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Final Draft

Design Documentation Report

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Tres Rios Phase 3
Ecosystem Restoration Project
Phoenix, Arizona

Prepared for:

US Army Corps of Engineers
Los Angeles District

City of Phoenix
Water Services Department

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A/E	**Architect/Engineer**
ADOT	Arizona Department of Transportation
ADWR	Arizona Department of Water Resources
ARMS	Automatic Response Management System
ARS	Arizona Revised Statutes
ASTM	Arizona Society of Testing and Materials
bgs	Below ground surface
CFR	Code of Federal Regulations
CAD	Computer Aided Design
CAE	Computer Aided Architecture
CAWCD	Central Arizona Water Conservation District
CEGS	Corps of Engineers Guide Specifications
cfs	cubic feet per second
cm/d	centimeters per day
cm/s	centimeters per second
CO	Contracting Officer
COC	chemicals of concern
COP	City of Phoenix
CPU	Central Processing Unit
D/B	Design-Build
DDR	Design Documentation Report
DoD	Department of Defense
EEC	Environmental Education Center
EIS	Environmental impact statement
EPA	U.S. Environmental Protection Agency
ER	Engineering Regulations (per USACE)
Et	evapotranspiration
EWA	East Washington Project Area
FAA	Federal Aviation Administration
FC	Fish consumption
FCDMC	Flood Control District of Maricopa County
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
fps	feet per second
ft^2	square feet
FY	Fiscal Year
GAC	Granular activated carbon
gpm	gallons per minute
HRT	hydraulic retention time
HUs	Habitat Units

LFC	Low Flow Channel
MCPDD	Maricopa County Planning and Development Department
MG	Million gallons (close up to number, e.g., 4MG)
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
mph	miles per hour
N/A	not available or not applicable
NPDES	National Pollutant Discharge Elimination System
NTP	Notice to Proceed
O/M	operations and maintenance
PED	Preconstruction Engineering and Design
PM	Project Manager
QA	quality assurance
QC	quality control
QCP	Quality Control Plan
SOP	standard operating procedure
SOW	scope of work
SRP	Salt River Project
USACE	U. S. Army Corps of Engineers
WWTP	wastewater treatment plant

1.1 Introduction

The Design Documentation Report (DDR) was prepared for the Tres Rios Phase 3, Environmental Restoration Project (Project). The report is prepared under contract W912PL-09-D-0027 for the US Army Corps of Engineers (USACE).

The Project is administered by the USACE Los Angeles District and the City of Phoenix – Water Services Department acts as the local non-Federal sponsor. The design team consisting of the prime consultant, GENTERRA Consultants, and subconsultants, RBF Consultants; J2 Engineering & Environmental; JE Fuller; and Natural Channel Design have collaborated key technical expertise to develop this document.

1.2 Project Authorization

The Project was authorized in accordance with the provisions of Section 101(b)(4) of the Water Resources Development Act of 2000 (WRDA 2000), Public Law 106-541 (PL 106-541), under authority given in Section 6 of Public Law 761, Seventy-fifth Congress, June 28, 1938, which reads in part as follows: "The Secretary of War (now Secretary of the Army) is hereby given authorized and directed to cause preliminary examination and surveys for flood control ...at the following named localities – Gila River and tributaries, Arizona and New Mexico."

1.3 Project History and Objectives

The Tres Rios total project is located in Maricopa County, Arizona and consists of that portion of the Salt and Gila rivers extending from 83rd Avenue downstream of the confluence with the Agua Fria River. The total project area is approximately 5,600 acres (9.2 miles long and one mile wide). The Phase 3 Project area extends approximately 5.2 miles in length and one-mile in width, along the Gila River. The Phase 3 project initiates near the 107th Avenue alignment near the Gila River & Salt River confluence area. The Project continues downstream along the Gila River terminating just upstream of the Aqua Fria River confluence.

The USACE investigated the Tres Rios area for the potential to improve fish and wildlife habitat values and diversity for threatened and endangered species, as well as to provide flood damage reduction, recreation and the incidental benefits associated with water quality and supply. In addition, the Tres Rios area was examined for opportunities to restore critical riparian and wetland habitats that may have been lost in the region due to water resources development in the Phoenix metropolitan area. The results and conclusion from the initial reconnaissance phase were presented in the Tres Rios, Arizona Reconnaissance Report, USACE, and April, 1997.

Following this reconnaissance phase, a feasibility study was performed to analyze the information and findings. The feasibility study proceeded to develop a consensus plan for improvements of the Tres Rios area. A number of habitat restoration alternatives with some flood control components were developed and evaluated with the non-Federal sponsor. The alternatives and the selected plan were presented in the Tres Rios, Arizona Feasibility Report, April 2000.

The selected plan, Alternative 3.5, was chosen because it most closely met the following environmental restoration project objectives (as taken from the Tres Rios, Arizona Feasibility Report):

- Restore and create conditions for sustainable riparian habitat in the vicinity of Tres Rios.
- Create a complete and diverse riparian system similar to the natural riparian habitat historically represented in this area, i.e., create a mosaic of habitat types including mesquite bosque, cottonwood-willow overstory, wetland marsh, and open water.
- Reduce flood damages to the Holly Acres community, surrounding development, and agricultural areas.
- Maximize environmental education and passive recreation opportunities, which are incidental to restoration.

The water supply for the selected plan for the environmental restoration project is the 91st Avenue Wastewater Treatment Plant (WWTP), a facility operated by the multi-city Sub Regional Operating Group (SROG). This WWTP currently discharges highly treated effluent to the Salt River east of 91st Avenue. The discharges have diurnal flow variations resulting from fluctuations in water usage, long travel times in the City of PhCOP collection system, and the contractual obligations to provide effluent as cooling water to Arizona Nuclear Power Plant (ANPP) generators.

In 1995, the COP, SROG and the United States Bureau of Reclamation (Reclamation) constructed and began operating the Tres Rios Constructed Wetlands Demonstration Project (demo project) located at the WWTP. These demonstration wetlands consist of the Hayfield Site (6 acres) on former agricultural fields and the Cobble Site (4 acres) in the Salt River channel. The objectives of the demo project were to: 1) determine if constructed wetland systems can polish pre-treated effluent to a level that will meet the perceived future discharge requirements, 2) develop scale-up parameters for larger systems, and 3) quantify the net environmental benefits such a system would return in the Tres Rios area. The research results from the demonstration wetlands influenced the design of the environmental restoration project that Phase 3 is a part of.

The development of the Phase 3 portion of the project offers an opportunity to restore critical riparian and wetland habitats within the actual river channel that have been lost in the region as a result of water resources development in the Phoenix metropolitan area. The project will take the opportunity to utilize various water sources that include natural river flow, groundwater and discharge flows from the 91st Avenue WWTP located approximately 2 miles upstream of the project area and along the northside of the Salt River.

The recently constructed wetlands associated with Tres Rios Phase 2 portion of this project have recently been completed and are an integral part of the Phase 3 project as one of the main water delivery sources. As an overview of these constructed improvements the following is a brief description of their influence on the Phase 3 project. The first wetland complex developed as part of the Phase 2 project is designed to "polish disinfected effluent" and provide incidental water quality improvements of discharges from the WWTP while moderating the diurnal flow variations. These wetlands are termed the Flow Regulating Wetlands (FRW) for their role in allowing the fluctuation in effluent flows to take place within these wetlands, which will allow a more constant flow to be discharged into the river and to a system of wetland corridors located on the north bank of the Salt River–known as the Overbank Wetlands (OBW). The second wetland complex, the linear, constructed wetlands along the north overbank, will receive seasonally constant flows discharged from the FRW. These wetlands, termed the Overbank Wetlands (OBW), begin at the southwest corner of the FRW (97th Avenue) and cover approximately 130 acres to the west, which include the land south of the newly constructed USACE levee west to 113th Avenue. In total these two constructed features are anticipated under "normal (average) operating conditions" to be able to deliver water in the range from 90 mgd in the summer to 120 mgd in the winter. In addition, the FRW and OBW systems have been designed to control and manage flows up to 200 mgd and can convey through their interlinked systems up to 450 mgd under contingency scenarios. The flows from both the FRW and the OBW will be one of Phase 3's main sources of water. The primary role of the OBW will be habitat enhancement and conveyance of water to the Phase 3 habitat design. Its western most outlet will be capitalized on and enhanced as part of the Phase 3 development. The combined water sources from the Phase 2 project along with the typical river flows and the exposure of the low ground water table will serve to expand and sustain riparian and wetland habitats along the watercourse without the need of temporary and/or permanent irrigation system.

The growth and development of the City's metropolitan area has brought changes to the river. The river provides public safety and protection of flood damages to property and the general public. The river also serves as a key regional environment setting for the river's ecosystem which has been impacted and altered by non-native species for over the last 100 years. Of the many changes perhaps the most influential has been the placement of upstream dams to divert water for irrigation of crops, control the cyclical flooding, and create a source of power for the latest inhabitants of this area. Today, those changes have severely limited the hydrology and the related natural wildlife community. The current desolate nature of the site has created a geographic and visual division in the community area. This Project looks to restore a river environment that represents many of the natural systems that were present along the river's path through the desert southwest.

The project features proposed in the Phase 3 reach of this project consists of the following: (A) a braided stream design that is flanked by a series of wetland marsh habitats that traverse out to a cottonwood/willow riparian corridors and transition to a native mesquite bosque. The braided stream design will support the riparian habitat and design to allow water to flow adjacent to the Cottonwood Willow habitat and continue downstream through a series of connected open water/marshes; (B) the project includes the design of several open water/ marshes with nesting islands, and benches, that take advantage of (1) the water continuing through the riparian corridors, (2) the natural flow of the river, and (3) exposing the groundwater in the area; and (C) design of the improved habitat areas to accommodate future trail-connections and alignments (by others). The detailed physical design of these future trails is not included in this project scope, however, the project design shall identify the space and setbacks required to safely design and construct a multi-use trail system with the designated Phase 3 area, for future allowance under this project

1.4 Purpose of DDR

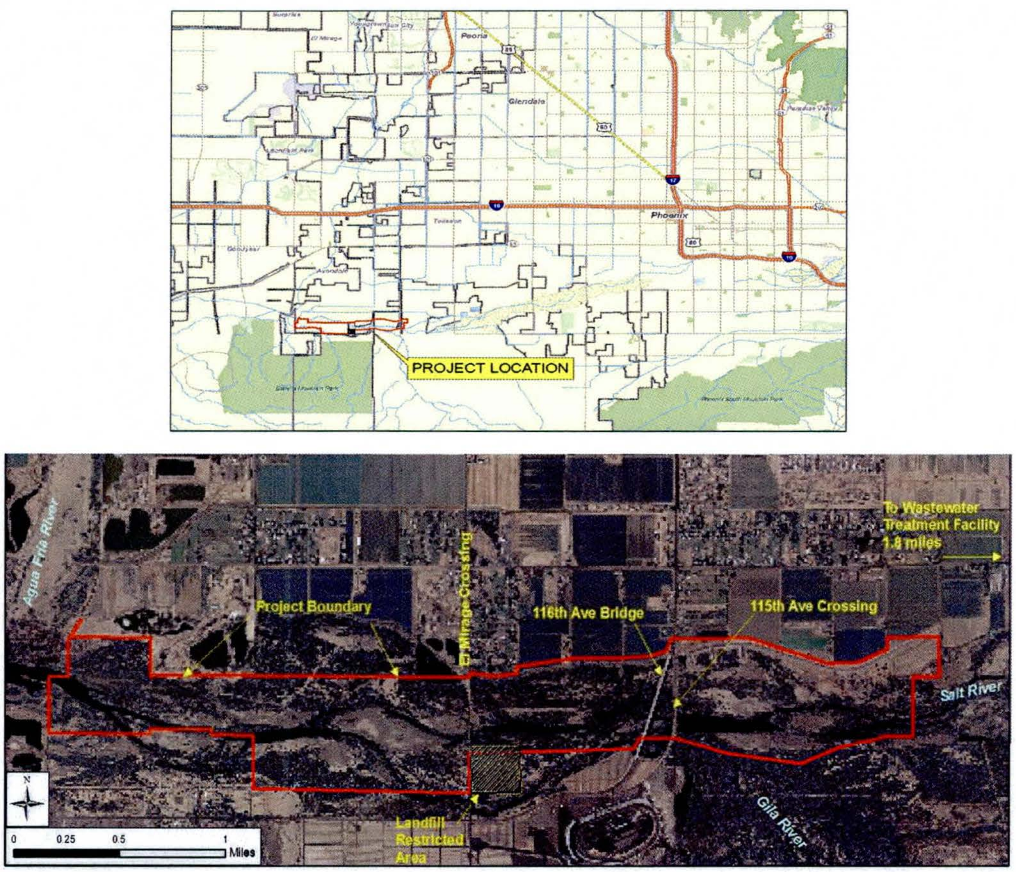
The purpose of this document is to provide a design plan that continues to support the overall Tres Rios Ecosystem Restoration Project. The DDR presents the results of the general location and design criteria for the habitat types, water supply and distribution system, and maintenance road network. The DDR also identifies potential risks to the success of the Project.

The DDR provides an overall framework for the Project and defines the design criteria that will be used during the Project's final design. This document is considered to be a 10 percent design at most and is not intended to offer a definitive picture of what the final Project will look like. Drawings are included to illustrate the conceptual designs for the required habitat development. The preliminary cost estimate was developed based on the conceptual designs included in this document. The final decision as to habitat development and proposed facilities will be incorporated into the final Project design process based on meeting the requirements under the authorized Final Feasibility Study and its cost effectiveness.

1.5 Project Site

The Tres Rios Phase 3 Environmental Restoration Project is located in Maricopa County, Arizona. The Project area extends approximately 5.2 miles in length and one-mile in width, along the Gila River. The project initiates near the extended alignment of 107th Avenue near the Gila River & Salt River confluence. The Project continues downstream along the Gila River upstream of the Aqua Fria River confluence. The development of the project offers an opportunity to restore critical riparian and wetland habitats that have been lost in the region as a result of water resources development in the Phoenix metropolitan area. The project will take the opportunity to utilize various water sources that include natural river flows, groundwater, agricultural tailwater, stormwater/nuisance water outfalls, and discharge flows from the 91st Avenue WWTP located approximately 2 miles upstream of the project area and along the northbank of the Salt River. The Project limits include the area within the riverbanks and Low Flow Channel (LFC). Figure 1-1 illustrates the Project vicinity and location.

Figure 1-1 Project Vicinity and Location



(*Tres Rios Project Limits, 2010*)

1.6 Related Documents and Reports

Related documents include those listed in Table 1-1.

TABLE 1-1
Related Documents and Reports

Document Title	Prepared By	Data, Results, or Assumptions Brought Into this Design
USACE Tres Rios, Arizona – Reconnaissance Study (April 1997)	USACE	Initial reconnaissance and federal interest.
USACE Tres Rios, Arizona - Feasibility Study, Appendices and Environmental Impact Statement (April 2000)	USACE	Identifies the Project limits and identifies habitat types to be restored (Wetland Ponds, Cottonwood-willow, Aquatic Strand, and Open Edges), required water supply/access facilities, and the development of associated recreational improvements.
USACE Tres Rios, Arizona - Feasibility Study, Technical Appendices (April 2000)	USACE	Basis of Design Calculations
Tres Rios Demonstration Constructed Wetlands – Project Status and Water Quality Data Analysis Report – Phase I 1995 to 1998 (September 2001)	Bureau of Reclamation	Research findings on water quality, hydraulic operations, and vector control
Tres Rios Constructed Wetland Full-Scale Project Visioning Workshop Report (June 2003)	WGA	Project objectives, lessons learned from demonstration wetlands, and design concepts
Arizona Water Protection Fund Grant No. 97-038 WPF Final Report (July 2002)	WGA	Results of metals, denitrification, and *E. coli* research
Status Report to the 1998 Research Plan for the Tres Rios Demonstration Wetlands Project (August 2001)	WGA	Research findings on water quality, hydraulic operations, and vector control
Status Report to the 2000 Research Plan for the Tres Rios Demonstration Wetlands Project (October 2003)	WGA	Research findings on water quality, hydraulic operations, and vector control
Geoarcheological Assessment for the Tres Rios Project, Maricopa County, Arizona (April 2004)	Statistical Research, Inc.	Potential for archeological sites in the project area
Site Hydrogeology and Discharge Area Impact Assessment, Tres Rios Wetlands, APP Applications (May 2005)	Water Resources Consulting Southwest	Results from hydrogeology assessment
Geotechnical Investigation Report for Tres Rios Environmental Restoration Project-Phase II (August 2005)	URS	Results from geotechnical field investigation and soils testing.
Arizona Water Protection Fund Demonstration Project documents (May, 2001)	PBS&J	Assessment of mosquitoes and an evaluation of the benefits to stormwater quality from wetlands treatment.

