CHAPTER V
PLAN FORMULATION AND EVALUATION

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

5.1 PLANNING PROCESS

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

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

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

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

4. Each plan is evaluated for its ability and extent of meeting the specified planning objectives and constraints, as well as efficiency, completeness, and acceptability. The impacts of alternative plans are evaluated using the system of accounts framework specified in the Principles and Guidelines and ER 1105-2-100.

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

6. The plan with the greatest net benefits is selected for recommendation if at least one plan exists displaying Federal interest. A locally preferred plan may be recommended and approved if the non-Federal sponsor desires other acceptable project features than those in the National Economic Development (NED) or National Ecosystem Restoration (NER) Plans.

5.2 PROBLEMS AND OPPORTUNITIES

Water resources projects are planned and implemented to solve problems, meet challenges, and seize opportunities. In the planning setting, a problem can be thought of as an undesirable condition, while an opportunity offers a chance for progress or improvement. The identification of problems and opportunities gives focus to the planning effort and aids in the development of planning objectives. Although they are considered in plan formulation they should not be confused with planning objectives for which solutions will be formulated or plans recommended. Problems and opportunities can also be viewed as local and regional resource conditions that could be modified in response to expressed public concerns. This section identifies the problems and opportunities in the study area based on the assessment of existing and expected future without-project conditions.

5.2.1 Public Concerns

Local experience with similar restoration projects and public input were considered during all phases of plan formulation. The initial public meeting was held on September 13, 2001. Meetings and presentations were also held with the Rio Salado and Tres Rios Advisory Committees to seek stakeholder and agency input. Areas of concern included technical considerations based upon the specifics of the study, vector control, flood damage reduction, and opportunities for recreation. Additional public meetings are being scheduled to correspond with release of the Draft Feasibility Report.

The planning effort included extensive involvement by the various offices of the City of Phoenix, as well as agencies (e.g., USFWS, FCDMC, AGFD). Numerous plan formulation workshops and meetings were held during the feasibility phase. These workshops and meetings introduced the project to the public, gave individuals and agencies an opportunity to identify issues for consideration in this feasibility report, and solicited input on the project.

5.2.2 Problems

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

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

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

- The greater Phoenix area is lacking in significant riparian habitat areas with supporting recreation facilities. The major parks in the area consist primarily of desert mountain preserves, which do not contain the types of habitat that could be supported in the study area. There are no formal existing recreation or environmental-education opportunities associated with the existing river corridor. As agricultural land near the river is converted to residential, the need for recreation will increase. The 27th Avenue Solid Waste Recycling Facility (just north of the river) has an existing environmental-education master plan. The facility provides tours for children and adults. The 23rd Avenue WWTP also does environmental-education programming and touring for water treatment.

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

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

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

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

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

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

- Existing cultural resources need protection from erosion and vandalism.

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

5.2.3 Opportunities

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

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

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

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

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

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

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

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

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

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

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

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

5.3 PLANNING OBJECTIVES AND CONSTRAINTS

5.3.1 Federal Planning Objectives

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

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

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

5.3.2 Specific Planning Objectives

Clear statements of specific planning objectives and constraints act as basic building blocks for developing alternative management measures and plans to alleviate stated problems and achieve opportunities. Through coordination with local and regional agencies, the public involvement process, site assessments, interpretation of prior studies and reports, and review of existing water projects, specific planning objectives were identified for this feasibility effort. The water and

