usery Mountain Recreation Area	73,600	This Maricopa County facility of 3,324 acres includes an archery range, 71 camp sites, 27.3 miles of trails, 1 group camp ground, 60 picnic sites, 3 playgrounds, 19 ramadas, 7 rest rooms, 4 restrooms with showers and a private water system.

The SRP-MIC has a limited number of outdoor recreation facilities nearby the study area. The two primary facilities include the Salt River Baseball Field and the Salt River Little League Field.

Other existing and planned recreation facilities along the Salt River downstream of the Study Area include Tempe Town Lake, the Rio Salado Project, and the Tres Rios Project.

The Rio Salado Project stretches from an upstream limit of 32nd street to a downstream limit of 19th Avenue and is comprised of environmental restoration and passive recreation components along the Salt River. Approximately five miles (and 580 acres) of the Salt River will be restored to create riparian and wetland habitat. Passive recreation facilities, including over ten miles of trails and interpretive signage are also included. Construction commenced on the project in 2000. Recreation project features include parking lots, information kiosks, a visitor center, overlooks, shade structures, bridges, trails, a staging area, signage and landscaping. Recreation activities provided by the plan include: walking, hiking, biking, horseback riding,

roller blading, picnicking, and bird watching. Scenic overlooks will be included for the enjoyment of the restored desert riparian habitat. Information kiosks and the visitor center will provide education on the resource, including restoration of the habitat, the hydro cycle, a historical perspective of the Salt River, and flora and fauna within the project area. As documented in the Rio Salado Feasibility Study, annual visitation is anticipated to exceed 500,000.

In addition to the Rio Salado Project, the Tres Rios project, located downstream of the 91st Avenue Wastewater Treatment Plant, will also provide recreation opportunities. Components of this plan include new levee alignments for flood control, the establishment of wetland, marsh and riparian habitat and passive recreation/environmental education facilities.

Immediately upstream of the Rio Salado Project is Tempe Town Lake. The lake was constructed within the existing Salt River flood control channel (about 850 feet in width), extending from the Salt River's confluence with Indian Bend Wash to approximately two miles downstream. The river's flood control conveyance capacity is retained through the use of a system of rubber dams which can be deflated during significant floods.

The lake contains about 220 surface acres and 20,000 feet of shoreline supporting paddle-boating, canoeing, sailing and fishing. Tempe is hoping to establish the state's largest urban fishing program. Over 1,000 acres of adjacent land has been dedicated for recreational development and open space. Activities will include picnicking, hiking, bicycling, horseback riding, softball/baseball, volleyball, golfing, water slides and play areas. Other possible recreational uses include soccer and major sports events, such as marathons.

Future recreation facilities being planned for the Mesa area include:

- South Canal Multi-use Path: Will include 6.5 miles of lit, paved multi-use trails along the Salt River Project South Canal bank from McKellips Road to Granite Reef Dam along the Salt River.
- Metro Park: 132 acres of undeveloped land in northeast Mesa to be developed as a Metro Park with trails, picnic facilities, sports courts and possibly lit sports fields pending public input.
- Development of the Crimson homestead site: 3.5-acre historic homestead with farmhouse, out buildings and citrus trees. A trailhead for the South Canal Multi-use path may be developed here.

Recreation Demand

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

1) Environment: Demand for recreation opportunities must be considered in the context of the surrounding environment. Although there are many recreation areas throughout Mesa and the Phoenix metropolitan area, the only recreation facilities located within wetland/riparian habitat areas are those which will be provided downstream of the study area by the Rio Salado and Tres Rios projects. Most of the existing parks are small community parks. The larger regional parks are located in desert mountain terrain (e.g., Red Mountain Park and South Mountain Park) and not in wetland and riparian habitat areas. This is expected to result in significant recreation demand at the study area if such habitat is established. As discussed previously, riparian habitat would also attract wildlife to the area. According to the 1991 *National Survey of Fishing, Hunting and Wildlife-Associated Recreation (Arizona)*, published by the U.S. Fish and Wildlife Service, over 1.1 million Arizona residents 16 years and older (or 40 percent of the population) participated in non-consumptive activities where the

enjoyment of wildlife was the primary purpose of the activity. Such activities include observing, feeding and photographing wildlife. Nearly 3.3 million trips were taken by Arizona residents to participate in non-consumptive activities one mile or greater from their residence.

2) Location: In a study conducted for the 1994 Arizona Statewide Comprehensive Outdoor Recreation Plan (SCORP), over 1,200 respondents were asked what the primary barriers were to outdoor recreation participation. After lack of time, the number two and three barriers cited were: 2) recreation areas are too far away; and 3) don't know where to go. The 1991 Fish and Wildlife Survey indicated that Arizona residents travel an average distance of nearly 30 miles to participate in non-consumptive recreation activities. The closest major water bodies to the city of Phoenix are located approximately 30 miles away. These barriers would not be associated with recreation at the study area. According to the publication, *Arizona Trails 2000*, prepared by the Arizona State Parks Board (October 1999), the number one reason given by recreation trail users for preferring a particular area is its proximity to home.

The study area is located within the Phoenix metropolitan area, which has a population exceeding three million. Portions of the study area are located within minutes of downtown Mesa, and are thus easily and quickly accessible to the public. This provides the area with tremendous exposure, and would likely attract many who would otherwise not frequent such a park.

Family and lifestyle changes also contribute to high demand for more local recreation facilities. As described in the *Town Lake Capacity and Needs Study: Rio Salado Project* (BRW Moffatt & Nichol Engineers, 1996), "More single-parent families, more families where both spouses work full-time, moderate growth in income and less time for leisure time activities all contribute to heavy pressure on local park and recreation facilities. People are looking for park and recreation facilities which are close, offer a variety of water-based and land-based activities and are in an attractive setting."

3) Attitudes: Arizonans place high importance on the state's outdoor recreation resources. In the 1994 SCORP survey, 94 percent of respondents stated that parks and recreation areas are important to their everyday lifestyles. There is also strong support for protecting natural and cultural resources and for environmental education. Arizonans care deeply about the state's air, water and riparian areas. Seventy-five percent (75%) favor preserving rivers and stream-side habitats, even if it means limiting some uses of privately owned lands. A separate study conducted by the Arizona Game & Fish Heritage Fund (*Attitudes Toward Urban Wildlife Management, Volume 1, May 1995*) supports these statistics. A statewide survey was conducted of 1,200 residents. In the Heritage Fund survey, 89 percent of respondents stated that the continued presence of wildlife in their town is important to them. The importance placed on protecting water-based habitat and recreation areas can be attributed to the limited amount of surface water available. Arizona has approximately 113,642 square miles of land surface, but only about 360 square miles are water-covered.

The *Mesa 2025* publication referenced earlier in this report also provides feedback on the attitudes of local residents regarding recreation. Surveys conducted for the study concluded that residents desire more parkland, particularly more passive recreation facilities. Participants support the City taking an active roll in identifying and pursuing a variety of partnerships with public and private entities to create new recreation facilities.

4) Activities: Potential recreational activities for the study area include trails for hiking, biking, jogging, and horseback riding, birdwatching, and picnicking. In addition, interpretive centers and lookout points could be established along the banks of the river at key scenic vantage points. In a ranking of overall demand for outdoor activities in the recent SCORP, visiting outstanding scenic areas was ranked first, picnicking ranked fourth, and walking ranked fifth. Other envisioned recreation features for the study area were ranked as follows: day trail hiking (10); bicycling (14); using a park playground (15); horseback riding (18); mountain biking in a natural setting (26); nature study/birdwatching (27); and jogging/running (36). Among those activities identified as having the greatest latent or unmet demand, picnicking, visiting outstanding scenic areas, walking, trail hiking, horseback riding and bicycling all ranked in the top fifteen. In terms of public funding priorities, visiting outstanding scenic areas, picnicking, trail hiking, using a park playground and walking all ranked in the top ten.

Mesa's 2025 report also details the demand by local residents for the types recreation that could be provided at the study area. When survey respondents were asked to identify the leisure activities they most frequently participate in, among the top thirteen responses were: walking/jogging (58%), picnicking (37%), biking (31%), hiking (30%) and visiting nature preserves (28%).

According *Arizona Trails 2000*, over half of Arizona residents consider themselves non-motorized recreation trail users. Surveys indicated that trail users spent an average of 22 days using trails during the prior year. Over 70 percent of respondents indicated that they supported using state funds to develop trails. Survey results are supported by the fact that Arizona State parks have experienced a 16 percent increase in visitation over the past five years.

There is also a shift in the types of recreation demanded by Americans in general. The National Survey on Recreation and the Environment conducts periodic surveys on public recreation use and demand. From 1983 to 1995, the percentage of Americans involved in such activities as fishing and hunting actually declined. On the other hand, the activities that have seen the most dramatic increases in demand have been hiking (+94%), birdwatching (+155%) and backpacking (+73%).

5) Population Growth: As demonstrated earlier in this report, the greater Phoenix area has experienced tremendous growth. For example, Maricopa County's population has grown from 2.12 million to over three million between 1990 and 2000 (or nearly 45 percent), and is expected to reach over 4.5 million by the year 2020. With this projected growth, there will be increasing demand for outdoor recreation opportunities. As quoted in the 1994 SCORP report (p. 68),

"This large and rapidly growing population in our two metropolitan counties has several implications for outdoor recreation. Most obvious, local providers are hard-pressed to keep up with demand for facilities and services. As development continues to expand, providing and protecting open space becomes an important issue. Increasingly, city dwellers mention a major barrier to participation that recreation providers must address: outdoor recreation areas are too far away."

6) Education: The establishment of riparian habitat would attract diverse wildlife to the study area. Elementary and high schools would frequent the area for class field trips, and colleges could utilize the area for environmental-related research.

According to the article, "Assessing Recreation Demand", posted on the U.S. Department of Transportation Statistics' Internet site, the use of population based standards represents one of the most widely used methods for assessing community demand and need for open space and recreation. This is attributed to the fact that they are easily understood and administratively convenient. Such standards are considered most useful as a means for generating alternatives for consideration and as a means for supporting participation data. The National Recreation and Parks Association (NRPA) established a range of standards, but also recommended that each community develop individual standards to the most appropriate range, quantity and quality of recreation facilities within their fiscal restrictions.

Mesa has developed standards for various types of recreation, in terms of desired and ideal service levels on a per capita basis. The desired levels are lower than the national standards, as set by NRPA. However, target levels were adjusted to reflect the realities of the limited amount of available land and funding. Table X summarizes the current and target service levels.

As shown on Table 23, the City currently has a supply of about 4.2 acres per thousand residents in the western portion of the City and about 8.5 acres per thousand residents in the eastern portion of the City. For the City as a whole, there is currently about 2,918 acres of park property, accounting for about 6.7 acres per thousand residents. In light of land and funding constraints, the City has established desired service level ratios of 4.65 acres/1000 for the west and 8.5 acres/1,000 for the east. These ratios are well below the national standard often referenced of 10 acres per thousand residents, which was also the standard previously adopted by the City in its 1996 General Plan. Even with these reduced standards, the City still falls below target levels, and the supply deficit will worsen over time due to the projected population growth. Table 23 shows that the City will need to add over 700 acres of new parks over the next 25 years to meet the demands of the growing population.

TABLE 23
City of Mesa Recreation Supply & Future Needs

Facilities Category	2000 Total (acres)	Current Population/ Facility Ratio Mesa-West (acres)	Current Population/ Facility Ratio Mesa-East (acres)	Mesa - West Guidelines	Mesa - East Guidelines	Add'l Acres Needed in West by 2006	Add'l Acres Needed in East by 2006	Add'l Acres Needed in West by 2010	Add'l Acres Needed in East by 2010	Add'l Acres Needed in West by 2025	Add'l Acres Needed in East by 2025
Neighborhood Parks (3-15 acres)	215.1	194.5 .56 ac/1,000	20.6 .23 ac/1,000	.65 ac/1,000	1 ac/1,000	20	50	20	50	10	60
Community Parks (15-40 acres)	382.7	294.2 1.17 ac/1,000	88.5 1 ac/1,000	1 ac/1,000	1.5/1,000	40	40	40	80	40	80
Metro Parks (40-200 acres)	269.9	269.9 .78 ac/1,000	0 .00 ac/1,000	1 ac/1,000	1.5 ac/1,000	50	160	50	50	50	80
Regional Parks (+200 acres)	1144.5	572 1.65 ac/1,000	572.5 6.40 ac/1,000	1.5 ac/1,000	4 ac/1,000						350
Special Use Facilities	118.4	118.4 .34 ac/1,000	0 .00 ac/1,000	.5 ac/1,000	.5 ac/1,000	10	20	15	30	10	40
All Parks (Subtotal)	2130.6	1449 4.17 ac/1,000	681.6 7.63 ac/1,000	4.65 ac/1,000	8.5 ac/1,000	120	270	125	210	110	610
Retention Basins (City maintained only)	424.4	243.4	181	Ratio of Total Parks/Open Space to 2000 Mesa Population = 6.69 ac/1,000							
Golf Courses (City-owned)	362.9	230.9	132								
Total Parks/Open Space	**2917.9**	**1923.3**	**994.6**								

Source: Mesa 2025 – A Shared Vision (June 2002)

WITH PROJECT CONDITIONS

Environmental Resources

The objective of this study was to develop alternatives that increased native riparian vegetation, increased vegetation connectivity, and stabilized bank sections, where necessary.

Fifteen overall alternatives have been developed, each with two irrigation options. The alternatives vary with respect to vegetation layout, river channelization, reshaping and method for distributing water. Levees, bank stabilization and water sources (groundwater and/or surface water) were also examined. These features can be applied to any of the alternatives and do not change the design of the vegetation or irrigation systems.

TABLE 24
Va Shly Ay Akimel
Environmental Restoration Alternatives

Alternative Name	Alternative Letter
LOAD	A
MEAD	B
HIAD	C
MINE	D
VHAD	E
F-MAX	F
CWAD	G
MSAD	H
CHNL	I
BRAD	J
NODL	K
POCK	L
WET	M
N-MAX	N
O-MAX	O

General Management Measures

Water Sources

There are five water sources for the project: 1) The surface water available for use by the Pima Maricopa Indian Community via existing water sources, 2) groundwater from existing and new wells, 3) storm water, 4) City of Mesa Wastewater Treatment Facility water, and 5) irrigation tailwater. The current alternatives rely primarily on surface water and groundwater from the Salt River Pima Maricopa Indian Community (SRPMIC) and effluent from the City of Mesa Wastewater Treatment Facility. Groundwater is considered a secondary source of water.

Water Distribution System

The water distribution system refers to the infrastructure needed to deliver water (surface water, groundwater, or wastewater) from the source (irrigation canal, well, or effluent line) to the vegetated areas. Surface water from the SRPMIC will be the primary source of water.

Irrigation Techniques

Surface water from the storm water sources, irrigation canals and ditches will be diverted to various vegetated areas by a network of lined irrigation channels and buried pipes. To irrigate the vegetated areas it is recommended that either a Surface Braided Irrigation Network, (SBIN), flood irrigation, or drip irrigation be used.

Reshaping

Many of the alternatives require surface reshaping. Four types of reshaping categories are discussed in this project: 1) Channelization, 2) Surface Reshaping, 3) Vegetation Reshaping and 4) Irrigation Reshaping. Channelization is defined as the material moved in the process of constructing the 200 ft wide low flow channel. Surface Reshaping is defined as the material moved to alter significant features such as large mounds, filling quarry pits and reducing the side slopes of the quarry walls. Vegetation Reshaping is defined as minor reshaping required for planting purposes and to ensure that gravity irrigation systems will be feasible. Irrigation Reshaping is defined as the construction of irrigation and drainage ditches.

Vegetation

Five vegetation types were evaluated: 1) Cottonwood/Willow, 2) Mesquite, 3) Wetlands, 4) Sonoran Desert, and 5) River Bottom:

1) Cottonwood/Willow (CW) – CW stands are restricted to the near over bank area of streams and rivers, or other areas with saturated soil conditions. Due to the relative high water demands of CW, a drip irrigation system may be used to help ensure establishment. Once established, CW stands will rely on flood irrigation or SBIN for its water needs.

2) Mesquite (MS) – MS are commonly found 5-20 feet above the river channel where water is adequate. A drip irrigation system may be necessary to establish the MS. However, once established, the MS will rely on a flood irrigation or SBIN for its water needs.

3) Wetland (WT) - WT areas can consist of open water, submerged vegetation or muddy shorelines, all requiring a high water table level at or near the surface. Due to the porous soils found in this project area, lining the WT will be required to maintain surface water. To distribute water from the WT laterally, a series of drainage ditches will be constructed from the WT and divert water to other areas that require irrigation. The WT will also be designed with an outlet channel leading to the main channel.

4) Sonoran Desert (SD) – The specific vegetation species can vary depending upon the site's soil aggregate type. However, proposed vegetation types will not require saturated soil conditions. The SD may need to be periodically inundated the first 1-5 yrs to establish the vegetation. Once established, SD should be sustained by annual precipitation or with periodic inundation, via flood irrigation, during extreme drought periods.

5) River Bottom (RB) - RB will require only surface reshaping, including partially filling large depressions and excavating large mounds to reduce possible impacts to restoration efforts. River bottom areas may also require hydro-seeding with a variety of native river bottom shrub species to help establish vegetation. These plants will be sustained with natural precipitation and any tail water that may enter the river from other feature irrigation systems. Irrigation is not required.

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

River Channelization

Some alternatives require segments of the Salt River to be channelized, offsetting the reduction in water conveyance, due to planting of vegetation within the main channel. The river bottom will be excavated to form a low flow channel with a bottom width of 200 ft, and 4 to 8 ft in depth. The channel will be free to migrate. The excavated material can be used to create benches along the channel, to fill quarry pits and to vary the local topography to encourage vegetation growth and reduce flood damage on proposed vegetation areas. Maintenance of the channel may be necessary after flow events. A two hundred foot buffer on both sides of the low flow channel will be incorporated to allow for the migration of the low flow channel.

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

Grade Control Structure

A grade control structure may be needed to protect the Gilbert Road Bridge due to the extensive mining that has occurred downstream of the bridge. Results indicate that the head cut could undermine the bridge and also damage features directly upstream of the quarry. The grade control structure would need to span the entire width of the riverbed and be designed to the estimated scour depth.

Bank Stabilization

Several areas require bank stabilization to protect commercial and culturally significant areas from channel erosion. Four general bank stabilization measures have been evaluated: 1) riprap, 2) buried groins, 3) bendway weirs (wingdams, groins), and 4) soil cement. The preferred method of bank stabilization is soil cement.

Description of Alternatives

Please refer to the Main Report for a detailed description of alternatives. In general:

- Alternatives A through C focus on xero-riparian vegetation, ranging from a minimal level of vegetation under Alternative A to an extensive amount under Alternative C.

- Alternatives D through F focus on meso-riparian vegetation, including a mix of cottonwood, mesquite and xero-riparian vegetation. Again, each successive alternative includes greater amounts of vegetation.

- Alternatives G and H feature extensive amounts of cottonwood and mesquite, respectively. In addition, both of the alternatives feature a braided channel network.

- Alternatives I through K focus on cottonwood vegetation. Alternative I also features a channelized stream. Alternatives J and K include more vegetation than Alternative I. The primary difference between Alternatives J and K is that Alternative J includes reshaping of sand and gravel mining operations within the channel, while Alternative K does not.

- Alternative L is focused on cottonwood and mesquite vegetation, with an emphasis on locating the vegetation in high visibility areas.
- Alternative M is the only hydro-riparian dominate alternative.
- Alternative N is a modification of Alternative F, but with reduced channel modifications.
- Alternative O is a modification of Alternative N, with added vegetation in the downstream reaches.
- For each alternative, two irrigation options were analyzed. Option 1 includes a drip irrigation system for each alternative, and Option 2 includes a braided irrigation network for each alternative. These options are distinguished in each alternative by the naming convention of A1, A2, B1, B2, etc.

Benefits of Alternatives

Based upon the individual features proposed for each alternative, the number of acres and functional capacity indices were projected in order to derive with-project estimates of average annual functional capacity units (AAFCUs). The same methodology as was employed for assessing without project conditions was also employed to assess the habitat output of each alternative. Benefits are defined as the increase in AAFCUs for each alternative relative to without project conditions. Table 25 shows the results. Note that benefits are assumed to be the same for the two irrigation options for each alternative, so separate benefit estimates are not shown.

TABLE 25 VA SHLY AY AKIMEL STUDY AREA WITH PROJECT AVERAGE ANNUAL FUNCTIONAL CAPACITY UNITS (FCUs)																
	Without Project	Alt A	Alt B	Alt C	Alt D	Alt E	Alt F	Alt G	Alt H	Alt I	Alt J	Alt K	Alt L	Alt M	Alt N	Alt O
F1	689	1088	1250	1317	1114	1452	1368	1371	1362	1108	1280	1175	1204	1235	1288	1316
F2	955	1362	1578	1772	1589	1942	2084	1975	1860	1771	1902	1710	1839	1899	1977	2038
F3	72	383	636	863	683	954	1227	1051	1011	803	973	833	816	934	963	1023
F4	131	203	371	431	514	527	825	683	666	720	771	750	823	908	783	788
F5	805	1129	1227	1397	1326	1495	1658	1555	1398	1407	1522	1377	1476	1472	1617	1656
F6	726	1001	1095	1192	1080	1293	1313	1280	1187	1135	1234	1130	1202	1202	1291	1316
F7	701	1086	1322	1513	1323	1655	1804	1692	1659	1365	1602	1417	1453	1531	1613	1677
F8	1353	1922	2162	2368	2080	2578	2601	2530	2393	2105	2397	1881	2273	2306	2480	2546
F9	889	1423	1729	1954	1644	2157	2266	2146	2036	1655	2020	1509	1836	1913	2067	2131
F10	854	1308	1741	2081	1804	2379	2376	2321	2104	1861	2197	1668	1832	2066	2224	2309
Avg	718	1091	1311	1489	1316	1643	1752	1660	1568	1393	1590	1345	1475	1547	1630	1680
Increase	T0-T50	**373**	**594**	**771**	**598**	**926**	**1035**	**943**	**850**	**675**	**872**	**627**	**758**	**829**	**913**	**963**
Increase	PY1-PY50	**389**	**619**	**807**	**628**	**966**	**1084**	**986**	**891**	**707**	**914**	**658**	**792**	**867**	**955**	**1006**

As shown on Table 25, the proposed alternatives result in increased AAFCUs (relative to without project conditions) ranging from 373 for Alternative A to 1,035 for Alternative F.

The above AAFCU values were calculated for the time period Target Year 0 (T0) through T50, with T0 being "base conditions" (prior to construction), and T1 being the first year of construction. Planning guidance specifies that benefits and costs for all alternatives should be analyzed over the same time period. For this study, a Base Year of 2011 was established based upon estimates of Feasibility Study completion, project authorization, and completion of engineering, design and construction. Construction is estimated to be completed within a three-year period for all alternatives. Therefore, T1 would correspond with three years prior to the Base Year, and T4 would correspond with the Base Year. AAFCUs were recalculated for the 50-year period commencing with the Base Year (PY1 through PY50), which corresponds with T4-T53. Although the results do not change significantly, it was deemed appropriate to make the adjustment for temporal consistency of benefits and costs. These results are shown in the last line of the table.

Cost Estimates

Tables 26 and 27 which follow show costs by alternative. Table 26 shows costs based upon a drip irrigation system (Option 1), while Table 27 shows costs based upon a braided irrigation system (Option 2). Table 28 shows a comparison of costs for the two water delivery systems.

TABLE 26
VA SHLY AY AKIMEL STUDY AREA
WITH PROJECT AVERAGE ANNUAL COSTS BY ALTERNATIVE (in $1,000s) - DRIP IRRIGATION OPTION

	Alt A1	Alt B1	Alt C1	Alt D1	Alt E1	Alt F1	Alt G1	Alt H1	Alt I1	Alt 1J1	Alt 1K1	Alt L1	Alt M1	Alt N1	Alt O1
Construction	$25,106	$62,128	$96,590	$91,796	$90,579	$155,599	$141,758	$144,398	$139,815	$101,980	$91,673	$86,282	$137,022	$89,927	$94,607
Contingency (25%)	$6,277	$15,532	$24,147	$22,949	$22,645	$38,900	$35,440	$36,100	$34,954	$25,495	$22,918	$21,571	$34,255	$22,482	$23,652
PED/EDC (11%)	$2,762	$6,834	$10,625	$10,098	$9,964	$17,116	$15,593	$15,884	$15,380	$11,218	$10,084	$9,491	$15,072	$9,892	$10,407
S&A (6.5%)	$1,632	$4,038	$6,278	$5,967	$5,888	$10,114	$9,214	$9,386	$9,088	$6,629	$5,959	$5,608	$8,906	$5,845	$6,149
Monitoring/Adaptive Mgmt.	$1,431	$3,541	$5,506	$5,232	$5,163	$8,869	$8,080	$8,231	$7,969	$5,813	$5,225	$4,918	$7,810	$5,126	$5,393
Real Estate	$9,722	$17,727	$21,707	$15,429	$24,557	$32,651	$25,936	$25,043	$14,296	$25,472	$24,178	$17,477	$24,131	$23,226	$24,949
Total First Cost	$46,930	$109,800	$164,853	$151,471	$158,795	$263,249	$236,021	$239,041	$221,502	$176,607	$160,037	$145,346	$227,197	$156,498	$165,157
IDC	$1,049	$4,452	$8,963	$8,226	$8,642	$21,762	$19,500	$19,746	$18,268	$9,607	$8,708	$7,899	$18,769	$8,515	$8,987
Gross Investment	$47,979	$114,252	$173,816	$159,697	$167,437	$285,011	$255,522	$258,787	$239,770	$186,214	$168,745	$153,246	$245,965	$165,013	$174,144
Annualized Invest. Cost	$2,886	$6,872	$10,455	$9,606	$10,071	$17,143	$15,369	$15,566	$14,422	$11,200	$10,150	$9,217	$14,794	$9,925	$10,474
Associated Cost (Water)	$93	$204	$347	$340	$426	$778	$533	$378	$461	$571	$591	$525	$608	$725	$801
O&M	$57	$192	$241	$208	$229	$323	$270	$268	$268	$232	$231	$107	$229	$118	$131
Total Annual Cost	$3,035	$7,268	$11,042	$10,154	$10,726	$18,245	$16,172	$16,211	$15,151	$12,003	$10,971	$9,849	$15,631	$10,768	$11,406

TABLE 27
VA SHLY AY AKIMEL STUDY AREA
WITH PROJECT AVERAGE ANNUAL COSTS BY ALTERNATIVE (in $1,000s) - BRAIDED IRRIGATION OPTION

	Alt A2	Alt B2	Alt C2	Alt D2	Alt E2	Alt F2	Alt G2	Alt H2	Alt I2	Alt 1J2	Alt 1K2	Alt L2	Alt M2	Alt N2	Alt O2
Construction	$18,857	$50,120	$81,382	$82,485	$72,737	$134,040	$124,332	$127,527	$129,496	$85,777	$75,280	$73,203	$120,818	$72,451	$75,871
Contingency (25%)	$4,714	$12,530	$20,345	$20,621	$18,184	$33,510	$31,083	$31,882	$32,374	$21,444	$18,820	$18,301	$30,204	$18,113	$18,968
PED/EDC (11%)	$2,074	$5,513	$8,952	$9,073	$8,001	$14,744	$13,677	$14,028	$14,245	$9,435	$8,281	$8,052	$13,290	$7,970	$8,346
S&A (6.5%)	$1,226	$3,258	$5,290	$5,361	$4,728	$8,713	$8,082	$8,289	$8,417	$5,575	$4,893	$4,758	$7,853	$4,709	$4,932
Monitoring/Adaptive Mgt.	$1,075	$2,857	$4,639	$4,702	$4,146	$7,640	$7,087	$7,269	$7,381	$4,889	$4,291	$4,173	$6,887	$4,130	$4,325
Real Estate	$9,722	$17,727	$21,707	$15,429	$24,557	$32,651	$25,936	$25,043	$14,296	$25,472	$24,178	$17,477	$24,131	$23,226	$24,949
Total First Cost	$37,668	$92,004	$142,314	$137,671	$132,354	$231,299	$210,196	$214,037	$206,209	$152,593	$135,743	$125,964	$203,183	$130,598	$137,390
IDC	$844	$3,735	$7,744	$7,480	$7,212	$19,134	$17,376	$17,689	$17,010	$8,308	$7,394	$6,851	$16,793	$7,114	$7,485
Gross Investment	$38,512	$95,739	$150,058	$145,151	$139,566	$250,433	$227,572	$231,726	$223,219	$160,901	$143,137	$132,814	$219,976	$137,712	$144,875
Annualized Invest. Cost	$2,316	$5,759	$9,026	$8,731	$8,395	$15,063	$13,688	$13,938	$13,426	$9,678	$8,609	$7,989	$13,231	$8,283	$8,714
Associated Cost (Water)	$149	$326	$554	$544	$681	$1,246	$854	$605	$738	$913	$946	$840	$973	$1,160	$1,283
O&M	$57	$192	$241	$208	$229	$323	$270	$268	$268	$232	$231	$107	$229	$118	$131
Total Annual Cost	$2,522	$6,276	$9,821	$9,483	$9,304	$16,632	$14,812	$14,811	$14,432	$10,823	$9,786	$8,935	$14,433	$9,561	$10,127

TABLE 28
VA SHLY AY AKIMEL STUDY AREA
COMPARISON OF DRIP VS. BRAIDED IRRIGATION SYSTEM COSTS BY ALTERNATIVE (IN $1,000s)

	Alt A	Alt B	Alt C	Alt D	Alt E	Alt F	Alt G	Alt H	Alt I	Alt 1J	Alt 1K	Alt L	Alt M	Alt N	Alt O
Total First Cost															
Drip	$ 46,930	$ 109,800	$ 164,853	$ 151,471	$ 158,795	$ 263,249	$ 236,021	$ 239,041	$ 221,502	$ 176,607	$ 160,037	$ 145,346	$ 227,197	$ 156,498	$ 165,157
Braided	$ 37,668	$ 92,004	$ 142,314	$ 137,671	$ 132,354	$ 231,299	$ 210,196	$ 214,037	$ 206,209	$ 152,593	$ 135,743	$ 125,964	$ 203,183	$ 130,598	$ 137,390
Total O&M&Water Cost															
Drip	$ 150	$ 396	$ 587	$ 548	$ 654	$ 1,102	$ 803	$ 646	$ 729	$ 803	$ 822	$ 632	$ 837	$ 843	$ 932
Braided	$ 205	$ 518	$ 795	$ 752	$ 910	$ 1,569	$ 1,123	$ 873	$ 1,006	$ 1,145	$ 1,176	$ 947	$ 1,202	$ 1,278	$ 1,413
Total Annual Cost															
Drip	$ 3,035	$ 7,268	$ 11,042	$ 10,154	$ 10,726	$ 18,245	$ 16,172	$ 16,211	$ 15,151	$ 12,003	$ 10,971	$ 9,849	$ 15,631	$ 10,768	$ 11,406
Braided	$ 2,522	$ 6,276	$ 9,821	$ 9,483	$ 9,304	$ 16,632	$ 14,812	$ 14,811	$ 14,432	$ 10,823	$ 9,786	$ 8,935	$ 14,433	$ 9,561	$ 10,127

As shown on Table 28, first costs vary significantly among the alternatives, ranging from as low as $37.7 million for Alternative A2 (Alternative A, braided irrigation system), to $263.2 million for Alternative F1 (Alternative F, drip irrigation system). First costs are higher for the drip irrigation options, but associated (water supply) costs are lower. Average annual costs for the two options are fairly close for each alternative, but for each alternative, the braided irrigation system has lower expected annual costs.