TABLE 1-1
Related Documents and Reports

Document Title	Prepared By	Data, Results, or Assumptions Brought Into this Design
Tres Rios Phase 3 Area – Phase II Environmental Assessment (February 2000)	SCS Engineers	Summarizes the investigations and findings of the Phase 1a EA
Tres Rios, Arizona Feasibility Study, Salt/Gila Groundwater Analysis: Task 2 – Water Budget Analyses and Development, Salt and Gila River Technical Memorandum (February 1998)	Greeley & Hansen	Memorandum focuses on the inflow sources and diversions from the Salt and Gila River within the Tres Rios study area.
Tres Rios River Management Plan: Draft Water Quality Summary Report (February 1998)	Tres Rios Management Plan Steering Committee	Development of alternatives for improving water quality in the Tres Rios Project.
Free Water Surface Wetlands for Wastewater Treatment: A Technology Assessment (January 1998)	USEPA, USBIA, City of Phoenix	Report summarizes current understanding of free water surfaces wetland processes, the performance of free water surface treatment wetlands, and identifies areas of inadequate understanding of this technology.
Tres Rios Demonstration Constructed Wetland Project-1996/1997 Operation & Water Quality Report	City of Phoenix	Summarizes O&M procedures and resultant changes in water quality at Tres Rios Demonstration Project.

1.7 Related Design and Engineering Projects

Table 1-4 identifies design projects that are associated with the design and/or construction of the Tres Rios Phase 3 improvements are identified in Table 1-2.

TABLE 1-2
Related Design And Engineering Projects

Document Title	Prepared By	Data, Results, or Assumptions Brought Into this Design
Rio Salado Oeste	USACE	Design of ecosystem restoration project upstream of Tres Rios along Salt River
91st Avenue WWTP Pump Station and Force Main	COP	Coordination regarding connection to pump station
91st Avenue WWTP Unified Plant 01	COP	Coordination regarding connection to pump station
Agua Fria Linear Recharge Project	COP	Reduction in overall quantity of water delivered.

TABLE 1-2
Related Design And Engineering Projects

Document Title	Prepared By	Data, Results, or Assumptions Brought Into this Design
Pee Posh Wetlands	Gila River Indian Community	Ecosystem restoration and flood water attenuation project along the south bank of Salt River in vicinity of Tres Rios
El Rio Watercourse Master Plan	Flood Control District of Maricopa County	Design for flood water attenuation, restoration, and exotic plant control within the Gila River, downstream of Tres Rios project.
123rd Avenue Landfill Investigation	USEPA and USACE	Historic landfill within river floodplain
Tres Rios Recreational Master Plan Update	COP	Master Plan for recreational components that traverse though and around the habitats of the project.

1.8 Related Construction Projects

Table 1-3 identifies ongoing construction projects that associated with the design and/or construction of the Tres Rios Phase

TABLE 1-3
Related Construction Projects

Document Title	Prepared By	Data, Results, or Assumptions Brought Into this Design
Tres Rios Phase 1a	USACE	
Tres Rios Phase 1b	USACE	
Rio Salado Phoenix	USACE	Ecosystem Restoration
Rio Salado Tempe	USACE	Ecosystem Restoration
Tres Rios Demonstration Constructed Wetland Project	COP	Wetlands
Va Shly' ay Akimel Salt River Ecosystem Restoration Project Located in Maricopa Arizona	USACE	Ecosystem Restoration

1.9 Site Survey Information

The DDR uses the 2000 survey information developed by the USACE and provided to the Genterra team. This survey was implemented by the USACE and includes information related to the topographic and cultural features of the site. In addition to the survethe Genterra Team hired local Phoenix Company Cooper Aerial to fly the site in 2010 to capture the storm water releases from the upstream dams to gain a better understanding of the rivers historic water course. In addition to the 2010 aerial images the design team also pulled historic aerial photographs from 1998 to 2010 from the FCDMC historic imagery to again better understand historic flow patterns in the river. These images in combination with the supplied topography provided the design team a solid base from which to develop its "braided stream" concept.

1.10 Preliminary Program of Facilities and Improvements

The DDR develops concepts for the following Project features:

Habitat Development:

- Wetland Marsh
- Cottonwood-willow
- Mesquite Bosque
- Salt Bush/Quail Bush/Burro brush
- Cobble Areas
- Open Water

Water Distribution System:

- Stormwater outfalls/channels
- Braided Stream Channels within River Bed
- Cross-vane Weirs
- Outfall from Overbank Wetlands
- Ground Water

Maintenance Road Improvements

- Soft-surfaced maintenance roads in the terrace area to service the wetlands/marsh habitats, stormwater outfalls, levee system inspections.

1.11 Preliminary Construction Budget

The proposed improvements for this Project have been divided into several construction packages. The USACE developed the preliminary construction budgets for these packages, which are shown in Table 1-4.

TABLE 1-4
Preliminary Construction Budget

Description	Budget
Environmental Restoration	$ 13,638,615.00
Maintenance Roads and Crossings	$ 25,540,460.00
Site Preparation	$ 1,288,602.00
Total	**$ 40,467,676.00**

1.12 Document Organization

This document is organized into the following sections and appendices. Exhibits that were deemed distracting to the reader, such as multiple exhibits and large tables, are included at the end of each section. The drawings provided in Appendix C have been provided to show the infrastructure concept for the Project. Certain existing features such as the LFC guide dikes and grade control structures are not shown for purposes of clarity. In addition, also for clarity, the only habitat type shown is the wetlands.

Section 1 Introduction
Section 2 Habitat
Section 3 Water Distribution System
Section 4 Grading and Earthwork
Section 5 References
Appendices
A Habitat and Water Balance Calculations
B Existing Vegetation Inventory & Characteristics
C Infrastructure Drawings
D Hydraulic Analysis
E Comments and Responses

2.1 Habitat Communities

The Tres Rios Phase 3, Environmental Restoration Project (Project) contributes to the restoration of some of the most rare and important ecosystems in the United States. Wetland marsh and riparian habitats in the southwest include communities dominated by mesquite bosques and cottonwood-willow. These communities are valuable to the southwestern riparian ecosystem and the wildlife that call these habitats home.

The natural riparian habitat model used to guide the conceptual design of the Tres Rios Phase 3's environmental restoration efforts was identified in the "Tres Rios, Arizona, Feasibility Report" (Feasibility Study) in September 2000. Preferred Alternative 3.5of that document depicts a diverse mixture of riparian habitat types including mesquite, cottonwood-willow, wetland marsh, aquatic strand/scrub, open water and open edges. Each of these habitat types is typically located within an active flood plain, subject to hydrogeomorphological conditions. In general, the riparian habitat zone is bounded by upland areas where depth to groundwater exceeds the limit of phreatophytic growth. Upland vegetation consists primarily of drought-tolerant trees, shrubs, and grasses. As the ground surface elevation decreases between the upland boundaries, terrace levels are encountered that may consist of old river channels and areas of cobble, sand, and silt deposition. In the terrace level, shallow or perched groundwater supports isolated wetland areas, cottonwood-willow riparian trees, and associated understory vegetation. At the lowest elevations in this continuum is a singular or multichannel low flow area in which wetland marsh and aquatic strand/scrub and true aquatic habitats are often found.

Urban development, irrigated agriculture, introduction of invasive non-native species and domestic grazing have eliminated or altered many of the natural plant communities that have historically occupied the Phoenix area and the river corridors that traverse through it. Modifications of the river systems, such as damming and flow diversion, allow no natural flow except during flooding events. The rivers therefore do not support the diversity of riparian communities that they supported historically. The area also has undergone substantial changes in vegetation types as a direct result of these hydrologic modifications and the urbanization of the corridor. The high-value cottonwood-willow riparian habitat has been substantially reduced due to the water diversion, sand and gravel operations, and the invasion of dense Saltcedar (Tamarisk species) stands, which have lower wildlife value, can out compete the cottonwood-willow, tend to grow in dense thickets resulting in higher hydrologic "N" values resulting in higher river flows and the potential for higher flood plain impacts, and can have up to three times the water uptake of native riparian species (Nature

Conservancy of California, Southern California Projects Office and the USACE Los Angeles District, Regulatory Branch, 1996).

In the southwest, riparian habitats represent less than 1 percent of the total area of the region (Knopf et al., 1989), but are extremely important ecosystem components. Approximately 75 percent-85 percent of vertebrate wildlife species in the southwest depend on riparian areas for food, cover, water, and migration routes (Gillis, 1991). Overall, there has been a loss of 90 percent of presettlement riparian ecosystems throughout Arizona and New Mexico. On the Lower Salt River and the Lower Gila River, the loss or modification of riparian habitat is close to 100 percent (AZ State Parks, 1988). Cottonwood-willow gallery forests were historically the most abundant riparian ecosystem among low-elevation rivers of the southwest (Stromberg, 1993a). However, having experienced a decline of 85 percent-95 percent, these forests are now considered endangered in Arizona and New Mexico (Noss et al.,1995). Wetlands have declined significantly (35 percent decline) since settlement in Arizona and cienegas, a type of wetland unique to the arid southwest, have declined by 70 percent. Mesquite bosques, another important element of the riparian ecosystem are the fourth rarest plant community of the 104 communities identified in the United States. Mesquite bosques were historically the most abundant riparian type in the southwest, covering areas of hundreds of square kilometers along the lower reaches of southwestern rivers. Currently, the bosques have been reduced to small isolated clusters, or islands with virtually none in pristine condition (Stromberg, 1993b).

Annual cycles of flooding in the spring and monsoon months, minimal baseflow of groundwater, and availability of sediment in areas disturbed by flooding are required for these riparian communities to regenerate. Urbanization in the Salt River watershed has resulted in the channelization of the Salt River resulting in the lowering of the groundwater table. The ecological consequence of this hydrologic alteration has been the virtual elimination of cottonwood-willow and mesquite bosque habitats along the Salt River and downstream confluence of the Gila River in the area of the habitat restoration Project. These historic habitats have been replaced with exotic and non-native vegetation (Salt Cedar), the scars of sand and gravel operations, large open pits, landfills, the remnants of illegal dumping of debris and waste, and the neglect that an ecosystem will undergo when the resources are not protected.

To the extent practicable, the Tres Rios Phase 3 design has adhered to the natural riparian model just described. The design intent, as shown on several of the attached plates, is the re-creation of a more natural braided stream network that is periodically punctuated by a larger open water zones. The braided stream channels will follow the historic routes carved over the past 50 years by the river while supplementing these channels with overflow from the recently completed Tres Rios Phase 2 project. This design will allow the following habitats to flourish; Open Water, Wetland Marsh, Cottonwood Willow, Mesquite Bosque, Salt Quail Burro Bush, and Ephemeral River Cobble areas.

2.2 Habitat Goals and Objectives

The goal of the Tres Rios Phase 3 is, to the extent possible, restore natural Sonoran Desert aquatic and riparian habitat that once occurred along the Salt River through Phoenix. To provide a complete and diverse system, the "natural riparian" model identified in the Feasibility Study will be used as a guide. Through this effort, the following is envisioned:

- A river ecosystem that will once again achieve a sustainable balance of flora and fauna, and include limited and controlled human interaction through passive recreation and educational opportunities.
- A river corridor that will be viewed and experienced, not as an obstacle to be bridged, but as an area that invites frequent visitation and incorporates the history of the river's significance to the desert southwest.
- As with all restoration scale projects, a prudent goal is to provide a design that can be operated and maintained for the long-term. This goal will be realized by a design that allows for access by maintenance equipment, provides a means for the wetland marsh habitats to be maintained, to control vectors and Salt cedars, meets the safety standards for operations staff and future recreational visitors and facilities that can be operated and maintained considering current budget constraints.
- A restoration Project that, by its development, will assist in repairing the intangible community fabric that has been torn apart by years of neglect and abuse.

To maintain and sustain this environment it will be necessary to educate the public to become stewards of these restored habitats—both local farming, and residential communities as well as the future visitors. Several of the main design principles the design team will strive to adhere to include:

- Future Accessibility – With an eye toward future public use provide the basis within the design that creates the possibility of a balance, controlled, safe and creative solutions for people of all ages and abilities without sacrificing the variety of challenging experiences and realities that a large diverse river ecosystem restoration project will present. Future public access will be balanced and controlled to ensure that it does not negatively impact the environmental restoration aspects of the Project.

- Respect the Setting – Enhance the river corridor in a manner that is compatible and consistent with its natural habitat and the environmental restoration Project that is the nucleus of this endeavor.

With these goals in mind, we have identified the following specific objectives for the environmental restoration within the Project area:

- Restore and create conditions for sustainable riparian habitat in and around the Tres Rios area. The project design will incorporate a braided channel configuration that would provide a functional floodplain to mimic natural processes found in other self-sustaining riparian forests in Arizona.
- Create a complete and diverse riparian system similar to the natural riparian habitat typical of this area. The restored areas should incorporate a diverse mix of riparian habitat types, including mesquite, cottonwood-willow, wetland marsh, and open water.
- Reduce flood damages to the Holly Acres community, surrounding development, and agricultural farm areas through the re creation of a more open river channel.
- Remove massive areas of Saltcedar from within the corridor and create a program of long term maintenance to keep the Saltcedar under control
- Increase future environmental education and passive recreation opportunities incidental to the restoration effort.

The Tres Rios Phase 3 will create a safe, attractive urban open space corridor for the public. We envision a site where the natural environment is protected, where excellent open space and natural habitats are provided, and where people can interact with nature without adversely impacting the environment.

2.3 Design Assumptions

2.3.1 Constraints

The type and distribution of habitat within the Tres Rios Phase 3 will be constrained by numerous site conditions and siting requirements, adjacent landuse, Saltcedar control, but most importantly from water supply and the operational constraints tied directly to the Phase 2 OBW and FRW operations. As the Project proceeded from feasibility to the conceptual design phase, additional constraints were identified. All of these constraints were considered during the development of the environmental restoration habitat alternatives. Some of these constraints are discussed in the following subsections.

2.3.1.1 Overall Constraints

The following constraints impact the entire Project:

- Necessity to maintain the existing flood conveyance capacity in light of the addition of vegetation within the Gila River in the terrace area and on the channel slopes.
- The initial removal and then the on-going control of the invasive Salt Cedar Tamarisk Species.
- The quality of ground and surface waters intended for use within the Project for plant establishment and maintenance affects vegetation and its ability to tolerate salinity and other potential pollutants.
- Seasonal River flows as a result of scheduled dam releases, or seasonal storm events.