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

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

5.3.3 Planning Constraints

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

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

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

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

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

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

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

5.4 DEVELOPMENT OF ALTERNATIVE PLANS

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

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

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

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

5.5 ALTERNATIVE DEVELOPMENT AND EVALUATION PROCESS

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

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

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

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

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

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

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

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

5.6 PRELIMINARY MANAGEMENT MEASURES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5.7 ALTERNATIVE DEVELOPMENT

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

5.7.1 Flood Damage Reduction

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

5.7.1.1 Structural Measures

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

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

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

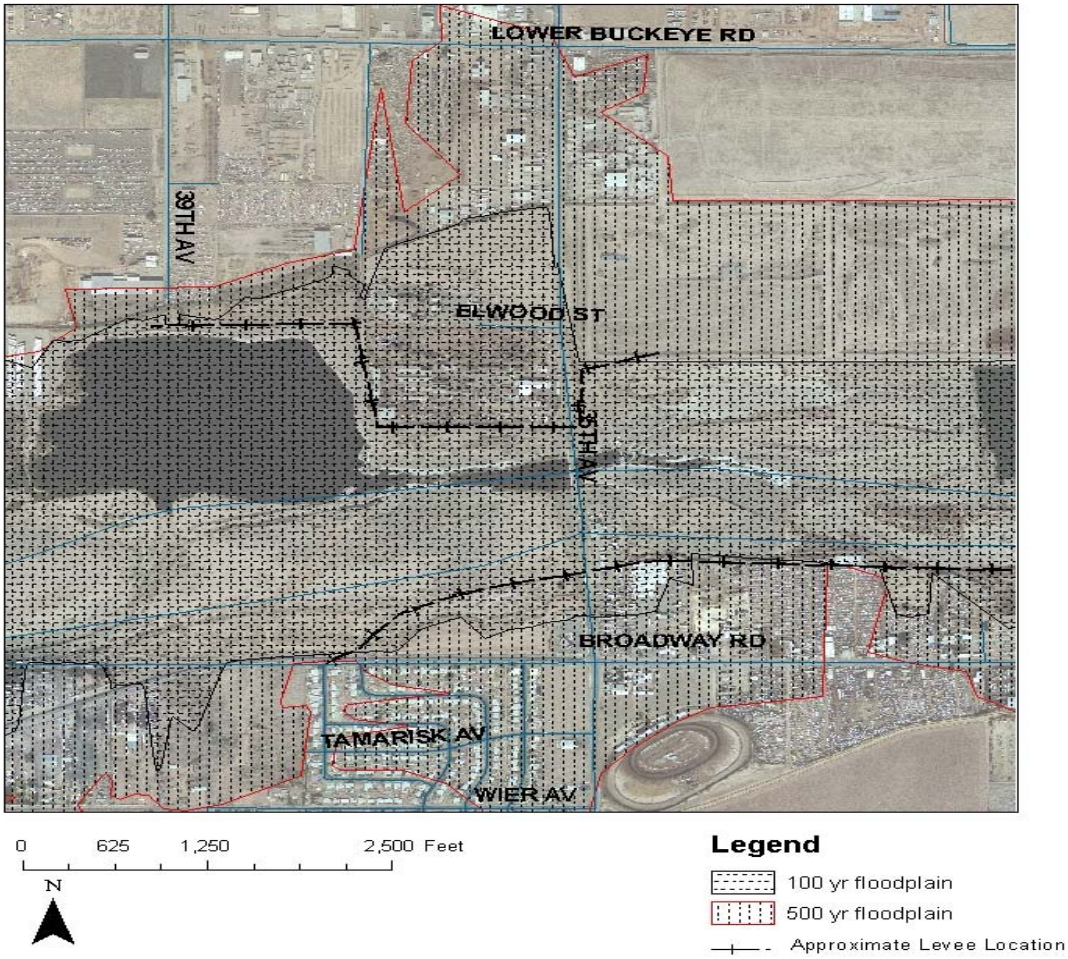


Figure V-1: Approximate Levee Locations

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

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

Results

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

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

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

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

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

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

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

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

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

5.7.1.2 Non-Structural Measures

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

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

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

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

Results

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

Summary

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

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

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

Rio Salado Oeste

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

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

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

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

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

5.7.2 Ecosystem Restoration

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

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

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

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

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

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

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

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

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

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

5.7.3 Preliminary Array of Alternatives

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

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

5.7.3.1 Screening Criteria

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

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

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

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

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

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

Table V-4: Preliminary Screening of Possible Alternatives

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

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

5.7.3.2 Alternative Formulation Rationale

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

Site-Specific Measures:

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

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

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

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

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

Figure V-3: Stormwater Outfall at 19th Avenue

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

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

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

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

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

Table V-6: Restoration Potential at Each Stormwater Outfall

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

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

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

Systemic Measures

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

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

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

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

5.7.4 Screening of Second Array of Alternatives

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

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

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

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

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

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

Table V-7: Second Array of 12 Alternatives

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

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

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

5.7.5 Detailed Description of Project Measures

5.7.5.1 Provide Water Supply

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

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

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

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

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

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

5.7.5.2 Provide Water Distribution

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

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

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

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

5.7.5.3 Revegetation

Cottonwood/Willow

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

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

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

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

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

Mesquite

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

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

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

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

Riparian scrub shrub

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

5.7.5.4 Wetlands

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

site would be required to maintain surface water. Excavation and layering of a silt-clay soil substrate overlain by a mixed gravel, and finally, cobble layer, is recommended. This soil structure would reduce disturbance of the soil-clay layer by reducing piping of fine material and reducing turbulent forces acting on the layer.