Cost Effectiveness & Incremental Cost Analysis

Average Cost per Average Annual Function Capacity Unit

Table 29 summarizes average annual output and cost by alternative, as well as average annual cost per AAFCU.

TABLE 29
VA SHLY AY AKIMEL STUDY AREA
AVERAGE ANNUAL COSTS PER AVERAGE ANNUAL FCU BY ALTERNATIVE ($1,000s)

	AAFCU	AA COST	AAC/AAFCU
Alt A1	389	$ 3,035	$ 7.8
Alt A2	389	$ 2,522	$ 6.5
Alt B1	619	$ 7,268	$ 11.7
Alt B2	619	$ 6,276	$ 10.1
Alt C1	807	$ 11,042	$ 13.7
Alt C2	807	$ 9,821	$ 12.2
Alt D1	628	$ 10,154	$ 16.2
Alt D2	628	$ 9,483	$ 15.1
Alt E1	966	$ 10,726	$ 11.1
Alt E2	966	$ 9,304	$ 9.6
Alt F1	1084	$ 18,245	$ 16.8
Alt F2	1084	$ 16,632	$ 15.3
Alt G1	986	$ 16,172	$ 16.4
Alt G2	986	$ 14,812	$ 15.0
Alt H1	891	$ 16,211	$ 18.2
Alt H2	891	$ 14,811	$ 16.6
Alt I1	707	$ 15,151	$ 21.4
Alt I2	707	$ 14,432	$ 20.4
Alt J1	914	$ 12,003	$ 13.1
Alt J2	914	$ 10,823	$ 11.8
Alt K1	658	$ 10,971	$ 16.7
Alt K2	658	$ 9,786	$ 14.9
Alt L1	792	$ 9,849	$ 12.4
Alt L2	792	$ 8,935	$ 11.3
Alt M1	867	$ 15,631	$ 18.0
Alt M2	867	$ 14,433	$ 16.6
Alt N1	955	$ 10,768	$ 11.3
Alt N2	955	$ 9,561	$ 10.0
Alt O1	1006	$ 11,406	$ 11.3
Alt O2	1006	$ 10,127	$ 10.1

Cost Effectiveness Analysis

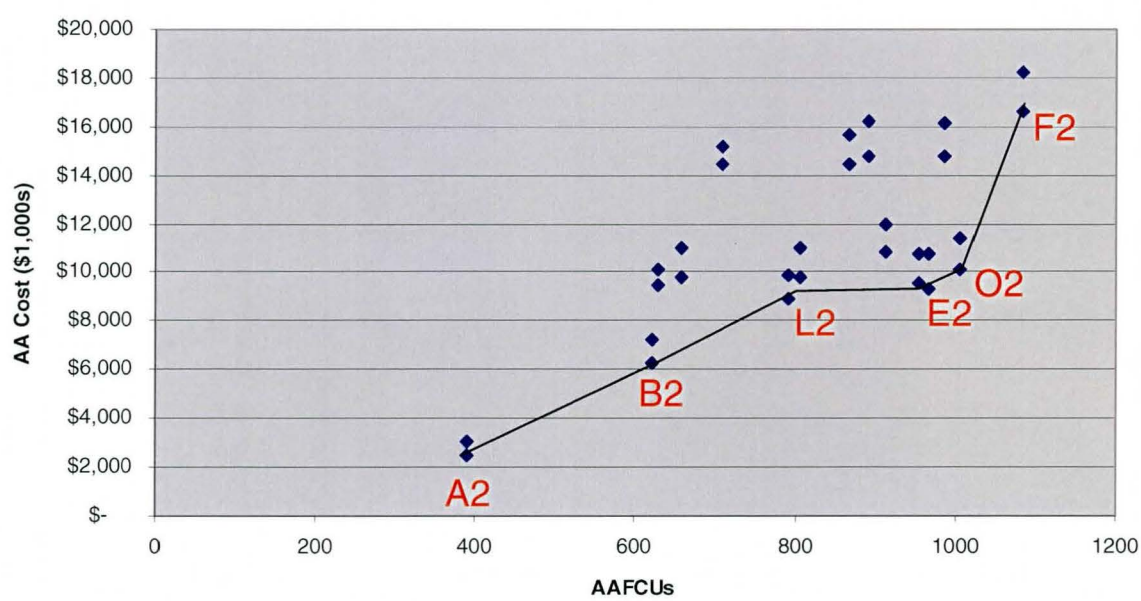
Alternatives are considered cost effective if there are not any other alternatives which provide greater output for the same cost or provide the same output for a lesser cost. This step eliminates alternatives that are inefficient from further consideration. Table 30 shows the cost effective plans.

TABLE 30
VA SHLY AY AKIMEL STUDY AREA
COST EFFECTIVENESS ANALYSIS
(in $1.000s)

	AAFCU	AA COST	AAC/AAFCU
A2	389	$ 2,522	$ 6.5
B2	619	$ 6,276	$ 10.1
L2	792	$ 8,935	$ 11.3
E2	966	$ 9,304	$ 9.6
O2	1006	$ 10,127	$ 10.1
F2	1084	$ 16,632	$ 15.3

Table 30 (and Figure 6 below) shows that only six alternatives are cost effective.

Figure 6
Va Shly ay Akimel
Cost Effective Alternatives

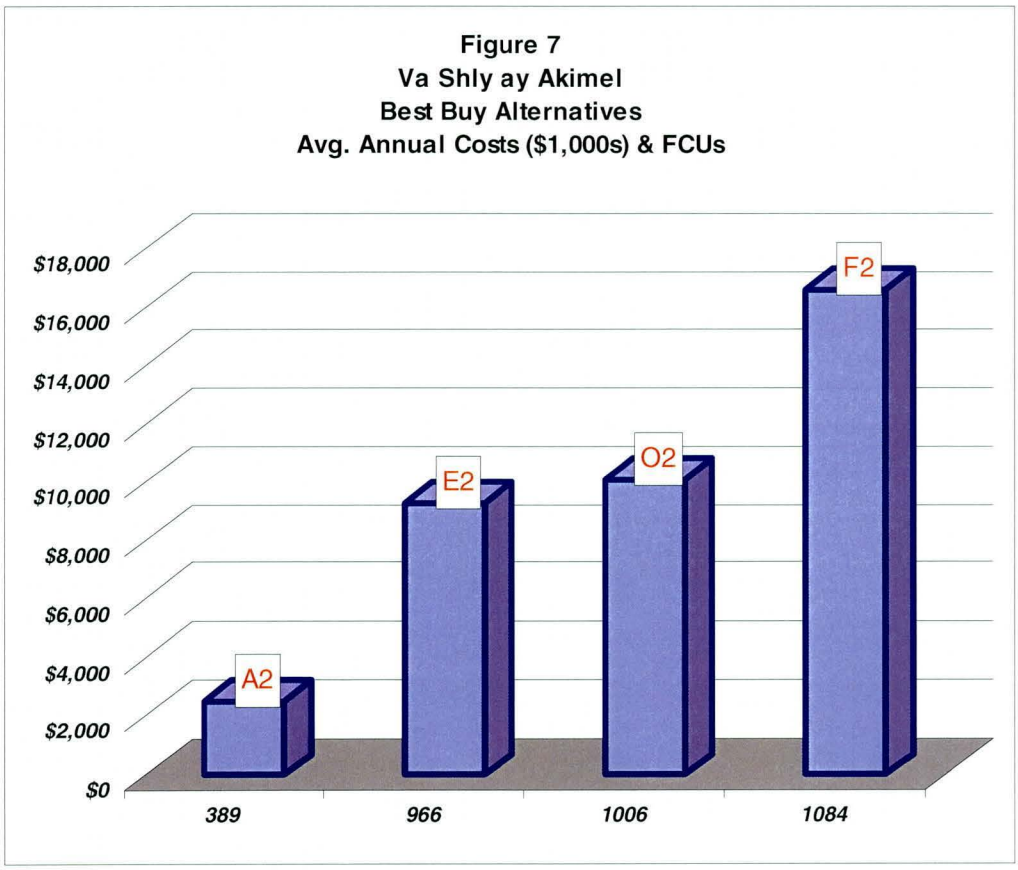


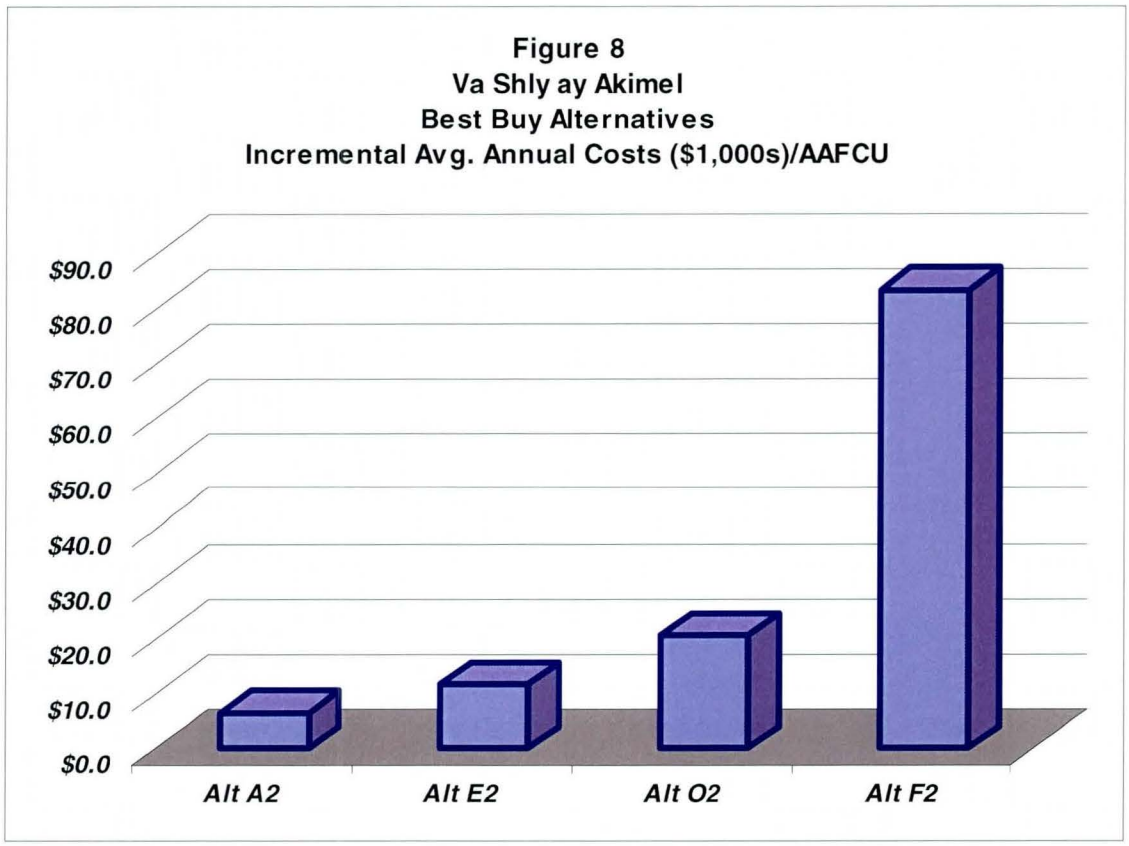
Incremental Cost Analysis

Incremental Cost Analysis goes beyond cost effectiveness analysis to identify "best buy" plans. Best Buy plans are those that have the lowest incremental average annual cost per incremental increase in output. Table 31 and Figures 7 and 8 show the results of the Incremental Cost Analysis.

TABLE 31
VA SHLY AY AKIMEL STUDY AREA
INCREMENTAL COST ANALYSIS
(in $1.000s)

	AAFCU	Incremental AAFCU	AA COST	Incremental AA Cost	Incremental AAC/AAFCU
Alt A2	389	389	$2,522	$2,522	$6.5
Alt E2	966	577	$9,304	$6,783	$11.8
Alt O2	1006	40	$10,127	$823	$20.6
Alt F2	1084	78	$16,632	$6,505	$83.4





Alternative A2 has the lowest average annual cost per AAFCU, and is therefore the first point on the ICA curve. ICA analysis then determines which alternative has the lowest incremental average annual cost (relative to Alternative A2) per incremental increase in output (relative to Alternative A2). Based upon this methodology, Alternative E2 is identified as the next Best Buy plan. Alternative E2 provides an increase of 577 AAFCUs for an additional average annual cost of about $6.8 million. The next Best Buy plan is Alternative O2, which provides an additional 40 AAFCUs relative to Alternative E2, for an additional average annual cost of $823,000. As the largest of all plans in terms of output, Alternative F2 is also shown on the final list of alternatives under the ICA analysis. However, this can be somewhat misleading, since this alternative is included because it serves as an "end point" and not because it is necessarily a good buy. For example, Alternative F2 only provides an extra 78 AAFCUs relative to Alternative O2, but has a 64 percent higher cost. As a result, the incremental AAC/AAFCU for Alternative F2 is equal to $83,400, which is more than four times higher than the incremental AAC/AAFCU for Alternative O2. Hence, from an ICA perspective, it would seem difficult to justify the additional costs for Alternative F2.

Although the above alternatives represent the best buys of the proposed alternatives, it should be pointed out that there are several alternatives that have similar output and cost to these alternatives. For example, Alternative N2 provides similar output and has similar costs relative to O2.

Recommended Ecosystem Restoration Plan

Based upon the CE/ICA analysis, Alternative O2 has been identified as the NER Plan. Although Alternative A2 has the lowest average annual cost per unit of output, it provides substantially lower environmental benefits than the other Best Buy plans. Alternatives E2, O2, and F2 all have similar output, and Alternatives E2 and O2 have similar average annual costs. However, Figure 8 clearly shows that the incremental costs associated

with Alternative F2 are very high relative to the other Best Buy plans, which is the basis for eliminating this alternative from further consideration.

While Alternative O2 only provides an extra 40 AAFCUs relative to Alternative E2, the additional cost was determined to be justified for reasons outlined in the Main Report. As shown in Table 31, the incremental average annual cost per incremental increase in output is estimated at $20,600. The Local Sponsors have also indicated that this is their preferred alternative, and therefore Alternative O2 is also designated as the Recommended Plan. Figure 9 shows the layout of the major features of the Recommended Plan. The following sections present detailed MCACES cost estimates for the Recommended Plan, as well as an analysis of with-project flood damages.

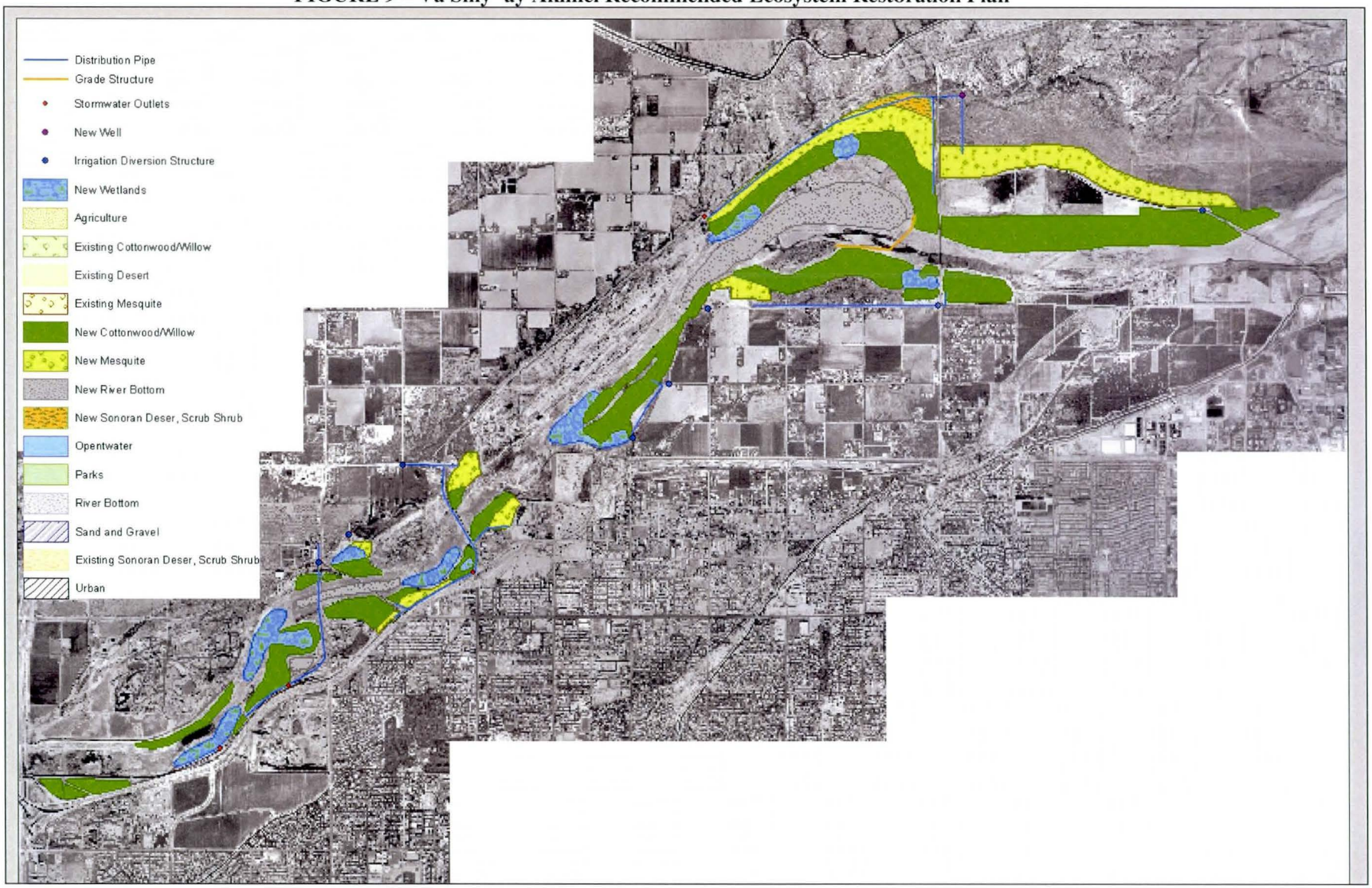
MCACES Cost Estimate

A more detailed estimate of construction costs was developed for the Recommended Plan utilizing the MCACES cost estimating software. The following table summarizes the results. It should also be noted that Monitoring, Adaptive Management and Real Estate costs were added to the construction costs to derive a Total First Cost estimate.

Table 32
Va Shly' ay Akimel
Detailed Cost Estimate
Recommended Plan (Alternative O2)
FY04 Price Levels, 5 5/8% Discount Rate

Low Flow Channel	$	1,401,000
Channel Reshaping	$	20,714,000
Wetland Features	$	24,911,000
Planting	$	4,163,000
Water Well	$	244,000
Grade Control Structure	$	7,323,000
Water Distribution System	$	1,282,000
Road Crossing	$	5,000
Planting Irrigation System	$	6,315,000
SRPMIC Irrigation Channel	$	43,000
Debris Removal	$	9,332,000
Cultural Mitigation	$	300,000
Construction Cost	$	76,033,000
Contingency (25%)	$	19,008,300
PE&D (10%)	$	7,603,300
EDC (1%)	$	760,300
S&A (6.5%)	$	4,942,100
Total Construction Cost	$	108,347,000
Monitoring & Adaptive Mgt. (4%)	$	4,334,000
Real Estate	$	24,949,400
Total First Cost (Rounded)	$	137,630,000
Interest During Construction	$	7,742,000
Gross Investment	$	145,372,000
Annualized Investment Cost	$	8,744,000
OMRR&R	$	131,000
Associated Cost (Water Supply)	$	1,283,000
Total Annual Cost	**$**	**10,158,000**

FIGURE 9 – Va Shly' ay Akimel Recommended Ecosystem Restoration Plan



Flood Damage Analysis

Ecosystem restoration alternatives were developed with the goal of maximizing environmental benefits without inducing flood damages. For the Recommended Plan, design considerations were incorporated to assure that flood damages would *at a minimum* be no higher than existing conditions. The following table shows with-project expected annual structure and content damages and damages reduced for the Recommended Plan for Base Year conditions.

Table 33
Va Shly ay Akimel
With Project Flood Damage Analysis (Structure & Content)
Base Year (in $1,000s)

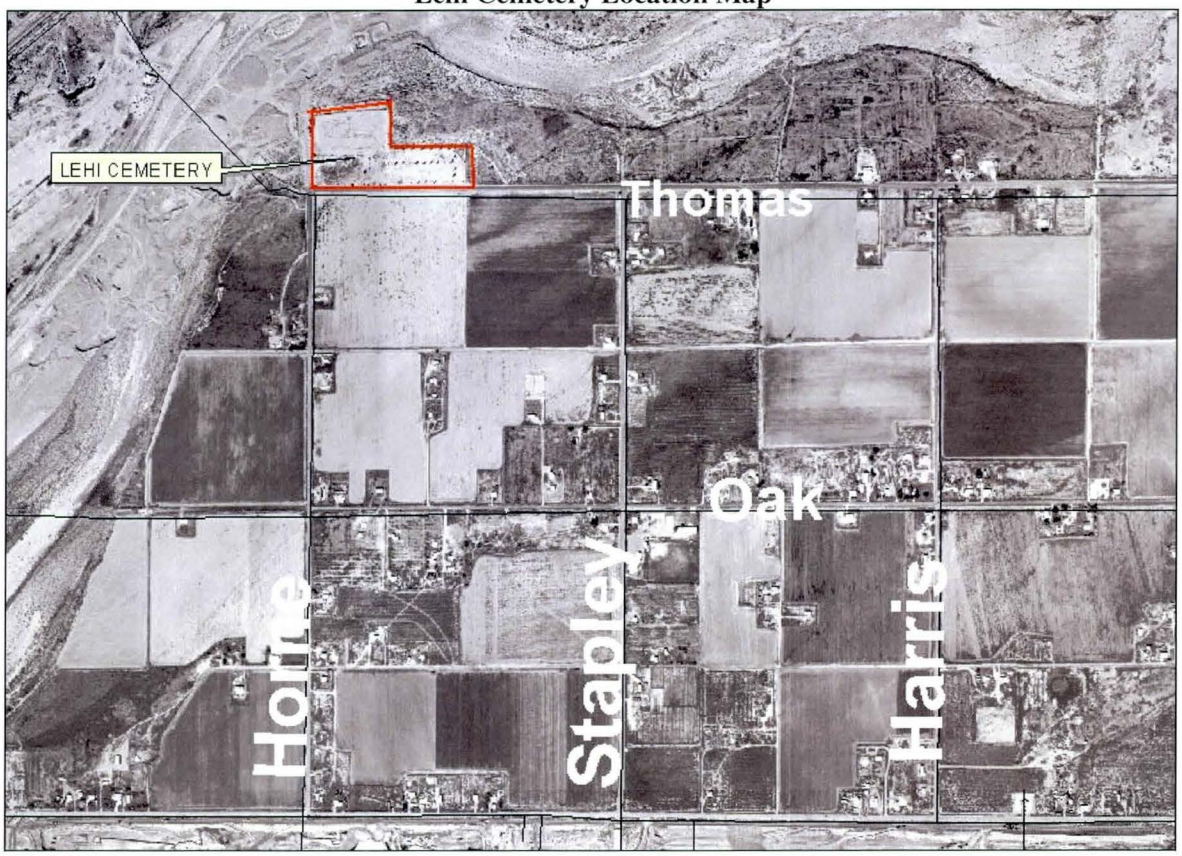
	Structure & Content		
Reach	**Without Project**	**With Project**	**Damages Reduced**
2	$ 15.4	$ 12.1	$ 3.3
3	$ 108.3	$ 98.2	$ 10.1
6	$ 193.5	$ 174.6	$ 18.9
Total	$ 317.2	$ 284.9	$ 32.3

The analysis verifies that the Recommended Plan actually lowers Base Year flood damages marginally. Including other damage categories (e.g., emergency, cleanup, etc.), with-project expected annual flood damages for Base Year conditions are estimated to be about $38,000 less than under without project conditions. Future with-project damages have not been calculated. However, it is possible that future with-project damages could be higher than future without-project damages, since the Recommended Plan would reduce the channel degradation and erosion which are the primary factors that result in the expected decline in future without project damages.

Erosion Analysis

The Lehi Cemetery is located on SRP-MIC property on the south side of the Salt River just north of Thomas Road (see Figure 10).

Figure 10
Lehi Cemetery Location Map



Local sponsors have expressed concern that bank erosion occurring near the Lehi Cemetery will affect/damage the cemetery in the near future. To address these concerns, an engineering analysis was conducted to determine: 1) if there is erosion occurring at Lehi Cemetery; and 2) if so, at what rate is it occurring and how long will it take to impact the Lehi Cemetery.

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

2) Using the location of the bank line position from 1935 to 2000, the long-term erosion rate was estimated to be on average 11 ft/yr. This rate is dependent on the frequency, discharge and duration of flow events and also the channel geometry. Due to the current hydrologic condition (continuing drought conditions and increased storage in the Salt River Watershed) the erosion rate may be less. But to address the sponsors concerns it has been assumed that the future without project erosion rate is 11ft/yr. Based on this rate, Lehi Cemetery will be impacted by erosion in 33 years. That is, the south bank line will reach the cemetery in 33 years.

Given that the engineering analysis indicates that impacts from erosion are not projected to occur until more than 30 years in the future, conducting a detailed benefit/cost analysis is not warranted at this time. The discounted present value of the avoided costs would be very small, making it extremely difficult to economically justify any incremental expenditures specifically for the purpose of streambank erosion protection.

Recreation

The VSA project provides a unique opportunity to enhance resource-based recreation and environmental education. The restoration of the dry Salt River channel will bring a riparian open space feature to the rapidly expanding planning areas. Drawing on a population base of over three million in the metropolitan Phoenix area, it is estimated that visitation to the VSA project could be significant. Primary use times for this unique resource would coincide with the "visitor season" between October and May when temperatures are moderate.

The goal of the environmental education and recreation component is to provide opportunities for visitors of all ages, abilities, and backgrounds to enjoy this unique resource while developing an awareness, knowledge and understanding of desert riparian habitat and its relationship to the surrounding environment. Additionally, it presents an opportunity to acknowledge and understand the influence of Salt Rivers on the environment and cultures throughout the Valley's history. Visitors to potential recreation facilities along the Study Area reach could participate in a variety of pursuits from enjoying scenic views, picnicking with the family, learning about the habitat, or exploring the resource on foot, by bicycle or horseback. Recognizing the diverse local society, the VSA project would employ design components ranging from areas adapted for special needs to multi-lingual signage.