2.3.1.2 Project Water Source Constraints

Project water sources and the manner in which water is delivered to the habitat restoration features are of concern because:

- The project relies on a combination of the natural river flows, accessibility to low ground water tables, and projected flows from and through the constructed FRW and OBW Phase 2 project. However, the Phase 3 Project is located at the confluence of three major rivers (the Salt, Gila and Agua Fria Rivers) and has an associated contributing area of approximately 45,000 square miles. This hydro-geographic condition results in a high groundwater table, which is evident from the persistent open water seen in historical aerial photographs dating back to 1937.
- All Project water must satisfy National Pollutant Discharge Elimination System permitting (NPDES) requirements and adhere to federal Clean Water Act (CWA) guidelines.
- The timing and quantity of discharges from upstream controls places a constraint on the type and placement of vegetation species based upon its susceptibility to scour and loss during peak and long-term discharges in the river.
- The amount and placement of such vegetation must not induce bank erosion.
- Surface and ground water salinity. Monitoring of salinity levels to provide plants the highest level of water quality.

2.3.1.3 Surrounding Landuse Constraints

Because of the urbanized setting, the Tres Rios Phase 3 habitat restoration features will be constrained by the adjacent, and sometimes within Project, landuse.

- Consideration of adjacent currently operational and future sand and gravel operations.
- Consideration of adjacent agricultural land use and agricultural field run off
- Consideration of the strong potential for future and currently limited residential development
- Consideration of the future recreational and public use and access to the site
- Consideration of the future surrounding projects including the El Rio Project to the west and the Pee Posh project to the south of this project.
- Consideration will also be given to the constraints associated with the setting, especially the presence of feral pets, trash, and human disturbance.

2.3.1.4 Feasibility Study Constraints

After the Feasibility Study was completed, additional Project constraints were identified. These included:

- A significant change in how water from the Phase 2 FRW and OBW water would be delivered to the river. The elimination of the piped water delivery system towards a more natural braided stream water delivery system associated with an outlet from the OBW to the river channel dramatically changed the design proposed in the feasibility report.
- A significant change from the feasibility report from the proposed locations and hard design of the cottonwood and willow stringer designs towards a more natural braided river system.
- Variability of the depth and quality of groundwater throughout the Project reach.
- Lack of a "natural" flood regime.
- Habitat features must take into account the various facilities current and planned along the banks of the river to minimize human disturbance in the restoration areas.
- For vector control, habitat features must be designed that minimize mosquito breeding while allowing access if needed for and successful life-cycling, and maximize their management.

2.3.1.5 Constraints Identified by the GENTERRA Team

As a part of the current habitat restoration design effort, the GENTERRA team has identified the following additional constraints:

Boundary Constraints

- The limits of the Phase 3 project are different than those depicted in the feasibility report due to land ownership and the ongoing coordination of this project with the City of Phoenix, Arizona Game and Fish and the Flood Control District of Maricopa County. These entities are all land owners within these project limits and coordination with each remains critical to the success of the overall project. The Phase 3 portion of the project begins at approximately the extended alignment of 107th Avenue and runs west ending just upstream of the confluence with the Agua Fria River and the future El Rio restoration project.

Operational Constraints

- All constructed restoration systems require periodic maintenance, such as vegetation maintenance (burning, harvesting, replanting), berm/road maintenance (repair of animal burrowing), and/or mechanical and structural repair, access to open water for vector monitoring and control and long term Saltcedar control.
- Ongoing activities shall be consistent with the reference material outlined in the USACE/COP Monitoring and Adaptive Management Plan.

Maintenance Constraints

- Although some maintenance issues can be considered after the Phase 3 facilities are designed, many issues are critical to consider during design. Mosquito management or vector control is a critical maintenance issue that is a design criterion that must be incorporated into the design of riparian areas. Mosquito borne diseases in the state of Arizona currently include: Western Equine encephalitis, St. Louis encephalitis, West Nile virus, Dengue fever, and dog heartworm. The plant species selection and layout, as well as the channel grading and layout will include the features and/ or dimensions necessary to facilitate mosquito management. A second maintenance issue that created a design criterion is maintaining and periodically clearing channels. In respect to the Phase 3 channels several features are being considered including the introduction of "Cross Vein Weirs" to help both direct flow and maintain a flow regime that helps to self maintain these channels. Secondly the proposed channels targeted in the Phase 3 approach follow the rivers historic flow pattern and the seasonal releases from upstream dams should provide some beneficial scour and removal of debris that occasionally occupy these river channels. The anticipated 5- and 10-year discharges for the Phase 3 Reach are approximately 23,500 cfs and 57,000 cfs, respectively. For additional discussion regarding anticipated flood flows, refer to the Phase 3 Hydraulic Analysis Report, provided under separate cover. The constant and vigilant control of Salt Cedar (Tamarix Species) will be a maintenance constraint that requires constant monitoring and control. The prevalence of this invasive species within the project limits and around the perimeter of this project will require that constant and long term maintenance (mechanical removal, herbicide treatment) and control of this species be continued. The Phase 3 project area is also serviced by several existing roadway corridors that cross the project and will allow for maintenance access points of heavier equipment when needed.

- Ongoing activities shall be consistent with the reference material outlined in the USACE/COP Monitoring and Adaptive Management Plan.

Educational and Passive Recreation Opportunities

- The reintroduction and the creation of an in-channel river restoration will be a unique attribute to the metropolitan Phoenix area and are expected to gain the interest of a variety of visitors. These will range from the academic and scientific communities to the avid bird watching community and the many interested visitors in between. This high profile project provides an opportunity to educate the public on many levels such as environmental protection, river restoration, arid riparian habitat, and the link to the adjacent treatment wetlands. The general public and others may realize the goals and mission of the USACE and the in-depth coordination within SROG to restore this portion of the Salt and Gila rivers.
- The educational and passive recreation components have resulted in secondary design criteria that may enhance the overall project. While trail systems and visitor experience are not a part of the project design, these facilities could accommodate these potential, future opportunities.

2.3.2 Soil Requirements

Insitu soils are currently supporting a great diversity of plant habitats and will be used as the medium for all of the restoration efforts with a minimum amount of soil amendments.

2.3.3 Hydraulic Analyses

The existing condition HEC-RAS model provided by the USACE was used as the basis for development of pre-project and with-project HEC-RAS models developed for the Phase 3 Project. Therefore, these three models (existing condition, pre-project and with-project) share many of the same characteristics, such as the following:

- Modeling limits.
- Cross-section locations and alignments.
- Discharge profiles.
- Boundary conditions.
- Stream centerline.
- Reach lengths.
- Bridge structures.

HEC-RAS modeling limits extend from the approximate 81st Avenue alignment downstream to Bullard Avenue, which is roughly 8.6 miles in length. In addition, approximately 1.7 miles of the Gila River, above the Salt River confluence, are included in the hydraulic models. However, because the Phase 3 Project restoration efforts are limited to within the Project Area, Phase 3 Project grading and re-vegetation efforts are not proposed beyond the Phase 3 Reach; and therefore, HEC-RAS cross-sections upstream and downstream of the Phase 3 Reach, and included in the pre- and with-project hydraulic models, are based solely on the USACE-provided HEC-RAS modeling of the existing condition.

A summary of relevant hydraulic modeling for the Phase 3 Project is provided below.

2.3.3.1 Existing Condition Hydraulic Modeling

Hydraulic modeling of the Phase 3 Reach existing condition was performed as part of the *North Levee PED*. The model reflects the conditions prior to Tres Rios Project Phases 1, 2 or 3. Discharges modeled for the existing condition included the 5-, 20- and 100-year return periods. Cross-section geometries used in the existing condition HEC-RAS model are based on 2001 topography. The existing condition HEC-RAS modeling was used a baseline for comparison with pre- and with-project hydraulic conditions (see Hydraulic Analyses Appendix, provided under separate cover); and as such, was not modified by JEF as part of the Phase 3 Project hydraulic evaluation. For a complete discussion regarding the USACE's existing condition hydraulic model, please refer to the *North Levee PED* report.

2.3.3.2 Pre-Project Hydraulic Modeling

The pre-project hydraulic modeling reflects the known changes that have occurred on the Salt and Gila Rivers since implementation of Tres Rios Phases 1 and 2. These known changes include the following:

- Construction of the Tres Rios North Levee (Phase 1), in the north overbank area, between the 105th Avenue alignment and El Mirage Road. The North Levee is reflected in the pre-project hydraulic model by using the HEC-RAS "Levees" option (a vertical line). The as-built levee alignment provided by the USACE was verified against recent aerial photography. The levee alignment is reflected in the pre-project HEC-RAS cross-sections. As-built top-of-levee information was not readily available and is not truly reflected in the pre-project HEC-RAS model.

- Construction of wetland ponds in the north overbank area between 91st Avenue and 111th Avenue (Phase 2). Wetland ponds reflected in the pre-project hydraulic model cross-sections are based on the topography provided to JEF by the USACE.

- Changes in land use and/or vegetation type and density (within the limits of inundation), which are reflected in the pre-project hydraulic model through roughness coefficient updates.

The pre-project HEC-RAS model is the most accurate hydraulic modeling of the Phase 3 project area as of the time of this report. Pre-project HEC-RAS modeling is discussed in more detail in the Hydraulic Analyses Appendix, provided under separate cover.

2.3.3.3 With-Project Hydraulic Modeling

The with-project HEC-RAS model is based on the pre-project condition, but also includes proposed grading and vegetation improvements within the Phase 3 Reach. With-project HEC-RAS modeling is discussed in more detail in the Hydraulic Analyses Appendix, provided under separate cover.

2.3.3.4 Conclusions Based on Hydraulic Modeling of the Phase 3 Reach

As discussed in the Hydraulic Analyses Appendix (under separate cover), hydraulic analyses were performed to evaluate the proposed design concepts. Based on the results of the analyses, the following conclusions regarding the proposed Phase 3 Reach design have been made.

1. **Channel Erosion and Scour.** River plantings within the Phase 3 Reach will be comprised primarily of cottonwood, mesquite woodland, quail bush, and wetland

habitats. In general, once established, this vegetation should provide increased channel and river bed protection from the erosive effects of flowing water by increasing channel roughness and limiting flow velocity. In addition, mature root systems increase the strength and durability of the surrounding soil matrix. However, the degree of channel protection from flood-induced erosion and scour is dependent upon the magnitude of flood and vegetation species, location, density and maturity. For example, anticipated average channel flow depth and velocity within the with-project Phase 3 Reach during the 5-year peak discharge (19,500 cfs and 23,000 cfs for the Salt and Lower Gila Rivers, respectively) is 11 ft and 4 ft/s, respectively. Comparatively, the anticipated average channel flow depth and velocity within the with-project Phase 3 Reach during the 100-year peak discharge (162,000 cfs and 227,000 cfs for the Salt and Lower Gila Rivers, respectively) is 20 ft and 8 ft/s, respectively. As one should expect, the potential for channel erosion is substantially higher during the relatively larger events (storms in excess of the 10-year event).

2. **Vegetation.** Established channel vegetation, compared to bare riverbed, increases roughness, which in turn will limit flow velocity and increase sedimentation. However, flow through areas of sparse vegetation may experience local acceleration around individual plantings, which in turn increases local sediment transport rates and the undermining of the plantings. Most susceptible to undermining are emergent plantings that have not yet developed mature root systems. Established vegetation is less likely to be undermined by general scouring of the channel; however, scour induced by localized high flow velocities may result in loss of mature vegetation. Localized high flow velocities may occur even during a moderate flood event, such as the 5- year event.

   The scale of the hydraulic modeling effort is insufficient to fully predict extreme, localized and 2-dimensional flow conditions that may induce scour and subsequently undermine mature vegetation. However, hydraulic modeling results are adequate for estimating areas of potential inundation. These results indicate that the Phase 3 Reach vegetation will be significantly inundated during a moderate event (such as a 5-year storm) and fully inundated during a relatively large event (such as a 10-year storm). The common, frequent flows (less than a 5-year storm) within the Phase 3 Reach will likely be conveyed via the areas of open water (low flow channels), as is the current condition, which should be sufficient for maintaining the wetland marsh habitat. Vegetation not adjacent to areas of open water will likely be sustained by the relatively high groundwater condition seen within the Phase 3

Reach, which is a result of the Phase 3 Project being located at the confluence of three major rivers (the Salt, Gila and Agua Fria Rivers) and having a contributing area of approximately 45,000 square miles.

While Phase 3 vegetation is subject to significant inundation during moderate flooding, once established and mature, the proposed plantings will experience, in general, non-damaging velocities during moderate events. For example, as discussed above, the anticipated average flow velocity during the 5-year event is 4 ft/s under the with-project condition. Typically flow velocities in excess of 5 ft/s are required to undermine established vegetation. However, as the frequency of flood events decrease, the magnitude of erosive discharges and flow velocities increase. As a consequence, mature vegetation is prone to damage and/or loss during the more infrequent, but relatively large magnitude flood events. Therefore, some damage and/or loss of vegetation should be anticipated during a relatively large event, such as the 10-year event (49,000 cfs and 57,000 cfs for the Salt and Lower Gila Rivers, respectively), and significant damage and/or loss of vegetation should be anticipated during a more severe event, such as the 20-year event (82,000 cfs and 92,000 cfs for the Salt and Lower Gila Rivers, respectively).

3. **Post-Project Change in Water Surface Elevation.** As discussed in the Hydraulic Analyses Appendix, given the lack of bathymetric survey data for the areas of open water (low flow channels), the pre- and with-project hydraulic models are only suitable for evaluating changes to hydraulic conditions such as a relative change in water surface elevation. This being said, a comparison of relative water surface profiles shows the pre- and with-project water surfaces are generally lower than the regulatory flood elevations and existing condition flood profiles.

   In addition, an approximate comparison of the 100-year flood profiles for the pre- and with-project hydraulic models was made against the best available top-of-levee (Tres Rios North Levee) data provided for the Phase 3 Project (see Hydraulic Analyses Appendix). This rough evaluation shows that the North Levee does not overtop during the 100-year event under the pre- or with-project conditions. The pre-project HEC-RAS model reflects construction of the North Levee and north overbank ponds, and although it is based on terrain data dated 2001, it is the most accurate hydraulic modeling of the Phase 3 project area as of the time of this report. The with-project HEC-RAS model is based on the pre-project condition, but also includes proposed Phase 3 grading and habitat (vegetation plantings) improvements.

TABLE 3.22.1A Table of Coefficients γ and β

Col. No.		1	2	3	3A	4	5	6	7	8	9	10	11	12	13	14	
			β FACTORS														
GROUP		γ	D	$(L+I)_n$	$(L+I)_p$	CF	E	B	SF	W	WL	LF	R+S+T	EQ	ICE	%	
SERVICE LOAD	I	1.0	1	1	0	1	β_E	1	1	0	0	0	0	0	0	100	
	IA	1.0	1	2	0	0	0	0	0	0	0	0	0	0	0	150	
	IB	1.0	1	0	1	1	β_E	1	1	0	0	0	0	0	0	**	
	II	1.0	1	0	0	0	1	1	1	1	0	0	0	0	0	125	
	III	1.0	1	1	0	1	β_E	1	1	0.3	1	1	0	0	0	125	
	IV	1.0	1	1	0	1	β_E	1	1	0	0	0	1	0	0	125	
	V	1.0	1	0	0	0	1	1	1	1	0	0	1	0	0	140	
	VI	1.0	1	1	0	1	β_E	1	1	0.3	1	1	1	0	0	140	
	VII	1.0	1	0	0	0	1	1	1	0	0	0	0	1	0	133	
	VIII	1.0	1	1	0	1	1	1	1	0	0	0	0	0	1	140	
	IX	1.0	1	0	0	0	1	1	1	1	0	0	0	0	1	150	
	X	1.0	1	1	0	0	β_E	0	0	0	0	0	0	0	0	100	Culvert
LOAD FACTOR DESIGN	I	1.3	β_D	1.67*	0	1.0	β_E	1	1	0	0	0	0	0	0	Not Applicable	
	IA	1.3	β_D	2.20	0	0	0	0	0	0	0	0	0	0	0		
	IB	1.3	β_D	0	1	1.0	β_E	1	1	0	0	0	0	0	0		
	II	1.3	β_D	0	0	0	β_E	1	1	1	0	0	0	0	0		
	III	1.3	β_D	1	0	1	β_E	1	1	0.3	1	1	0	0	0		
	IV	1.3	β_D	1	0	1	β_E	1	1	0	0	0	1	0	0		
	V	1.25	β_D	0	0	0	β_E	1	1	1	0	0	1	0	0		
	VI	1.25	β_D	1	0	1	β_E	1	1	0.3	1	1	1	0	0		
	VII	1.3	β_D	0	0	0	β_E	1	1	0	0	0	0	1	0		
	VIII	1.3	β_D	1	0	1	β_E	1	1	0	0	0	0	0	1		
	IX	1.20	β_D	0	0	0	β_E	1	1	1	0	0	0	0	1		
	X	1.30	1	1.67	0	0	β_E	0	0	0	0	0	0	0	0		Culvert

$(L + I)_n$ - Live load plus impact for AASHTO Highway H or HS loading

$(L + I)_p$ - Live load plus impact consistent with the overload criteria of the operation agency.