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

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

5.7.5.5 Lake "Gravel Pit" Restoration

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

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

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

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

5.7.5.6 Invasive Species Management

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

5.7.5.7 River Channel Restoration

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

River channel habitats

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

5.8 THIRD/FINAL ARRAY OF ALTERNATIVES

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

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

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

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

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

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

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

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

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

Table V-8: Final Array of Restoration Alternatives Evaluated

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

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

Comparison and Evaluation of the Third Array of Alternatives

5.8.1.1 Water Supply and Water Budget

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

Table V-9: Water Demand for Alternative Plans

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

5.8.1.2 Hydraulics

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

5.8.1.3 Cultural Resources

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

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

5.8.1.4 Hazardous, Toxic, or Radioactive Waste

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

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

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

5.8.1.5 Environmental Benefits

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

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

Refined Alternatives

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

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

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

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

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

Functional Capacity Index

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

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

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

Acres Restored

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

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

Average Annual Functional Capacity Units (AAFCUs)

Based upon the functional assessment completed for this study, the number of acres and functional capacity indices were projected in order to derive with-project estimates AAFCUs. The same methodology that was employed for assessing without-project conditions was also employed to assess the habitat output of each alternative. Benefits are defined as the increase in AAFCUs for each alternative relative to without-project conditions. As a reminder, the Functional Capacity Unit (FCU) represents the factor of habitat quality multiplied by the quantity or FCI from above multiplied by acreage of habitat restored.

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

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

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

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

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

Associated Planning and Future Conditions

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

5.8.1.6 Costs

Project Construction Costs

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

Real Estate

The proposed project features are located on areas of land that can be best described as the river corridor and floodplain mostly occurring within the 100-year floodplain. On some portions of the project, terraces or banks that are situated above floodplains may be incorporated into the project and used for ecosystem restoration and recreation. The lands are all undeveloped with the principle economic or industrial use being sand and gravel extraction. For project planning, an average cost of $20,000 per acre was utilized.

Operation and Maintenance (O&M) Consideration

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

Associated Costs

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

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

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

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

Table V-12 Continued

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

Cost-Effectiveness and Incremental Cost Analysis

Cost-Effectiveness (CE) and Incremental Cost Analyses (ICAs) were performed on the above alternatives. CE identifies the least-costly solution for each level of output. The three criteria used for identifying non-cost-effective plans or combinations include (1) the same level of output could be produced by another plan at less cost, (2) a larger output level could be produced at the same cost, or (3) a larger output level could be produced at the least cost.

ICA compares the incremental costs for each additional unit of output. The first step in developing "best buy" plans is to determine the incremental cost per unit. The plan with the lowest incremental cost per unit over the No Action Alternative is the first incremental best buy plan. Plans that have a higher incremental cost per unit for a lower level of output are eliminated. The next step is to recalculate the incremental cost per unit for the remaining plans. This process is reiterated until the incremental cost per unit for maximum level of output is determined. The intent of the incremental analysis is to identify increases in cost relative to output.