Proposed Recreation Alternatives

Three recreational trail alternatives were developed. In addition to trailheads with small parking lots located approximately every four miles of trail length, all trail options include a larger parking lot and restroom facility, which would also feature utilities, lighting, a habitat interpretive center, picnic facilities, benches and signage. It should also be noted that the Local Sponsors have indicated a potential desire to locate a cultural center complex that may cost in excess of $10 million in the location designated for the parking and restroom facility. However, Federal cost sharing would be based upon the cost sharable options included in this analysis. More aggressive recreational components, such as lakes, sporting centers, parks, ball fields, etc. were rejected as out-of-harmony with the character of this project. Please refer to the Main Report for a detailed description of recreation alternatives.

Trail Option A In Option A, a trail on the west end of the project would connect to the City of Mesa's Riverview Park where an existing underpass under the freeway is located. It would also connect to Dobson Road at the existing Dobson Road freeway underpass. From these connection points, trail users could proceed south on Dobson Road (using existing bike paths and sidewalks within the Dobson Road right-of-way) to connect to the City of Mesa's existing trail system along the Tempe Canal. In Option A, a trail on the south side of the river between Gilbert Road and Val Vista Drive would serve to connect residents living north of the Red Mountain Freeway (the 202 Freeway) to the City of Mesa's existing trail system along the South Canal. At Gilbert Road, trail users could use sidewalks and bike paths within the Gilbert Road right-of-way to access South Canal to the south. At Val Vista Drive, the trail would tie in to the South Canal at the existing underpass for the canal under the freeway. Thus, connection to the South Canal trail would be complete.

Trail Option B Option B is the same as Option A, with the exception that it deletes the trail on the south side of the river between Gilbert Road and Val Vista Drive. This option offers the fewest recreational opportunities of the three options that are presented, but is also the least costly.

Trail Option C Option C includes all of the features of Option A, plus a continuous trail on the south side of the river between the Pima/Price Freeway (Loop 101 Freeway) and Val Vista Drive. Of the three options, this option provides the most recreational opportunities. It provides for connectivity to the City of Mesa's existing trail systems on the east and west ends of the project and for connection to the arterial street grid.

All trails would be available for use by pedestrians, bicyclists and equestrians (i.e., "multi-use"). Motorized vehicles of all types would be prohibited, with the exception of project maintenance vehicles and motorized wheelchairs.

Major features planned for trail improvements include:

- 12-foot wide dirt trail/path surfaced with decomposed granite, crushed aggregate or similar
- Trail lined with boulders or curbing to define the trail location.
- Mileage markers.
- Plaques or similar markers at significant project features to educate the public relative to cultural, biological or environmental aspects of the project
- Concrete benches located approximately every quarter mile.
- Bike stop/ rest stations spaced approximately one per mile (perhaps overlooking significant project features and having the plaques or markers discussed above)
- Integral art that highlights the cultural, biological and/or environmental theme of the project (e.g., artwork incorporated into the design of such things as ramadas, bike racks, the trail surface, etc.)
- Signs at major mile cross streets

Benefit Analysis

National Economic Development benefits arising from recreation opportunities created by a project are measured in terms of aggregate willingness to pay. Corps Principles and Guidelines describes three techniques which have been developed to estimate recreation demand and value. They include: 1) the Travel Cost Method; 2) the Contingent Value Method; and 3) the Unit Day Method. The Unit Day method was the method chosen for this analysis.

The Unit Day method does not attempt to account for the impact of price on visitation to a recreation site. Instead, an assigned user day value is applied to the total number of estimated visitors. User day values are simulated market values judgmentally derived from a range of values agreed to by Federal water resource agencies. It is intended to represent the users average willingness to pay for a day of recreation activity at the site. When a properly formulated unit day value is applied to estimated use, an approximation of the area under the site demand curve is obtained, which is used in estimating recreation benefits.

A national schedule is available showing a range of values for both specialized and general recreation opportunities. A point rating system can be used to select a specific value from the published schedule of value ranges. Once alternatives have been formulated and recreation and environmental components identified and described, then unit day values can be selected with the input of Corps and local government agencies. These values are then applied to projected visitation.

Visitation Projections

National Recreation and Parks (NRPA) standards for trail capacity and use range from 40 to 90 users per day per trail mile (or between 14,600 to 32,850 users per year per trail mile). The City of Mesa has estimated an average annual use of 40 users per day (or 14,600 per year) per mile, based upon use of existing trail systems, proximity to existing development and the unique features of the proposed environmental restoration project. This ratio reflects an average of 30 users per day per mile for the summer months of June through September, and 45 users per day per mile during the remaining months. Visitation for each recreation option has been estimated by applying this visitation factor to the proposed length of trails.

Transfers of visitation from competing facilities are expected to be minimal due to the unique recreation opportunities and setting offered at the restoration site. The primary transfers are expected to be in the categories of education field trips, bird watchers, passive nature watchers, joggers and recreational cyclists.

Unit Day Point Value Estimates

Unit day values will be calculated by assigning points to each activity (based upon Federal guidelines) and then converting total points to dollar recreation values (per the conversion table included in Economic Guidance Memorandum 04-03). Point values are derived by ranking the potential recreation resource according to five different criteria:

Criteria	Key Variables	Range of Point Values
Recreation Experience	Number & type of activities	0-30
Availability of Opportunity	# of similar opportunities nearby	0-18
Carrying Capacity	Adequacy of facilities for activities	0-14
Accessibility	Ease of access to and within site	0-18
Environmental	Esthetic quality of site	0-20
Total		0-100

Based upon the total number of points assigned, UDV's (FY 04) can range from $3.00 to $9.01 per recreation day.

Separate UDV point values were derived for trail features (included in all options) and the cultural center (included in Options 3 and 4). The following shows the results.

Table 34
Va Shly ay Akimel Recreation Analysis
Unit Day Value Assessment

Trails	General Rec.		
Criteria	Max Points	Total Points	Discussion
Recreation Experience	30	20	Several general recreational activities, e.g., hiking, bike riding, horseback riding, but in high quality setting
Availability of Opportunity	18	8	Several trail systems within a one hour travel time, but few in similar environment (e.g., Rio Salado Project)
Carrying Capacity	14	8	Adequate facilities to conduct recreation without deterioration of the resource
Accessibility	18	15	Good access to site provided by roads due to urban setting & links to existing parks
Environmental	20	15	High quality esthetic setting adjacent to environmental restoration project
	100	66	UDV Dollar Equivalent = $7.17

Based upon the visitation estimates and UDV values discussed above, Table 35 shows the expected annual benefits for each of the proposed recreation options.

Table 35 Va Shly ay Akimel Recreation Analysis Benefits By Alternative						
Benefits		1		2		3
Trails						
Trail Length		7.8		5.1		13.6
Avg Users/Mile (Oct-May)		45		45		45
Avg. Users/Mile (June-Sept)		30		30		30
Avg. Users/Mile/Year		14,600		14,600		14,600
Estimated Annual Visitation		113,442		74,898		199,144
Less Transfers (5%)		5,672		3,745		9,957
Estimated Annual Visitation		107,770		71,153		189,187
Unit Day Value	$	7.17	$	7.17	$	7.17
Annual Benefits	**$**	**772,495**	**$**	**510,025**	**$**	**1,356,091**

Recreation Costs & Benefit/Cost Analysis

Table 36 shows estimated costs for each recreation option. In addition, net benefits and benefit/cost ratios are also presented.

Table 36 Va Shly ay Akimel Recreation Analysis Costs By Alternative & Benefit/Cost Analysis						
Costs		1		2		3
Trail Length (Miles)		7.77		5.13		13.64
Trail Construction Cost	$	1,227,303	$	798,700	$	2,121,783
Restrooms/Interpretive Center	$	140,000	$	140,000	$	140,000
Total Construction Cost	$	1,367,303	$	938,700	$	2,261,783
Contingency (25%)	$	341,826	$	234,675	$	565,446
PED/EDC (11%)	$	150,403	$	103,257	$	248,796
S&A (6.5%)	$	88,875	$	61,016	$	147,016
Total First Cost	$	1,948,400	$	1,337,600	$	3,223,000
IDC (1 Yr Const. Period)	$	54,000	$	37,100	$	89,400
Gross Investment	$	2,002,400	$	1,374,700	$	3,312,400
Annualized Investment Cost	$	120,400	$	82,700	$	199,200
O&M*	$	388,500	$	256,500	$	682,000
Total Annual Cost	$	508,900	$	339,200	$	881,200
Annual Benefits	$	772,500	$	510,000	$	1,356,100
Net Benefits	$	263,600	$	170,800	$	474,900
Benefit/Cost Ratio		1.52		1.50		1.54

*** O&M Includes $50,000/mile of trail.*

Table 36 shows that each of the recreation options is economically justified.

ADDENDUM 1

AGRICULTURAL DAMAGE ANALYSIS

7-21-03
Revised

Agricultural Flood Damage Analysis
For

Va Shly'Ay Akimel Salt River
Restoration Project

Economic Section

Vashly4.doc

INTRODUCTION

Purpose

The purpose of this section is for calculating National Economic Development (NED) benefits for agricultural flood damage reduction pertaining to the Va Shly' Ay Akimel Salt River Restoration Project. The method and procedures follows the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) and the manual on Agricultural Flood Damage (IWR Report 87-R-10).

Process

Crop Flood Damage Analysis Process

The major crops located in the project area consist of alfalfa, cotton, and citrus orchards. A small nursery tree farm exists in the project area, but of a limited exposure. The flood events of 50, 100, 200, and 500 –years were examined. The areas of these flood events are graphically mapped and outlined in the following map. The following table and map were provided by the City of Mesa, Arizona. The table shows the estimated agricultural acreages affected by the different flood events.

Table 1 – Crop Acreage

Va Shly' Ay Akimel Salt River Restoration Project (COM Project No. 02-001)

Estimate of Crop Acreages in Gilbert Road "Break-out" Area

8/12/2002

	Number of Acres Enclosed within Flood Event Demarcation Line (acres)			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

The following map identifies the crops in the various fields. Description of the legends is as follows:

PF = Permanently fallow. The parcel has the appearance of being farmed some time in the past (5-10 year ago), but has not be farmed in the last few years. The land can be re-activated for farming at anytime.

R = Residential areas. These areas are not used for commercial farming. Some contain citrus trees, fruit trees, livestock, and home gardens but of commercial nature.

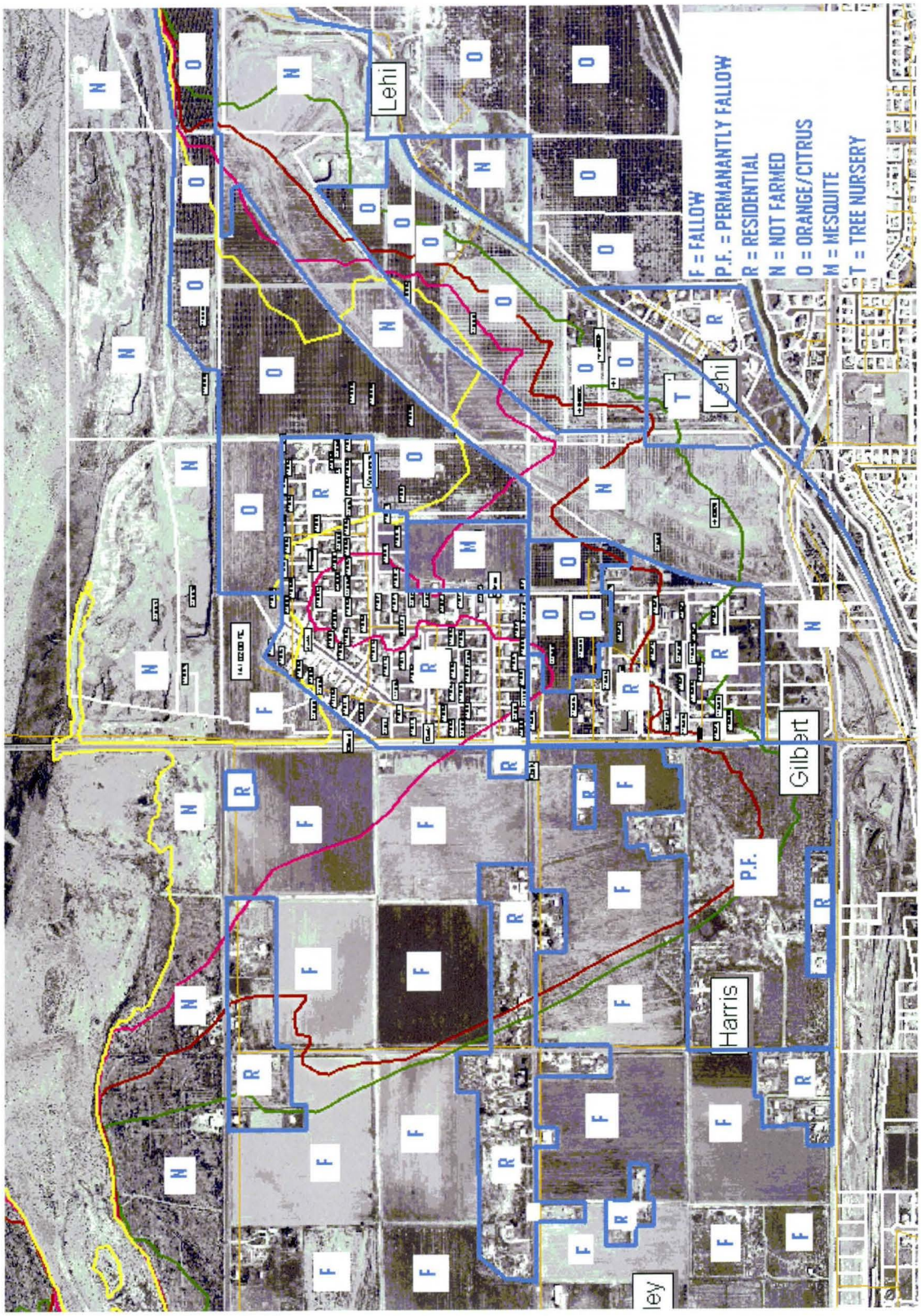
N = Not farmed. As described by Gordon Haws, these areas have not been farmed in the past few years nor at anytime within the past 15 years. This includes the land purchased for ongoing freeway extension.

O = Orange and/or other citrus grove areas.

M = Mesquite and other desert vegetation. Mentioned as used for cattle range land.

T = Tree nursery. A parcel of land used as a commercial nursery. The parcel contained trees of palm and citrus.

Figure 1 - Map of Flood Event Area



Analysis

Agricultural Crop Damage Function

Information has been collected from various resources in regards to production cost of the crops within the various flood plains (500, 200, 100, and 50 year). Separate crop budgets have been collected for alfalfa hay, cotton, and orange/grapefruit/lemon orchards in Maricopa County. Crop damage functions were estimated from these crop budgets and are presented here. For each crop budget the following was done:

- Establish Monthly Crop Budget and Flood Loss Potential
- Derive Cumulative Production Expenses subject to flood loss by dates
- Develop by date the damage function in dollars
- Graph the potential direct production loss (data from damage function).

This approach may under value the crop damages in that income/revenue losses are not accounted for initially. The market crop value method is more robust but tends the over value the crop damage losses. Also information has been obtained from the University of Arizona (Yuma Mesa Agriculture Center) regarding citrus costs, which substantiates and backups the results.

Table 2 – Harvest Season, Arizona

Crop	Period
Alfalfa Hay	April - September
Cotton	September – October
Grapefruit	August – December
Lemon	September – February
Valencias Oranges	February - June

Crop

Alfalfa Hay

Maricopa County

Table 3

Setup for Crop Budget and Flood Loss Potential

crop - alfalfa hay - maricopa co.

note to file: a difference between cash cost basis and total cost basis

Item	unit	quantity	price/unit	Total/acre
INCOME	ton	8.5	$98.10	$833.85

		Costs		Flood Loss Potential		
Production Item	Total	Fixed	Variable	Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	3.91	2.74	1.17	1.17	2.74	3.91
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	50.72		50.72	50.72		50.72
cash land prep & growing exp-water	112.5		112.5	112.5		112.5
cash land prep & growing exp-etc	66.09		66.09	66.09		66.09
Harvest Machinery						
cash harvest & post harvest exp	94.58	81.42	13.16		81.42	81.42
Harvest others						
cash harvest & post harvest exp-other mat.	23.83		23.83		0	0
harvest & post harvest exp-oper overhead-pickup	10.19		10.19		0	0
harvest & post harvest exp-oper interest at 10%	32.03		32.03		0	0
Labor						
cash land prep & growing exp	48.26		48.26	48.26	0	48.26
cash harvest & post harvest exp	39.65		39.65	0	0	0
Real Estate Taxes						
* land cost/ownership(100% equity) prop tax	13.98	13.98			13.98	13.98
Return to Land & Managemnet						
* cash overhead exp-taxes,housing,ins,farm mach	10.01	10.01			10.01	10.01
* cash overhead exp-gen&office (5% of t. oper exp)	24.09	24.09			24.09	24.09
* cash overhead exp-gen farm maint(3% of t oper exp)	14.45	14.45			14.45	14.45
* cap alloc(100% equity) -stand est(3yr crop)	110.89	110.89			110.89	110.89
* **cap alloc(100% equity)-cap repl,mach,vehicles**	**68.7**	68.7			68.7	68.7
* **cap alloc(100% equity)-int on equity,mach,veh**	**5.41**	5.41			5.41	5.41
* **land cost/ownership(100% equity) opp int. on land**	**37.14**	37.14			37.14	37.14
* land cost/ownership(100% equity) water assmt.	20	20			20	20
* **management ser (8% of total oper. Exp)**	**38.54**	38.54			38.54	38.54
Total (per acre)	824.97	427.37	397.6	278.74	427.37	706.11

* = ownership cost

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Table 4

Cumulative production expenses subject to flood loss for alfalfa hay

(Dollars per acre)

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
15-Sep	0.00				land preparation			
1-Oct	3.21				land preparation	renovate	3.21	3.21
15-Oct	74.40				planting	plant	71.19	74.4
1-Nov	74.40				growing			74.4
15-Nov	74.40				growing			74.4
1-Dec	74.40				growing			74.4
15-Dec	74.40				growing			74.4
1-Jan	74.40				growing			74.4
15-Jan	74.40				growing			74.4
1-Feb	125.72				growing	irrigate	51.32	125.72
15-Feb	125.72				growing			125.72
1-Mar	269.72				growing	irrigate, herbicide	144	269.72
15-Mar	269.72				growing			269.72
1-Apr	278.74				growing	apply insecticide, Air	11.76	281.48
15-Apr	185.83				harvest	swathing,ranking,baling,roadsiding	158.05	439.53
1-May	92.91							439.53
15-May	0.00							439.53
1-Jun								439.53
15-Jun								439.53
1-Jul								439.53
15-Jul								439.53
1-Aug								439.53
15-Aug								439.53
1-Sep								439.53
15-Sep								439.53
1-Oct								439.53
					pickup use		10.19	449.72
					oper int. at 10.0		32.03	481.75
								481.75
DPI=	278.74							481.75

Direct Production Investments

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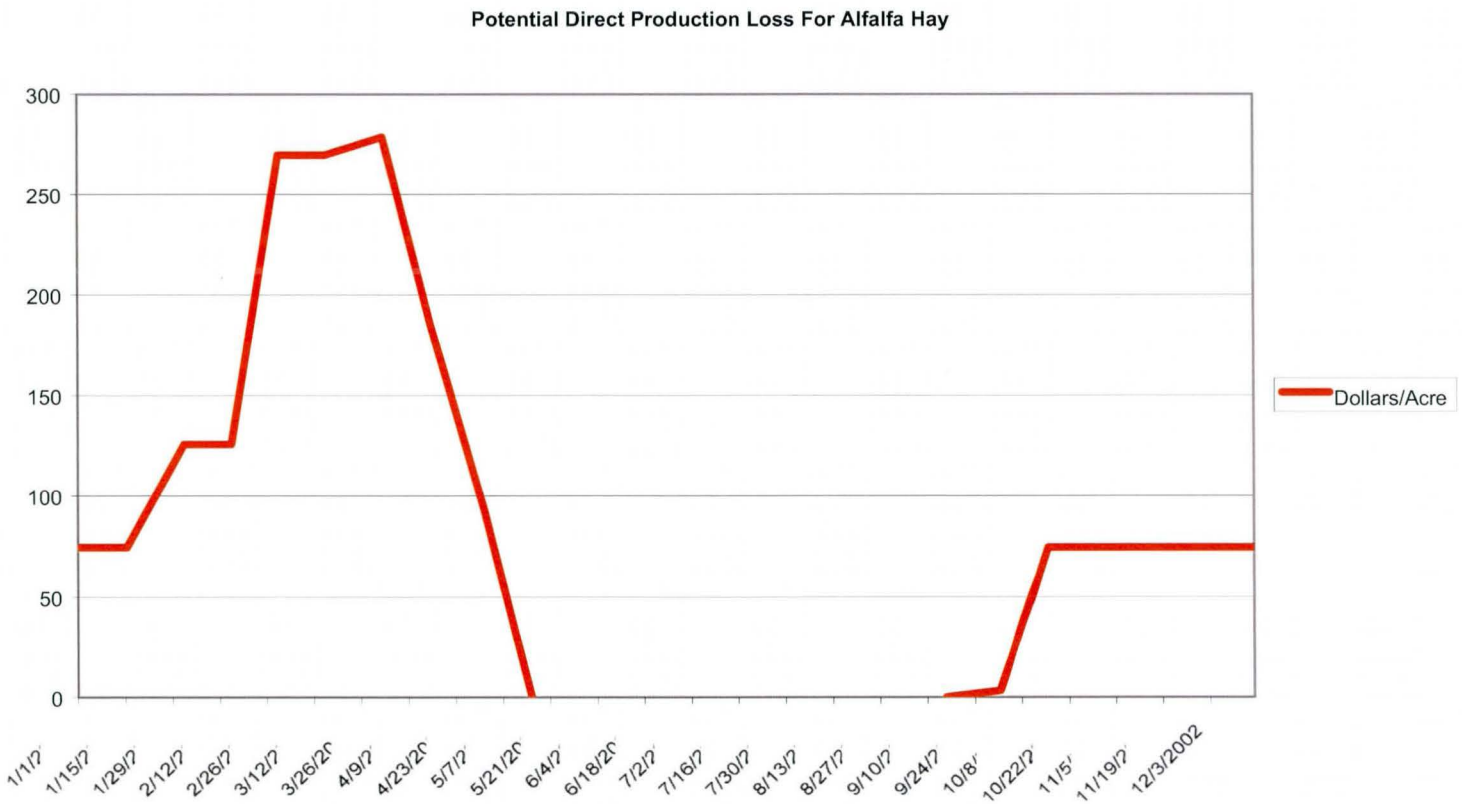
Figure 2


Potential Direct Production Loss For Alfalfa Hay
300
250
200
150
100
50
0
1/1/2
1/15/2
1/29/2
2/12/2
2/26/2
3/12/2
3/26/2
4/9/2
4/23/2
5/7/2
5/21/2
6/4/2
6/18/2
7/2/2
7/16/2
7/30/2
8/13/2
8/27/2
9/10/2
9/24/2
10/8/
10/22/2
11/5/
11/19/2
12/3/2002
Dollars/Acre

Crop

Cotton

Maricopa County

Table 5

Setup for Crop Budget and Flood Loss Potential

crop - cotton, Upland - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

Item	unit	quantity	price/unit	sub Total/acre	Total/acre
INCOME-lint	lb	1227	$0.58	$714.11	$869.99
cottonseed	ton	1.08	144.33	$155.88	

Production Item	Total	Costs Fixed	Variable	Flood Loss Potential Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	40.34	23.88	16.46	16.46	23.88	40.34
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	204.96		204.96	204.96		204.96
cash land prep & growing exp-water	30		30	30		30
cash land prep & growing exp-etc	33.84		33.84	33.84		33.84
Harvest Machinery						
cash harvest & post harvest exp	60.07	51.72	8.35		51.72	51.72
Harvest others						
cash harvest & post harvest exp-other chem	28.16		28.16		0	0
cash harvest & post harvest exp-custom H.&postH.	10.18		10.18		0	0
cash harvest & post harvest exp-cotton ginning	104.66		104.66		0	0
cash harvest & post harvest exp-crop assessment	8.98		8.98		0	0
harvest & post harvest exp-oper overhead-pickup	15.29		15.29		0	0
harvest & post harvest exp-oper interest at 10%	25.68		25.68		0	0
Labor						
cash land prep & growing exp	66		66	66	0	66
cash harvest & post harvest exp	22.33		22.33	0	0	0
Real Estate Taxes						
* land cost/ownership(100% equity) prop tax	13.98	13.98			13.98	13.98
Return to Land & Managemnet						
* cash overhead exp-taxes,housing,ins,farm mach	10.72	10.72			10.72	10.72
* cash overhead exp-gen&office (5% of t. oper exp)	32.52	32.52			32.52	32.52
* cash overhead exp-gen farm maint(3% of t oper exp)	19.51	19.51			19.51	19.51
* cap alloc(100% equity) -cash basis	0	0			0	0
* **cap alloc(100% equity)-cap repl,mach,vehicles**	**74.9**	74.9			74.9	74.9
* **cap alloc(100% equity)-int on equity,mach,veh**	**31.41**	31.41			31.41	31.41
* **land cost/ownership(100% equity) opp int. on land**	**37.14**	37.14			37.14	37.14
* land cost/ownership(100% equity) water assmt.	20	20			20	20
* **management ser (8% of total oper. Exp)**	**52.04**	52.04			52.04	52.04
Total (per acre)	942.71	367.82	574.89	351.26	367.82	719.08

* = ownership cost

Table 6

Cumulative production expenses subject to flood loss for cotton

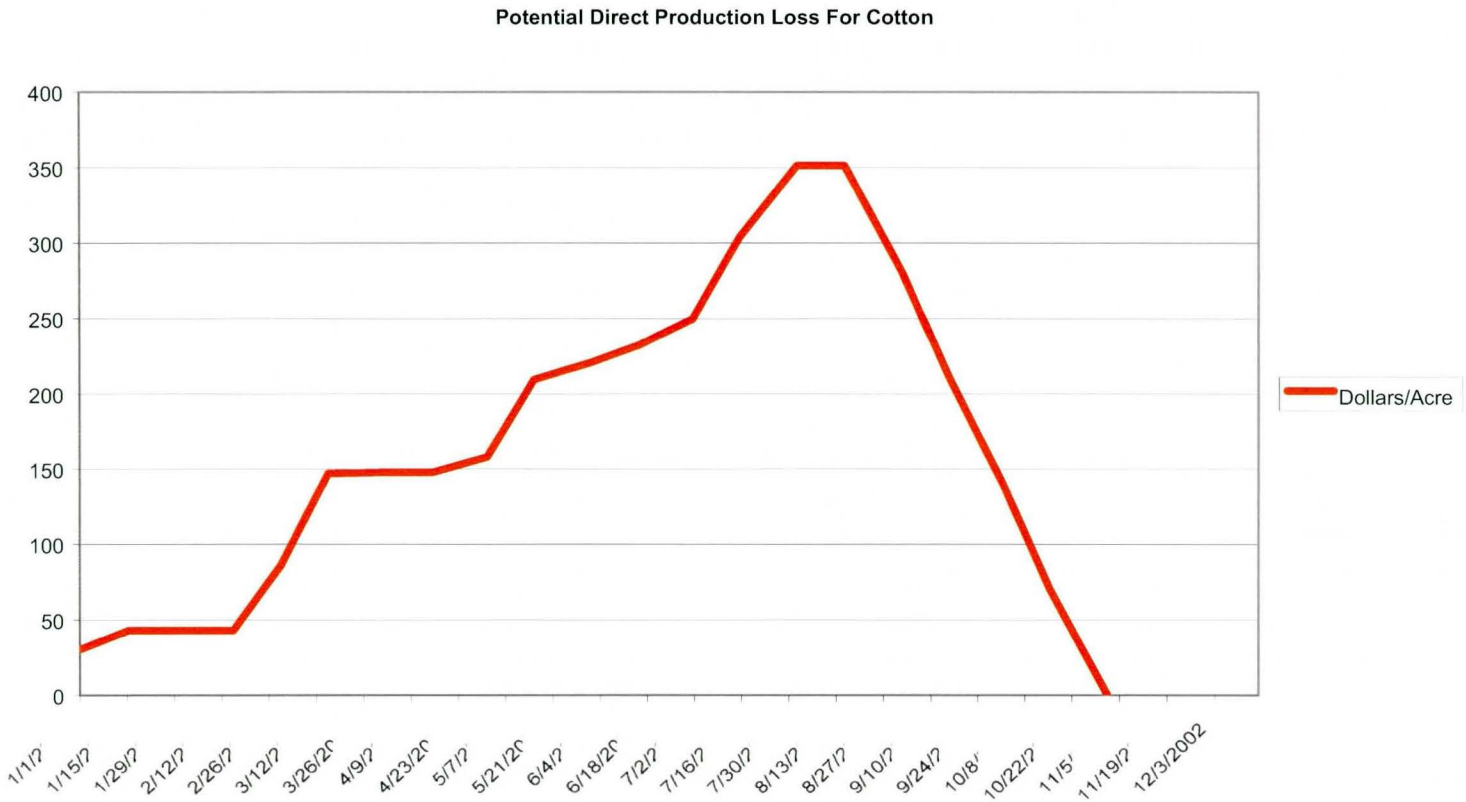
(Dollars per acre)