* 1.25 may be used for design of outside roadway beam when combination of sidewalk live load as well as traffic live load plus impact governs the design, but the capacity of the section should not be less than required for highway traffic live load only using a beta factor of 1.67. 1.00 may be used for design of deck slab with combination of loads as described in Article 3.24.2.2.

$$** \text{ Percentage} = \frac{\text{Maximum Unit Stress (Operating Rating)}}{\text{Allowable Basic Unit Stress}} \times 100$$

For Service Load Design

% (Column 14) Percentage of Basic Unit Stress

No increase in allowable unit stresses shall be permitted for members or connections carrying wind loads only.

β_E = 1.00 for vertical and lateral loads on all other structures.

For culvert loading specifications, see Article 6.2.

β_E = 1.0 and 0.5 for lateral loads on rigid frames (check both loadings to see which one governs). See Article 3.20.

For Load Factor Design

β_E = 1.3 for lateral earth pressure for retaining walls and rigid frames excluding rigid culverts. For lateral at-rest earth pressures, β_E = 1.15

β_E = 0.5 for lateral earth pressure when checking positive moments in rigid frames. This complies with Article 3.20.

β_E = 1.0 for vertical earth pressure

β_D = 0.75 when checking member for minimum axial load and maximum moment or maximum eccentricity .....For

β_D = 1.0 when checking member for maximum axial Column load and minimum moment ....Design

β_D = 1.0 for flexural and tension members

β_E = 1.0 for Rigid Culverts

β_E = 1.5 for Flexible Culverts

For Group X loading (culverts) the β_E factor shall be applied to vertical and horizontal loads.

195.16

200.30

196.69 start

~~Start~~

|

200.58

Given the apparent decrease in water surface elevations when comparing the pre- and with-project models to the regulatory flood elevations and existing condition flood profiles, the Tres Rios Projects (Phases 1, 2 and 3) appear to decrease the potential flood hazard within and adjacent to the Phase 3 Reach. HEC-RAS water surface profiles are provided in **Appendix F**.

4. **100-Year Flood Inundation Comparison.** For evaluation of project related changes to the 100-year limits of flooding, the following limits of inundation were overlaid (see Hydraulic Analyses Appendix):

    - Current regulatory floodplain (FEMA floodplain).
    - Existing condition 100-year inundation.
    - Pre-project 100-year inundation.
    - With-project 100-year inundation.

The overlay comparison shows that the Tres Rios projects (Phases 1, 2 and 3) reduce the area of inundation when compared to the FEMA floodplain and existing condition 100-year inundation limits. For further comparison of the FEMA floodplain against the existing condition, pre-project and with-project limits of inundation, refer to the 100-year inundation mapping provided in the Hydraulic Analyses Appendix.

A comparison of the pre- and with-project 100-year inundation limits (the pre-project is the most accurate approximation of flooding given the Project Reach condition at the time of this report) shows that the Phase 3 Project, although providing considerable improvements to habitat, provides no significant reduction to the extents of likely 100-year pre-project flooding. Pre and with-project flood inundation mapping is provided in the Hydraulic Analyses Appendix.

2.4 Open Water Habitat

2.4.1 Marsh Area Features

To address the constraints identified in Section 2.2.1, all open water marsh and cottonwood-willow habitats are located along the braided stream network that is being developed as part of this project. These braided streams have been located to follow historic channels that the river continually uses. Figure 2-1, illustrates a typical design and habitat cross section for the open water marsh habitat. Proposed locations for the open water marsh habitats only are also shown on the drawings presented in Appendix C. The open water marsh habitat features will serve as transitional habitats from the aquatic environments to the Cottonwood willow areas and to provide incidental water quality improvement. Open water and emergent marsh areas will occupy the majority of this habitat type. In the open water areas, submerged and floating aquatic plants such as *Hydrocotyle* and/or *Cerratophylum sp.* will be established. This area will provide an open water surface available for gas exchange with the atmosphere, sunlight penetration, and wind induced mixing, all of which tend to improve overall water quality. The deeper water in these areas will also provide refuge and forage for fish, mammals, and invertebrates that utilize the open water marsh habitat for all or part of their life cycle.

The emergent marsh areas will be typified by bulrush (*Scirpus sp.*), cattail (*Typha sp.*), and floating aquatic vegetation (*Ludwigia sp.*). The shallow water column and dense vegetation located in these areas will provide habitat for juvenile fish, amphibians, reptiles, and forage for mammals. Avian species such as the Red-winged blackbird may find these areas suitable for nesting, as may the Yuma Clapper Rail. Because of the densely vegetated areas, mosquito breeding may occur in the open water marsh basins. Key access points into the open water marsh habitat will be provided for vegetation removal and control, dispersal points if needed for larvicides to minimize mosquito breeding activity in the open water marsh habitat. The open water marsh features will be designed for the development of balanced floral and biotic components that also will minimize mosquito activity.

2.4.1.1 Wetland Area Features

As shown in Figure 2-2, open water marsh systems generally will be in areas of the river that currently and historically have open water zones. A total of approximately 279.0 acres of open water marsh habitat are proposed. Their main source of water will be primarily from exposing the low ground water table and from the flows expected to be generated from the Phase 2 project water emanating from the OBW outlet.

2.4.1.2 Configuration

Open Water Marshes and cienegas are proposed for the Tres Rios Phase 3. These habitat types will have both open-water, emergent marsh zones, and areas of subsurface flow. Terrestrial features such as peninsulas or immediately adjacent cottonwood-willow riparian areas will be provided where appropriate, to maximize habitat value and to serve as a platform for riparian plantings. These areas will also provide vertical structure to the open water marsh habitat.

Open water deep zones will be created within the proposed open water marsh habitats. In general, emergent macrophytes will be excluded from these zones by depth that will be approximately 4-feet or deeper than the emergent areas. Open water zones will have both vegetated and unvegetated areas. Submerged aquatic and floating aquatic plants will occupy the interior of the open water zone and emergent plants established along the perimeter.

Typical Habitat Section

Figure 2-1

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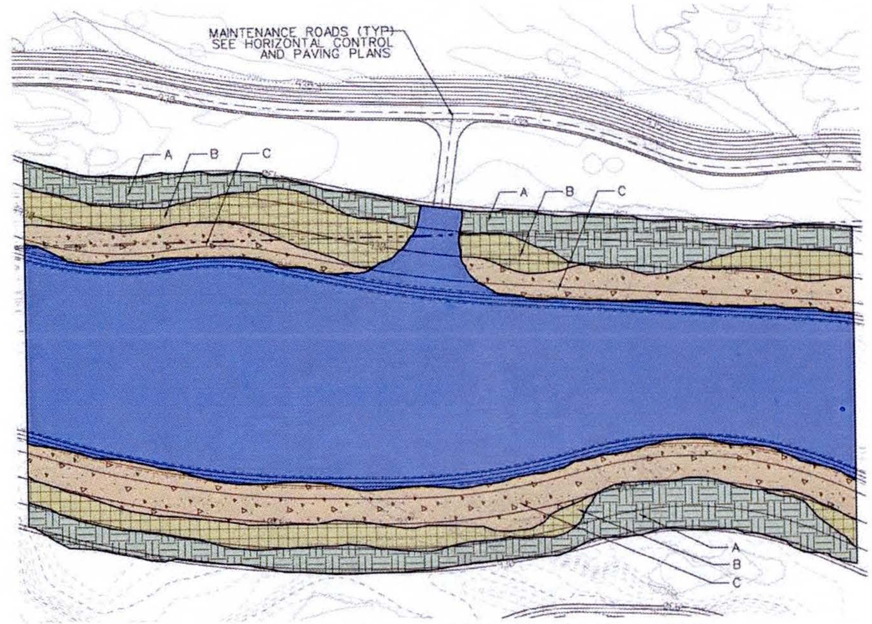
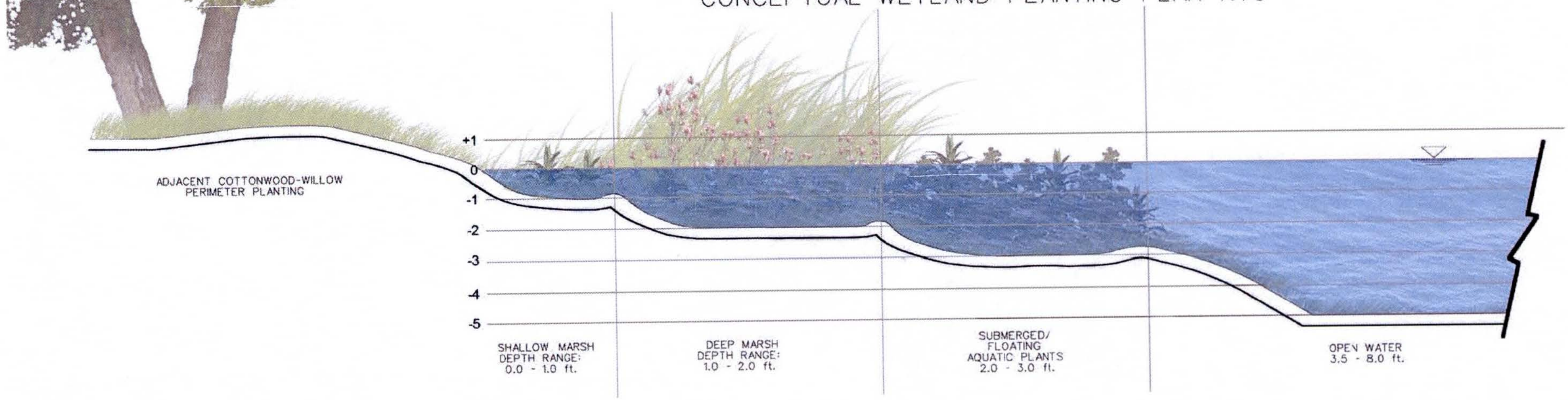
WETLAND PLANT LEGEND

PATTERN TYPE	PLANT TYPE	SELECTED SPECIES AND SCIENTIFIC NAME
	WETLAND MARSH: EMERGENT & SPREADING PLANTS	
A	SHALLOW MARSH DEPTH RANGE: 0.0 - 1.0 ft.	SCIRPUS AMERICANUS, SCIRPUS ACUTUS, SAGITTARIA GREGGII, SAGITTARIA LATIFOLIA, ALISMA TRIVIALE
B	DEEP MARSH DEPTH RANGE: 1.0 - 2.0 ft.	SCIRPUS CALIFORNICUS, SCIRPUS VALIDUS
C	SUBMERGED/FLOATING AQUATIC PLANTS ESTABLISHED IN MOIST SOILS	HYDROCOTYLE SP., LUDWEGIA PALUSTRUS, POLYGONUM HYDROPIPEROIDES, POTOMOGETON SP., RORIPPA NASTURTIUM-AQUATICUM, VERONICA SP.
	OPEN WATER: DEEP ZONE	



CONCEPTUAL WETLAND PLANTING PLAN NTS



Open Water Marsh

Figure 2-2

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These deeper zones will serve as refuge for fish and aquatic invertebrates when the emergent areas are depleated of water due to seasonal water level fluctuations.

Emergent areas within the open water marsh areas will be characterized by operational depths from moist mud to > 2-feet deep. Emergent areas in the open water marsh habitat will have interior side slopes of 3:1 (horizontal: vertical) or steeper (leading from the emergent area to the invert of the internal deep zone(s)), while slopes from the emergent area to the perimeter of the wetland will have slopes of 25:1.

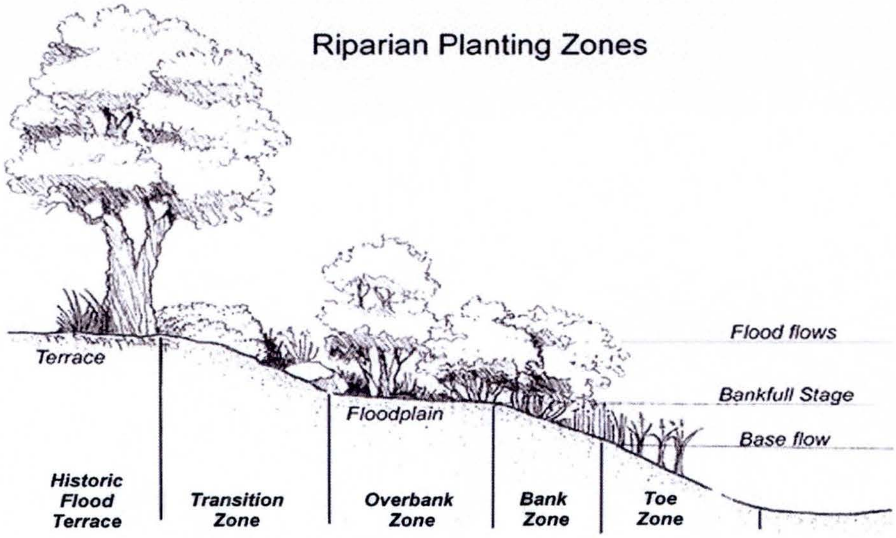
Subsurface flow areas will be associated with cienega type wetland features. Cienegas are riparian spring-fed marshes that are surrounded by upland and characterized by permanently saturated organic soils (Arizona State Parks, 1989). On a temporal basis such systems can have varying amounts of open-water standing above, at, or, immediately below the soil surface. In areas where groundwater salinity is high, the vegetation can be a complex of salt-tolerant grasses, forbs, rushes, and sedges.

2.5 Riparian Vegetation

Riparian vegetation provides critical benefits to the physical stream system. Plant roots provide additional strength for erodible banks. Equally important, the vegetation increases roughness or resistance to flow along the channel and overbank areas, slowing flow velocities and dissipating energy. The species and distribution of vegetation are largely dependent on two critical variables: soil moisture and disturbance. Flooding is the driver for both of these variables. As a result of flooding, both soil moisture and disturbance are highest closest to the stream channel and decrease laterally moving away and upward. Plants adapted to varying degrees of soil moisture and disturbances thrive along zones running roughly parallel to the stream channel.

Researchers at the NRCS Plant Materials Center in Idaho have divided the riparian corridor into discreet linear planting zones parallel to the central channel (Hoag, et al, 2001). These zones correspond to alluvial features that generally rise in elevation away from the central channel. As a result each feature and planting zone has a distinct flood and disturbance regime and is characterized by differing levels of soil moisture and disturbance. As illustrated in Figure 2-3, each planting zone supports a different community, complimenting stream processes and creating habitats. In the arid southwest, these zones are redrawn to correspond with common alluvial features described previously.