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

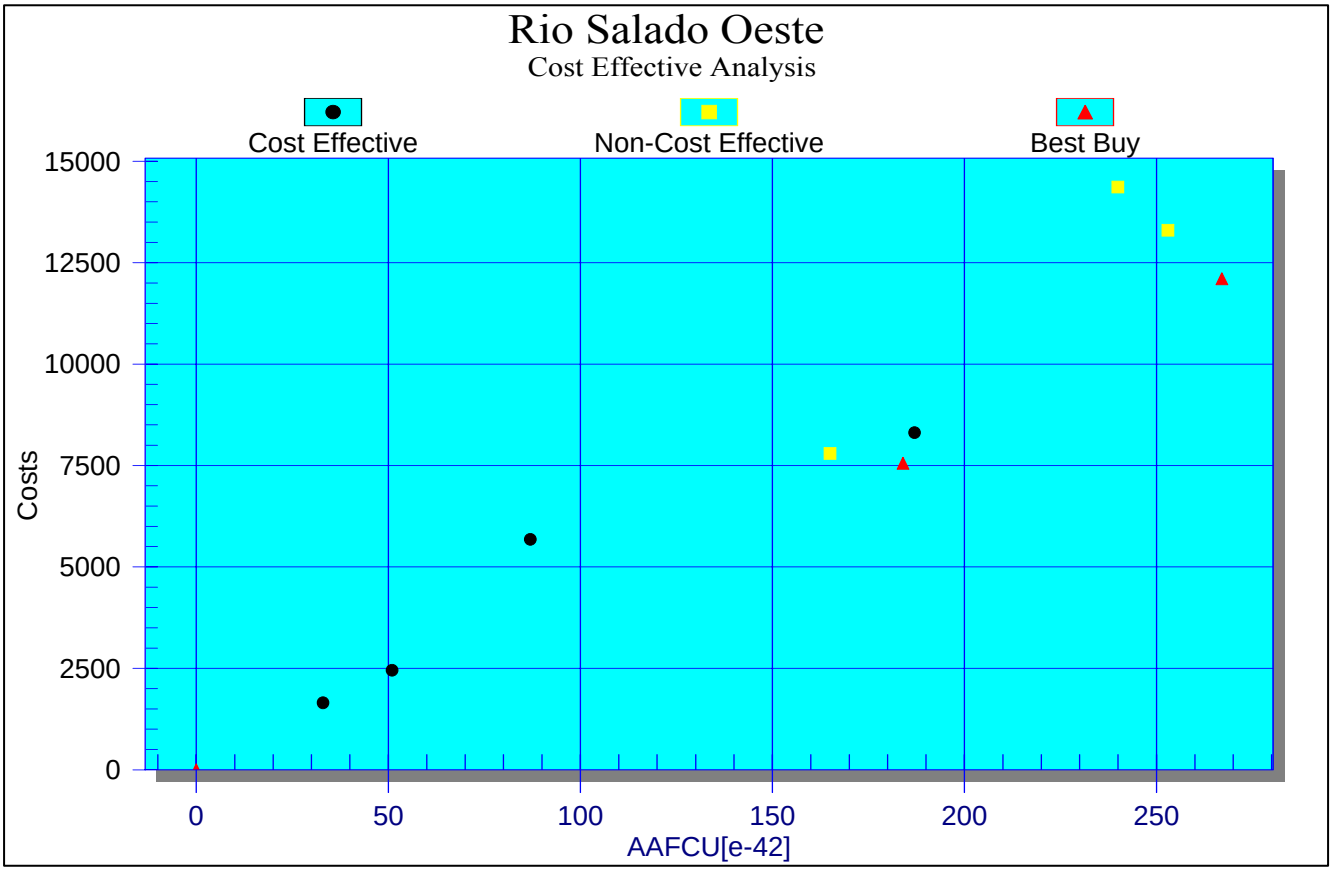
Table V-13: Average Annual Costs Per Annual FCU by Alternative (in $1,000s)

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

Cost Effectiveness Analysis

Alternatives are considered cost effective if there are no other alternatives that provide greater output for the same cost or provide the same output for a lesser cost. This step eliminates alternatives that are inefficient from further consideration. As can be seen in Figure V-4 there are six cost effective alternatives, Alternatives 4, 5, and 5B are not cost effective.