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	30.53				land preparation	rip,disk,landplane	30.53	30.53
15-Jan	43.08				land preparation	apply herb,list	12.55	43.08
1-Feb	43.08				land preparation			43.08
15-Feb	43.08				land preparation			43.08
1-Mar	86.03				land preparation	mulch,plant	42.95	86.03
15-Mar	147.17				growing	buck row, irrigate	61.14	147.17
1-Apr	148.01				growing	disk ends	0.84	148.01
15-Apr	148.01				growing			148.01
1-May	158.18				growing	Cultivate	10.17	158.18
15-May	209.26				growing	apply fert/ground	51.08	209.26
1-Jun	220.79				growing	hand week,apply insecticide	11.53	220.79
15-Jun	232.14				growing	apply growth regulator	11.35	232.14
1-Jul	249.49				growing	apply insecticide	17.35	249.49
15-Jul	303.75				growing	apply insecticide	54.26	303.75
1-Aug	351.26				growing	apply insecticide	54.25	358
15-Aug	351.26				growing/harvest	apply defoliant/air spray	31.16	389.16
1-Sep	281.01				harvest	apply defoliant/air spray	7.71	396.87
15-Sep	210.76				harvest			396.87
1-Oct	140.50				harvest	prepare ends	0.96	397.83
15-Oct	70.25				harvest	cotton,first pick,make modules	53.49	451.32
1-Nov	0.00				harvest/post	cotton,second pick,haul,ginning	130.29	581.61
15-Nov					harvest/post	cotton second pick,rood	5.38	586.99
1-Dec					harvest/post	classing,assessment,cut stalks	16.11	603.1
15-Dec					land preparation	disk residue	6.41	609.51
								609.51
					pickup use		15.29	624.8
					oper int. at 10.0		25.68	650.48

DPI= 351.26

Direct Production Investment

Figure 3


Potential Direct Production Loss For Cotton
400
350
300
250
200
150
100
50
0
1/1/2
1/15/2
1/29/2
2/12/2
2/26/2
3/12/2
3/26/2
4/9/2
4/23/2
5/7/2
5/21/2
6/4/2
6/18/2
7/2/2
7/16/2
7/30/2
8/13/2
8/27/2
9/10/2
9/24/2
10/8/
10/22/2
11/5/
11/19/2
12/3/2002
Dollars/Acre

Crop

Citrus – Grapefruit

Maricopa County

Table 7

Setup for Crop Budget and Flood Loss Potential

crop - citrus (generic- template Texas citrus - mature 10th yr) - Mature Grapefruit orchard production - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

THIS IS ONLY ILLUSTRATIVE

Item	unit	quantity	price/unit	sub Total/acre	Total/acre
INCOME-grapefruit	ton	23	$125.00	$2,875.00	$2,875.00

Production Item		Total	Costs Fixed	Variable	Flood Loss Potential Direct costs	Income Loss	Total
Preharvest Machinery							
cash land prep & growing exp		0	0	0	0	0	0
Seed/Chemicals/etc.							
cash land prep & growing exp-chem		627.5		627.5	627.5		627.5
cash land prep & growing exp-water		56		56	56		56
cash land prep & growing exp-etc(int.)		65.19		65.19	65.19		65.19
Harvest Machinery							
cash harvest & post harvest exp	1.35	0	0	0		0	0
Harvest others							
cash harvest & post harvest exp-other chem		0		0		0	0
cash harvest & post harvest exp-custom H.&postH.		0		0		0	0
cash harvest & post harvest exp-halding		160		160		0	0
cash harvest & post harvest exp-crop assessment		0		0		0	0
harvest & post harvest exp-oper overhead-pickup		0		0		0	0
harvest & post harvest exp-oper interest at 10%		0		0		0	0
Labor							
cash land prep & growing exp		66.5		66.5	66.5	0	66.5
cash harvest & post harvest exp		640		640	0	0	0
Real Estate Taxes							
* land cost/ownership(100% equity) prop tax		186.09	186.09			186.09	186.09
Return to Land & Managemnet							
* cash overhead exp-taxes,housing,ins,farm mach		115	115			115	115
* cash overhead exp-gen&office		35	35			35	35
* cash overhead exp-gen farm maint(3% of t oper exp)		0	0			0	0
* cap alloc(100% equity) -cash basis		0	0			0	0
* **cap alloc(100% equity)-cap repl,mach,vehicles**		**43.42**	43.42			43.42	43.42
* **cap alloc(100% equity)-int on equity,mach,veh**		**0**	0			0	0
* **land cost/ownership(100% equity) perennial crop**		**186.53**	186.53			186.53	186.53
* land cost/ownership(100% equity) water assmt.		0	0			0	0
* **management ser (8% of total oper. Exp)**		**0**	0			0	0
Total (per acre)		2181.23	566.04	1615.19	815.19	566.04	1381.23

* = ownership cost

Table 8

Cumulative production expenses subject to flood loss
for citrus-Grapefruit per az ext.

(Dollars per acre) 815.19

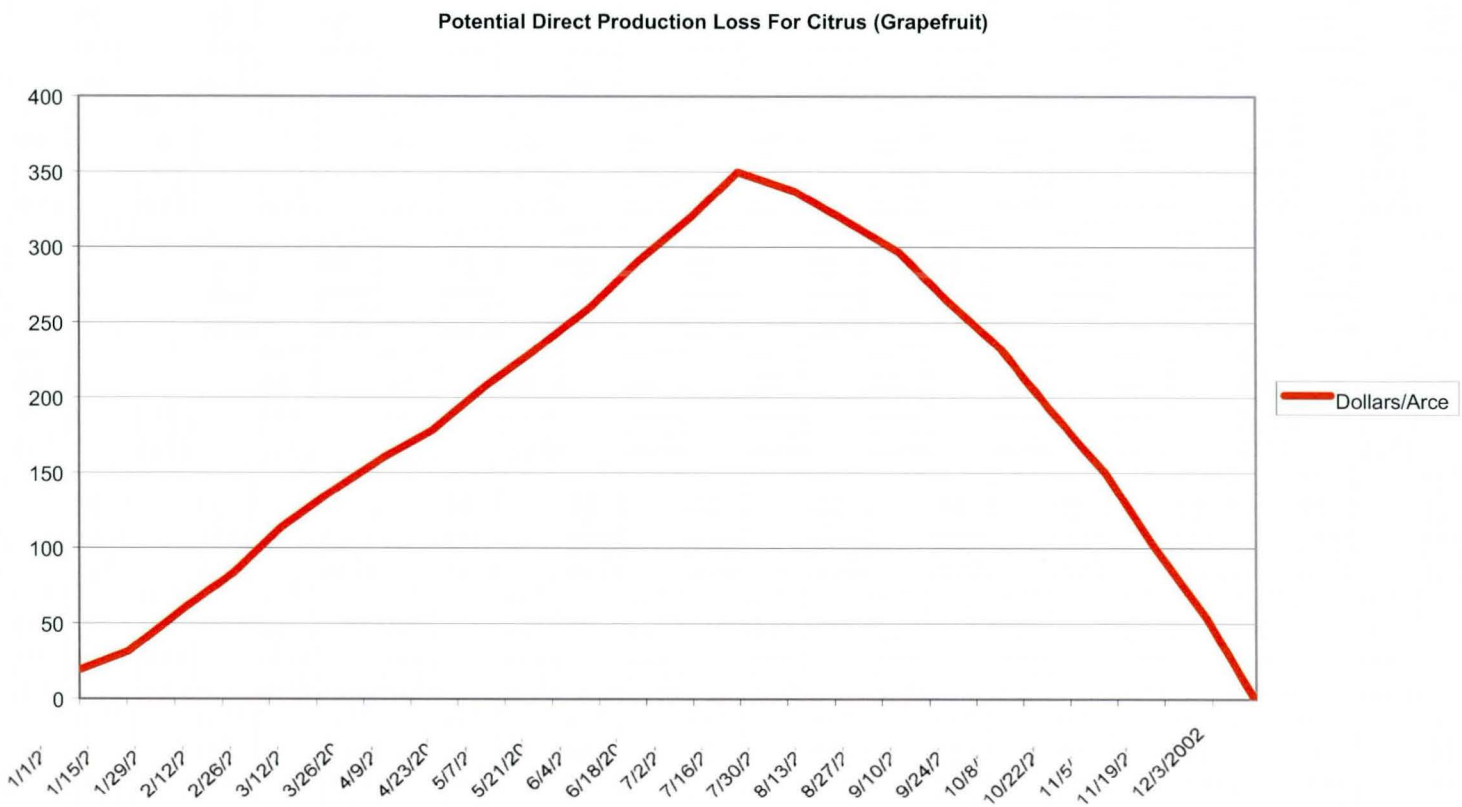
Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	19.38				open	water,sprayingPOF,i	19.38	19.38
15-Jan	31.42				open	sprayingPOF ,i	12.04	31.42
1-Feb	61.25				growing	fertilizing,water, sprayingHPOF,i	29.83	61.25
15-Feb	83.75				growing	fertilizing, sprayingHPOF,i	22.50	83.75
1-Mar	113.58				growing	fertilizing,water, sprayingHPOF,i	29.83	113.58
15-Mar	136.08				growing	fertilizing, sprayingHPOF,i	22.50	136.08
1-Apr	160.79				growing	fertilizing,water, sprayingPOF,i	24.71	160.79
15-Apr	178.17				growing	fertilizing, sprayingPOF,i	17.38	178.17
1-May	208.00				growing	fertilizing,water, sprayingSPOF,i	29.83	208.00
15-May	230.50				growing	fertilizing, sprayingSPOF,i	22.50	230.50
1-Jun	260.33				growing	fertilizing,water, sprayingSPOF,i	29.83	260.33
15-Jun	290.17				growing	fertilizing,water, sprayingSPOF,i	29.83	290.17
1-Jul	320.00				growing	fertilizing,water, sprayingSPOF,i	29.83	320.00
15-Jul	349.83				growing	fertilizing,water, sprayingSPOF,i	29.83	349.83
1-Aug	336.90				growing/harvest	water, sprayingSPOF,i	24.50	374.33
15-Aug	319.07				growing/harvest	water, sprayingSPOF,i	24.50	398.83
1-Sep	296.33				growing/harvest	water, sprayingSPOF,i	24.50	423.33
15-Sep	264.30				growing/harvest	sprayingSPOF,i	17.17	440.50
1-Oct	232.50				growing/harvest	water, sprayingSPOF,i	24.50	465.00
15-Oct	192.87				growing/harvest	sprayingSPOF,i	17.17	482.17
1-Nov	150.46				growing/harvest	water, sprayingPOF,i	19.38	501.54
15-Nov	102.72				growing/harvest	sprayingPOF,i	12.04	513.58
1-Dec	53.30				growing/harvest	water, sprayingPOF,i	19.38	532.96
15-Dec	0.00				growing/harvest	sprayingPOF,i	12.04	545.00
								545.00
					pickup use		7.00	552.00
					oper int. at 10.0		23.00	575.00

sprayingH = preemerge herbicide
sprayingS = spot herbicide
sprayingP = Pesticide
sprayingF = Fungicides
i = interest
sprayingO = other chemicals

DPI=
Direct Production Investment

file: crops.xls

Figure 4


Potential Direct Production Loss For Citrus (Grapefruit)
400
350
300
250
200
150
100
50
0
1/1/2
1/15/2
1/29/2
2/12/2
2/26/2
3/12/2
3/26/2
4/9/2
4/23/2
5/7/2
5/21/2
6/4/2
6/18/2
7/2/2
7/16/2
7/30/2
8/13/2
8/27/2
9/10/2
9/24/2
10/8/
10/22/2
11/5/
11/19/2
12/3/2002
Dollars/Arce

Crop

Citrus – Lemon

Maricopa County

Table 9

Setup for Crop Budget and Flood Loss Potential

crop - citrus (fr AZ univ ext cost of prod maricopa co) - Mature lemon orchard production - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

PLEASE NOTE THIS DOES NOT INCLUDE HARVESTING COST

Item	unit	quantity	price/unit	Total/acre	sub Total/acre
INCOME-lemon	cartons	310	$4.05	$1,255.50	$1,255.50

Production Item	Total	Costs Fixed	Variable	Flood Loss Potential Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	87	0	0	0	0	0
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	295		295	295		295
cash land prep & growing exp-water	56		56	56		56
cash land prep & growing exp-etc(int.)	0		0	0		0
Harvest Machinery - Excluded - cost by harvesting company						
cash harvest & post harvest exp	0	0	0		0	0
Harvest others - Excluded - cost by harvesting company						
cash harvest & post harvest exp-other chem	0		0		0	0
cash harvest & post harvest exp-custom H.&postH.	0		0		0	0
cash harvest & post harvest exp-halding	0		0		0	0
cash harvest & post harvest exp-crop assessment	0		0		0	0
harvest & post harvest exp-oper overhead-pickup	0		0		0	0
harvest & post harvest exp-oper interest at 10%	0		0		0	0
Labor						
machine operations	48		48	48	0	48
Irrigation	54		54	0	0	0
other labor,Hand	26					
Real Estate Taxes (or rent)						
land cost/ownership(100% equity) prop tax	200	200			200	200
Return to Land & Managemnet						
cash overhead exp	41	41			41	41
cash overhead exp-gen&office	0	0			0	0
cash overhead exp-gen farm maint(3% of t oper exp)	0	0			0	0
cap alloc(100% equity) -cash basis	0	0			0	0
cap alloc(100% equity)-cap repl,mach,vehicles	**52**	52			52	52
cap alloc(100% equity)-int on equity,mach,veh	**0**	0			0	0
land cost/ownership(100% equity) perennial crop	**0**	0			0	0
land cost/ownership(100% equity) water assmt.	0	0			0	0
management serices	**46**	46			46	46
Total (per acre)	905	339	453	399	339	738
oper int and pickup use	31					
file: crops.xls	936					

Table 10

Cumulative production expenses subject to flood loss

for Lemon per az ext. & UCCE Riverside Cnty templete

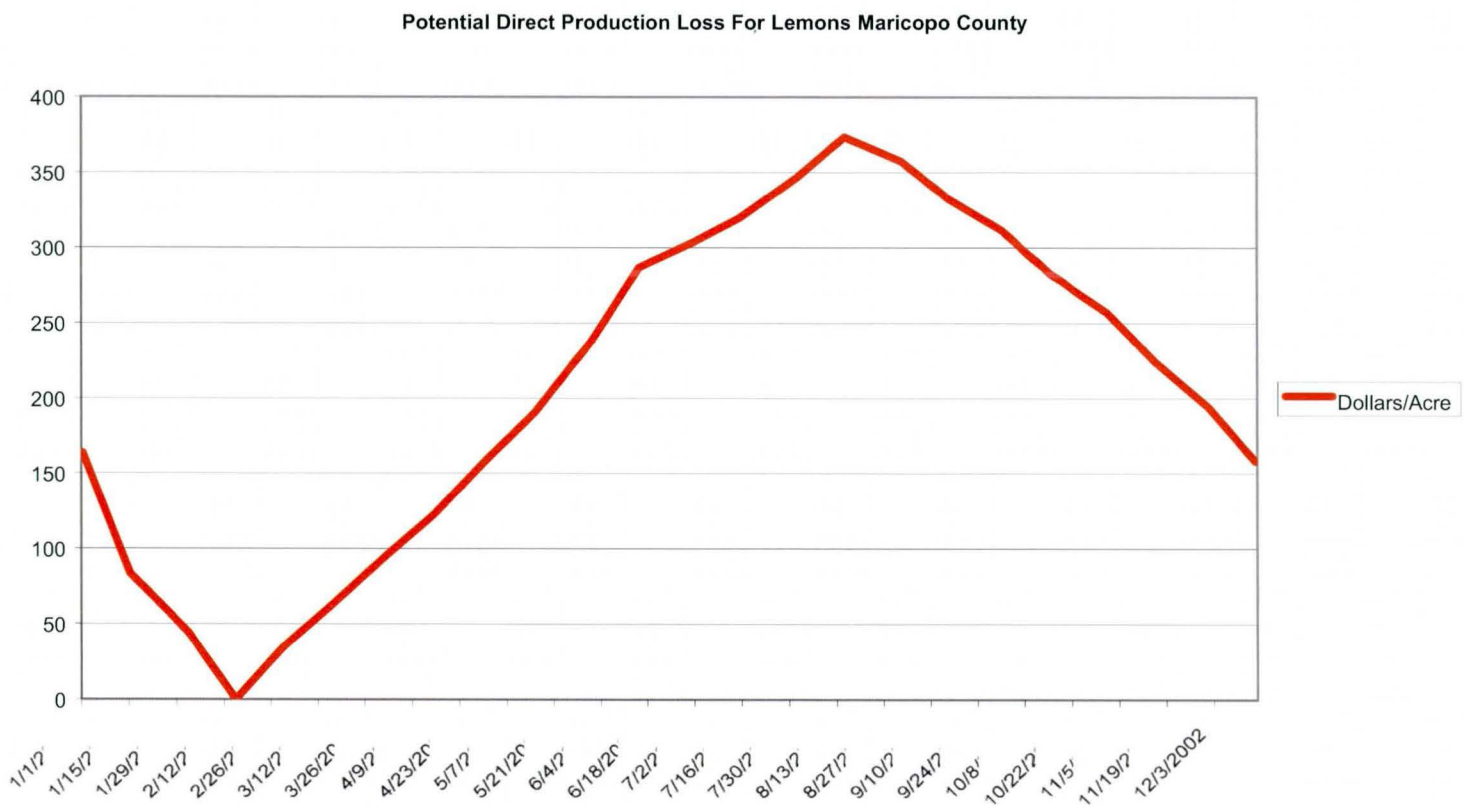
(Dollars per acre) 815.19

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	163.85				growing/harvest	water,sprayingPO	16.38	491.54
15-Jan	83.43				growing/harvest	sprayingPO	9.04	500.58
1-Feb	44.75				growing/harvest	water,sprayingPOH	36.38	536.96
15-Feb	0.00				growing/harvest	sprayingPOH	29.04	566.00
1-Mar	34.38				open	water,sprayingPOF	34.38	34.38
15-Mar	61.42				open	sprayingPOF	27.04	61.42
1-Apr	95.79				growing	water,sprayingPOF	34.38	95.79
15-Apr	122.83				growing	sprayingPOF	27.04	122.83
1-May	160.46				growing	water,sprayingPO,fertilizing	37.63	160.46
15-May	190.75				growing	sprayingPO,fertilizing	30.29	190.75
1-Jun	238.88				growing	water,sprayingPOS,fertilizing	48.13	238.88
15-Jun	287.00				growing	water,sprayingPOS,fertilizing	48.13	287.00
1-Jul	303.38				growing	water,sprayingPO	16.38	303.38
15-Jul	319.75				growing	water,sprayingPO	16.38	319.75
1-Aug	346.63				growing	water,sprayingPOS	26.88	346.63
15-Aug	373.50				growing	water,sprayingPOS	26.88	373.50
1-Sep	357.39				growing/harvest	water,sprayingPO	16.38	389.88
15-Sep	332.43				growing/harvest	sprayingPO	9.04	398.92
1-Oct	311.47				growing/harvest	water,sprayingPO	16.38	415.29
15-Oct	282.89				growing/harvest	sprayingPO	9.04	424.33
1-Nov	257.08				growing/harvest	water,sprayingPO	16.38	440.71
15-Nov	224.88				growing/harvest	sprayingPO	9.04	449.75
1-Dec	194.22				growing/harvest	water,sprayingPO	16.38	466.13
15-Dec	158.39				growing/harvest	sprayingPO	9.04	475.17
		note formulas in harvest period					566.00	566.00
					pickup use		7.00	573.00
					oper int. at 10.0		24.00	597.00

sprayingH = preemerge herbicide
sprayingS = spot herbicide
sprayingP = Pesticide(insecticide)
sprayingF = Fungicides
i = interest
sprayingO = other chemicals

DPI=
Direct Production Investment file: crops.xls

Figure 5


Potential Direct Production Loss For Lemons Maricopo County
400
350
300
250
200
150
100
50
0
1/1/2
1/15/2
1/29/2
2/12/2
2/26/2
3/12/2
3/26/2
4/9/2
4/23/2
5/7/2
5/21/2
6/4/2
6/18/2
7/2/2
7/16/2
7/30/2
8/13/2
8/27/2
9/10/2
9/24/2
10/8/
10/22/2
11/5/
11/19/2
12/3/2002
Dollars/Acre

Crop

Citrus – Valencias Oranges

Maricopa County

Table 11

Setup for Crop Budget and Flood Loss Potential

crop - citrus (fr AZ univ ext cost of prod maricopa co) - Mature Valencias Orange orchard production - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

PLEASE NOTE THIS DOES NOT INCLUDE HARVESTING COST sub

Item	unit	quantity	price/unit	Total/acre	Total/acre
INCOME-valencias orange	cartons	460	$3.30	$1,518.00	$1,518.00

		Costs		Flood Loss Potential		
Production Item	Total	Fixed	Variable	Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	87	0	0	0	0	0
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	295		295	295		295
cash land prep & growing exp-water	56		56	56		56
cash land prep & growing exp-etc(int.)	0		0	0		0
Harvest Machinery - Excluded - cost by harvesting company						
cash harvest & post harvest exp	0	0	0		0	0
Harvest others - Excluded - cost by harvesting company						
cash harvest & post harvest exp-other chem	0		0		0	0
cash harvest & post harvest exp-custom H.&postH.	0		0		0	0
cash harvest & post harvest exp-halding	0		0		0	0
cash harvest & post harvest exp-crop assessment	0		0		0	0
harvest & post harvest exp-oper overhead-pickup	0		0		0	0
harvest & post harvest exp-oper interest at 10%	0		0		0	0
Labor						
machine operations	48		48	48	0	48
Irrigation	54		54	0	0	0
other labor,Hand	26					
Real Estate Taxes (or rent)						
land cost/ownership(100% equity) prop tax	200	200			200	200
Return to Land & Managemnet						
cash overhead exp	41	41			41	41
cash overhead exp-gen&office	0	0			0	0
cash overhead exp-gen farm maint(3% of t oper exp)	0	0			0	0
cap alloc(100% equity) -cash basis	0	0			0	0
cap alloc(100% equity)-cap repl,mach,vehicles	**52**	52			52	52
cap alloc(100% equity)-int on equity,mach,veh	**0**	0			0	0
land cost/ownership(100% equity) perennial crop	**0**	0			0	0
land cost/ownership(100% equity) water assmt.	0	0			0	0
management serices	**46**	46			46	46
Total (per acre)	905	339	453	399	339	738
oper int and pickup use	31					
file: crops.xls	936					

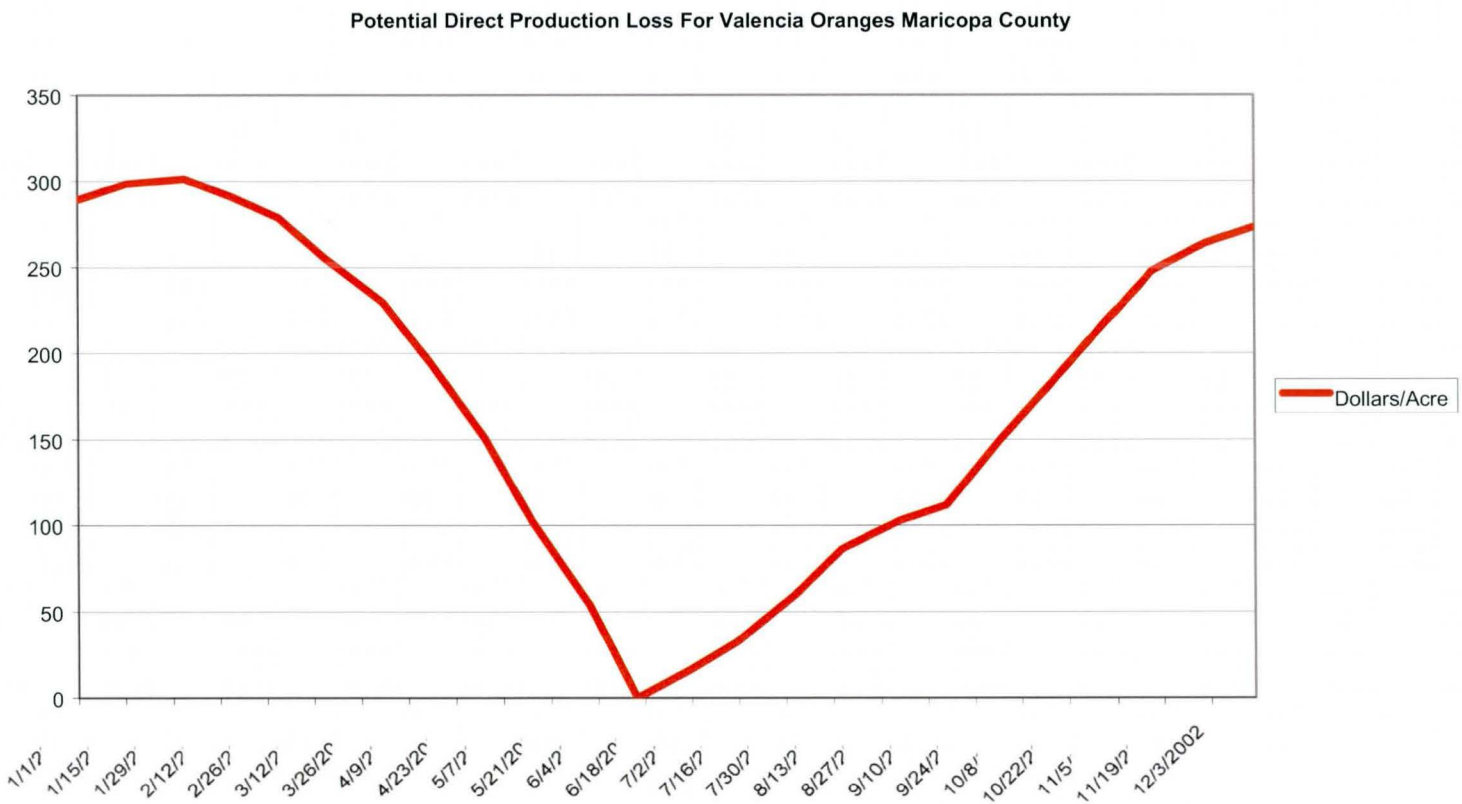
Table 12

Cumulative production expenses subject to flood loss
for Valencia Oranges per az ext. & UCCE Riverside Cnty templete

(Dollars per acre) 815.19

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	289.54				growing	water,sprayingPO	16.38	289.54
15-Jan	298.58				growing	sprayingPO	9.04	298.58
1-Feb	301.46				growing/harvest	water,sprayingPOH	36.38	334.96
15-Feb	291.20				growing/harvest	sprayingPOH	29.04	364.00
1-Mar	278.86				growing/harvest	water,sprayingPOF	34.38	398.38
15-Mar	255.25				growing/harvest	sprayingPOF	27.04	425.42
1-Apr	229.90				growing/harvest	water,sprayingPOF	34.38	459.79
15-Apr	194.73				growing/harvest	sprayingPOF	27.04	486.83
1-May	150.96				growing/harvest	water,sprayingPO	16.38	503.21
15-May	102.45				growing/harvest	sprayingPO	9.04	512.25
1-Jun	53.91				growing/harvest	water,sprayingPOS	26.88	539.13
15-Jun	0.00				growing/harvest	water,sprayingPOS	26.88	566.00
1-Jul	16.38				open	water,sprayingPO	16.38	16.38
15-Jul	32.75				open	water,sprayingPO	16.38	32.75
1-Aug	59.63				growing	water,sprayingPOS	26.88	59.63
15-Aug	86.50				growing	water,sprayingPOS	26.88	86.50
1-Sep	102.88				growing	water,sprayingPO	16.38	102.88
15-Sep	111.92				growing	sprayingPO	9.04	111.92
1-Oct	149.54				growing	water,fertilizing,sprayingPO	37.63	149.54
15-Oct	179.83				growing	fertilizing,sprayingPO	30.29	179.83
1-Nov	217.46				growing	water,fertilizing,sprayingPO	37.63	217.46
15-Nov	247.75				growing	fertilizing,sprayingPO	30.29	247.75
1-Dec	264.13				growing	water,sprayingPO	16.38	264.13
15-Dec	273.17				growing	sprayingPO	9.04	273.17
		note formulas in harvest period					566.00	566.00
					pickup use		7.00	573.00
					oper int. at 10.0		24.00	597.00
						sprayingH = preemerge herbicide		
						prayings = spot herbicide		
						sprayingP = Pesticide(insecticide)		
						sprayingF = Fungicides		
						I = interest		
						sprayingO = other chemicals		
					file:	crops.xls		

Figure 6


Potential Direct Production Loss For Valencia Oranges Maricopa County
350
300
250
200
150
100
50
0
1/1/2
1/15/2
1/29/2
2/12/2
2/26/2
3/12/2
3/26/2
4/9/2
4/23/2
5/7/2
5/21/2
6/4/2
6/18/2
7/2/2
7/16/2
7/30/2
8/13/2
8/27/2
9/10/2
9/24/2
10/8/
10/22/2
11/5/
11/19/2
12/3/2002
Dollars/Acre

Estimation of Crop Damages and Benefits

The actual crop damages will be estimated using normalized prices to smooth out the effects of short-term fluctuation and provide a more realistic basis for the evaluation of the project. The table of normalized prices for the state of Arizona is shown along with a table showing the historical prices for crops of cotton, alfalfa (hay), and citrus orchards (oranges and grapefruits)

Table 13 – Normalized Prices

Arizona

Va Shly' Akimel Salt River Restoration Project

Year	Hay All Baled per Ton	Cotton Lint Upland per pounds	Oranges per Box	Lemons per Box *	Grapefruit per Box
2002	$98.10	$0.582	$8.89	not available	$4.44
2001	$97.22	$0.613	$9.16	not available	$4.58
2000	$94.64	$0.693	$9.36	$7.46	$4.60
1999	$90.96	$0.675	$5.74	$6.67	$4.20

* not normalized, source:USDA Arizona - at packinghouse door

source: The Economic Research Service (ERS)

Table 14 - Crop Prices

Cotton – AZ – pound	$0.582
Hay (Baled) – Ton	$98.10
Oranges – AZ – Box	$8.89
Grapefruit – AZ – Box	$4.44

Tables on Market Values and Direct Production Losses

The numbers in the following tables are based upon the **total estimated crop acres** in the Va Shly' Ay Akimel Salt River Restoration Project. Numbers have not been discounted but used normalized prices and current estimates of citrus and nursery tree values.