Figure 2-3 Riparian Planting Zones



Source: Hoag, et al., 2001. Riparian Planting Zones in the Intermountain West. Information Series #16. NRCS - Plant Material Center, Aberdeen, ID.

Riparian vegetation grows in distinct bands or zones that lie parallel to the stream channel. Differing soil moisture and levels of disturbance define the zones.

2.5.1 Site Plant Classification

For the purpose of this study vegetation was classified into seven broad community types. As described above, availability of water (ground and surface) and disturbance regime are the primary influences to the composition and developmental stage of each community type. Within the project area the broad vegetative community classifications are Tamarisk (mature, immature), Non-native grasses, Emergent (within the water) species, Native Riparian Trees, Native Low Flood Terrace Shrubs, Native High Flood Terrace Shrubs, Native Flood Terrace Trees. Additionally, Open Ground and Open Water areas were delineated. Field mapping and reduction of data within GIS also included information on the species composition and overall cover density for each vegetation polygon. Descriptions of each broad category are given below.

Tamarisk

Salt cedar or Tamarisk is a common, widespread, non-native riparian tree species in southwest riparian systems. Several species of tamarisk are established in Arizona. Tamarix chinensis has been reported from the site and closely related Tamarix ramosissima also likely inhabits the site. Both species and their hybrids have similar ecological traits and are treated as a single taxa for this inventory. Tamarisk often occurs in dense, monotypic stands, which can exclude native riparian plants and reduce habitat heterogeneity affecting riparian insect and animal populations. Widespread seed dispersal, deep tap roots and drought tolerance can give this species a competitive edge over native species and make control difficult once stands become established. This is especially true in stream corridors that have highly regulated stream flows. Seedlings generally only become established in open areas without significant vegetative cover. Seedlings can germinate in moist soil after flood events but need stable, high soil moisture to become established and mature. Resprout from the roots of damaged trees is common, making removal difficult.

Removal methods may differ for different age class of trees and cover density. Younger trees may be easier to remove with foliar herbicide application while older trees with more established root systems may have to be physically removed with follow up herbicide treatments. Smaller adult trees can be mulched effectively, while larger trees may require too much time to mulch efficiently.

Tamarisk patches were generally categorized as having a main trunk greater or less than 6-inches diameter. Previously burned and resprouting tamarisk was categorized separately due to complications with removal of dead trunks and multiple root resprouts.

Emergents

Emergent species are generally associated with shallow surface water and are rooted below the water's surface. The dominant emergent taxon in the project area is cattail. Several species may be present including narrowleaf cattail (Typha angustifolia), southern cattail (T. domingensis) and common cattail (T. latifolia). It forms dense stands around the margins of permanent water bodies and in broad areas of shallow, persistent water, found throughout the project. It does not become established in areas with water deeper than three to four feet or in portions of the channel that experience frequent high velocities. Baltic rush (Scirpus balticus) was also found in the project area. It can grow in slightly deeper waters than cattail. Emergent/marsh vegetation forms important habitat for the federally protected Yuma clapper rail (Rallus longirostris yumanensis) throughout the project area.

Native Riparian Willows

The most common native riparian trees in the project area are Fremont cottonwood (Populus fremotii) and Gooddings willow (Salix goodingii). Gooddings willow was the most abundant and widespread of the two. Goodings willow seldom occurred in pure stands and was most often associated with tamarisk. Younger trees were present on site indicating some reproduction through either seed or resprout. Goodings willows were distributed in close proximity to surface water.

Native Riparian Cottonwoods

Fremont cottonwoods were found throughout the site. Most trees were mature individuals with very little indication of reproduction. Trees generally occurred as individuals among stands of tamarisk. There were dead, partially decayed cottonwoods in some areas of the project. Dead trees were generally farthest from open water.

Native Floodplain Shrubs

This category consisted of native plants that inhabit the fringes of the central channel and adjacent geomorphic floodplains. They can withstand frequent disturbance and inundation as well as extended dry periods. However, they are dependent on the higher soil moistures associated with the riparian system. Arrowweed (Pluchea sericea), desert broom (Baccharis sarothroides), Seep willow (Baccharis salicifolia) and tree tobacco (Nicotiana glauca) were the major constituents of this community. Arrow weed and desert broom were the dominant members, with arrow weed especially occurring in a few dense pure stands with no other canopy cover. These species were mapped as a single community.

Native Flood Terrace Shrubs

Plants in this category are associated with less frequent flooding and drier soils. Brittle bush (Encilia farinosa), Sweet bush (Bebbia juncea), burro brush (Hymenoclea salsola), Snake weed (Gutierrezia sp.), four winged saltbush (Atriplex canescens) and quailbush (A. lentiformis) are associated with this community. Within the project site, quail bush and sweetbush are the most common taxa. This community type generally occurs as patches of mixed species. For mapping and analysis purposes all polygons have dominated by these taxa have been lumped together.

Open Ground

There are several larger areas of open ground located in the project area. These areas have less than 10% cover of any vegetation type. Open ground in the area is generally maintained by high water velocities during flood flows which remove vegetation and fine soil particles. Most patches of open ground are relatively high compared to base flow water surface elevations. Recolonization of these areas is hindered by the coarse soils and limited access to moisture.

Open Water

Open water is common in the project area is maintained in multi-thread river channels. These portions of the channel experience flood flows and high velocities on an irregular basis due to flow regulation. However, high ground water levels and releases from the 91st Ave. Sewage Treatment Plant maintain base flow through the reach. Main channel areas are presumed to be greater than 4-5 feet deep since they remain free of emergent vegetation even during periods of extended base flows.

Miscellaneous

There are several other species that did not comprise enough area to be analyzed. While their presence is noted they are not major constituents of a community type. These species were often in association with other dominant vegetation types and were unmapped. However in the case of some tree type species their locations are part of the GIS data set. These taxa are generally non-native and in most cases have been introduced as landscape plants. For a listing of these taxa, refer to the partial species list in Table 1.

Existing Vegetation Patterns and General Observations

The project area was divided into four reaches of roughly equal acreage to accommodate a phased construction approach. The extents of the reaches for each phase are shown in Fig. 4. Reach vegetation maps are provided in Appendix I. The dominant vegetation community at the site is tamarisk. Tamarisk dominated stands cover 58 % of the 1102 project area (Table 2, Fig. 4). A significant portion of the total tamarisk acreage is recently re-sprouted after a recent wildfire has killed the mature trees. Marsh habitat constitutes only about 2.5% of the project currently but once the constructed wetland marsh habitat in the upstream portion of the project is completed another 4.5% of the project area will be covered with wetland marsh. Open water made up about 8.4% and bare ground was approximately 16.2%.. Flood plain and flood terrace shrubs covered about 3.5% of the project. Native riparian trees (cottonwood and willow) were diffuse throughout the site. They seldom occurred as the dominant species within a given patch but mature trees existed with tamarisk understory. Almost 20% of the site had stands with mixed native and tamarisk trees. Significant stands of riparian habitat (tamarisk and native trees) and mesquite bosque exist outside the project areas, especially along the southern border.

The vegetation communities inventoried included many of the species commonly associated with riparian systems in the desert southwest. However, the species richness of trees and shrubs normally associated with healthy riparian systems was not observed. The high density and wide extent of tamarisk is likely reducing the abundance of other riparian species. Sandbar willow (Salix exigua) and seep willow (Baccharus salicifolia) were noticeably less abundant than anticipated. Large Gooding willow and tamarisk dominate the channel margins. The presence of the Gooding willow with their flexible stemmed species was located where anticipated with the altered regime of this river. This is likely a product of the reduced flood disturbance regime created by flow regulation.

Gooding's willow was very closely associated with margins of open water suggesting a close association with shallow saturated soils. Cottonwoods were found farther from surface water but most existed at relatively low elevations compared to surface water. This again suggests that proximity to shallow surface water is key to long-term survival of these trees.

Arizona Game and Fish resource managers have noticed periodic dieback and mortality of cottonwoods at Tres Rios and sites farther downstream. Lack of sufficient water or high salinity was the presumed cause for this dieback. However, there is insufficient data to fully access the cause. Well data form the 91st Ave. Waste Water Treatment plant upstream of the project and the El Rio site downstream of the project have been collected by Arizona State University. This is a very limited set of data but salinities and water depth were within the range to support Cottonwoods (<1800 ppm salinity). Arizona Game and Fish Department has periodically collected surface water with much higher salinities that would be detrimental to cottonwood growth. The limited data suggests that water quality is variable and at times limiting to cottonwood growth. However, the presence of mature cottonwoods on site along with the far less salt tolerant Gooding's willow suggests that conditions at the site can and will support these native trees.

Existing wetlands are important habitat for federally protected Yuma clapper rail. All efforts should be made to preserve existing marsh habitat and expand this habitat type where appropriate.

2.6 Plant Material

The goal of developing a specific planting palette for this project is all based upon sustaining native habitats, and is reflective of identifying existing high quality riparian habitats and assessing where the design could facilitate it augmentation or expansion. The diversity of the plant materials that are being proposed for the Project is based on the diversity that comprises the Sonoran Desert's unique riparian habitat zones. The variety of plant materials and habitats that are part of this Project will speak to that diversity and to the habitat types along the Gila and Salt River and within and throughout the Sonoran desert. The goal of growing and sustaining vegetation goes to the basis of designing a physical platform that can accommodate a sustainable diverse assemblage of wetland, aquatic, and terrestrial vegetation. The plant palettes described in this report are based on those described and developed as part of the Tres Rios Phase 2 Design Documentation Report.

2.6.1 Cottonwood-Willow

Vegetation: Cottonwood-willow is representative of high-quality riparian habitat in Arizona. Riparian habitats are defined as habitats or ecosystems that are associated with adjacent bodies of water (rivers, streams, or lakes) or are dependent on the existence of perennial or ephemeral surface or subsurface water drainage. They are further characterized by having diverse assemblages of plant and animal species in comparison with adjacent upland areas. The cottonwood-willow habitat is important as a relatively continuous migration corridor connecting large areas throughout the western United States. This habitat type provides valuable nesting habitat for birds, supporting the greatest density and diversity of breeding bird species in the southwest. The diversity of habitat stratification makes this habitat type valuable to a wide range of wildlife species.

Wildlife: Cottonwood-willow supports the most dense and diverse wildlife communities in valleys and deserts of the southwest United States. The diversity of plant species and growth forms provides a variety of foods and microclimate conditions for wildlife. Cottonwoods and willows provide substantial nesting support for large birds, such as great blue and green herons, red-tailed hawks, American kestrels, western screech owls, great horned owls, and northern flickers. Although salt cedar has displaced large amounts of riparian and other vegetation along the Salt River, the remaining riparian habitat still provides high wildlife value, especially for resident and migratory birds. Great blue herons, great egrets, yellow-billed cuckoo, and black-crowned night herons also roost in the cottonwood-willow vegetation and forage in nearby habitats.

The cottonwood-willow habitats are especially important for resident and migratory songbirds because these and other native riparian habitats have high wildlife value and have substantially declined throughout the western United States. Many bird species have been observed in the study area, including ash-throated flycatchers, black phoebes, dusk flycatcher, western wood pewees, tree swallows, house wrens, Bewick's wrens, Lucy's warblers, yellow warblers, verdin, yellow-rumped warblers, Anna's hummingbirds, red-winged blackbirds, and western kingbirds.

Recruitment of most woody riparian vegetation, including the cottonwood-willow habitat, in the southwest has been shown to correlate with high flows followed by a year or more without high flows. Upstream dams regulate discharge into the river systems. Modifications of river systems, such as damming and flow diversion, has delayed spring flows, lowered groundwater elevations and contributed to the decline in cottonwood and willow species. These same conditions have also favored the establishment and dominance of saltcedar.

The structural types of most stands of cottonwood-willow that can still be found within the corridor show evidence of disturbed and early successional conditions consistent with past histories of water diversion, infrequent severe floods, and land clearing. These plant species also are found in strand habitats within the corridor that are narrow, linear strands of vegetation oriented in the main direction of water flow that is occurring from stormwater outfalls, and flood control channel outlets. The creation of the LFC also has created a saturated zone that is conducive to the reestablishment of the cottonwood-willow habitat and the initiation of that succession is already occurring. One of the objectives of the Project is to restore the ability of these habitats to create succession zones and allow them to naturally regenerate.

Application: The cottonwood-willow habitat would be located within the active floodplain and would be associated with the edges of the open water marsh habitats.. It serves as a transitional habitat from the lush wetland aquatic zones to the drier mesquite bosque and Sonoran desert habitat zones. As the name implies, dominant canopy species include cottonwoods (*Populus fremontii*) and willows (*Salix goddingii* and *S. exigua*). Other important canopy species include ash (*Fraxinus velutina*) and elderberry (*Sambucus mexicana*) in mesic areas and a variety of mesquite (*P. velutina, P. torreyana,* and *P. pubescens*) in drier areas (Aspen Environmental Group, 2000). These cottonwood-willow habitat zones would be restored or created in association and along the banks of the proposed braided river channel,, within areas served by stormwater outfalls and the OBW outfall. The proposed cottonwood willow corridors would use water from existing river flows that would be conveyed by regrading portions of the channel and bywater discharged from the constructed Tres Rios Phase 2 OBW. In addition, reshaping of the ground surface will create groundwater conditions conducive to growth.

Cottonwoods may be susceptible to uprooting during flood events and the debris may lodge at downstream bridge crossings. Measures to minimize the potential for uprooting will be evaluated during the detailed design. Measures to minimize the potential for uprooting may include the orientation of the habitat relative to the LFC, decreasing plant density, or maintenance practices such as thinning.

It is anticipated that the succession of cottonwood-willow habitat would have an initial, low vegetation stage consisting of 0-7 years of growth following planting, a medium height stage taking 7-14 years, and a mature stage taking over 21 years to reasonably mature.

The comprehensive list of plant species associated with this specific habitat is presented in the peak irrigation water demand calculations presented in Appendix B.

2.6.2 Mesquite Bosque

Vegetation: The mesquite bosque habitat proposed for the Project area is a modified, low-density mesquite bosque with additional plant species that have been added for increased diversity within the Project. Mesquite bosques (groves or stands) dominated by mesquite are most prevalent on the old alluvium of dissected floodplains, especially at the confluence of major rivers and streams. As a result, mesquite bosques generally occur between 5 and 20 feet above the most recently active river channel. As with the cottonwood-willow habitat, the mesquite habitat has been substantially reduced and has been replaced by saltcedar.

Wildlife. Although few wildlife species are completely dependent on this habitat type, mesquite provides cover, foraging habitat, and breeding habitat for a many wildlife species. Most wildlife species that use mesquite habitats also use other similar habitats, including quailbush and salt cedar. Mesquite is common throughout the region. Many bird species, including mourning dove, white-winged dove, Lucy's warbler, Bell's vireo, Abert's towhee, elf owl, gila woodpecker, verdin, European starling, and house finch use this wildlife habitat type. Mammals that use this habitat include coyotes, gray fox, bobcats, pocket gophers, black-tailed jackrabbit, desert cottontails, and cactus mice. Reptiles that often use mesquite habitat include earless lizard, side-blotched lizard, spiny desert lizard, western whiptail, gopher snake, common kingsnake, banded sand snake, and western diamondback rattlesnake.

Application: This habitat zone occurs as the transitional habitat away from the cottonwood willow. The mesquite bosque habitat serves as a transition zone between cottonwood-willow and the drier Sonoran desert habitat zones.

The comprehensive list of plant species associated with this specific habitat is presented in the peak irrigation water demand calculations presented in Appendix B.

2.6.3 Aquatic Strand

Vegetation: Aquatic strand habitat is associated with the edge of our braided stream network and consists primarily of opportunistic plant species provided by upstream seed sources. Species found in this habitat type are typically those that are adapted to periodic

flooding, scouring, and soil deposition. This habitat will likely include strands of cattail, rushes, native grasses and shrubs, and the occasional cottonwood seedling. The braided stream edges may require periodic removal or cutting back of woody vegetation to ensure that adequate conveyance capacity is maintained.