Figure V-4: Cost Effective Analysis



Incremental Cost Analysis

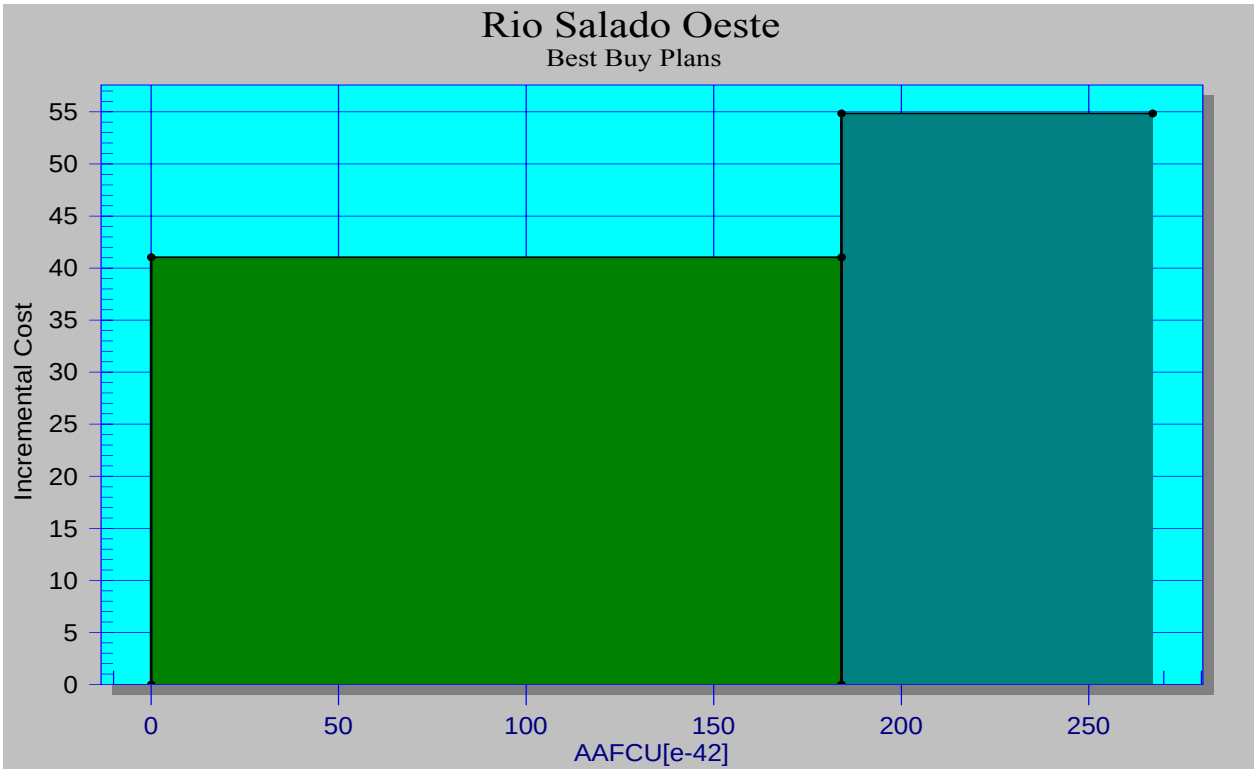
ICA goes beyond cost effectiveness analysis to consider the incremental change in cost and outputs from one alternative to the next. As you step through the successive levels of outputs in the AAFCU column in Table V-14 below you can see an increasing level of outputs (AAFCU's) from 184 to 267. Likewise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

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

Table V-14: Incremental Cost Analysis

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

Figure V-5: Incremental Cost Analysis



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

5.8.1.7 Recreation

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

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

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

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

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

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

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

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

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

5.9 EVALUATION OF FINAL ARRAY OF ALTERNATIVES

5.9.1 System of Accounts

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

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

5.9.1.1 National Economic Development (NED)

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

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

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

Recreation Benefit Analysis

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

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

The above visitation projections were also compared to standards established by the National Recreation & Parks Association (NRPA), regarding trail usage and capacity. NRPA standards for trail capacity and use range from 40 to 90 users per day per trail mile (or between 14,600 to

32,850 users per year per trail mile). The proposed recreation plan includes approximately 16 miles of multipurpose trails. With baseline visitation projected at 350,000, this equates with a value of about 22,000 users per year per trail mile, which supports that the proposed facilities should be able to accommodate the projected visitation. Further, the proposed facilities should also be able to support likely increases in visitation over time, as the general population growth in the study area will inevitably increase demand and use of the facilities.

Unit Day Point Value Estimates

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

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

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

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

Recreation Costs & Benefit/Cost Analysis

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

Table V-17: Recreation Plan Expected Annual Costs

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

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

5.9.1.2 Regional Economic Development (RED)

The RED Account is intended to illustrate the effects that the proposed plans would have on regional economic activity, specifically, regional income and regional employment. The

comparison of possible effects that the plans may have on these resources is shown in Table V-18.

Table V-18: Regional Economic Development Account

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

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

Rio Salado Beyond the Banks

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

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

Local Property Values

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

5.9.1.3 Environmental Quality (EQ)

The EQ account is another means of evaluating the alternatives to assist in making a plan recommendation. This account is intended to display the long-term effects the alternative plans could have on significant environmental resources. Table V-19 shows the accounts for each alternative.

Table V-19: Environmental Quality (EQ) Account

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

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

5.9.1.4 Other Social Effects (OSE)

The OSE Account typically includes long-term community impacts in the areas of public facilities and services, recreational opportunities, transportation and traffic, and manmade and natural resources. A comparison of the effects that the proposed alternatives would have on OSE resources is shown in Table V-20.

Table V-20: Other Social Effects Account

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

5.9.2 Associated Evaluation Criteria

The selection of a recommended plan from the alternative plans requires a combination of decision-making factors. As suggested by the U.S. Water Resources Council, the alternative plans are compared using the following criteria: completeness, effectiveness, efficiency, and acceptability. The evaluation of the alternative plans by established criteria are described below.