Table 15 - Market Value Analysis

Va Shly' Ay Akimel Salt River Restoration Project (COM Project No. 02-001)

Estimate of Crop Acreages in Gilbert Road "Break-out" Area

	Number of Acres Enclosed within Flood Event Demarcation Line (acres)			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

Table 16 - Market Values per Acre

Estimate of Crop Mkt. Values Per Acre in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm
50	$870	$834	$6,840	0.0
100	$870	$834	$6,840	0.0
200	$870	$834	$6,840	$104,544
500	$870	$834	$6,840	$104,544

* 152 trees per acre, each tree $45

one acre = 43,560 square feet w eff usage at 60% w 1 gal = 1tree @$4.00

NOTE a tree ready for planting valued at $8.00

Table 17 - Market Losses

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$11,553	$5,537	$589,471	0.0	$606,561
100	$33,297	$15,957	$767,380	0.0	$816,634
200	$117,095	$56,115	$991,526	$27,181	$1,191,918
500	$125,366	$60,079	$1,160,474	$242,542	$1,588,461

Table 18 – Direct Production Losses Analysis

Va Shly' Ay Akimel Salt River Restoration Project (COM Project No. 02-001)

Estimate of Crop Acreages in Gilbert Road "Break-out" Area

	Number of Acres Enclosed within Flood Event Demarcation Line (acres)			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

Table 19 – Direct Production Losses per Acre

Estimate of Crop Prod. Values Per Acre in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus *	Nursery Tree Farm
50	$351	$279	$3,648	$0
100	$351	$279	$3,648	$0
200	$351	$279	$3,648	$52,272
500	$351	$279	$3,648	$52,272

* 152 trees per acre, each tree $24

one acre = 43,560 square feet w eff usage at 60% w 1 gal = 1tree @$2.00

NOTE a tree ready for planting valued at $8.00

Table 20 – Direct Production Losses

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$4,661	$1,851	$314,385	0.0	$320,897
100	$13,434	$5,334	$409,269	0.0	$428,037
200	$47,242	$18,758	$528,814	$13,591	$608,405
500	$50,579	$20,083	$618,920	$121,271	$810,853

Conclusion

The expected values of damages resulting from flooding are very small. When the damage numbers are shown on an annualized basis the economic impacts are rather insignificant. The losses of these crops on a national level will not affect prices because the quantities are relatively small. The following table 1s based upon 100 percent losses within the flooded areas.

Table 21 – Crop Losses (Without Project)

Expected Annual Damages
(Not discounted for seasonality, flood duration or limiting losses)

Category	Based on Market Prices	Based on Production Losses
Cotton	$1,205	$487
Alfalfa	$576	$193
Citrus	$21,464	$11,448
Nursery Tree Farm	$715	$357
Total	$23,961	$12,485

Expected Annual Damages ranges from $12,485 based upon maximum Production losses to $23,961 based upon maximum Market losses. These results do not take into account factors of flood duration and seasonality.

It is not realistic to assume 100 percent losses are going to occur. Therefore, the following table takes into account the factors of duration, season, and distribution of the flooding during the year. H&H provided seasonality information. Information on duration was not readily available instead a representative distribution was inserted.

Table 22 – Crop Losses (Without Project)

Expected Annual Damages
(Discounted for seasonality, flood duration or limiting losses)

Category	Based on Market Prices	Based on Production Losses
Cotton	$56	$22
Alfalfa	$219	$73
Citrus	$2,684	$1,431
Nursery Tree Farm	$179	$89
Total	$3,138	$1,615

Factoring in seasonal flood distribution probabilities, and duration the EAD is estimated to be approximately $1,615 based upon Production losses and $3,138 based upon Market value losses.

Appendix

Summary Analyses

Of

Flood Loss Calculation

As Function of Flooding Durations

50-Year Flood Event

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season r6-03

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Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

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Water standing of 7 days would cause about 50% of treee loss.

Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

COTTON	**percent by flood duration**						0.3	0.3	0.1	0.1	0.2	1
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 50 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.438	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.247	$0	$86	$71	$143	$285	$585
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$585

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 50 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.315	$0	$52	$87	$174	$349	$662
February	0	10	50	100	100	0.438	$0	$73	$121	$243	$485	$922
March	0	10	50	100	100	0.247	$0	$41	$68	$137	$274	$520
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$2,104

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.315	$0	$0	$0	$4,638	$18,553	$23,191
February	0	0	0	25	50	0.438	$0	$0	$0	$6,458	$25,833	$32,292
March	0	0	0	25	50	0.247	$0	$0	$0	$3,640	$14,561	$18,201
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$73,684

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.438	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.247	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

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Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

COTTON	**percent by flood duration**						0.3	0.3	0.1	0.1	0.2	1
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 50 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.438	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.247	$0	$35	$29	$58	$115	$236
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$236

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 50 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.315	$0	$17	$29	$58	$117	$221
February	0	10	50	100	100	0.438	$0	$24	$41	$81	$162	$308
March	0	10	50	100	100	0.247	$0	$14	$23	$46	$91	$174
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$703

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.315	$0	$0	$0	$2,474	$9,895	$12,369
February	0	0	0	25	50	0.438	$0	$0	$0	$3,444	$13,778	$17,222
March	0	0	0	25	50	0.247	$0	$0	$0	$1,941	$7,766	$9,707
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$39,298

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.438	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.247	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

100-Year Flood Event

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Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

COTTON	**percent by flood duration**						0.3	0.3	0.1	0.1	0.2	1
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 100 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.432	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.216	$0	$216	$180	$360	$720	$1,476
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$1,476

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 100 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.351	$0	$168	$280	$561	$1,121	$2,130
February	0	10	50	100	100	0.432	$0	$207	$345	$690	$1,380	$2,622
March	0	10	50	100	100	0.216	$0	$104	$173	$345	$690	$1,311
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$6,064

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.351	$0	$0	$0	$6,740	$26,962	$33,702
February	0	0	0	25	50	0.432	$0	$0	$0	$8,296	$33,184	$41,480
March	0	0	0	25	50	0.216	$0	$0	$0	$4,148	$16,592	$20,740
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$95,922

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.432	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.216	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

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	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 100 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.432	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.216	$0	$87	$73	$145	$290	$595
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$595

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 100 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.351	$0	$56	$94	$187	$375	$712
February	0	10	50	100	100	0.432	$0	$69	$115	$231	$461	$877
March	0	10	50	100	100	0.216	$0	$35	$58	$115	$231	$438
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$2,027

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.351	$0	$0	$0	$3,595	$14,380	$17,975
February	0	0	0	25	50	0.432	$0	$0	$0	$4,425	$17,698	$22,123
March	0	0	0	25	50	0.216	$0	$0	$0	$2,212	$8,849	$11,061
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$51,159

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.432	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.216	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

200-Year Flood Event

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	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 200 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.356	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.423	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.220	$0	$775	$645	$1,291	$2,582	$5,293
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$5,293

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 200 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.356	$0	$600	$1,000	$2,000	$3,999	$7,599
February	0	10	50	100	100	0.423	$0	$712	$1,187	$2,375	$4,749	$9,023
March	0	10	50	100	100	0.220	$0	$371	$619	$1,237	$2,475	$4,702
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$21,324

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.356	$0	$0	$0	$8,833	$35,333	$44,166
February	0	0	0	25	50	0.423	$0	$0	$0	$10,489	$41,958	$52,447
March	0	0	0	25	50	0.220	$0	$0	$0	$5,466	$21,862	$27,328
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$123,941

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.356	$0	$0	$0	$484	$1,937	$2,422
February	0	0	0	50	100	0.423	$0	$0	$0	$575	$2,300	$2,876
March	0	0	0	50	100	0.220	$0	$0	$0	$300	$1,199	$1,498
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$6,795

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
no damage possible in the months of Jan & Feb. when no plants are in the ground
In california cannot plant until March 1, 2002 or when the soil temperature is 50 to 60F
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Water standing of 7 days would cause about 50% of treee loss.
Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

COTTON	**percent by flood duration**						0.3	0.3	0.1	0.1	0.2	1
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 200 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.356	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.423	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.220	$0	$312	$260	$521	$1,042	$2,135
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$2,135

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 200 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.356	$0	$201	$334	$668	$1,337	$2,540
February	0	10	50	100	100	0.423	$0	$238	$397	$794	$1,588	$3,016
March	0	10	50	100	100	0.220	$0	$124	$207	$414	$827	$1,572
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$7,128

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.356	$0	$0	$0	$4,711	$18,844	$23,555
February	0	0	0	25	50	0.423	$0	$0	$0	$5,594	$22,377	$27,972
March	0	0	0	25	50	0.220	$0	$0	$0	$2,915	$11,660	$14,575
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$66,102

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.356	$0	$0	$0	$242	$969	$1,211
February	0	0	0	50	100	0.423	$0	$0	$0	$288	$1,150	$1,438
March	0	0	0	50	100	0.220	$0	$0	$0	$150	$599	$749
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$3,398

500-Year Flood Event

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season Rev6-16-03
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
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Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

COTTON	**percent by flood duration**						0.3	0.3	0.1	0.1	0.2	1
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 500 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.370	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.407	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.222	$0	$836	$696	$1,393	$2,786	$5,711
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$5,711

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 500 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.370	$0	$668	$1,113	$2,225	$4,450	$8,456
February	0	10	50	100	100	0.407	$0	$734	$1,224	$2,448	$4,895	$9,301
March	0	10	50	100	100	0.222	$0	$401	$668	$1,335	$2,670	$5,073
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$22,830

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.370	$0	$0	$0	$10,745	$42,981	$53,726
February	0	0	0	25	50	0.407	$0	$0	$0	$11,820	$47,279	$59,098
March	0	0	0	25	50	0.222	$0	$0	$0	$6,447	$25,788	$32,235
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$145,059

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.370	$0	$0	$0	$4,492	$17,966	$22,458
February	0	0	0	50	100	0.407	$0	$0	$0	$4,941	$19,763	$24,703
March	0	0	0	50	100	0.222	$0	$0	$0	$2,695	$10,780	$13,475
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$60,636

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

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Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

COTTON	**percent by flood duration**						0.3	0.3	0.1	0.1	0.2	1
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 500 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.370	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.407	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.222	$0	$337	$281	$562	$1,124	$2,304
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$2,304

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 500 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.370	$0	$223	$372	$744	$1,488	$2,827
February	0	10	50	100	100	0.407	$0	$245	$409	$818	$1,636	$3,109
March	0	10	50	100	100	0.222	$0	$134	$223	$446	$893	$1,696
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$7,632

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.370	$0	$0	$0	$5,731	$22,923	$28,654
February	0	0	0	25	50	0.407	$0	$0	$0	$6,304	$25,215	$31,519
March	0	0	0	25	50	0.222	$0	$0	$0	$3,438	$13,754	$17,192
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$77,365

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.370	$0	$0	$0	$2,246	$8,983	$11,229
February	0	0	0	50	100	0.407	$0	$0	$0	$2,470	$9,881	$12,352
March	0	0	0	50	100	0.222	$0	$0	$0	$1,347	$5,390	$6,737
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$30,318

Appendix

Table of Citrus Costs

By Glenn Wright, PhD.

Estimated Value of mature trees located in Maricopa County

	Estimated Value per acre	Estimated Value per tree	Trees per acre	Distance between rows	Distance between trees	1994-2001 Average Yield[1]	1994-2001 Average Yield	1994-2001 On-tree Returns	Preharvest Costs[2]
	$ per acre	$ per tree		ft.	ft.	Cartons per acre[3]	Cartons per tree	$ per carton	$
White Grapefruit	($401.19)	$2.63	75.6	24	24	334.14	4.42	$0.60	$600.00
Red Grapefruit	($37.31)	$7.44	75.6	24	24	334.14	4.42	$1.68	$600.00
Navel Orange	$179.35	$10.60	75.6	24	24	243.57	3.22	$3.29	$622.00
Valencia Orange	$222.87	$11.17	75.6	24	24	380.57	5.03	$2.22	$622.00
Lemon	$1,041.97	$22.00	75.6	24	24	502.71	6.65	$3.31	$622.00

1 Yield data and On-tree returns from Arizona Agriculture Statistics and conversations with packinghouse managers.

2 Preharvest Costs estimated from Arizona Citrus Budgets

3 Carton Weights: Grapefruit = 33.9 lbs., Oranges = 37.5 lbs., Lemons = 38 lbs.

Appendix

Information from

H&H

Raw numbers of annual maximum discharges

period in years	500	200	100	50	20
jan	200	160	130	79	25
feb	220	190	160	110	46
mar	120	99	80	62	37
apr					
SUM	540	449	370	251	108

Monthly probability % of flooding

period in years	500	200	100	50	20
jan	0.370	0.356	0.351	0.315	0.231
feb	0.407	0.423	0.432	0.438	0.426
mar	0.222	0.220	0.216	0.247	0.343
apr					
SUM	1	1	1	1	1

note: meeting held with H&H on October 1, 2002 at 2pm 12th floor conference room.
Duration discussed - further resolution ongoing

10-2-02 contact - University of California Cooperative Extension
Peggy Mauk 909-683-6491 ext 221
Tom Shea 909-6491 ext 224

10-8-02 contacted - Agr Commissioner Office
Mike Rethwisch 760-921-7844
Knows alfalfa hay and cotton

ADDENDUM 2

HYDROLOGIC ANALYSIS SUPPORTING AGRICULTURAL FLOOD DAMAGE ANALYSIS

SUBJECT: HYDROLOGY TO SUPPORT DETERMINATION OF AGRICULTURAL DAMAGES, Salt River below Granite Reef Diversion Dam (Va Shly'ay Akimel Restoration Study)

TO: CESPL-ED-HH

FROM: CESPL-ED-HH, Nick N. Adelmeyer (x3570)

DATE: 16 April 2003

Background

The Los Angeles District (LAD), Corps of Engineers, developed discharge-frequency relationships for the Salt River through the City of Phoenix in order to establish the Water Control Plan for Modified Theodore Roosevelt Dam (Roosevelt Dam). The Water Control Plan is an explicit statement of how releases from the flood control pool at Roosevelt Dam should be scheduled when reservoir stage reaches certain key elevations within that pool. Discharge-frequency relationships were determined based upon simulation of long-term inflows to the upstream Salt River Project (SRP) reservoir system, with the system operated in accordance with existing criteria, objectives, and obligations. This included the existence of Roosevelt Dam on the Salt River, and five other dams and reservoirs on the lower Salt and on the Verde River which comprise the storage facilities that make up the SRP. The simulation period was from 1889 through 1993.

Based upon the analysis described above and thoroughly documented in reference a), below, the probability that a specified discharge would be exceeded during any given year was determined for the Salt River below Granite Reef Diversion Dam and other locations. In addition, the probability that specified discharges for certain durations would be exceeded during any given year was also determined.

In the Va Shly'ay Akimel (VSA) study area, overflows from the Salt River may inundate farmable land within the Salt River floodplain. Hydraulic analysis indicates that the limiting channel capacity within the study reach is approximately 160,000 ft^3/s. Hence, flow rates in excess of 160,000 ft^3/s might escape the river and flood surrounding land. Inundation maps for the VSA study reach of the Salt River were prepared for hypothetical floods ranging from the 20% annual exceedance event (5-year annual maximum peak discharge) to the 0.2% annual exceedance event (500-year annual maximum). This information, as well as discharge-frequency values, is published in the Hydraulic Appendix (ref. b)).

However, to adequately address potential agricultural damages, more detailed hydrologic information is often necessary. *Annual maximum discharges* may not capture the variation in impact resulting *from seasonally-variable* or even *monthly-variable* discharge-frequency results. To estimate the damage potential from inundation of agricultural areas by Salt River overflows, monthly-variable, discharge-frequency values were requested to perform economic evaluations. This kind of detailed information is useful for determining the flood threat to a variety of crops during the planting, growing, and harvesting seasons. Hence, the following analysis describes

the variability in flood threat throughout the year with special emphasis given to the season in which the greatest potential threat to the agricultural area exists – viz., January through March.

1. References.

a) "Section 7 Study for Modified Theodore Roosevelt Dam, Arizona (Theodore Roosevelt Dam)", Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam", U.S. Army Corps of Engineers, Los Angeles District, dated March 1996.

b) "Va Shly'Ay Akimel, Hydraulic & Sedimentation Analysis, Volumes 1 – 3", prepared for Los Angeles District, U.S. Army Corps of Engineers by WEST Consultants, dated September 20, 2002.

c) "Santa Cruz River Watershed Management Study: Mixed Population Discharge-Frequency Analysis, Pima County, Arizona, Continental Road to Cortaro Road", Hydrology Appendix (E1), Los Angeles District, U.S. Army Corps of Engineers, dated 29 September 2000.

d) "Mixed-Population Frequency Analysis", Training Document No.17, The Hydrologic Engineering Center, dated April 1982.

e) HEC-FFA, Flood Frequency Analysis.

2. Drainage Area Description.

a) *MODIFIED ROOSEVELT DAM TO GRANITE REEF DIVERSION DAM.* The Salt River originates on the eastern portion of the Mogollon Plateau, in the White Mountains, with peaks as high as 11,590 feet (Baldy Peak). The Salt River is formed by the confluence of two westward flowing streams, the White and Black rivers, and drains the rugged central section of Arizona, which is marked by isolated mountain ranges with steep-walled canyons and gorges. The Salt River drains directly into Theodore Roosevelt Lake where it is joined by Tonto Creek, which flows southward out of the Tonto Basin at the base of the Mogollon Plateau. The United States Geological Survey (USGS) operates streamgages on both the Salt River (near Roosevelt) and Tonto Creek (above Gun Creek), which measure inflow to Modified Roosevelt Dam from 4,981 sq. mi. of the contributing drainage area. The total contributing drainage area upstream of Modified Roosevelt Dam, including Theodore Roosevelt Lake, is approximately 5800 sq. mi. The total drainage area of the Salt River at the most downstream facility - Stewart Mountain Dam - is approximately 6200 sq. mi. Releases from the Salt River system reservoirs are measured by the USGS at a streamgage located 3.5 mi. downstream of Stewart Mountain Dam. The Salt River is joined by its major tributary, the Verde River, approximately 9.5 mi. below Stewart Mountain Dam.

b) *VERDE RIVER TO THE SALT RIVER CONFLUENCE.* The Verde River flows south out of the Chino valley, which is bounded on the west by the Juniper and Santa Maria

Mountains, and is separated from Tonto Basin on the east by the Mazatzal Mountains. Horseshoe Dam, which has a contributing drainage area of 5657 sq. mi., excluding Aubrey Basin which is closed, is 9 miles downstream from the USGS streamgage located on the Verde River below Tangle Creek, and is the upstream SRP dam on the Verde River. Bartlett Dam is the downstream SRP facility on the Verde River and is approximately 15 miles below Horseshoe Dam and 25 miles upstream from the confluence with the Salt River. The total drainage area at Bartlett Dam is 5851 sq. mi., excluding the 373 sq. mi. Aubrey Basin. Releases from the Verde River system reservoirs are measured by the USGS approximately 2.1 mi. downstream of Bartlett Dam. Sycamore Creek (drainage area = 164 sq. mi.) is the major tributary of the Verde River downstream of Bartlett Dam. The Verde River joins the Salt River approximately 25 miles downstream of Bartlett Dam. The effective drainage area at the mouth (excluding the Aubrey Basin) is approximately 6300 sq. mi.

c) *SALT-VERDE CONFLUENCE TO THE GILA RIVER.* Granite Reef Diversion Dam, located about 3 mi. downstream of the Salt River and Verde River confluence, is the final SRP dam on the Salt River. This dam normally diverts upstream SRP releases from the Salt River into the Arizona Canal to the north of the dam and the South Canal to the south of the dam. During periods of high flows, water passes over the dam and continues down the Salt River. The Salt River ultimately joins the Gila River at mile 198 (measured from the mouth of the Gila River at Yuma, Arizona, and approximately 40 miles downstream of Granite Reef Diversion Dam. The Salt River drains a total area of about 13,000 sq. mi. (excluding Aubrey Basin) to the Gila River, of which nearly 12,600 sq. mi. above the Granite Reef Diversion Dam is regulated.

3. Operation of the Salt River Project Reservoir System (SRP).

a) *GENERAL.* The SRP system is comprised of six reservoirs on the Salt and Verde Rivers, including Modified Roosevelt Dam, and a diversion dam located 3 miles downstream of the Salt River and Verde River confluence. The other reservoirs on the Salt River are Horse Mesa Dam, Mormon Flat Dam and Stewart Mountain Dam; Horseshoe Dam and Bartlett Dam are located on the Verde River, and Granite Reef Diversion Dam is located below the confluence of the Salt River and the Verde River. The reservoirs receive runoff from a combined watershed of more than 12,600 sq. mi. (excluding Aubrey Basin). Modified Roosevelt Dam is the oldest and has the largest reservoir storage. The SRP reservoir system in central Arizona provides water supply for much of the metropolitan Phoenix area. Hydroelectric power is also generated within the system.

b) *SALT RIVER RESERVOIRS.* Normal[1] releases from Modified Roosevelt Dam generate hydropower as they pass through the hydroelectric generating facilities downstream of Modified Roosevelt Dam and the three downstream regulatory dams - Horse Mesa Dam,

[1] Normal releases refers specifically to releases made, when the reservoir pool is within the allocated water supply space, to satisfy downstream demand, rather than releases which are necessary, when the reservoir pool is within the allocated flood control space, due to excess inflow, and which must be "wasted" to the Salt River downstream of Granite Reef Diversion Dam.

Mormon Flat Dam, and Stewart Mountain dam. The "normal" releases from Modified Roosevelt Dam and the other Salt River dams are generally scheduled for the warmest months of the year, when runoff is low and demand for both electrical power and water are highest. During the winter months, when runoff is generally greater, downstream demand is typically satisfied by releasing water from the Verde River reservoirs. The storage space in the Verde River reservoirs is considerably smaller than in the Salt River reservoirs[2], which makes carry-over storage on the Verde side impractical. In addition to the considerably greater quantity of storage space available within the Salt River reservoirs, this storage space is more flexible because of pump-back storage capability, which allows hydroelectric power generation during periods of peak demand without "wasting" water. To fully utilize the pump-back storage system, the lake levels in the 3 reservoirs downstream of Modified Roosevelt Dam are typically maintained at about 90% full. The remaining space allows capture and regulation of local inflow.

c) *VERDE RIVER RESERVOIRS.* The Verde River reservoirs generally store water during the high runoff season (i.e., the winter months) and release this water at a rate compatible with the demand. As discussed in the previous section, releases from Bartlett Dam are normally made in the winter, when demands are less, because there is insufficient space in the Verde River reservoirs to allow carry-over storage until the warmer summer months, which are accompanied by an increase in demand. During periods when the water available in the Verde River reservoirs is insufficient to meet the downstream demand, surface water from the Salt River reservoirs and/or groundwater may be utilized to meet that demand. During periods of excess inflow, it may be necessary to "waste" water by making releases from the Verde River spillways, which exceed the downstream demand. No hydropower facilities exist at Horseshoe and Bartlett dams.

4. <u>Precipitation.</u> Average annual precipitation for the upper Salt River and Verde Rivers (above the SRP system reservoirs) ranges from about 20 inches near Cibecue on the west to nearly 30 inches in the higher elevations of the White Mountains on the east. Two precipitation gages in the area - at McNary and Whiteriver - have recorded a mean annual precipitation of 24.9 and 17.4 inches, respectively. Precipitation in this region occurs throughout the year, with the wettest periods being during the monsoon months of July and August. The maximum average monthly precipitation at the two reference gages occurs in August, 3.95 and 3.49 inches, respectively. The precipitation is distributed somewhat evenly between the summer months (May through October) and winter months (November through April), although the heaviest short-duration showers occur in the summer and early fall. Certain sections of Arizona *average* more than one thunderstorm per day in July and August; the southern slopes of the White Mountains may experience between 80 and 90 thunderstorms during these two midsummer months. In the higher parts of the plateau section more than 75% of the winter precipitation falls as snow. These areas typically receive between 8 and 11 feet of snow annually, with more than 100 inches falling in a single month during unusually cold and wet periods. Precipitation is characterized by the season in which it occurs, and is described accordingly below:

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[2] The Salt River reservoirs can store approximately 2.5 million ac-ft of water (including approximately 560,000 ac-ft within the flood pool at Modified Roosevelt Dam). In comparison, the Verde River reservoirs can only store approximately 310,000 ac-ft, all of which is water supply space.

a) *SUMMER MONTHS.* The summer "monsoon" season (typically June through September) is characterized by intense local precipitation, often in the form of thunderstorms, of short duration and small areal extent. Smaller drainage areas (< 500 sq. mi.) are more responsive to this type of rainfall event, resulting in higher peak flows in such basins.

b) *WINTER MONTHS.* The winter season (typically November through March) is characterized by more general precipitation, less intense in nature, and covering large areas for extended periods of time. Larger drainage areas (> 1000 sq. mi.) are more responsive to this type of rainfall, and higher peaks will result; runoff will continue for a longer duration.

c) *LATE SUMMER TO EARLY FALL.* Occasionally a late-summer to early fall (typically August through October) event resulting from a dissipating tropical depression or hurricane (such as the August 1951 General Summer Storm or the Labor Day 1970 storm) may occur; this type of storm may include intensities characteristic of thunderstorms with areal extent and duration associated with the general winter storms. Such an event might produce high peak flow as well as volume from all size drainage areas.

d) *SPRING MONTHS.* During the late spring-early summer (April though May) period there is typically less precipitation. Most runoff occurring in this period is the result of snowmelt, and occasionally accompanied by rainfall.

5. <u>Runoff</u>. In general, the larger drainage areas (such as the Salt and Verde Rivers) respond more to general winter precipitation (i.e. the maximum discharge occurs in the winter), while for smaller drainage areas, the larger peak discharges may occur during summer months. During the winter months, snowmelt often contributes to runoff during warm rainstorms; general accelerated snowmelt may also occur during early spring when above-normal temperatures prevail. The percentage of precipitation which contributes immediately to runoff in this area, as in other high elevation areas in Arizona, is considerably less than in low-lying desert areas, and more sparsely vegetated transition areas of the state. The upper Salt and Verde Rivers, as well as headwater streams, are perennial. During major storms, streamflow increases rapidly, and in combination with steep gradients and often-barren slopes, results in major floods. Snowmelt is a contributing factor in most winter floods.

Because of construction of SRP dams and the operation of the SRP reservoir system, most runoff is stored for later downstream use. The simulated flood history of the Salt River below Granite Reef Diversion Dam (ref. a), Fig.1 below) indicates that with the existing dam and reservoir system in place, and operated according to today's criteria, there are 34 years in the 105-year simulation period in which water is wasted over Granite Reef Diversion Dam ("spills") due to an excess of upstream inflow and impounded water compared to demand.

Based upon historical information and long-term simulated flood history (105-year period from 1889 through 1993) representative of *existing condition*", a summary of spills for the meteorological cases described above is summarized in the following and displayed graphically in Figure 2.