Wildlife. Riparian and wetland vegetation communities that include aquatic strand habitat typically supports a diversity and abundance of wildlife species. Wildlife that utilize this habitat type includes mammalian species such as mule deer, javelina, coyote, gray fox, beaver, muskrat, raccoon, ringtail, striped skunk, deer mice, pocket mice, white-throated woodrat, kangaroo rats, squirrels, black-tailed jackrabbit and the big brown bat.

Reptile and amphibian species may include Sonoran mud turtle, banded gecko, regal-horned lizard, tree lizard, western whiptail, chuckwalla, gopher snake, common kingsnake, garter snakes, rattlesnakes, Couch's spadefoot toad, great plains toad, lowland leopard frog, and the non native spiny softshell turtle and bullfrog.

Application: Aquatic strand habitat will be along the edges of our braided stream network and our open water marsh habitats.

Incorporation of the aquatic strand habitat type will help to control erosion along the braided stream banks , while providing habitat value within the channel for aquatic species. Aesthetically, aquatic strand habitat will help to visually define the braided stream network while reinforcing the aesthetic image of a healthy, diverse riparian corridor. Aquatic strand habitat will serve as nesting and roosting habitat supporting numerous wetland-dependent bird species, including the abundant red winged blackbird. This habitat type will require periodic maintenance to manage its spread into areas along the braided stream network that could benefit from natural stabilization and in other areas to minimize its effect on surrounding habitats.

2.6.4 Cobble Areas

Vegetation: Cobble Areas are defined as the areas where the river has deposited substantial river cobble along its banks or in mounds and areas in the river channel. There are no specific or dominate plant types for this habitat type and the braded stream design of this project respects and maintains these open cobble areas as historical deposition zones and for open un-vegetated zones within the project corridor .

Wildlife. Open Cobble Areas are often used by birds and mammals for foraging and hunting and can serve as a transitional buffer zone between habitats. Open Cobble areas are most effective as a habitat type when interspersed with habitat types that provide cover (Aspen Environmental Group, 2000). This habitat supports a diverse understory of wildlife food sources. Edges of habitats along Cobble Areas provide an important niche for many wildlife species. Aesthetically, Cobble Areas creates an opportunity for viewing areas and helps to define the difference between habitat types.

Application: All remaining zones not occupied by any of the above-mentioned habitats will be considered Cobble Areas. This habitat zone will offer the greatest transition between the habitats discussed above. Open-space habitat will be occupied by both native seed mixes and other native desert grasses and forbs that will be utilized to assist in stabilizing banks, and creating a unifying habitat for the corridor. This open-space habitat area will be a common feature for all habitat zones discussed above.

2.7 Habitat Units

The Feasibility Report identified a total of 172.0 acres of potential habitat. Table 2-1 describes the habitat distribution for the Tres Rios Project as described in the Feasibility Report.

TABLE 2-1 Habitat Areas Described in Feasibility Study	
Tres Rios Phase 3	
Habitats*	Area (Acres)
Open Water Marsh	134.0
Riparian Corridors	38.0
TOTAL	172.0
*Note: Data from Tres Rios Feasibility Phase Study, Section VI-3 "Riparian Corridors and Open Water Marsh"	

The GENTERRA team identified opportunities to modify the original habitat distribution.

- The habitat design reflects the natural and historic flow pattern of the river and does not artificially create habitat areas
- The habitat design reflects and capitalizes on the current and historic open water areas of the project increasing their prominence within the project design
- The habitat design capitalizes on the existing low ground water aquifer
- The habitat design takes advantage of the existing storm water outfalls, and the Tres Rios Phase 2 OBW outfall as key water sources for the project
- The habitat design utilizes the existing road crossings at old 115th Avenue and El Mirage Road as grade breaks and habitat design influences
- The habitat design has been refined to reflect the existing topographic changes that influence both water regime flow and associated habitat development
- The habitat design is directly related to the aggressive removal and control of Saltcedar and the reestablishment of a more native habitat

- The habit design to the extent possible works with and attempts to protect in place selective strands and individual species of native plants that reflect the projects overall goal of native restoration
- To the extent possible, the revised habitat distribution matches vegetation type to depth of groundwater

TABLE 2-2.
GENTERRA Team Modified Habitat Acreages and Units

Habitat Types	Area 3A (ac)	Area 3B (ac)	Area 3C (ac)
Open Water	56.15	57.81	78.50
Wetland Marsh	30.25	28.73	27.62
Cottonwood Willow	28.80	39.42	64.83
Mesquite Woodland	29.00	25.78	97.04
Salt Quail Burro Bush	38.00	4.85	57.80
Cobble Area	4.20	1.42	20.33
TOTAL	186.41	158.01	346.12

2.8 Operation/Maintenance Considerations

As with any restoration project, operation and maintenance of the facilities will be necessary. The following list represents a non-inclusive listing of potential activities the owner/operator of the Project will likely encounter. Removal of and continued diligence in keeping SaltCedar and other exotic species under control within project boundaries.

- Reestablishment of wetlands and habitats following large flood events.
- Fertilization of plant materials during establishment phase.
- Maintenance/monitoring of water delivery system.
- Water quantity and quality monitoring.
- Maintenance and monitoring of existing bank protection.
- Maintenance and monitoring of landfill cover material.
- Monitoring and maintenance of wetland liner material
- Monitoring and control of vectors.
- Periodic removal of trash and debris.

- Visual inspection of inlet and outlet devices.
- Management of beavers.
- Cleanup/repair after graffiti and vandalism.
- Periodic removal of sediment.
- Removal and disposal of dead animals.
- Inspection of culverts.
- Removal of debris from culverts.
- Management of wildlife.
- Monitor critical habitat and wildlife activity.
- Inspection priorities after rain events.
- Permits/reporting.

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3.1 Alluvial Stream Characteristics

Riparian vegetation is organized around the hydrology and geomorphic features of streams. The location of the geomorphic features of the stream dictates the substrate type, groundwater availability, and disturbance regime, which are critical factors in determining the species composition of the plant community. It is important to understand the geomorphic context of riparian communities in order to understand patterns in riparian plant communities. Current site conditions can be compared to these general patterns to examine restoration potential.

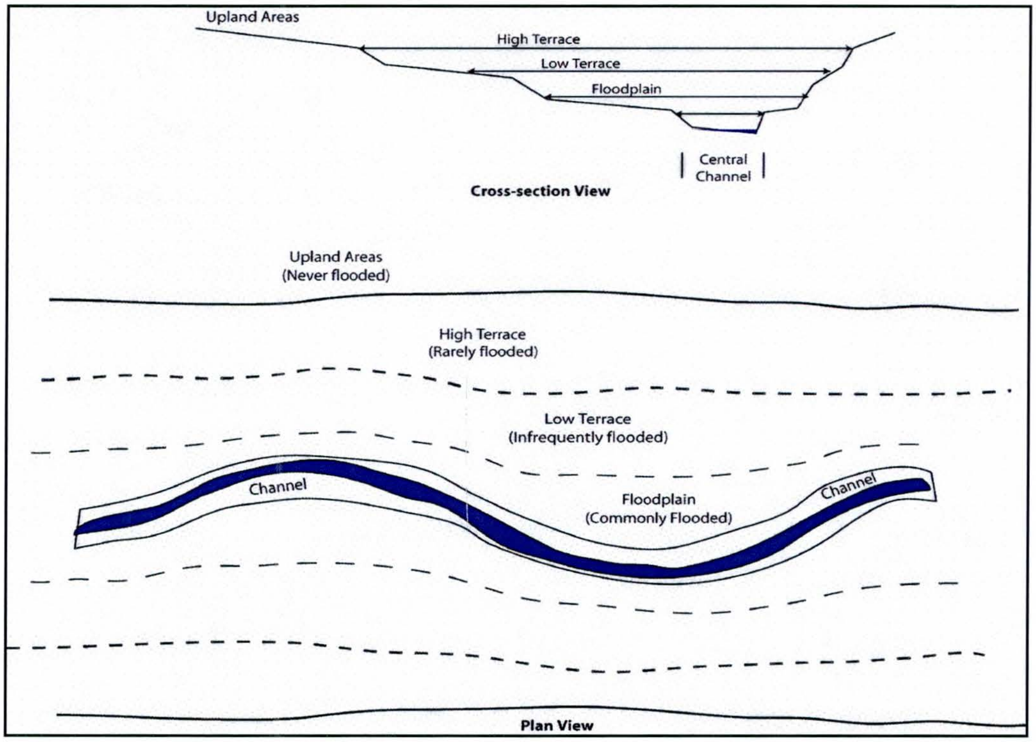
Alluvial stream channels are composed of a consistent and distinct set of physical features (channel, floodplain, terraces) (Figure 3-1). These features are created and maintained by the stream processes and are critical to primary stream functions of conveying flood flows, transporting sediment, and dissipating energy. A central (or bankfull) channel carries moderate, frequent flow events and is responsible for the transport of the volume of bedload sediment over time. An adjacent geomorphic floodplain allows the conveyance of high flows and spreads water to dissipate energy (reduce velocities). High and low terrace features occur at a higher elevation and spread infrequent, moderate to extreme flow events. The distribution of vegetation is closely correlated to these alluvial features.

Central Channel

Physical characteristics: The stream channel represents the center of the stream. Commonly called active or bankfull channel, this feature carries base flows and moderate, frequent flood events. The primary function of the channel is to successfully transport sediment. Inadequate size and shape of the channel can reduce or alter sediment transport and increase instability. The channel experiences the highest flow velocities and depths and transports the greatest portion of bedload sediment through the system. As a result the channel bed is generally coarser than the floodplain and terraces and composed of more resistant sands, gravels, or cobbles.

Associated vegetation: Much of the central channel is composed of bare substrate with a fringe of vegetation along banks of central channels. These communities are composed of well-rooted herbaceous plants, emergent wetland species (perennial flow) and supple, shrubby woody species along stream banks. Seep willow (Baccharis salicifolia), Burro brush (Hymanoclea salsola), or Coyote willow (Salix exigua) are common species within the stream channel. In perennial or intermittent reaches, cattails (Typha spp), bulrush (Scirpis spp), and other emergents are present. Each of these species has dense root systems and recovers well after disturbance. Mature tree species are too rigid and are easily scoured in this area.

Figure 3-1 Channel, floodplain, terrace features.



Geomorphic Floodplain

Physical characteristics: The geomorphic floodplain is defined as a level feature adjacent to the stream channel, created by the stream and overtopped by moderate, frequent flow events. Geomorphic floodplains in gravel streams in the Southwest are generally not smooth, level surfaces found in more mesic climates and often include shallow overflow or cutoff channels. The feature is flooded annually or every couple of years with up to approximately the 5 to 10-year floods. Disturbance is naturally high especially near the channel due to the common flooding and the surface is relatively close to ground water, ensuring greater soil moisture. This low feature should not be confused with the 100-year floodplain identified for regulatory purposes.

Associated vegetation: Due to the variability of flooding duration, a wide variety of species are associated with this feature. Supple woody species including Seep willow (Baccharis salicifolia), Burro brush (Hymanoclea salsola), or Coyote willow (Salix exigua) are commonly found in areas immediately adjacent to the central and overflow channels. Stiffer tree/shrubs such as Desert broom (Baccharis sarothroides), Arrowweed (Pluchea sericea), and Desert willow (Chilopsis linearis) as well as mature tree species such as Goodding willow (Salix gooddingi), Fremont cottonwood (Populus fremontii) are often found in higher areas that experience less disturbance. A variety of shrubs and forbs such as Brittlebush (Encilia farinosa), Quailbush (Atriplex lentifomis), Sweetbush (Bebbia juncea) and others can successfully occupy these areas.

These areas are prone to large and unpredictable scour and deposition during high magnitude flood events and plant species are adapted to this dynamic feature. The most stable areas for persistent vegetation within this feature are in protected pockets against the low terraces.

Flood Terraces

Physical characteristics: Terraces are generally old floodplains abandoned when channel elevations are lowered by incision or surfaces are aggraded by sediment deposition during high flow events. There are commonly two levels of terrace largely differentiated by inundation frequency. Low terraces can be expected to be flooded by moderate, infrequent floods (~10 to 25-year) but can be used for trails and other infrastructure that can withstand periodic flooding. High terraces are flooded by high and extreme floods (25 to 100-year) and can be incorporated into a variety of recreational uses.

Associated vegetation: In the desert southwest, surface soil moistures on flood terraces vary little from the surrounding desert uplands. However, access to groundwater can support a wide variety of deep rooted native xeric riparian tree species such as Honey mesquite (Prosopsis glandulosa), Screwbean mesquite (Prosopsis pubescens), and a variety of acacia, palo verde, and other desert species. These species would likely require irrigation for establishment but not for maintenance. A variety of desert shrubs and cacti are also associated with these communities. Wetter riparian species such as willow or cottonwood can grow in these areas but will require perpetual irrigation. Although infrequently flooded, the vegetation in these areas is important to stream stability. Plant communities should be structured (i.e., mesquite thickets) to create periodic roughness or resistance to overland flows to slow velocities and redirect high flows back to the central channel.

3.2 Water Requirements

3.2.1 Water Demand

A water demand analysis was conducted for the Tres Rios Phase 3 Environmental Restoration Project was largely based on an evaluation of the water delivery discussions in the Feasibility report and the water budget analysis in the Tres Rios Phase 2 DDR. These documents are supplemented by the design team's experience with water use estimates for the Rio Salado Environmental Restoration Project, Phoenix Reach. Based on this data, the team formulated a water demand model that allows the team to design for peak water demand that will sustain newly installed vegetation. The peak water demand is the demand necessary to establish the newly installed vegetation in the June/July timeframe and sustain the vegetation after the initial establishment period. The peak water demand is based on the June/July evapotranspiration rates for the Phoenix metro area. Sustainability is defined as the minimum amount of water required to keep the plant materials alive.

The team evaluated all potential water sources for the Project and intends to utilize generally three primary sources of water perennial flow of the Gila and Salt Rivers, capitalize and utilize the readily available and currently exposed low sub flow water table and the second being the flows that will be generated from the OBW developed as part of the Tres Rios Phase 2 project. The primary reliable, and quantitative source of water for this project will be the water generated from the 91st Avenue Wastewater Treatment Plant (WWTP). As part of the Phase 2 Tres Rios project this water will be routed through both the FRW and the OBW wetlands of the project prior to its entrance into the river environment though a spillway outlet into the Salt River. Table 3-1 identifies the potential water volume available for the restoration project from the OBW outfall (*USACE Tres Rios Project, Phase 2*).

TABLE 3-1
Potential Water Sources

Delivery Source	Average Daily Discharge (cfs)	Daily Volume (CF)	Daily Volume (Ac-Ft)
January	142	12,268,800	281.7
February	142.2	12,286,080	282.0
March	141.6	12,234,240	280.9
April	141.0	12,182,400	279.7
May	94.4	8,156,160	187.2
June	94.3	8,147,520	187.0
July	94.8	8,190,720	188.0
August	94.8	8,190,720	188.0
September	94.9	8,199,360	188.2
October	95.2	8,225,280	188.8
November	141.9	12,260,160	281.5
December	142.0	12,268,800	281.7
Average	**118.2583**	**10,217,520**	**234.6**

*OBW Outfall Tres Rios Phase 2 DDR Table 8.4.1

The design intent of the water distribution system for the various habitats is to primarily utilize perennial flows and exposed sub flow water that capitalizes on the eventual flows from the OBW that is routed through a surface braided stream system (SBSS). This is a different delivery method than was proposed in the feasibility report where a piped water delivery system was eliminated from consideration. The design team firmly believes that this method of water distribution, particularly due to the high potential of future increased native riparian vegetation growth not planted as part of the project improvements will only serve to enhance the overall restoration efforts. In discussions with City of Phoenix personnel involved with the Rio Salado Environmental Restoration Project, Phoenix Reach, it was determined that the City of Phoenix believes future phases of Rio Salado would benefit immensely from larger areas of habitat sustained by a SBSS system as opposed to any formal water delivery method.