5.9.2.1 Completeness

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure realization of the planning objectives. A complete alternative (1) meets the objectives, (2) needs no further actions for complete fulfillment of the project, (3) is consistent and reliable, (4) is capable of being physically implemented, and (5) mitigates unavoidable adverse environmental effects, as appropriate. In general, all of the final alternatives are fully formulated and complete. Completeness was a

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

5.9.2.2 Effectiveness

Effectiveness is the extent to which an alternative resolves the identified problems and achieves the specified objectives. The proposed plans must restore the long-term health of the ecosystem structure, function, and dynamic processes in the Rio Salado Oeste portion of the Salt River. The No Action Alternative is ineffective in meeting any of the planning objectives. Action alternatives evaluated are all effective to some extent, although some are more effective than others to the extent to which they meet the objectives.

5.9.2.3 Efficiency

Efficiency is the extent to which an alternative is the most cost-effective means of addressing the identified problems while realizing the specified objectives consistent with protecting the Nation's environment. Cost effectiveness analysis identifies the plans that have the highest levels of output relative to costs. The No Action Alternative is the least cost alternative, but fails to restore valuable habitats, which have suffered historic losses and provide important habitat to many species. It also does not address un-met recreation demand in the study area.

5.9.2.4 Acceptability

Acceptability is the workability and viability of an alternative to other Federal agencies, affected State, tribal, and local agencies, and public entities, given existing laws, regulations, and public policies. The comparison of acceptability is defined as acceptance of the plan by the local sponsor and the concerned public. It is assumed that the action alternatives are all acceptable, although this will be assessed further with public review of the draft report.

Table V-21: Associated Evaluation Criteria

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

5.10 SELECTION OF THE RECOMMENDED PLAN

Upon consideration of the National Objectives and other evaluation criteria Alternative 5A is selected as the NER Plan. The NER Plan is identified by the Federal Government as the plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective.

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

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

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

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

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

Ecosystem Restoration Significance

As discussed earlier in this report riparian habitat is significant in the Desert Southwest. Historically comprising a mere three percent of the landscape, over 95 percent has already been lost in Arizona. This type of river-connected riparian and fringe habitat is of an extremely high value due to its rarity. Arid southwest riparian ecosystems are recognized as a critically endangered habitat type. It has been estimated that 75 to 90 percent of all wildlife in the arid Southwest is riparian dependent during some part of its life cycle. The significance of riparian habitat in the Desert Southwest is recognized at various levels. Institutional, public and technical

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

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

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

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

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

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

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

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

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

5.11 RISK AND UNCERTAINTY

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

5.11.1 Flood Damage Reduction

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

Expected annual flood damage must take into account the uncertainty in hydrologic, hydraulic, and economic factors. Risk and uncertainty are intrinsic in water resource planning and design.

They arise from measurement errors and the inherent variability of complex physical, social, and economic situations. Best estimates of key variables, factors, parameters and data components are developed, but are often based on short periods of record, small sample sizes, measurements subject to error, and innate residual variability in estimating methods. RBA explicitly analytically incorporates these uncertainties by defining key variables in terms of probability distributions, rather than single-point estimates. Uncertainties in flood damage analysis includes discharge/probability, stage/discharge, geotechnical features, structure elevation and values, and inundation depth/damage.

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

- Structure data, including structure I.D., category (sfr, mfr, etc.), stream location, ground and/or first floor elevation, structure value and content value. This data was developed in a Microsoft Excel spreadsheet and imported into the HEC-FDA program.

- Hydrologic and hydraulic data, including water surface profiles, frequency/discharge relationships, and stage/discharge relationships. For this study, water surface profiles were developed using the HEC-RAS program. These functions were imported into the HEC-FDA program.

- Depth/Damage functions. Functions for residential and non-residential structures were obtained from the Institute for Water Resources and FEMA's National Flood Insurance Program.

- Risk & Uncertainty Parameters, as described in detail previously, were also entered into the program.

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

5.11.2 Ecosystem Restoration

Some risk and uncertainty are assumed in nearly every aspect of a water resources project. The variability of outcome associated with the recommended plan does not fit the definition of risk. That variability is better characterized as uncertainty in that the potential outcomes cannot be described in known probability distributions. Natural systems are dynamic and change depending upon physical, chemical, and biological processes. While some of these factors can be controlled or compensated for, others cannot. Unpredictable physical changes may include changes in land use (e.g., sand and gravel operations), a dramatic alteration of the river course due to flood damages, or anthropogenic influences such as increases in trash and debris, structures, or human presence.

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

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

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

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

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

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

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