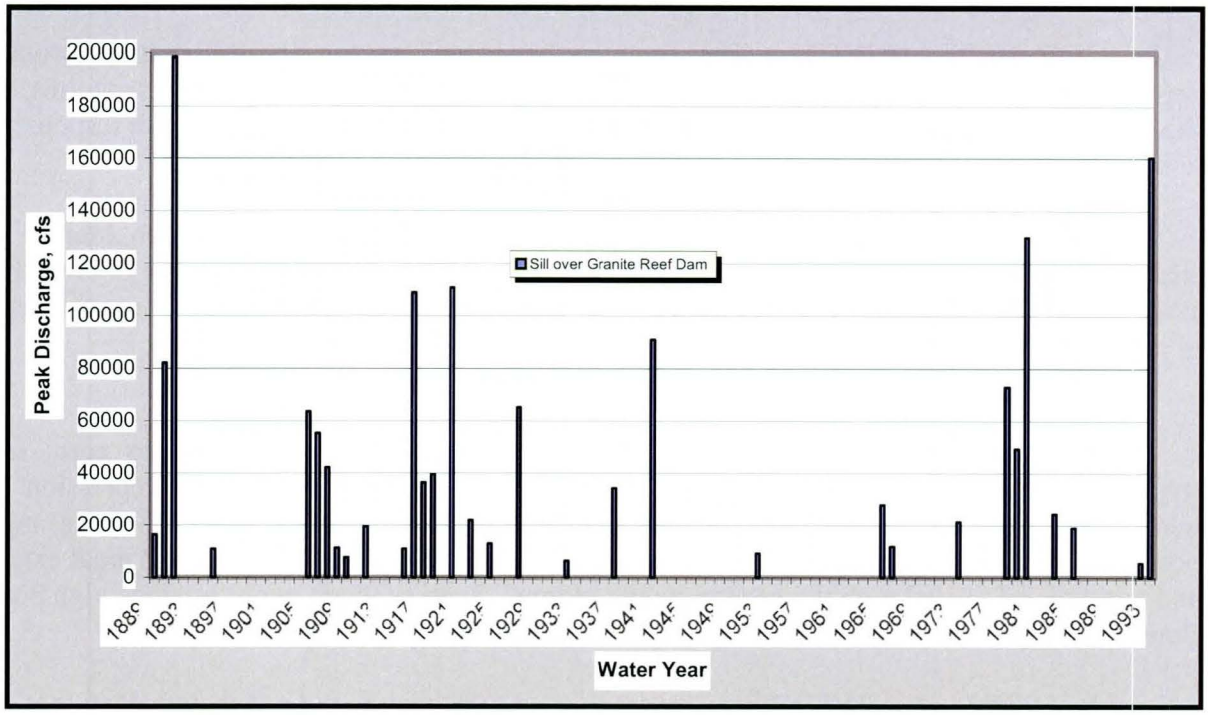

Figure 1. Simulated Spill History: Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 – 2003.

The impact of the upstream dams on the Salt and Verde Rivers on flood flows in the Salt River below Granite Reef is partially portrayed in Table 1. This table summarizes the peak flow rates for many of the largest events shown in Figure 1 for both *existing conditions* and *natural conditions*, i.e. without the SRP system in place. It should also be noted that the gaps in "spills" over Granite Reef Diversion Dam (Figure 1) would not be present under *natural conditions*. In the absence of upstream SRP dams, flows intercepted by the dams and stored in the reservoirs would continue downstream during most years.

Table1. Comparison Of Significant Floods Of Record, Simulated Existing Versus Natural Runoff[1], Peak Discharge In Salt River At Granite Reef Diversion Dam

Water Year	Month	Existing Conditions	Natural[2]
1890	February	97,000	190,000
1891	February	199,000	300,000
1906	November	*No spill*	220,000
1906	March	55,600	63,400
1907	March	49,000	55,800
1916	January	109,000	164,000
1917	April	44,000	59,900
1920	February	111,000	155,000
1927	February	65,200	123,000

Table1. Comparison Of Significant Floods Of Record, Simulated Existing Versus Natural Runoff[1], Peak Discharge In Salt River At Granite Reef Diversion Dam

Water Year	Month	Existing Conditions	Natural[2]
1932	February	*No spill*	117,000
1938	March	*No spill*	115,000
1941	March	90,100	170000
1966	December-January	27,900	85,000
1978	March	72,900	260,000
1979	January	49,300	235,000
1980	February	130,000	241,000
1993	March	160,000	329,000

Notes:

1. Natural flow is the peak discharge that would have occurred in the absence of SRP reservoirs.
2. Results based on simulations reported in Table 4 of the May 1982 CAWCS Hydrology Report for the period from 1889 through 1980 only; results from 1980 to 1993 based upon simulations performed for the study of Modified Theodore Roosevelt Dam, reference a).

During most months of most years (please refer to Fig. 1, previous, and Table 2, following) there is no flow in the Salt River downstream of Granite Reef Diversion Dam. Almost the entire volume of runoff reaching the study area results from releases/spills from upstream SRP dams in excess of the delivery system capacity and user demand. These flows, typically lasting for a week or more, spill across Granite Reef Diversion Dam and continue downstream. During periods of sustained or high releases from the upstream SRP Dams, these spills reach Painted Rock Dam. Spills from the Salt River Dams occur almost always during the cold-weather months, and result from above normal precipitation, often accompanied by additional runoff from snowmelt or from snowmelt alone. The simulated flood history referred to above (1889-1993, Table 2) indicated spills would have occurred most frequently in the months of January through April, with the maximum spill threat in terms of volume occurring in January and February.

There is strong serial correlation between spills and *above normal* precipitation, both in the short-term (water year) and long-term (several water years). Moreover, the reservoirs tend to fill during the winter months, while the major demand is during the warm-to-hot-weather months. Typically reservoirs are "drawn-down" in the summer for hydropower, irrigation, and water supply, and "refilled" during the wet winter months. Hence, fewer spills occur early in the runoff season (November and December), and relatively more as the runoff season progresses (February through April). Refer to Table 2, and Figure 2, which follow. Similarly, above-normal runoff years result in high reservoir pools, such that even "normal" runoff during the following runoff season(s) may result in spills. Finally, as reservoirs begin to refill during the runoff season, severe storms, including melting snow, may produce spills and high discharges from the SRP dams. The majority of these types of storms occur during the months of January and February; as the runoff season progresses the likelihood of a storm intense enough to produce high peak discharges diminishes. During the warm-weather months the areal extent of

intense-precipitation storms diminishes, hence runoff from the large Salt River watershed is reduced; in addition, since the reservoirs are drawn-down due to increased demand, more space is available to store seasonal runoff. This disparity is seasonal spills is clearly shown in Table 2 and Figure 2.

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1889	0.0	0.0	116.8	118.4	0.0	208.5	35.9	0.0	0.0	0.0	0.0	0.0	479.6
1890	0.0	0.0	0.0	0.0	282.2	209.9	0.0	0.0	0.0	0.0	0.0	0.0	492.1
1891	0.0	67.8	162.2	123.7	1975.4	122.9	0.0	0.0	0.0	0.0	0.0	0.0	2452.0
1892	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1893	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1894	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1895	0.0	0.0	0.0	0.0	36.9	149.7	0.0	0.0	0.0	0.0	0.0	0.0	186.6
1896	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1897	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1898	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1899	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1901	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1902	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1903	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1904	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1905	0.0	0.0	0.0	0.0	277.5	480.7	847.9	112.4	0.0	0.0	0.0	0.0	1718.5
1906	0.0	122.3	87.3	84.1	54.2	652.0	168.0	0.0	0.0	0.0	0.0	0.0	1167.9
1907	0.0	0.0	0.0	208.3	196.6	296.0	0.0	0.0	0.0	0.0	0.0	0.0	700.9
1908	0.0	0.0	0.0	0.0	0.0	29.6	0.0	0.0	0.0	0.0	0.0	0.0	29.6
1909	0.0	0.0	0.0	80.2	157.1	134.9	100.5	0.0	0.0	0.0	0.0	0.0	472.7
1910	0.0	0.0	0.0	60.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.2
1911	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
1912	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1913	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1914	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1915	0.0	0.0	0.0	0.0	0.0	57.0	270.5	195.0	0.0	0.0	0.0	0.0	522.5
1916	0.0	0.0	0.0	1257.7	416.8	713.5	124.4	0.0	0.0	0.0	0.0	0.0	2512.4
1917	0.0	0.0	0.0	0.0	0.0	38.5	333.4	0.0	0.0	0.0	0.0	0.0	371.9
1918	0.0	0.0	0.0	0.0	0.0	44.9	0.0	0.0	0.0	0.0	0.0	0.0	44.9
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	21.4	302.3	284.9	1081.0	167.1	27.0	0.0	0.0	0.0	0.0	0.0	1883.7
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	21.5	55.1	0.0	0.0	0.0	0.0	0.0	0.0	76.6
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	38.1	33.4	0.0	0.0	42.4	0.0	0.0	0.0	0.0	0.0	113.9
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	97.1	63.8	0.0	0.0	0.0	0.0	0.0	0.0	160.9
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	107.1	199.5	70.4	0.0	0.0	0.0	0.0	0.0	377.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	45.1	121.3	17.8	0.0	0.0	0.0	0.0	0.0	184.2
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1941	0.0	0.0	0.0	0.0	146.2	386.0	532.5	190.0	0.0	0.0	0.0	0.0	1254.7
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1947	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	0.0	42.5	89.8	0.0	0.0	0.0	0.0	0.0	132.3
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	0.0	0.0	106.3	0.0	0.0	0.0	0.0	0.0	106.3
1966	0.0	0.0	59.4	41.2	0.0	83.9	0.0	0.0	0.0	0.0	0.0	0.0	184.5

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Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.0	13.1	54.6	11.7	48.8	170.1	642.3	275.7	0.0	0.0	0.0	0.0	1216.3
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	437.0	0.0	0.0	0.0	0.0	0.0	0.0	437.0
1979	0.0	0.0	244.3	432.5	238.4	529.2	361.6	3.8	0.0	0.0	0.0	0.0	1809.8
1980	0.0	0.0	0.0	0.0	1220.8	239.3	168.9	0.0	0.0	0.0	0.0	0.0	1629.0
1981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0	93.7	568.1	240.7	33.8	0.0	0.0	0.0	0.0	936.3
1984	3.0	0.0	152.8	44.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	200.0
1985	0.0	0.0	0.0	152.8	93.0	363.2	78.0	0.0	0.0	0.0	0.0	0.0	687.0
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0	0.0	0.0	0.0	24.6

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1993	0.0	0.0	0.0	1684.7	970.2	381.0	178.1	0.0	0.0	0.0	0.0	0.0	3214.0
Total Monthly Volume, (1000 Ac-ft)	**3.0**	**224.6**	**1217.8**	**4618.0**	**7559.6**	**7019.8**	**4436.4**	**810.7**	**0.0**	**0.0**	**0.0**	**0.0**	

Note: values highlighted in red represent the greatest spill volume in each month during the simulation period.

The simulated monthly spill history is displayed in the following graph (Fig. 2). Maximum spill volumes for each month are depicted along with the number of spills, as well as a summary of the largest spill and the largest number of monthly spills in any year.

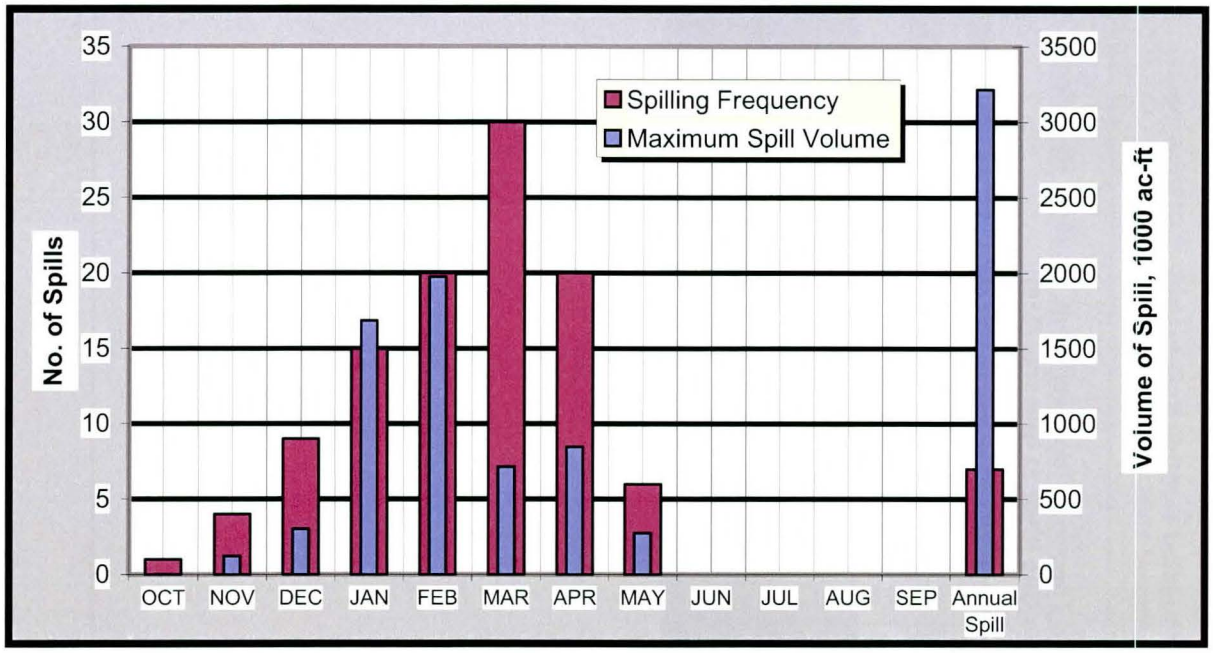

Figure 2. Monthly Summary of Spills: Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 - 1993

As shown in Figure 2, simulation of the POR did not result in any spill during the months of June through September; in addition there was only a single spill in October, of negligible volume (3000 ac-ft), and only four spills in November, with the greatest spill (122,000 ac-ft) being *less than half* of the greatest spill from any of the other months from December through May. The simulated POR (1889 –1993, 105 years) resulted in a total of 105 months during which some spill would have occurred (monthly spills for the entire POR were summarized in Table 2). The simulated spills ranged from 3000 ac-ft (October 1983) to nearly 2,000,000 ac-ft (February 1891), and *averaged about 250,000 ac-ft, per month, per spill event*. In other words, the "average" monthly spill was about a quarter-million ac-ft., while simulated spills *occurred on average* about once per year. However, there were only 34 years during which a simulated spill actually occurred (about a 32% chance of a spill occurring in a given year, or a 3-year recurrence interval). Many of the years in which spills would have occurred resulted from extended periods of above-normal runoff, and produced spills that occurred intermittently or continuously during a period of several months.

The foregoing Table 2 detailed the simulated spill volume over Granite Reef Diversion Dam for each month of the simulation period, as well as the relative frequency or infrequency of spills. On a monthly basis, spills occur only once every 12 months, or approximately 8% of the time. During the months of January through March (the 3 consecutive months with the greatest spill volumes) the frequency of spilling increases to approximately 62%, with greatest likelihood during February, nearly 29%. There is a late season flood threat in April and May, which

accounts for approximately a quarter of all monthly spill events (26 total spill months within the POR, with the greatest threat in April, 20 spill events, or approximately 19% of the time; the likelihood of a spill during May decreases to approximately 6% of the time, with 6 spill events in the POR). However, spills in these months are usually associated with continuing runoff from previous storms and floods, and late-season snowmelt. Of the 10 greatest simulated peak discharges at Granite Reef Diversion Dam, only one of those, April 1905, occurred during this late-season period. That event was the 10th largest in history (refer to Table 3, later in this report, for more details). Streamflow in the Salt River downstream of Granite Reef Diversion Dam is characterized in the following paragraphs.

a) *WARM WEATHER MONTHS.* During the "monsoon" season through the late-summer to early-autumn "hurricane" season (the months of June through October) there was only 1 simulated spill[3] (very minor) during the entire 105-year period; hence it is reasonable to conclude that the Salt River will be dry during this season. As a consequence, there will be no agricultural damages resulting from Salt River overflows during these months.

b) *COLD WEATHER MONTHS.* Most significant spills from the upstream SRP system occur during the cold-weather period (November through March), especially between the months of January and March[4].

c) *TRANSITION MONTHS.* Significant spills can also occur on a less frequent basis during the colder-weather transition months of November through December, and the warmer-weather transition months of April through May. However, the flood threat, that is flow *in excess of the conveyance capacity of the Salt River*, is very low during these months (refer to Table 3, which summarizes the simulated maximum annual peak resulting from the spills, and the months in which these occur).

Baseline information for *existing conditions* "spills" to the Salt River below Granite Reef Diversion Dam is portrayed in Figures 2 and 3. Figure 2 presented a summary of the simulated spilling frequency and volume on a monthly basis. Figure 3 includes the annual maxima and resulting discharge-frequency relationship.

[3] As previously mentioned, the volume was only 3000 ac-ft, in October 1983 (Water Year 1984).

[4] Of the 105 months in the POR during which spills occur, 78 are in the cold weather months (nearly 75%), and of these, 65 are in the months of January to March (62%).

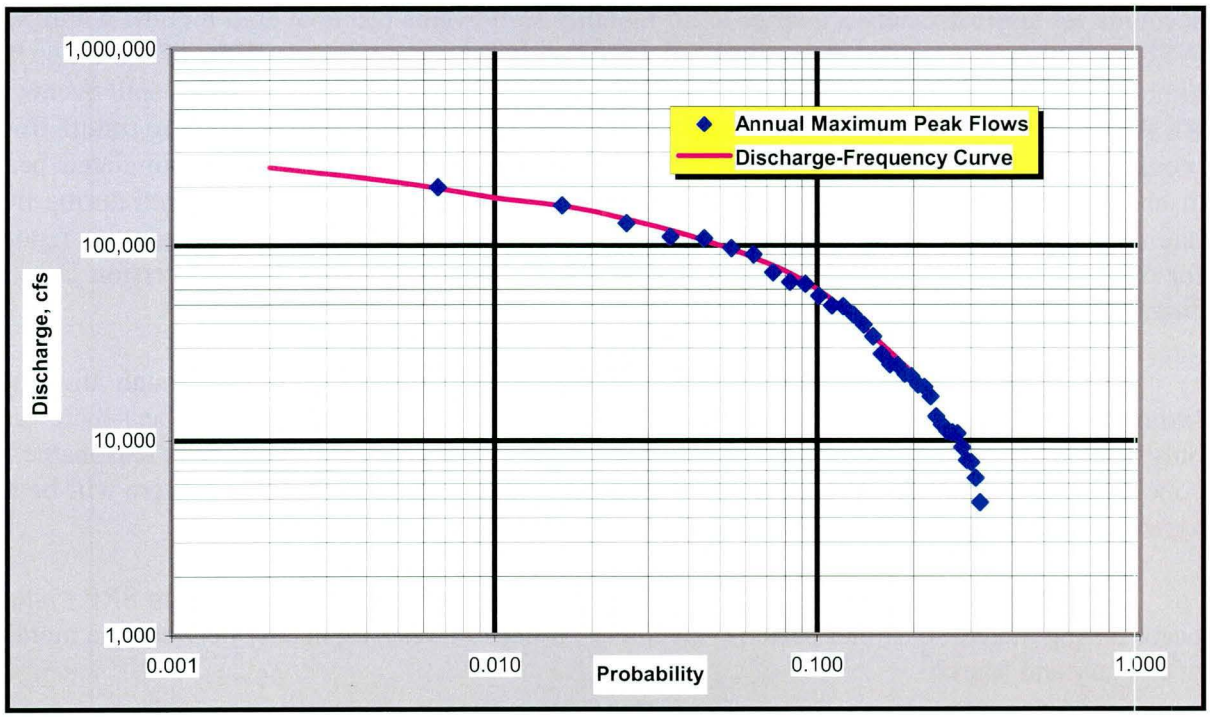

Figure 3. Annual Maximum Discharge-Frequency Curve, Salt River below Granite Reef Diversion Dam, *Existing Conditions.*

Table 3 (following page) includes the annual maxima in order of magnitude, as well as the months during which each simulated peak discharge occurred. **Note: none of the annual maxima occurred during the months of May through November.**

Table 3. SALT RIVER BELOW GRANITE REEF DIVERSION DAM: Simulated Spill History, *Existing Conditions*, 1889 - 1993														
RANK	PP	Discharge cfs	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.007	199,000		1891										
2	0.016	160,200	1993											
3	0.026	130,000		1980										
4	0.035	111,000		1920										
5	0.045	109,000	1916											
6	0.054	97,100		1890										
7	0.064	90,100			1941									
8	0.073	72,900			1978									
9	0.083	65,200		1927										
10	0.092	63,700				1905								
11	0.102	55,500			1906									
12	0.111	49,300	1979 (T)											1979 (T)
13	0.120	49,000			1907									
14	0.130	44,200				1917								
15	0.139	39,400			1918									
16	0.149	34,300			1937									
17	0.158	27,900	1966 (T)											1966 (T)
18	0.168	24,700												1983
19	0.177	24,500			1983									
20	0.187	22,000			1922									
21	0.196	21,400			1973 (T)	1973 (T)								
22	0.206	19,400			1911									
23	0.215	18,900			1985									
24	0.225	16,900			1889									
25	0.234	13,300			1924									
26	0.244	12,100			1966									
27	0.253	11,200			1908									
28	0.263	11,000			1895									

Table 3. SALT RIVER BELOW GRANITE REEF DIVERSION DAM: Simulated Spill History, *Existing Conditions,* 1889 - 1993

RANK	PP	Discharge cfs	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
29	0.272	10,900				1915								
30	0.282	9,200				1952								
31	0.291	7,900				1965								
32	0.301	7,700		1909 (T)	1909 (T)									
33	0.310	6,400			1932									
34	0.320	4,800			1992									

Note:
Cells highlighted in red indicate months during which the annual maximum NEVER occurred.
(T) Indicates year in which the annual maximum occurred over 2 consecutive months.

6. Monthly and Seasonal Discharge-Frequency Analysis.

a) *GENERAL.* In order to conduct an adequate evaluation of the potential damages to agriculture along the overbank of the Salt River, LAD economists requested discharge-frequency relationships be differentiated on a monthly basis. The purpose of breaking the discharge-frequency relationships down to this level was to provide information on potential damages to a variety of crops and growth cycles. Separation of annual maximum streamflow data into smaller time intervals (e.g. monthly or seasonal) may provide real insight into flooding potential, especially when the data set is homogeneous from a hydro-meteorological viewpoint, or is easily differentiable from that viewpoint. In addition there must be sufficient data to adequately describe the resulting differentiated series. Finally, it is necessary that analysis of the differentiated samples and the annual maximum series be consistent. Thus, the integrated results of the monthly/seasonal discharge-frequency relationships must support the annual maximum results.[5] The risk of agricultural damage resulting from overflows from the Salt River below Granite Reef Dam is confined to the cold-weather months, especially January through March, as previously documented. Hence, the monthly analysis has been restricted to the relative risk during the cold weather months. **Note: April, a transition month, has been included in this analysis, while November has been dropped, because the April flood threat is much greater than in November, and in the upper Salt and Verde River watersheds retains characteristics of cold weather regimes, i.e. frontal event precipitation coupled with snowmelt.**

b) *MONTHLY DATA.* Sequential depictions of the monthly (cold-weather) contribution to the annual flooding potential are provided in Figures 4 and 5. Figure 4 includes all the cold weather months from December to April (refer also to Figure 2 and Table 3 which indicate these are the months with the most frequent and large spills); the differentiated[6] annual maxima are compared with the annual maximum discharge-frequency relationship. Similarly, Figure 5 limits the cold weather monthly spills to the most volatile of all the months, January to March (again re: Figure 2 and Table 3). It is apparent from the differentiated data that the annual maximum discharge-frequency relationship is almost entirely dependent upon the spills during the cold weather months, especially January through March.

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[5] The exception would be if a "Mixed Population" analysis is appropriate and being conducted for the explicit purpose of modifying or more accurately defining the "Annual Maximum Series" results. In the case of a "Mixed Population" analysis, the annual maximum streamflow series is considered "non-homogeneous" because it represents several distinct meteorological causes. In such a case, the discharge-frequency relationship for each type of meteorological agent may be separated, a series developed, and separate analysis of each series performed. The integrated, combined-population discharge-frequency relationships are then considered more reflective of the true flood potential. Examples of this approach are documented in references c) and d).

[6] The annual maximum peak discharges are plotted according to annual rank, but "differentiated" as to their month of occurrence.

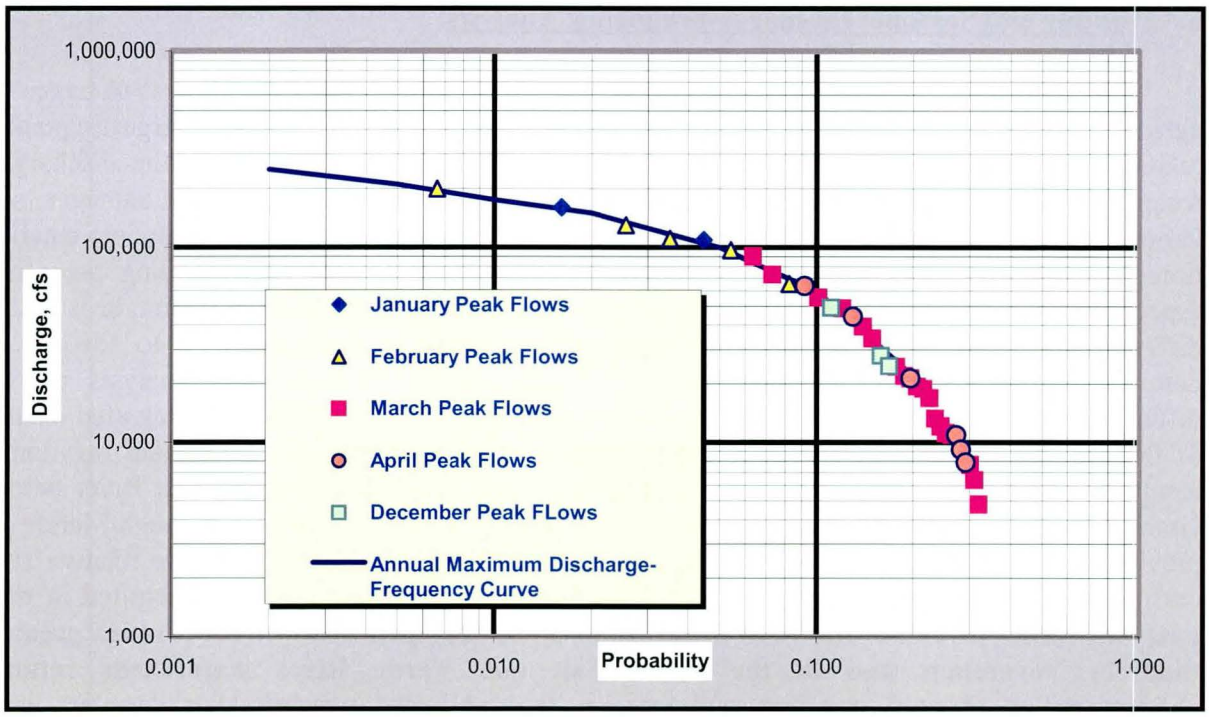

Figure 4. Annual Maximum Discharge-Frequency Curve with December – April Maxima, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

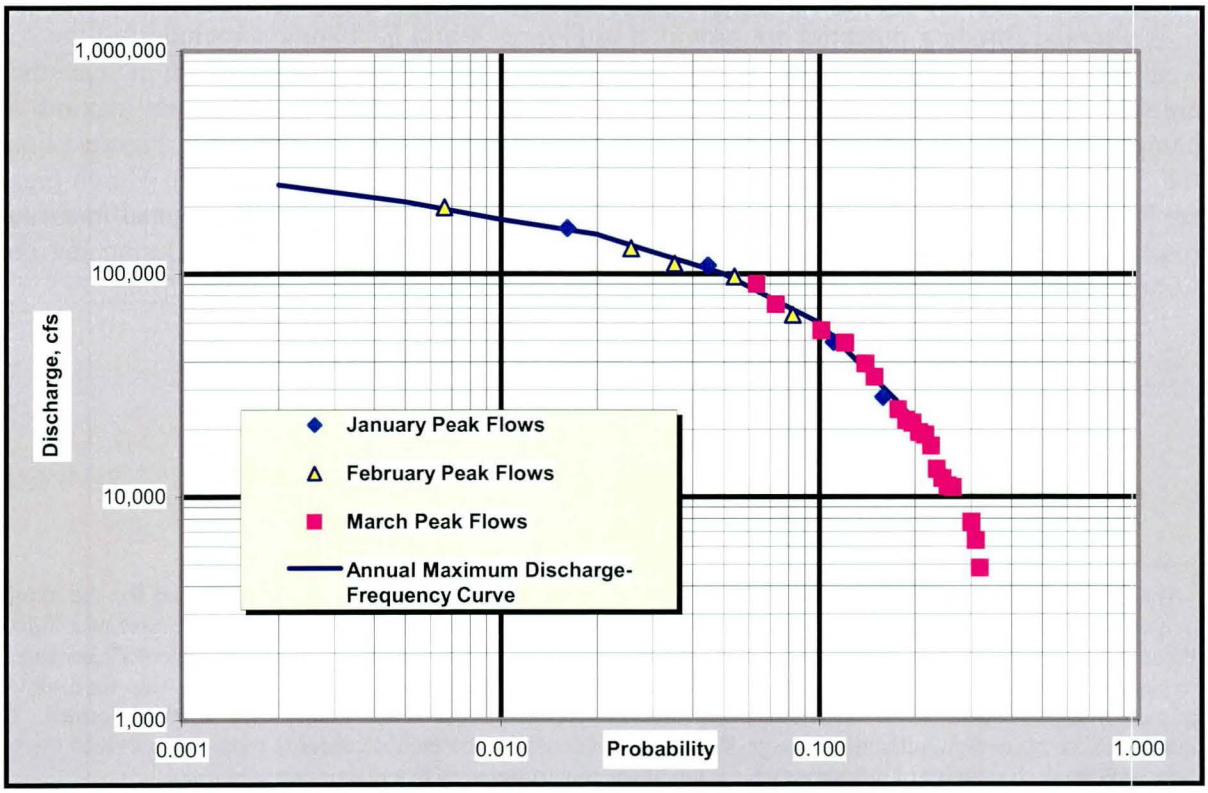

Figure 5. Annual Maximum Discharge-Frequency Curve with January – March Maxima only, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

Monthly maxima were not available for each of the 105 months in the POR during which simulated spills would have occurred. However, this information is available for the largest of these events, which as previously emphasized occurred during the cold-weather months. The peak discharges presented in Table 3 were assigned "annual" plotting positions within each of the differentiated monthly samples. In other words, the largest peak discharge for each of the months in the POR is ranked as number 1, and assigned a plotting position associated with that ranking. Based upon the length of the simulation record (105 years), the median plotting position value assigned to each of the largest monthly discharges is 0.007.