The design will assume that the efficiency of the SBSS system will be 75%. This efficiency is based on current perennial stream flows and exposed open water areas that exist within the corridor and is very visible in several sand and gravel pits adjacent to the project that continually hold substantial amounts of open water.

Based on the 75% efficiency model for a SBSS water supply system, the team has calculated an estimated water demand based on updated habitat acreages. Through the early stages of this DDR process, the team has evaluated and updated the habitat layout based on project constraints, hydraulic modeling, property boundaries, and meetings with USACE, Arizona Game and Fish, and the Flood Control District of Maricopa County. Tables 3-2 through 3-7 illustrate the estimated project water demand and demand comparison for the project sub-Areas 3A-3C.

TABLE 3-2
Project Water Demand (Area 3A) for Month of July

Habitat	Acres	et $_{July}$ ac-ft/ac/mo	et $_{July*}$ gal/ac/mo	Total V* gal
Open Water	60.22107	0	-	-
Wetland Marsh	17.98914	0.98	317,850	5,717,849
Cotton Wood Willow	46.27663	0.95	308,070	14,256,441
Mesquite Woodland	58.69927	0.45	146,700	8,611,182
Salt Quail Burro Bush	36.13062	0.3	97,800	3,533,575
Cobble Area	22.81779	0	-	-
Total	242.1345	2.67	870,420	32,119,047.28

* Volume, V_i (gal) = A (acre) * et_i * 326,000 (gal/ac-ft)

TABLE 3-3
Project Water Demand Comparison (Area 3A)

Habitat	Gal/Mo/Acre	Total Gal/Mo
Open Water	-	-
Wetland Marsh	317,850	5,717,849
Cotton Wood Willow	308,070	14,256,441
Mesquite Woodland	146,700	8,611,182
Salt Quail Burro Bush	97,800	3,533,575
Cobble Area	-	-
Total	870,420	32,119,047

TABLE 3-4
Peak Project Water Demand (Area 3B) For Month of July

Habitat	Acres	et $_{July}$ ac-ft/ac/mo	et $_{July*}$ gal/ac/mo	Total V* gal
Open Water	53.7290	0	-	-
Wetland Marsh	29.7016	0.98	317,850	9,440,641
Cotton Wood Willow	42.4754	0.95	308,070	13,085,408
Mesquite Woodland	49.2204	0.45	146,700	7,220,631
Salt Quail Burro Bush	14.2618	0.30	97,800	1,394,802
Cobble Area	7.9965	0	-	-
Total	197.3845	2.67	870,420	31,141,481.16

* Volume, V_i (gal) = A (acre) * et_i * 326,000 (gal/ac-ft)

TABLE 3-5
Project Water Demand Comparison (Area 3B)

Habitat	Gal/Mo/Acre	Total Gal/Mo
Open Water	-	-
Wetland Marsh	317,850	9,440,641
Cotton Wood Willow	308,070	13,085,408
Mesquite Woodland	146,700	7,220,631
Salt Quail Burro Bush	97,800	1,394,802
Cobble Area	-	-
Total	870,420	31,141,481

TABLE 3-6
Peak Project Water Demand (Area 3C) For Month of July

Habitat	Acres	et $_{July}$ ac-ft/ac/mo	et $_{July^*}$ gal/ac/mo	Total V* gal
Open Water	138.2066	0	-	-
Wetland Marsh	30.84894	0.98	317,850	9,805,337
Cotton Wood Willow	64.90565	0.95	308,070	19,995,483
Mesquite Woodland	171.3225	0.45	146,700	25,133,017
Salt Quail Burro Bush	77.21212	0.30	97,800	7,551,345
Cobble Area	28.92195	0	-	-
Total	511.4178	2.67	870,420	62,485,182.24

* Volume, V_i (gal) = A (acre) * et_i * 326,000 (gal/ac-ft)

TABLE 3-7
Project Water Demand Comparison (Area 3C)

Habitat	Gal/Mo/Acre	Total Gal/Mo
Open Water	-	-
Wetland Marsh	317,850	9,805,337
Cotton Wood Willow	308,070	19,995,483
Mesquite Woodland	146,700	25,133,017
Salt Quail Burro Bush	97,800	7,551,345
Cobble Area	-	-
Total	870,420	62,485,182

3.2.2 Wetland Water Demand

To sustain wetland vegetation and provide diverse aquatic habitat, the proposed wetland features must receive a sufficient quantity of water to overcome infiltration losses and evapotranspiration (ET). Site-specific infiltration rates are not known with great certainty. In other reaches of the Salt River, infiltration rates in cobble substrates have exceeded 1 foot per day (ft/d). Over time, observed infiltration rates at the Tres Rios cobble wetlands decreased to about 0.1 ft/d (DSWA 2007).

Wetland ET rates have been found to be similar to open water (lake) evaporation rates (Kadlec and Knight 1996).

Based on the USACE Tres Rios Phase 2 DDR, the annual ET and infiltration rates for the OBW of between 3.57 to 3.98 mgd these losses took into account infiltration, and evapotranspiration. For project design purposes, the estimated Wetland Marsh ET rate has been established at .98, which places this in line with the higher end of the range and consistent with the average open water evaporation and infiltration rates.

The project has been broken out into three areas to allow eventual biding and construction packages to be developed (see Figure 3-2).

AREA 3A: The wetland marsh components in Area 1 have an approximate total surface area of 30.25 acres and therefore an estimated annual water demand of about 196.6 ac-ft. Peak water demands in the summer months are estimated to be an average 29.5 ac-ft per month (June through August).

AREA 3B: The wetland marsh components in Area 2 have an approximate total surface area of 28.73 acres and therefore an estimated annual water demand of about 186.8 ac-ft. Peak water demands in the summer months are estimated to be an average 28.0 ac-ft per month (June through August).

AREA 3C: The wetland marsh components in Area 3 have an approximate total surface area of 27.62 acres and therefore an estimated annual water demand of about 179.5 ac-ft. Peak water demands in the summer months are estimated to be an average 26.9 ac-ft per month (June through August).

The water demand rates cited above should be considered the minimum rates needed to sustain the vegetation but higher water delivery rates will be required to provide year-round open water and/or overflows to adjacent restored habitat areas.

Annual evaporation rates average over 73.20 inches with peak monthly values occurring May through August. In May and June, the high evaporation rates coincide with minimum rainfall volumes at the end of the dry season. Tables 3-8 provide a summary of the estimated monthly rainfall and evaporation for Maricopa County, Arizona. Tables 3-9 through 3-11 provide a summary of the estimated monthly rainfall and evaporation for the project sub Areas 3A-3C and vicinity (*USACE 2004*).

Project Sub-Areas

Figure 3-2

Tres Rios Phase 3 - Ecosystem Restoration
Draft Design Documentation Report (DDR)
USACE LOS ANGELES DISTRICT • CITY OF PHOENIX, ARIZONA

Project Sub-Areas

Figure 3-2

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TABLE 3-8
Average Maricopa County Monthly Rainfall and Evaporation

Month	Rainfall (in)	Evaporation (in)	Deficit (in)
January	0.67	2.16	(1.5)
February	0.68	3.12	(2.4)
March	0.88	5.04	(4.2)
April	0.22	6.6	(6.4)
May	0.12	9.0	(8.9)
June	0.13	9.96	(9.8)
July	0.83	9.96	(9.1)
August	0.96	9.0	(8.0)
September	0.86	6.96	(6.1)
October	0.65	5.28	(1.6)
November	0.66	3.96	(3.3)
December	1.0	2.16	(1.2)
Annual Total	7.66	73.2	(65.5)

TABLE 3-9
Average in Area 3A Rainfall and Evaporation

Total Habitat Area (ac)	Vol Rain (ac-ft)	Open Water Area (ac)	Vol Evap (ac-ft)	Deficit (ac-ft)
242	13.5	60	10.8	2.7
242	13.7	60	15.7	(1.9)
242	17.8	60	25.3	(7.5)
242	4.4	60	33.1	(28.7)
242	2.4	60	45.2	(42.7)
242	2.6	60	50.0	(47.4)
242	16.7	60	50.0	(33.2)
242	19.4	60	45.2	(25.8)
242	17.4	60	34.9	(17.6)
242	13.1	60	26.5	(13.4)
242	13.3	60	19.9	(6.6)
242	20.2	60	10.8	9.3
Annual Total	154.6		367.3	(212.8)

TABLE 3-10
Average in Area 3B Rainfall and Evaporation

Total Habitat Area (ac)	Vol Rain (ac-ft)	Open Water Area (ac)	Vol Evap (ac-ft)	Deficit (ac-ft)
197	11	54	9.7	1.3
197	11.2	54	14.0	(2.8)
197	14.5	54	22.6	(8.1)
197	3.6	54	29.6	(25.9)
197	2.0	54	40.3	(38.3)
197	2.1	54	44.6	(42.5)
197	13.7	54	44.6	(30.9)
197	15.8	54	40.3	(24.5)
197	14.1	54	31.2	(17.0)
197	10.7	54	23.6	(12.9)
197	10.9	54	17.7	(6.9)
197	16.4	54	9.7	6.8
Annual Total	126		327.7	201.7

TABLE 3-11
Average in Area 3C Rainfall and Evaporation

Total Habitat Area (ac)	Vol Rain (ac-ft)	Open Water Area (ac)	Vol Evap (ac-ft)	Deficit (ac-ft)
511	28.6	138	24.9	3.7
511	29.0	138	35.9	(7.0)
511	37.5	138	58.0	(20.5)
511	9.4	138	76.0	(66.6)
511	5.1	138	103.7	(98.5)
511	5.5	138	114.7	(109.2)
511	35.4	138	114.7	(79.3)
511	40.9	138	103.7	(62.7)
511	36.7	138	80.2	(43.5)
511	27.7	138	60.8	(33.1)
511	28.1	138	45.6	(17.5)
511	42.6	138	24.9	17.7
Annual Total	326.5		843.1	(516.6)

3.2.2.1 Cottonwood/Willow Water Demand

The peak water demand for the Cottonwood/Willow habitat was calculated using the monthly vegetation ET rate of 0.95 feet per month, as shown in Table 3-12. Utilizing a 75% efficiency rate for an SBSS delivery system, it is estimated that one acre of Cottonwood/Willow habitat will use 308,070 gallons of water for the peak demand months of either June or July.

3.2.2.2 Mesquite Bosque Water Demand

The peak water demand for the Mesquite Bosque habitat was calculated using the monthly vegetation ET rate of 0.45 feet per month, as shown in Table 3-12. Utilizing a 75% efficiency rate for an SBSS delivery system, it is estimated that one acre of Mesquite Bosque habitat will use 146,700 gallons of water for the peak demand months of either June or July.

3.2.2.3 Salt Quail Burro Bush Water Demand

The peak water demand for the Salt Quail Burro Bush habitat was calculated using the monthly vegetation ET rate of 0.30 feet per month, as shown in Table 3-12. Utilizing a 75% efficiency rate for an SBSS delivery system, it is estimated that one acre of Salt Quail Burro Bush habitat will use 97,800 gallons of water for the peak demand months of either June or July.

3.2.2.4 Irrigation Water Demands - Design Assumptions

Several water sources will be utilized for this project but only one that will have a reliable long term quantifiable number the flows from Phase 2 OBW outfall. The primary sources include perennial stream flows, stormwater outfall discharges, agricultural tailwater, and sub flow water and the Phase 2 OBW outfall. The primary delivery methods for project water will be: open channel, SBSS.

3.2.2.5 Habitat Features Water Balance Equations

The general water balance for various habitat features is given by the following equation:

$$\Delta S = V_{IN} + V_{PPT} - V_{ET} - V_{INF} - V_{EVAP} - V_{OUT}$$

Where,

ΔS	=	Surplus/shortage (ac-ft)
V_{IN}	=	volume delivered surface water diversions (ac-ft)
V_{PPT}	=	volume added by direct precipitation (ac-ft)
V_{ET}	=	volume lost by evapotranspiration (ac-ft)
V_{INF}	=	volume gained or lost as groundwater infiltration (ac-ft)
V_{EVAP}	=	volume lost to evaporation (ac-ft)
V_{OUT}	=	volume lost to outflows (ac-ft)

3.2.2.6 Water Balance Components

This section describes the methods that will be used to develop monthly water balances for each of the habitat features and areas described in this document.

3.2.2.7 Inflow Rate

Each habitat feature will require a dedicated and reliable water source. At present, the only quantifiable and reliable water source will be from the outlet of the OBW. Any free flows from tailwater or storm water outlets will only reduce the amount that is needed from the OBW. In all cases, the available water will have to be routed through the various habitat features using the natural braided stream network that currently defines this river corridor. To the extent possible, grading of the braided stream network will be completed to meet the water demands summarized above.

In determining water balances for each habitat feature unreliable sources such as infrequent water releases from the storm drain outlets and tail water collection systems are not included.

3.2.2.8 Precipitation

The monthly precipitation volume will be estimated based on the product of the long-term average monthly precipitation depths (*see Table 3-8*) and the surface area of each habitat feature as follows:

$$V_{PPT} = PPT * A$$

Where,

V_{PPT}	=	Volume of monthly precipitation (ac-ft)
PPT	=	monthly precipitation (rainfall/snowfall) depth (ft)
A	=	habitat feature surface area (ac)

3.2.2.9 Evapotranspiration

ET losses will vary by habitat type as described above (Water Demand) and by month based on the normalized ET pattern described in the Feasibility Report and the Tres Rios Phase 2 DDR and shown in Table 3-12. The monthly ET loss for a specific habitat feature will be estimated as follows:

$$et_i = n_i * ET$$

Where,

et_i	=	monthly evapotranspiration (ft)
n_i	=	normalized ET factor
ET	=	annual ET rate for habitat type (ft)

TABLE 3-12
Normalized Evapotranspiration Rates

Month	Mean Average Daily Evapotranspiration n_i (in)	Wetland Marsh	Cottonwood Willow	Mesquite Woodland	Salt Quail Burro Bush
January	0.05	0.33	0.32	0.15	0.10
February	0.05	0.33	0.32	0.15	0.10
March	0.05	0.33	0.32	0.15	0.10
April	0.10	0.65	0.63	0.30	0.20
May	0.10	0.65	0.63	0.30	0.20
June	0.15	0.98	0.95	0.45	0.30
July	0.15	0.98	0.95	0.45	0.30
August	0.15	0.98	0.95	0.45	0.30
September	0.05	0.33	0.32	0.15	0.10
October	0.05	0.33	0.32	0.15	0.10
November	0.05	0.33	0.32	0.15	0.10
December	0.05	0.33	0.32	0.15	0.10
Annual Total	**1.00**	**6.50**	**6.30**	**3.00**	**2.00**

et_i - $n_i ET$;
Et_i = 325851.4333 gal/ac-ft
1 acre-foot = 325851.43326 gallon [US, liquid]

3.2.2.10 Infiltration Losses

Infiltration losses are uncertain and may exceed 1 ft/d in habitat features or the braided stream network. In the water balance calculations, infiltration losses will be calculated from the habitat feature area and a general infiltration rate representative of the soil type under each feature. Site-specific investigations have been proposed to develop more representative infiltration rates. For this submittal, infiltration is estimated as 25% of the calculated ET value.