Table 4. SALT RIVER BELOW GRANITE REEF DIVERSION DAM: Simulated Spill History, *Existing Conditions*, 1889 - 1993

RANK	Peak Q, cfs	Median Plotting Position				
		JAN	FEB	MAR	APR	DEC
1	199,000		0.007			
2	160,200	0.007				
3	130,000		0.016			
4	111,000		0.026			
5	109,000	0.016				
6	97,100		0.035			
7	90,100			0.007		
8	72,900			0.016		
9	65,200		0.045			
10	63,700				0.007	
11	55,500			0.026		
12	49,300	0.026				0.007
13	49,000			0.035		
14	44,200				0.016	
15	39,400			0.045		
16	34,300			0.054		
17	27,900	0.035				0.016
18	24,700					0.026
19	24,500			0.064		
20	22,000			0.073	0.026	
21	21,400			0.083	0.035	
22	19,400			0.092		
23	18,900			0.102		
24	16,900			0.111		
25	13,300			0.120		
26	12,100			0.130		
27	11,200			0.139		
28	11,000			0.149		
29	10,900				0.045	
30	9,200				0.054	
31	7,900				0.064	
32	7,700		0.054	0.158		
33	6,400			0.168		
34	4,800			0.177		

Table 4 above presents the POR, *Existing Conditions,* peak-discharges in the Salt River below Granite Reef Diversion Dam, originally displayed as a "differentiated"[7] annual series in Table 3, reassembled into multiple monthly series. As stated earlier, the annual maximum series was developed using graphical procedures, since the data did not fit the statistical requirements: i.e., *random, independent events.* Hence the monthly series were analyzed in a similar manner. In this case a graphical, curve-fitting procedure was utilized to generate consistent, smooth curves (please refer to Figure 6, below). To enhance the portrayal, the 0.002 probability event (500-year) was computed using the regressed equations for discharge (y) in Figure 6, and included in the plotted data. Months other than January to April and December were not included since the flood threat during those months is nearly non-existent.

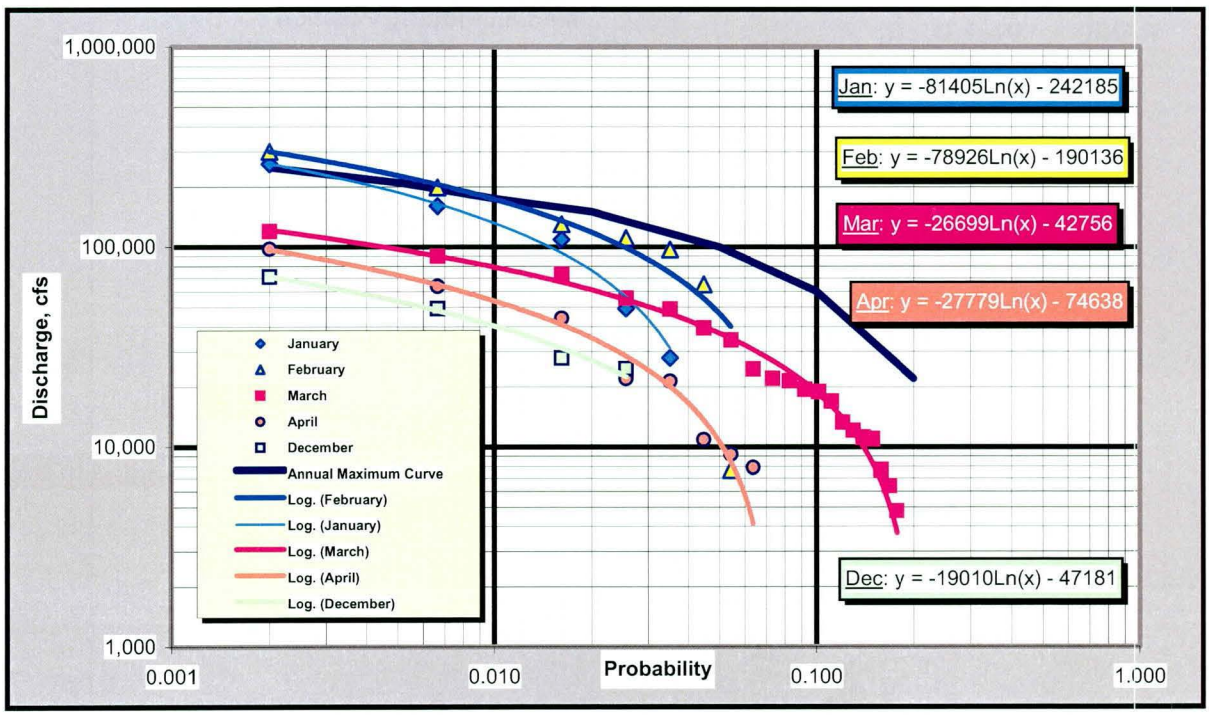

Figure 6. December – April Monthly Discharge-Frequency Curves (unadjusted) vs. Annual Curve, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

In Figure 6 above, the annual maximum discharge-frequency curve is compared to discharge-frequency curves developed from the data sets in Table 4 for each of the months in which significant spills have occurred during the simulation period (1889 – 1993). Each curve is a regressed best-fit curve, or "graphical" curve[8]. In is obvious from the graphs that two of the monthly curves, viz. January and February, are in conflict with the annual maximum curve, since for more rare frequency events the January and February curves equal or exceed the annual

[7] The data for the annual series in Table 3 was "differentiated" by indicating the month(s) in which the annual maxima occurred.

[8] Analytical curves for the Salt River below Granite Reef Diversion Dam are inappropriate since the data set is not composed of random independent events. A "best-fit" scheme based upon regression was selected for consistency across each data set. These "results" are intermediate, and only portrayed for comparison purposes.

maximum curve. It is also apparent that the December and April monthly discharge-frequency curves (and contributing data) have little impact on the annual maximum curve. To maintain consistency with the "parent" curve for the annual maximum series, adjustments were made to the January and February discharge-frequency curves[9], based upon the difference between the integrated monthly results and the annual maximum discharge-frequency curves. The adjustment procedure is shown in Table 5, following pages, and the adjusted January, February, and March values are highlighted on the last page of Table 5.

[9] The March discharge-frequency curve was also adjusted because the values for this month were also significant. In addition, the investigator wanted to develop a single-season curve for the months of January – March. It is apparent in Table 5, following, that the peak spills during March have much less contribution to the Combined Probability Function that the January and February data, especially for significant discharges (≥ 100,000 cfs).

Table 5. Salt River below Granite Reef Dam: Seasonal Discharge-Frequency Analysis Results, *Existing Conditions*, Based upon graphical curves, January - March, Computed Probability

INITIAL DEVELOPMENT OF ANNUAL SEASONAL CURVE (JAN-MAR) USING CULLED DATA FOR THOSE MONTHS

Q, cfs	Pr(Jan)	Pr(Feb)	Pr(Mar)	Pr(J)+Pr(F)+Pr(C)	Pr(J)xPr(F)	Pr(J)xPr(M)	Pr(F)xPr(M)	Pr(J)xPr(F)xPr(M)	Pr(CombAnn)	Pr, %	Pr(Annual Max), %
250,000	0.00237	0.00379	1.72957E-05	0.00617	8.960E-06	4.094E-08	6.5474E-08	1.54976E-10	0.00616	0.62	0.20
200,000	0.00437	0.00713	1.12526E-04	0.01162	3.120E-05	4.923E-07	8.0262E-07	3.51123E-09	0.01159	1.16	0.55
150,000	0.00809	0.01344	7.32098E-04	0.02226	1.087E-04	5.919E-06	9.8390E-06	7.95521E-08	0.02213	2.21	2.00
125,000	0.01099	0.01845	1.86736E-03	0.03131	2.028E-04	2.053E-05	3.4449E-05	3.78659E-07	0.03105	3.10	3.00
100,000	0.01494	0.02532	4.76305E-03	0.04503	3.784E-04	7.118E-05	1.2061E-04	1.80237E-06	0.04446	4.45	5.00
75,000	0.02032	0.03476	1.21491E-02	0.06722	7.062E-04	2.468E-04	4.2230E-04	8.57909E-06	0.06586	6.59	7.30
50,000	0.02762	0.04771	3.09885E-02	0.10632	1.318E-03	8.559E-04	1.4786E-03	4.08355E-05	0.10271	10.27	12.00
25,000	0.03755	0.06549	7.90422E-02	0.18208	2.459E-03	2.968E-03	5.1768E-03	1.94372E-04	0.17167	17.17	18.00
20,000	0.03993	0.06978	9.53215E-02	0.20502	2.786E-03	3.806E-03	6.6513E-03	2.65554E-04	0.19205	19.20	20.00
15,000	0.04245	0.07434	1.14954E-01	0.23175	3.156E-03	4.880E-03	8.5458E-03	3.62804E-04	0.21553	21.55	23.00
10,000	0.04514	0.07920	1.38629E-01	0.26298	3.576E-03	6.258E-03	1.0980E-02	4.95669E-04	0.24266	24.27	27.00
5,000	0.04800	0.08438	1.67180E-01	0.29957	4.051E-03	8.025E-03	1.4107E-02	6.77191E-04	0.27406	27.41	32.00

Notes:

Pr(J) = probability that a *January* event will be >, = the reference discharge, Q
Pr(F) = probability that a *February* event will >, = the reference discharge, Q
Pr(M) = probability that a *March* event will >, = the reference discharge, Q
Pr(Comb Ann) = probability that the combination of the seasonal events will be >, = the reference discharge, Q

Calculation of January - March Adjustment

Q, cfs	Pr(CombAnn)	Pr(Annual Max)	Adjustment Δ	Σ, Jan-Mar	Adj/Σ
250,000	0.00616	0.00200	0.00416	0.00617	0.67437
200,000	0.01159	0.00550	0.00609	0.01162	0.52388
150,000	0.02213	0.02000	0.00213	0.02226	0.09582
125,000	0.03105	0.03000	0.00105	0.03131	0.03353

ADJUSTMENT OF MONTHLY CURVES BASED UPON COMPARISON OF COMBINED RESULTS W/ ANNUAL MAXIMUM CURVE

Unadjusted Probability				Incremental And Adjusted Monthly Probability					
Q	Pr(Jan)	Pr(Feb)	Pr(Mar)	Δ, Jan	Adj., Jan	Δ, Feb	Adj., Feb	Δ, Mar	Adj., Mar
250,000	0.00237	0.00379	1.7296E-05	0.00160	0.00077	0.00255	0.00123	1.16637E-05	5.63192E-06
200,000	0.00437	0.00713	1.1253E-04	0.00229	0.00208	0.00374	0.00340	5.89502E-05	5.35759E-05
150,000	0.00809	0.01344	7.3210E-04	0.00077	0.00731	0.00129	0.01215	7.01483E-05	6.61950E-04
125,000	0.01099	0.01845	1.8674E-03	0.00037	0.01062	0.00062	0.01783	6.26180E-05	1.80474E-03
100,000	0.01494	0.02532	4.7631E-03		0.01494		0.02532		4.76305E-03
75,000	0.02032	0.03476	1.2149E-02		0.02032		0.03476		1.21491E-02
50,000	0.02762	0.04771	3.0989E-02		0.02762		0.04771		3.09885E-02
25,000	0.03755	0.06549	7.9042E-02		0.03755		0.06549		7.90422E-02
20,000	0.03993	0.06978	9.5321E-02		0.03993		0.06978		9.53215E-02
15,000	0.04245	0.07434	1.1495E-01		0.04245		0.07434		1.14954E-01
10,000	0.04514	0.07920	1.3863E-01		0.04514		0.07920		1.38629E-01
5,000	0.04800	0.08438	1.6718E-01		0.04800		0.08438		1.67180E-01

Notes:

Adjustments calculated in previous table for discharges between 125,000 cfs and 250,000 cfs are applied proportionally to the probability of each monthly occurrence. That is the "adjustment/summation" is multiplied by the probability for each month to estimate the monthly adjustment to the probability (Δ). That (Δ) was then subtracted from the monthly probability to determine the "adjusted" monthly probability. Probabilities for discharges < 125,000 cfs did not require adjustments.

Figure 7, below, depicts the January to March data, **adjusted monthly curves**, and the resulting integrated (Combined-Population), seasonal discharge-frequency curve.

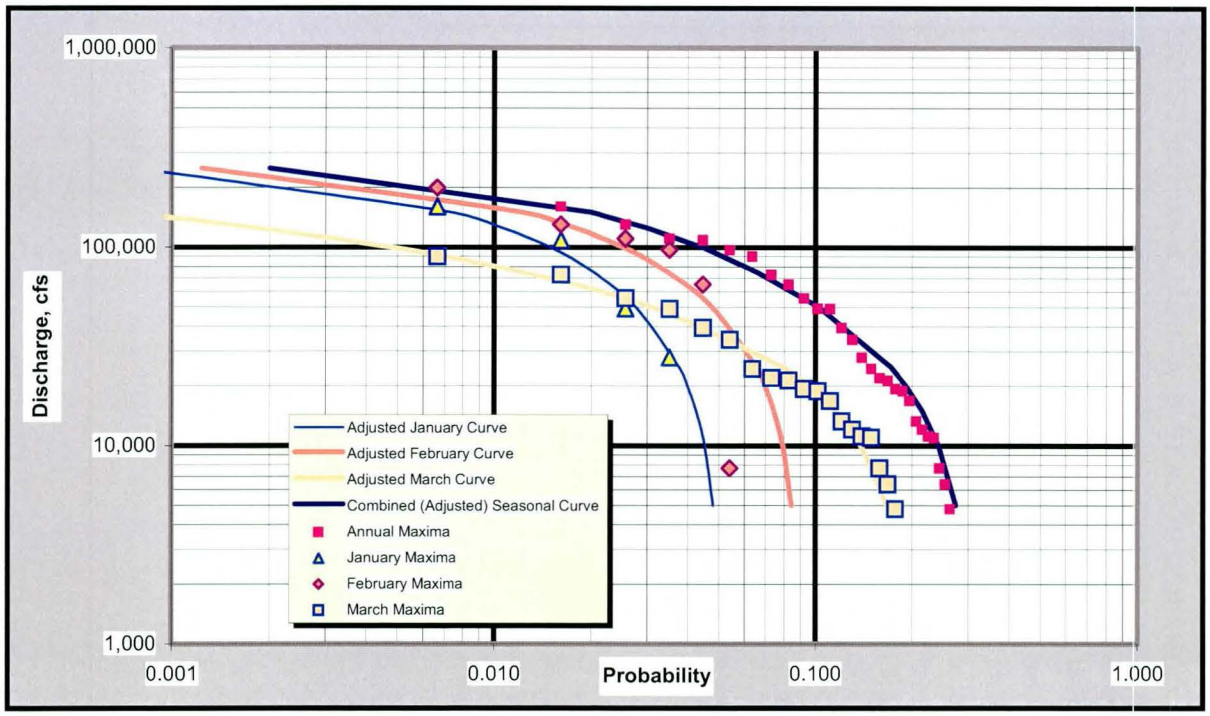

Figure 7. January – March Monthly Discharge-Frequency Curves (adjusted), and Combined Seasonal (Adjusted) Curve (Jan-Mar) w/ Simulated Monthly and Annual Maxima - FINAL RESULTS, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

Annual maximum and monthly (viz. January to March) discharge-frequency values for two locations, one at the upstream end of the study area and the other near the downstream end are displayed in Table 6, which follows. Based upon hydraulic analysis of the Salt River in the study reach, discharges of approximately 160,000 ft^3/s may exceed the channel capacity. As indicated in Figure 6, a flood peak of this magnitude has less than a 0.2% chance of being equaled or exceeded in any year during the months of April and December (< 1 chance in 500, or a flood > 500-year return period). Hence, no discharge-frequency values are included for the remaining months because the flood threat is nearly non-existent.

Table 6. DISCHARGE FREQUENCY VALUES FOR THE SALT RIVER

LOCATION	RETURN PERIOD						
	500-YR	200-YR	100-YR	50-YR	20-YR	10-YR	5-YR
Annual Maximum Discharges (ft^3/s) in Salt River at:							
CP-40	250,000	210,000	**175,000**	**150,000**	100,000	60,000	22,000
CP-109	246,000	207,000	172,000	145,000	95,000	58,000	21,000
Annual Maximum Discharges (ft^3/s) in Salt River below Granite Reef Diversion Dam for Month of::							
Jan	200,000	160,000	130,000	79,000	~2500	< 1000	~0
Feb	220,000	190,000	160,000	110,000	46,000	< 1000	~0
Mar	120,000	99,000	80,000	62,000	37,000	19,000	~2500

NOTES:

Spill from Granite Reef Diversion Dam results in Flow in Salt River approximately once in three years. The flow may occur for continuous durations of several weeks, and sometimes months, or sporadically over those same durations. During other times the river is dry, except for locally wetted areas near side drains.

- ***CP-40 is the upstream end of the study reach.***
- ***CP-109 is above the downstream end of the study reach***
- ***Discharges highlighted indicate flow might break out from channel. Note this happens at/around the 0.5 % annual chance in January and at/around the 1.0 % annual chance in February. For any other month the annual chance is < 0.2 %. The annual chance of a any flow exceeding the channel capacity is between 1% and 2 %, and the annual chance of a flow exceeding the channel capacity during the months of January through March is the same. The months of January through March are the most flood-prone months of the year from the perspective of "damaging discharges". Further information on the monthly flood threat is available in a series of tables/charts summarizing the frequency and volume of spills over Granite Reef Diversion Dam.***

DEFINITIONS:
CP-40, at Granite Reef Diversion Dam
CP-109, at Gilbert Road

c) *SEASONAL DATA* Separation of streamflow data and resulting discharge-frequency relationships across artificial boundaries, such as months, can be misleading. A flood event in January might just as likely occurred in February or December. If the agent causing the floods changes in the same temporal cycle, then the resulting runoff can be differentiated in a meaningful way. In the case of the Salt River watershed, spills result from accumulated antecedent effects during the runoff season and even prior runoff seasons. In addition spills are also the result of instantaneous response to intense rainfall and/or snowmelt. Based upon the preceding discussions, it is preferable from a hydrologic viewpoint to develop a seasonal discharge-frequency relationship; especially because in the case of the Salt River watershed, the flood threat (i.e., high peak discharges) is nearly completely reflective of the flood threat during the hydro-meteorologically similar months of January through March. Hence, the monthly discharge-frequency curves generated for January through March were integrated to provide a Combined-Population discharge-frequency relationship for the Salt River below Granite Reef Diversion Dam. This combined curve better characterizes the flood threat during the season than a differentiated monthly curve might. Whether this seasonal curve adequately describes damages to a variety of crops and crop cycles is an issue to be addressed within the economic framework of this or any other study.

Table 7, following page, summarizes the integration of the monthly discharge-frequency relationships into a Combined-Probability relationship.

Table 7. Salt River below Granite Reef Diversion Dam: Adjusted Seasonal Discharge-Frequency Analysis Results, based upon graphical curves, January - March

Computed Probability

Q	Pr(Jan)	Pr(Feb)	Pr(Mar)	Pr(J)+Pr(F)+Pr(M)	Pr(J)xPr(F)	Pr(J)xPr(M)	Pr(F)xPr(M)	Pr(J)xPr(F)xPr(M)	Pr(CombAnn)	Pr, %
250,000	0.000771	0.00123267	5.63192E-06	0.002009	9.50097E-07	4.34087E-09	6.94232E-09	5.35087E-12	0.0020081	0.20
200,000	0.002083	0.00339603	5.35759E-05	0.005532	7.07355E-06	1.11592E-07	1.81945E-07	3.78971E-10	0.0055251	0.55
150,000	0.007311	0.01215177	0.00066195	0.020124	8.8837E-05	4.83927E-06	8.04386E-06	5.88056E-08	0.0200227	2.00
125,000	0.010623	0.01782931	0.001804738	0.030257	0.000189407	1.91723E-05	3.21772E-05	3.41829E-07	0.0300170	3.00
100,000	0.014943	0.02532278	0.004763051	0.045029	0.000378407	7.11759E-05	0.000120614	1.80237E-06	0.0444608	4.45
75,000	0.020315	0.03475963	0.012149075	0.067224	0.000706151	0.000246812	0.000422297	8.57909E-06	0.0658573	6.59
50,000	0.027618	0.04771325	0.030988547	0.10632	0.00131776	0.000855852	0.001478564	4.08355E-05	0.1027088	10.27
25,000	0.037547	0.06549419	0.079042235	0.182083	0.002459092	0.002967776	0.005176807	0.000194372	0.1716738	17.17
20,000	0.039925	0.06977753	0.095321488	0.205024	0.00278588	0.003805727	0.006651298	0.000265554	0.1920468	19.20
15,000	0.042454	0.07434099	0.114953557	0.231749	0.003156095	0.004880274	0.008545761	0.000362804	0.2155295	21.55
10,000	0.045144	0.0792029	0.138628976	0.262976	0.003575509	0.006258219	0.010979817	0.000495669	0.2426577	24.27
5,000	0.048003	0.08438279	0.167180498	0.299567	0.004050657	0.008025226	0.014107156	0.000677191	0.2740608	27.41

Notes:

Pr(J) = probability that a *January* event will be >, = the reference discharge, Q

Pr(F) = probability that a *February* event will >, = the reference discharge, Q

Pr(M) = probability that a *March* event will >, = the reference discharge, Q

Pr(Annual) = probability that the combination of the seasonal events will be >, = the reference discharge, Q

Finally, Figure 8 compares the annual maxima, and annual maximum discharge-frequency curve to the integrated cold-weather curve for the months of January through March. The results indicate that the flood threat in the Salt River is almost entirely contained within the months of January through March. The flood threat from the remaining months only affects the discharge-frequency relationship at about the 5% annual chance or 20-year level (refer to Figure 8 below, and Table 8, which compares the annual maximum relationship to the integrated monthly relationship, Jan. to March). As indicated in Table 6, discharges associated with the 20-year event will not escape the Salt River channel and flood agricultural areas in the overbank.

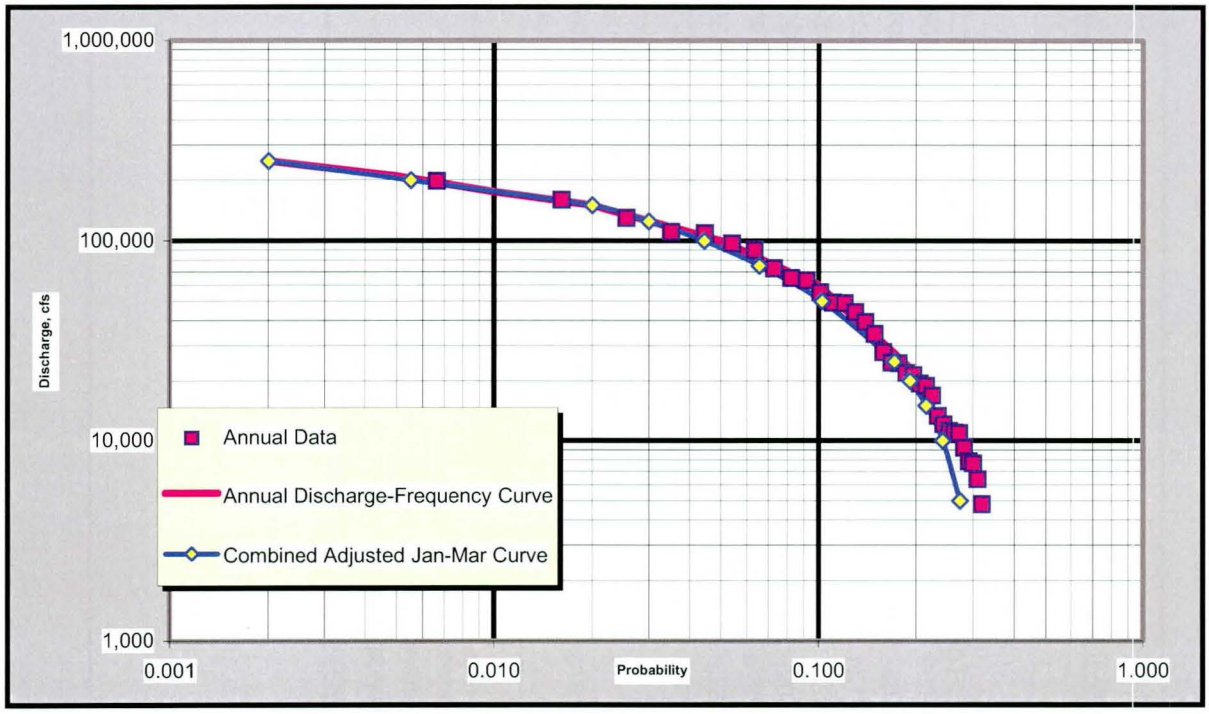

Figure 8. January – March Seasonal Discharge-Frequency Curve (adjusted) vs. Annual Curve, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

Consideration was given to inundation-duration frequency relationships[10], *since damage may be more the function of sustained rather than instantaneous flooding*, but since the recurrence interval associated with peak discharges is so infrequent (< 2% annual exceedance chance for the January to March season, and < 1% annual exceedance chance for the individual months, this aspect of the discharge-frequency relationships for agricultural damages was not considered critical to agricultural damage potential. In fact, as shown in Table 9, the chance of a damaging discharge being exceeded for even 1-day is between 0.5 and 0.2 % *in any given year*, or between a 200-year and 500-year event. The probability of this occurring during any month would be ≤ to the annual exceedance probability, or very remote.

[10] Defined as a reference discharge, exceeded for a specified duration, at a specified return period. For example, from Table 9, a discharge of 100,000 ft^3/s is exceeded for 1-day during a 100-year event, or has a 1% chance of being exceeded for a day during any given year (or a 0.2% chance of being exceeded for 3 consecutive days during any given year).

Table 8. Comparison of Annual Maximum Series Results to Combined January - March Results. Salt River below Granite Reef Diversion Dam		
Q	Pr E > Q, (Annual Max)	Pr E > Q, (Combined Monthly)
cfs	%	%
250,000	0.20	0.20
200,000	0.55	0.55
150,000	2.00	2.00
125,000	3.00	3.00
100,000	5.00	4.45
75,000	7.30	6.59
50,000	12.00	10.27
25,000	18.00	17.17
20,000	20.00	19.20
15,000	23.00	21.55
10,000	27.00	24.27
5,000	32.00	27.41

TABLE 9. INUNDATION-DURATION-FREQUENCY: SALT RIVER NEAR CENTRAL AVE.

DURATION	FREQUENCY, years						
	500	200	100	50	20	10	5
DISCHARGE EXCEEDED FOR SPECIFIED DURATION, SALT RIVER AT CENTRAL AVENUE[1], ft^3/s							
Peak[2]	240,000	202,000	**166,000**	135,000	87,000	53,000	20,200
1-Day	**190,000**	**145,000**	100,000	70,000	40,000	21,000	8000
3-Day	100,000	75,000	60,000	40,000	22,000	11,000	3500
5-Day	70,000	55,000	40,000	29,000	15,000	7000	2100
10-Day	46,000	33,000	25,000	18,000	10,000	5200	1500
30-Day	25,000	19,000	15,000	10,000	5300	2700	800
60-Day	14,000	9000	7000	5000	2800	1400	(0)[3]

Note:
Values **highlighted in blue** represent discharges that might break out of the channel in the VSA study area.

(1) Discharges exceeded for specified frequencies, with durations greater than or equal to 1-day, are approximately equal throughout *Rio Salado* project reach. Central Avenue is used as a reference location.

(2) Values from Table 2-4, Reference a).

(3) During the 5-year event, the upstream release from the Salt River Project reservoirs does not last for 60-days. A flow rate of approximately 200 ft^3/s is exceeded for 53-days during this event. Results are based upon simulation of Balanced Hydrographs. Please refer to previous note for the information source.

APPENDIX

K

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

REAL ESTATE

Real Estate Appendix
Va Shly'Ay Akimel Environmental Restoration Study
Date: April 12, 2004

Salt River, Phoenix, Arizona

1. Abstract of Project Data:

Project Name: Va Shly'ay Akimel, Salt River Restoration

The Native American names of this project signify "River People"

Location: Mesa and Salt River Pima-Maricopa Indian Community, Arizona

Project Purpose: Environmental Restoration

Acreage: all project acreage is to in fee simple and allocated to environmental restoration.

City of Mesa:	100	acres
SRPMIC	4003	acres
Total	4103	acres

Project Sponsors: City of Mesa and Salt River Pima-Maricopa Indian Community, Arizona
Two sponsors: each for their respective lands and project component.

2. Introduction:

This project is aimed as environmental restoration of the riparian area along this segment of the Salt River below Granite Reef Dam. This reach of the river has experienced extensive degradation compared to the natural river system due to human intervention and development. Granite Reef Dam immediately upstream of the study reach is the main diversion works for the Salt River Project that is the central reclamation project for municipal water supply and irrigation for Maricopa County. From Granite Reef Dam the stored waters of the river are diverted and delivered into three major canal systems providing irrigation water to the valley. The Salt River Project is a collaborative effort between the Bureau of Reclamation and a local organized municipal water and irrigation district (Salt River Project of Arizona- SRP)). The project was organized and undertaken in the early 1900's as a Federal Reclamation Project. The Salt River has been extensively modified including the construction of three major Bureau of Reclamation/SRP dam and reservoir projects. The project area is immediately downstream of last irrigation /water supply diversion dam on the system, Granite Reef Dam. Further development and urbanization of this area has resulted in subsequent degradation of the natural system. Current uses include sand and gravel extraction operations and other industrial uses. The land inside the study area generally is under the influence of the floodplain and river channel. This influence tends to limit development potential. In addition past uses have included several sites generating or utilizing potentially hazardous and toxic waste and previous landfill sites that have further contributed to the degradation of the area.

Overall project purposes or planning objectives.

With the new emphasis nationwide on environmental restoration and sustainable and beneficial environmental projects, this project is aimed at habitat restoration and prompting a balanced and harmoniously functioning riparian system. The purpose of the currently proposed project is to restore the riparian habitat and the holistic functioning of the riparian corridor and river system. The Federal interests would be aimed primarily at environmental, increasing habitat values and diversity with some potential for incidental benefits to floodplain management, better flood conveyance and improved functioning of the river system . Such benefits and improvements are now called Hydro-geomorphic system benefits. Incidental recreation and increased awareness or appreciation of natural and cultural resources may also be derivative benefits of such a project.

3. Authority:

The statutory authority for this project is contained in the following enacted laws:

Section 6, Public Law 761, Seventy-fifth Congress, dated June 28, 1938, which reads, " The Secretary of War is hereby authorized and directed to cause preliminary examination and surveys at the following locations..... Gila River and Tributaries, Arizona."

Additional authority was provided in the Energy and Water Development Appropriations Act of 2001 (P.L. 106-377 dated October 17, 2000), which provided $150,000 to the Corps of engineers to evaluate opportunities for environmental restoration on the Salt River.

Authority for project implementation will be sought in an upcoming Water Resources Development Project as a separately authorized civil works project.

4. Purpose of this Report:

This report is submitted as the Real Estate Plan to support the decision document that is a full feasibility report that will serve as the basis for eventual authorization in the next Water Resources Development Act.

5. Indian Community Lands:

The land principally upon the north or right bank of the study area is within a Reservation, now called a Community, established by Federal Treaty. This community is now designated the Salt River Pima-Maricopa Indian Community (SRPMIC). This is a self governing, sovereign entity created and governed through treaty obligations and responsibilities of the United States and the Tribe. Because they are a distinct sovereign entity, the Community will not subsume their sovereignty to a lesser sovereign. Due to the unique aspects of law that govern Native American peoples and their lands, and their unique treaty relationship with the Federal government, the Community (SRPMIC) must be contracted with as the official local sponsor for the project as situated on Community lands. Full project Sponsorship and participation by the SRPMIC is the only mechanism that will ensure that the tribal reservation lands can be made available for the construction, operation, maintenance, repair and replacement of the project.

As of this writing, the governing Tribal council is considering and reviewing input from the tribal Community including environmental reviews and public information meetings and forums before deciding to proceed with the actual implementation of the proposed environmental restoration

project. This is expected to coincide with the Corps public comment period and final approval of the feasibility report.

6. Estates:

The prescribed estate for environmental restoration projects is fee simple title: This is prescribed by ER-405-1-12, chapter 12. The recommended estate is fee simple.

The Non Federal Sponsors will need to issue a right-of-entry to the Corps of Engineers, its agents, contractors, etc. to enter upon the lands it owns or controls for purposes of constructing the Project. This is a standard Non-Federal Sponsor responsibility as included in a Model PCA.

7. Federal Lands, Interests or Reservations:

There are no Federally owned lands within the study area.

8. Navigational Servitude:

The riverbed is usually dry and is not considered a navigable waterway. The river has been harnessed and developed for irrigation, hydro-electric power, flood control and municipal water supply projects. Three major dams have been constructed under the auspices of the "Salt River Project" a project undertaken by the Bureau of Reclamation and the Salt River Project, a local municipal corporation organized for operating and maintaining irrigation, municipal water supply and electric generation and supply as a public utility concern. Although the river does not support navigation, there may be some Federal interests in the regulation and use of the water, flood control and regulations on the river and water resources of the Salt River, including environmental regulations relevant to water resources. This Federal interest is indicated by the prior Federal experience and authorities in participating in major projects for regional irrigation, flood control, and other purposes on the Salt River. Federal regulations and control is exercised through various programs and sections of the Clean Water Act and through the various programs of FEMA within the 100 year floodplain including the National Floodplain Insurance Program and the Floodplain Hazard Elimination Program.

The water to supply the proposed environmental restoration features in the riverbed will originate from Granite Reef Dam and is allocated to the SRPMIC as an adjudicated water right deriving from their historic use on the Salt River. This is a Federally assisted project constructed under authorization of the Bureau of Reclamation and operated locally by a municipal corporation, the Salt River Project. Irrigation is an authorized purpose of that project.

Given these considerations there are no outstanding water rights issues governing the use or allocation of the water to restore this portion of the Salt River. Further, there may be some modifications or measures that could be done in the natural river system, where the use or regulation of water or water resources would not result in a "taking" of property or property rights, such as regulations enforced through the Clean Water Act.

9. Description of Lands:

The study area includes the Salt River below Granite Reef Dam. The land includes the SRPMIC and some portions are within the City of Mesa . The study area runs from Granite Reef for approximately 14 miles to the Pima Freeway- Arizona Route 101. The land can be best described as the river corridor and floodplain. On some portions of the project terraces or banks

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

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

10. Acquisition Authorities and PCA Responsibilities:

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

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

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

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

11. Project Maps:

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

12. Land Value Estimate:

A gross appraisal, in four separate appraisal reports for 4 reaches or segments, has now been obtained and provided to Real Estate Division on April 12, 2004. The report carries a submittal date by the appraiser of Mach 26 and a date of valuation of February 27, 2004. Due to the limited time allowed between mandated project milestones, these appraisal reports have not yet been reviewed by the Corps of Engineers. Thus we are providing a disclaimer and caveat the no guarantee or representation should be made by these estimates as to the actual approved LERRD crediting that might be available to either Non-Federal sponsor. The actual crediting will be governed by separate appraisals after a PCA is signed and when the final crediting determinations as provided in those PCA's are accomplished and approved.

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

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

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

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

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

Note: The gross appraisal reports submitted as of March 26, 2004 have not yet been reviewed by Corps reviewing appraisers as of the writing of this appendix. Any such estimates are preliminary in nature pending such review and approval and are subject to revision. Crediting appraisals will be used to approve any actual LERRD credits to be applied to an approved project.

13. Crediting for LERRD's:

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

14. Facility Relocations:

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

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

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

15. Mineral Activity:

There is some sand and gravel extraction in the project area. However these operations are under leases with the sponsor, the SRPMIC. The continuance or discontinuance of these mineral extraction operations are under the control of the Non-Federal sponsor. Where there is a common variety mineral extraction potential (sand and gravel and the like) the project real estate estimate has considered the residual value attached to minerals for any and all required lands that are needed for project implementation.

16. Estates:

Acquisition of real estate environmental restoration purposes will be in fee simple title. This is the recommended estate needed to construct and implement the project, including operation, maintenance, repair, replacement and sustainability.

17. Construction Induced Flooding:

As this creek is a dry wash most of the time appropriate measures will be taken for the care and diversion of water, if any, during construction and there will be no construction induced flooding outside the project take areas.

18. Cost Estimate:

The revised cost estimate according to the recent gross appraisal reports for the respective components are:

City Of Mesa: LERRD's	$2,260,000	
Incidentals, Admin/Contigency 10%	$226,000	
		$2,486,000
SRPMIC LERRD's	$21,750,000	
Incidentals. Admin/Contigency 10%	$2,175,000	
		$23,925,000
Total both components:		**$26,411, 000**

Administrative and contingent costs are considered to be nominal part of total costs as the SRPMIC already owns all of their lands needed for the project and the City of Mesa only needs to acquire one additional parcel of 47 acres in the riverbed for the project. Thus, the 10 percent allocation to such expenses is deemed adequate.

19. Relocation Assistance (URA Relocations):

All property acquisitions will be accomplished in accordance with Public Law 91-646, as amended, and the Uniform Regulations as promulgated by the U.S. Department of Transportation. The property is unimproved and it does not appear that any displacements of businesses or residences will be required due to the design and configuration of the project. There appears to be only one additional tract needed to be acquired for the project of approximately 47 acres that would be acquired by the City of Mesa. The city of Mesa will be required to follow all applicable land acquisition and appraisal policies of Public Law 91-646, as amended, and the Uniform Regulations in their acquisition of this property. The plan would be to purchase this property after sand and gravel extractions have been "played out" and the business has already terminated operations at that specific location.

20. Other Matters:

No timber activity affects these lands. The sponsor is not using any zoning ordinances in lieu of acquisitions of lands or easements within the project areas.

21. Hazardous Waste Assessments:

The Geotechnical Appendix mentions several possible sources of hazardous waste that could affect the project area, however in reading the treatment on this subject in the Geotechnical appendix there was either insufficient testing or inconclusive results as to the presence or possible migration of hazardous and toxic waste into the project areas. For example on page 34 on the Geotechnical Appendix ,it reads":

"Available data are highly inconclusive regarding whether or not any released contaminants from Talley Defense Systems operations have impacted the currently (early 2004) planned environmental restoration features of the Va'Shly Akimel study area."

On Page 22 of the Geotechnical appendix it reads:

"The first stage inventory and site assessment identified "over 50 different sites of development and or utilization (sic: of potential HTRW)....in the study area. "

Table 4 of the Geotechnical Appendix on pages 51 and 52 lists 24 "Non_Hazardous Waste and Debris Sites Catalogue" , essentially solid waste sites , illegal dumping and past landfill sites that have been located within the project area.

It is apparent from the full discussion and recommendations contained in the Geotechnical Appendix that there is a risk of finding or uncovering HTRW substances or mixed substances in soil or substrates within the project area. It also expresses the concern of groundwater contact with any such substances or waste zones and the potential leaching or migration of any such contaminants. The study team has recommended additional testing and study in this area during Preconstruction Engineering and Design in the hopes of avoiding areas of HTRW or contaminated soils or substances. Any such areas that eliminated and not used as project lands would not be eligible as LERRD contributions. Such lands that are deemed surplus to project needs do not receive credit according to a PCA.

The potential presence of any HTRW substances in the project area, the required cost for remediation and clean up, and any impact on any market value of any of the project lands, are all unknown. The presence and number of potential sites where such substances were used, generated or dumped in the project area is yet one more factor underlying the uncertainty of the LERRD estimate.

The PCA conditions contain specific terms and conditions governing the sponsor's responsibility for environmental cleanup for CERCLA regulated substances.

In light of the possibilities for environmental contaminants in the study area as characterized in the Geotechnical Appendix, the Non Federal Sponsors must be fully informed of their responsibilities to address any remediation or removal of CERCLA regulated substances that might be discovered or unearthed during construction operations, and the possibly impact on continuance of project construction should such contamination be uncovered on the project lands.

The information contained here in the real estate appendix is provided as information and disclosure as to the known information and data as to HTRW sources and the possible impacts

on projects lands, land acquisition and valuation. The professional recommendations and findings to date on HTRW aspects are contained in the Geotechnical Appendix and the reader is referred there for the scientific data and findings and recommendations as to the handling and disposition of HTRW related matters.

The affects on acquisition of subject properties fall upon the City of Mesa as the SRPMIC lands are already owned by the Community and DO NOT require land acquisition. However the City of Mesa will be required to purchase a rock and gravel operation in the area designated for "annexation by the City of Mesa"

In light of the known potential for HTRW soils or substrates or waste that could be found in the project area, it is strongly recommended that the City Of Mesa require the present owner-operators to remediate and obtain all required certifications that contaminants have been remediated below applicable threshold levels for clean up. Further the City of Mesa, as Non Federal Sponsor will be responsible for any remediation or clean up of HTRW materials found on project lands that it owns or acquires and that such costs are not a cost share or project costs. The City of Mesa must be fully appraised of its responsibilities vis - a - vis the clean up, remediation and removal of hazardous waste materials as their sole responsibility; and <u>that the clean up of such materials IS NOT an objective of the proposed Corps project.</u>

Similarly, the SRPMIC must be advised that the Federal project for environmental restoration has as its objective the restoration of riparian habitat values, <u>not the remediation of contaminants</u>; and that the SRPMIC, as Non Federal Sponsor will be responsible for any remediation or clean up of HTRW materials found on project lands, as specified in the Project Cooperation Agreement, and that such costs are not a cost share or project costs.

<u>22. Recreation:</u>

There are no separable recreation lands. All of the land "blocked out" in the project footprint is required for environmental restoration features. The real estate requirements are based on designated floodplain and floodway limits and borders, parcel boundaries and considerations of avoiding uneconomic remnants or severance damages. The authorized Federal project will be for the purposes of environmental restoration.

To respond to another review comment on the use of recreation trails or features by members of the general public, it has now been determined that any recreation trails or facilities constructed with Federal assistance and funds will be available for use and enjoyment by the general public. This is consistent with policy on Corps-assisted projects in order that these benefits accrue to the public without restriction or discriminative affect.

<u>23. Attitude of Landowners:</u>

There is not expected to be a high degree of landowner opposition to the project. There appears to be only one ownership that needs to be acquired by the City of Mesa on its component. All other lands are already owned by City of Mesa or SRPMIC.

<u>24. Report Content:</u>

This report follows the requirements of ER-405-1-12, Chapter 12 and has been prepared using the information on the project formulation that has been provided. Revisions and amendments stemming from Independent Technical Review and HQ policy review have been incorporated and addressed.

APPENDIX

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VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

RECREATION

Va Shly'ay Akimel
Salt River Restoration Project

Recreation Analysis

April 6, 2004

1.0 Introduction

The goal of the recreation component is to provide opportunities for visitors of all ages, abilities, and backgrounds to enjoy this unique resource while developing an awareness, knowledge, and understanding of desert riparian habitat and its relationship to the surrounding environment. Additionally, it presents an opportunity to acknowledge and understand the influence of the Salt River on the environment and cultures throughout the Valley's history. Visitors to potential recreation facilities along the study area reach could participate in a variety of pursuits from enjoying scenic views, picnicking with the family, learning about the habitat, or exploring the resource on foot, by bicycle, or on horseback.

Recreational components that were considered for this project have been limited to trails and a Cultural Center. More aggressive recreational components, such as recreational lakes, sporting centers, sports fields, etc., were rejected as out-of-harmony with the character of this project. The following section (Section 1.1) discusses the general nature of the planned trails. Section 1.2 discusses the Cultural Center. Later sections discuss how various trail alignments were combined with the Cultural Center to create recreation plan alternatives, referred to herein as "Recreation Options". Three options are then presented for consideration.

2.0 Trails

2.1 Description of Trail Amenities

The trails are proposed as multi-use trails, available for access by pedestrians, bicyclists, wheelchairs, and equestrians. Motorized vehicles would be prohibited, with the exception of project maintenance vehicles and motorized wheelchairs.

Access to the trails would be available to both SRPMIC Community members and also to non-Community members. Use of the trails would be limited to daylight hours and after dark lighting will not be available along the trails or at the rest stops.

The following design elements are currently anticipated for the trails:

- 12-foot wide dirt trail/path surfaced with decomposed granite, crushed aggregate or similar
- Trail lined with boulders or curbing to define the trail location. (Curbing along both sides of the trail assumed for costing purposes)

- Parking lot and trailhead with appropriate signage at major access points. For costing purposes, one such parking lot is assumed for every four trail miles.

- Mileage markers every 1/4 mile

- Plaques or similar markers or signs at significant project feature locations to educate the public relative to cultural, biological or environmental aspects of the project.

- Concrete benches approximately every quarter mile

- Rest stops spaced at approximately one per mile, each perhaps overlooking a significant project feature. Each rest stop is currently envisioned as including a 12'x12' shade structure constructed on a concrete pad, one metal picnic table, two trash receptacles, a bike stand, low height masonry wall, and a stand alone plaque or other signage to discuss a nearby project feature or to present other historical, cultural or educational material.

- As appropriate, incorporate art that highlights the cultural, historical or environmental aspects of the project into the design of such things as bike racks, rest stations, shade structures, signage, etc.

- Gates at the major access points, so that the trails can be closed at night and/or during maintenance activities.

- Guard posts or other barriers at access points to prevent unauthorized vehicular access.

- No fencing is currently contemplated.

- Signage at major street crossings, both to identify the street and to identify the trail

- At bridged crossings, the trail will cross under the bridge to avoid conflict with vehicular traffic on the roadways. At unbridged crossings (e.g., McKellips Road), the project will include construction of a refuge island in the middle of the roadway as a zone of protection for pedestrians. The project will not include pedestrian overpass bridges or traffic signals for pedestrian access.

Potable water is not available within the project boundaries. Therefore, drinking fountains and restrooms are not included.

Where possible, the trails have been designed to connect with the City of Mesa's existing trail system along the canals within the City of Mesa. Refer to Figure 1 (attached) for the City of Mesa's existing trail system.

2.2 Construction Costs for the Trails

The estimated construction cost of the trails, including the amenities described in the foregoing section and including a 15% design contingency, is approximately $420,000 per trail mile. The U.S. Army Corps of Engineers will verify the costs of the trails in the text of the main feasibility study report.

2.3 Operation and Maintenance Costs for the Trails

Based on City of Mesa experience with their trails, the operation and maintenance costs for the trails are anticipated to be approximately $50,000 per year per trail mile.

2.4 Trail Visitation Rates

The City of Mesa has several trails that are similar in design and use to the trails proposed for the project. There currently are no recorded data available for usage rates on the existing City of Mesa trails. Visitation estimates provided herein are based on City of Mesa Parks and Recreation staffers personal observations and estimates of trail use.

The City of Mesa Parks and Recreation staffers estimate that approximately 30 people per day will use each project trail mile in the summer (for the purposes of this section, "summer" is defined as June through September) and 45 people per day per trail mile in the winter (i.e., the rest of the year). This equates to an average usage rate for the entire year of approximately 40 people per day per trail mile.

The City of Mesa Parks and Recreation staffers also provided the following additional information about anticipated, estimated peak usage rates on the trail system. Peak days for trail usage are Saturday and Sunday. Peak hours for trail usage are estimated to be between 6 am and 9 am and again between 3 pm and 6 pm. The table below summarizes estimated usage during different peak and non-peak periods:

Trail Usage Period	**Visitors**
Average Winter Month Usage	45 users per day
Average Summer Month Usage	30 users per day
Usage Averaged Year-Round	40 users per day
Winter Peak Days (Sat & Sun)	70 users per day
Winter Non-Peak Days (weekdays)	35 users per day
Peak Hour on Peak Day in Winter	7.8 users per hour
Non-Peak Hour on Peak Day in Winter	3.9 users per hour
Peak Hour on Non-Peak Day in Winter	3.9 users per hour
Non-Peak Hour on Non-Peak Day in Winter	1.9 users per hour
Summer Peak Days (Sat & Sun)	46.7 users per day
Summer Non-Peak Days (weekdays)	23.4 users per day
Peak Hour on Peak Day in Summer	5.2 users per hour
Non-Peak Hour on Peak Day in Summer	2.6 users per hour
Peak Hour on Non-Peak Day in Summer	2.6 users per hour
Non-Peak Hour on Non-Peak Day in Summer	1.3 users per hour

3.0 Cultural Center

3.1 Description of Cultural Center

The concept for the Cultural Center comes from a programming document for a "Museum and Cultural Center", as provided to the project team by SRPMIC staff ("Museum and Cultural Center Conceptual Design 20% Submittal" by David N. Sloan and Associates, StastnyBrun Architects, Inc., and Native American Design Collaborative). The programming

document discusses a complex of several buildings that, taken together, comprise the Museum and Cultural Center (hereafter referred to only as the "Cultural Center"). The attached figure labeled "Schematic Design" shows the proposed layout of the Cultural Center. The individual buildings listed in the programming document are shown below with their estimated square footages:

Buildings included in the Programming Document	**Estimated Square Footage**
Museum	19,200
Cultural Education Center	10,200
Performing Arts Center	18,200
Food Services	7,900
Traditional Habitat Interpretive Center	4,000
Restored Environmental/Botanical Center	4,800
Total Square Footage	**64,300**

The project trail system will have ties and connections to the Cultural Center. Refer to the attached recreation option plans.

3.2 Costs and Eligibility for Cost-Sharing

Not all elements within the Museum and Cultural Center complex are eligible for cost-sharing by the USACE. It has not yet been determined which elements of the Cultural Center are cost-sharable and which are not. A preliminary list of cost-sharable items (subject to final determination) was obtained from Mike Hallisy, USACE Los Angeles District office, and is given below with the estimated costs of each element:

Design Element	**Additional Comments**	**Estimated Costs**
Museum: • Restrooms (only) in the Museum or as a stand alone building	Restrooms are a support feature for the trail system	• 615SF x $150/SF = $92,250
Habitat Interpretive Center: • Outdoor demonstration area only	Exact character of the outdoor demonstration area not yet determined	• 1050 SF x $15/SF for hardscape = $15,750
Ramadas and Outdoor Shelters	None	• 1 each x $15,000/ea = $15,000 (other ramadas are already built into the cost of the project trails)
Access Road and Parking	Limit cost to a small parking lot to support the trailhead, not the full cost of the parking lot for the Cultural Center	• Estimate $50,000 for a small parking lot
Utilities	Portion of the overall utility installation costs for the Cultural Center to support the restrooms	• Per programming document, "Site Utilities" for the Cultural Center are $207,000. Assume that approx. 20% of this could be related back to the restrooms = $41,000
Electrical lighting	For the parking lot, restrooms and ramadas	• $15,000

Miscellaneous: • Picnic Tables • Trash Receptacles • Benches • Signs	None	• Estimated at $35,000 for planning purposes.
		Total Estimated Construction Cost of Cost-Sharable Improvements = $264,000

As shown in the foregoing table, the construction cost for cost-sharable items at the Cultural Center are anticipated to be in the range of $200,000 - $300,000 (costs to be verified by the U.S. Army Corps of Engineers in the main feasibility study report.) For reference only, according to the programming document, the total construction cost of the entire Cultural Center complex is estimated to be $10,978,600.

For the purposes of this report, it is assumed that USACE participation in the Cultural Center will be limited to the elements listed in the table above and that the non-federal sponsor will provide other funding to allow the remainder of the Cultural Center to be added to the project during the PED phase as a "betterment". The "betterment" will be entirely locally funded. The portion of the Cultural Center included in the project during the feasibility phase is limited to the cost-sharable items. The cost-sharable items (taken alone) are referred to hereafter as the "restroom/ramada facility", but it shall be understood that such term includes the parking lot and other associated improvements listed in the table above. Furthermore, where the recreation plans show a "Cultural Center", it shall be understood to mean a cost-sharable "restroom/ramada" facility that will be upgraded during PED to a Cultural Center (via a locally funded "betterment").

3.3 Operation and Maintenance Costs for the Cultural Center

The operation and maintenance costs discussed previously for the trail system ($50,000 per trail mile per year) are adequate to cover the minimal O&M costs for the restroom/ramada facility. The O&M costs for the upgraded Cultural Center are immaterial, since the upgrade to a full Cultural Center will be a "betterment" fully funded by the local sponsor. Economic justification for said "betterment" is not required in the feasibility study.

3.4 Visitation Rates for the Cultural Center

For the purposes of the feasibility study, visitation numbers will not be credited to the restroom/ramada facility as a stand-alone feature. (By itself, the restroom/ramada facility has little very "draw".) For the purposes of the feasibility study, the restroom/ramada facility is viewed as being part of the trail system, and will be justified based on the visitation numbers for the trail system.

Visitations for the upgraded Cultural Center are immaterial since economic justification of said "betterment" is not required in the feasibility study.

3.5 Location for the Cultural Center

In past iterations of this report, the Cultural Center has been shown at the southeast corner of the intersection of Dobson Road and McKellips Road, with an alternative location at the

southwest corner of Gilbert Road and the Beeline Highway. The USACE has since ruled that the Cultural Center must be within the limits of the river restoration project to be eligible for cost-sharing by the USACE. Therefore, the location at Dobson Road and McKellips Road has been discarded in favor of the location at the intersection of Gilbert Road and the Beeline Highway.

4.0 Recreational Options

Three recreation options are presented herein for consideration. Each option includes the Cultural Center location at the southwest corner of Gilbert Road and Beeline Highway and varies the trail alignments.

4.1 Option A

In Option A (figure attached), a trail on the west end of the project would connect to the City of Mesa's Riverview Park where an existing underpass under the freeway is located. It would also connect to Dobson Road at the existing Dobson Road freeway underpass. From these connection points, trail users could proceed south on Dobson Road (using existing bike paths and sidewalks within the Dobson Road right-of-way) to connect to the City of Mesa's existing trail system along the Tempe Canal. The City of Mesa's existing trail system is shown in Figure 1 (attached) for reference.

In Option A, a trail on the south side of the river between Gilbert Road and Val Vista Drive would serve to connect residents living north of the Red Mountain Freeway (the 202 Freeway) to the City of Mesa's existing trail system along the South Canal. At Gilbert Road, trail users could use sidewalks and bike paths within the Gilbert Road right-of-way to access South Canal to the south. At Val Vista Drive, the trail would tie in to the South Canal at the existing underpass for the canal under the freeway. Thus, connection to the South Canal trail would be complete.

Option A also includes placement of a Cultural Center at the southwest corner of the intersection of Beeline Highway and Gilbert Road. A trail is included along Gilbert Road from the Cultural Center to Thomas Road. This connector trail would allow residents living south of the river to more easily access the Cultural Center and would also provide a tie between the Cultural Center and the trail along the south side of the river discussed above.

4.2 Option B

Option B is the same as Option A, with the exception that it deletes the trail on the south side of the river between Gilbert Road and Val Vista Drive. This option offers the fewest recreational opportunities of the three options that are presented, but is also the least costly.

4.3 Option C

Option C includes all of the features of Option A, plus a continuous trail on the south side of the river between the Pima/Price Freeway (Loop 101 Freeway) and Val Vista Drive. Of the three options, this option provides the most recreational opportunities. It provides for connectivity to the City of Mesa's existing trail systems on the east and west ends of the project and for connection to the arterial street grid.

5.0 Cost/Benefit Analysis

The USACE will perform the cost/benefit analysis that will be presented in the feasibility study report. The cost/benefit analysis is not presented here. However, based on preliminary calculations by the USACE, it appears as though all of the recreation options are economically justifiable.

6.0 Conclusion

It is anticipated that the SRPMIC Tribal Council and/or the SRPMIC voters (if the matter is referred to them by the SRPMIC Tribal Council) will make the final selection of the Recreation Option that will be incorporated into the restoration project.

As an additional outstanding issue, a final determination must be made relative to which aspects of the Cultural Center are eligible for cost-sharing, and which other/additional features the local sponsor would like to add to the Cultural Center as a "betterment".