The project team's observations of water levels in the existing open water areas within the project corridor suggest that the depth to sub flow water is in the range of 3 to 8 feet below land surface and that sub flow water elevations are relatively stable. This is a drastically improved condition relative to the data reported in the Feasibility Study (ref) that indicated sub flow water depths as much as 17 feet below land surface. Site-specific investigations have been proposed to confirm the sub flow water elevations. If the results of these studies show that sub flow water is close to the surface, then the proposed cottonwood/willow and mesquite habitats will quickly develop a root system that taps into available sub flow water and increases the likelihood of long term establishment.

The following equation will be used in subsequent infiltration estimates:

$$V_{INF} = k * A * n$$

Where,

V_{INF} = Volume of infiltration in 1 month (ac-ft)
k = hydraulic conductivity of substrate (ft/d)
A = Area of infiltration (ac)
n = number of days per month (d)

3.2.2.11 Outflow Rate

Efforts will be made to either minimize outflows from the habitat features or direct outflows to down gradient features. Overflow and spillway structures will be designed so that a rating curve can be developed to measure outflow. If a sharp crested rectangular weir is designed to control outflows, the following equation can be used to measure outflow rates:

$$Q_{OUT} = C * L * H^{3/2}$$

Where,

Q_{OUT} = discharge (cfs)
C = weir coefficient
L = weir length (ft)
H = depth of water over weir (ft)

TABLE 3-13
Area 1 Total Water Demand (Monthly Rainfall and Evaporation)

Month	Wetland Marsh		Cottonwood		Mesquite		Salt Quail Burro		Total Demand (ac-ft)
	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	
January	0.33	5.8	0.32	14.6	0.15	8.8	0.10	3.6	32.8
February	0.33	5.8	0.32	14.6	0.15	8.8	0.10	3.6	32.8
March	0.33	5.8	0.32	14.6	0.15	8.8	0.10	3.6	32.8
April	0.65	11.7	0.63	29.2	0.30	17.6	0.20	7.2	65.7
May	0.65	11.7	0.63	29.2	0.30	17.6	0.20	7.2	65.7
June	0.98	17.5	0.95	43.7	0.45	26.4	0.30	10.8	98.5
July	0.98	17.5	0.95	43.7	0.45	26.4	0.30	10.8	98.5
August	0.98	17.5	0.95	43.7	0.45	26.4	0.30	10.8	98.5
September	0.33	5.8	0.32	14.6	0.15	8.8	0.10	3.6	32.8
October	0.33	5.8	0.32	14.6	0.15	8.8	0.10	3.6	32.8
November	0.33	5.8	0.32	14.6	0.15	8.8	0.10	3.6	32.8
December	0.33	5.8	0.32	14.6	0.15	8.8	0.10	3.6	32.8
Annual Total		116.9		291.5		176.1		72.3	656.8

TABLE 3-14
Area 2 Total Water Demand (Monthly Rainfall and Evaporation)

Month	Wetland Marsh		Cottonwood		Mesquite		Salt Quail Burro		Total Demand (ac-ft)
	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	
January	0.33	9.7	0.32	13.4	0.15	7.4	0.10	1.43	31.8
February	0.33	9.7	0.32	13.4	0.15	7.4	0.10	1.43	31.8
March	0.33	9.7	0.32	13.4	0.15	7.4	0.10	1.43	31.8
April	0.65	19.3	0.63	26.8	0.30	14.8	0.20	2.85	63.7
May	0.65	19.3	0.63	26.8	0.30	14.8	0.20	2.85	63.7
June	0.98	29.0	0.95	40.1	0.45	22.1	0.30	4.28	95.5
July	0.98	29.0	0.95	40.1	0.45	22.1	0.30	4.28	95.5
August	0.98	29.0	0.95	40.1	0.45	22.1	0.30	4.28	95.5
September	0.33	9.7	0.32	13.4	0.15	7.4	0.10	1.43	31.8
October	0.33	9.7	0.32	13.4	0.15	7.4	0.10	1.43	31.8
November	0.33	9.7	0.32	13.4	0.15	7.4	0.10	1.43	31.8
December	0.33	9.7	0.32	13.4	0.15	7.4	0.10	1.43	31.8
Annual Total		193.5		267.7		147.7		28.6	636.5

TABLE 3-15
Area 3 Total Water Demand (Monthly Rainfall and Evaporation)

Month	Wetland Marsh		Cottonwood		Mesquite		Salt Quail Burro		Total Demand (ac-ft)
	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	et_i	Demand (ac-ft)	
January	0.33	10.0	0.32	20.4	0.15	25.7	0.10	7.7	63.9
February	0.33	10.0	0.32	20.4	0.15	25.7	0.10	7.7	63.9
March	0.33	10.0	0.32	20.4	0.15	25.7	0.10	7.7	63.9
April	0.65	20.1	0.63	40.9	0.30	51.4	0.20	15.4	127.8
May	0.65	20.1	0.63	40.9	0.30	51.4	0.20	15.4	127.8
June	0.98	30.1	0.95	61.3	0.45	77.1	0.30	23.2	191.7
July	0.98	30.1	0.95	61.3	0.45	77.1	0.30	23.2	191.7
August	0.98	30.1	0.95	61.3	0.45	77.1	0.30	23.2	191.7
September	0.33	10.0	0.32	20.4	0.15	25.7	0.10	7.7	63.9
October	0.33	10.0	0.32	20.4	0.15	25.7	0.10	7.7	63.9
November	0.33	10.0	0.32	20.4	0.15	25.7	0.10	7.7	63.9
December	0.33	10.0	0.32	20.4	0.15	25.7	0.10	7.7	63.9
Annual Total		200.5		408.5		514.0		154.3	1,278.0

3.2.2.12 Water Balance

The following tables illustrate the estimated water balance for this Project using the aforementioned assumptions and equations.

TABLE 3-16
Project Water Balance Area 1

Time		System Inflow	Water Gains		Water Losses Area 1					
		1	2	3	4	5*	6**	7***	8	9
Month	Days / Mo	Inflow (ac-ft)	Rainfall (ac-ft)	Total Area 1 Inflows (ac-ft)	ET (ac-ft)	Infiltration (ac-ft)	Berm Seepage (ac-ft)	Outflow (ac-ft)	Evaporation (ac-ft)	Total Area 1 Outflows (ac-ft)
January	31	8,731.2	13.5	13.5	32.8	8.2	0.8	61.5	10.8	114.2
February	28	7,897.4	13.7	13.7	32.8	8.2	0.8	55.5	15.7	113.1
March	31	8,706.6	17.8	17.8	32.8	8.2	0.8	61.5	25.3	128.7
April	30	8,390.1	4.4	4.4	65.7	16.4	1.6	59.5	33.1	176.4
May	31	5,804.4	2.4	2.4	65.7	16.4	1.6	61.5	45.2	190.4
June	30	5,611.2	2.6	2.6	98.5	24.6	2.5	59.5	50	235.1
July	31	5,829.0	16.7	16.7	98.5	24.6	2.5	61.5	50	237.1
August	31	5,829.0	19.4	19.4	98.5	24.6	2.5	61.5	45.2	232.3
September	30	5,646.9	17.4	17.4	32.8	8.2	0.8	59.5	34.9	136.3
October	31	5,853.6	13.1	13.1	32.8	8.2	0.8	61.5	26.5	129.9
November	30	8,773.2	13.3	13.3	32.8	8.2	0.8	59.5	19.9	121.3
December	31	8,731.2	20.2	20.2	32.8	8.2	0.8	61.5	10.8	114.2
Annual Total	365	85,474.5	155	154.6	657	164	16	724	367	1928.8
*Considered 75% irrigation efficiency ** Assumed 10% of infiltration ***Considering 1 cfs moving through system										

TABLE 3-17
Project Water Balance Area 2

Time		System Inflow	Water Gains		Water Losses Area 2					
		1	2	3	4	5*	6**	7***	8	9
Month	Days/ Mo	Inflow (ac-ft)	Rainfall (ac-ft)	Total Area 2 Inflows (ac-ft)	ET (ac-ft)	Infiltraion (ac-ft)	Berm Seepage (ac-ft)	Outflow (ac-ft)	Evaporation (ac-ft)	Total Area 2 Outflows (ac-ft)
January	31	8,731.2	11.0	11.0	31.8	8.0	0.8	61.5	9.7	111.8
February	28	7,897.4	11.2	11.2	31.8	8.0	0.8	55.5	14.0	110.1
March	31	8,706.6	14.5	14.5	31.8	8.0	0.8	61.5	22.6	124.7
April	30	8,390.1	3.6	3.6	63.7	15.9	1.6	59.5	29.6	170.3
May	31	5,804.4	2.0	2.0	63.7	15.9	1.6	61.5	40.3	183.0
June	30	5,611.2	2.1	2.1	95.5	23.9	2.4	59.5	44.6	225.9
July	31	5,829.0	13.7	13.7	95.5	23.9	2.4	61.5	44.6	227.9
August	31	5,829.0	15.8	15.8	95.5	23.9	2.4	61.5	40.3	223.6
September	30	5,646.9	14.1	14.1	31.8	8.0	0.8	59.5	31.2	131.3
October	31	5,853.6	10.7	10.7	31.8	8.0	0.8	61.5	23.6	125.7
November	30	8,773.2	10.9	10.9	31.8	8.0	0.8	59.5	17.7	117.8
December	31	8,731.2	16.4	16.4	31.8	8.0	0.8	61.5	9.7	111.8
Annual Total	365	**85,474.5**	**126.0**	**126.0**	**636.8**	**159.0**	**16.0**	**724.0**	**328.0**	**1,863.7**

*Considered 75% irrigation efficiency   ** Assumed 10% of infiltration   ***Considering 1 cfs moving through system

TABLE 3-18
Project Water Balance Area 3

Time		System Inflow	Water Gains		Water Losses Area 3					
		1	2	3	4	5*	6**	7***	8	9
Month	Days/ Mo	Inflow (ac-ft)	Rainfall (ac-ft)	Total Area 3 Inflows (ac-ft)	ET (ac-ft)	Infiltraion (ac-ft)	Berm Seepage (ac-ft)	Outflow (ac-ft)	Evaporation (ac-ft)	Total Area 3 Outflows (ac-ft)
January	31	8,731.2	28.6	28.6	63.9	16.0	1.60	61.5	24.9	167.8
February	28	7,897.4	29.0	29.0	63.9	16.0	1.60	55.5	35.9	172.9
March	31	8,706.6	37.5	37.5	63.9	16.0	1.60	61.5	58.0	201.0
April	30	8,390.1	9.4	9.4	127.8	31.9	3.19	59.5	76.0	298.4
May	31	5,804.4	5.1	5.1	127.8	31.9	3.19	61.5	103.7	328.1
June	30	5,611.2	5.5	5.5	191.7	47.9	4.79	59.5	114.7	418.6
July	31	5,829.0	35.4	35.4	191.7	47.9	4.79	61.5	114.7	420.6
August	31	5,829.0	40.9	40.9	191.7	47.9	4.79	61.5	103.7	409.5
September	30	5,646.9	36.7	36.7	63.9	16.0	1.60	59.5	80.2	221.1
October	31	5,853.6	27.7	27.7	63.9	16.0	1.60	61.5	60.8	203.8
November	30	8,773.2	28.1	28.1	63.9	16.0	1.60	59.5	45.6	186.6
December	31	8,731.2	42.6	42.6	63.9	16.0	1.60	61.5	24.9	167.8
Annual Total	365	**85,474.5**	**327**	**326.5**	**1,277.8**	**319.0**	**31.95**	**724.0**	**843.0**	**3,196.2**

*Considered 75% irrigation efficiency   ** Assumed 10% of infiltration   ***Considering 1 cfs moving through system

TABLE 3-19
Summary Project Water Balance Area 3

10	11
Total System Outflows (ac-ft)	Water Balance / (Deficit (ac-ft)
8,390.6	340.7
7,555.2	342.2
8,322.1	384.6
7,762.5	627.6
5,112.5	691.9
4,741.9	869.3
5,009.2	819.8
5,039.7	789.3
5,226.4	420.5
5,445.8	407.8
8,070.3	373.4
8,416.7	314.5
79,092.8	6,381.7

3.3 Water Distribution

The water supply and distribution system is critical to the success and sustainability of the Tres Rios Phase 3, Environmental Restoration Project (Project). A sufficient quantity and adequate quality of water must be available to maintain the viability of the various habitat types that are being considered for the Project with the future flows from the Tres Rios Phase 2 OBW flows adding substantial and vital water flow to the project. In addition the project will capitalize on any dry weather flows from storm drains being a secondary source.

The water supply and distribution system consists of the following facilities:

- Groundwater
- Phase 2 OBW Flow
- Storm Water Outlets

3.3.1 Design Assumptions

The prevalent assumptions and approaches for the Tres Rios Phase 3's water delivery system, defined by the GENTERRA team, are:

1. The Phase 3 Project is located at the confluence of three major rivers (the Salt, Gila and Agua Fria Rivers) and has an associated contributing area of approximately 45,000 square miles. This hydro-geographic condition results in a high groundwater table, which is evident from the persistent open water seen in historical aerial photographs dating back to 1937. This high groundwater condition will be the primary source of water for the proposed habitat vegetation.

2. Delivering water to the habitat vegetation, for the most part, will be accomplished through grading a natural semi-braided stream network that takes advantage of historic river flow patterns and capitalizes on existing open water zones, available high ground water aquifer, and flows that will be generated from Tres Rios Phase 2 OBW.

3. In the case of a flood event during the establishment period, the COP and the USACE will decide, depending on the level of destruction to the habitats whether or not the habitats would be abandoned, repaired, or reinstalled. For discussion regarding the hydraulic modeling of flood flows performed for the Phase 3 Project, refer to the Phase 3 Hydraulic Analysis Report, provided under separate cover.

4. Following final acceptance by both the COP and the USACE regarding the contractor's contractual obligations for the establishment and warranty periods associated with the entire Project, the Arizona Game and Fish Department will operate and maintain all habitats associated with this project.

5. To provide saturated soil conditions for cottonwoods to regenerate naturally from seed, the surface grading will be designed to facilitate local flooding of these areas.

3.3.2 Impacts to Design

The approach to water delivery outlined above will be further defined and refined as the design moves forward. It should be noted that this approach will have some direct impacts to the Project's overall design such as:

1. There will be areas within the habitats along the Project that will display some stress associated with lack of available water during times of drought and extended periods of high heat in the summer.

2. There are strong indications that the quality of the groundwater to be used for the Project may contain high levels of dissolved solids (salts). This condition may result in leaf burn associated with airborne water distribution or herbicide contact.

3. Vegetation selection and placement will be critical. For example, deep-rooted species (mesquite, palo verde, etc.) will be placed in areas of deeper groundwater, and shallower-

rooted species will be located in areas within areas where a perched aquifer (i.e., around wetlands) will naturally exist. In subsequent design phases, pole-planting and/or tall pot-grown vegetative planting stock will be considered for strategic locations with respect to expected local groundwater conditions.

3.4 Stormwater Outfalls

There are very few storm water outlets associated with the Phase 3 reach of the project. Where these do occur the associated channels will be graded to give the appearance of a meandering stream, and will promote runoff through these outlets to the project wetland and riparian corridors.

4.1 Introduction

The grading and earthwork for the Tres Rios Phase 3, Environmental Restoration Project (Project) will be more limited in its nature and extent than the grading and earthwork for a typical development Project of similar size. Because the purpose of this Project is environmental restoration, the grading is not an enhancement in itself but is required primarily to accommodate the infrastructure features. Grading solely for aesthetic purposes will be minimized, especially in the terrace level.

The existing soils on the Project vary considerably, but silty sand mixed with river cobbles is the predominant soil type.

4.2 Design Assumptions

The project is almost exclusively cut, with very limited fill areas. Cut and fill slopes will vary, however, 4:1 slopes will be preferred in most instances. Steeper slopes and armored slopes, or stepped slopes may be used in some instances due to horizontal constraints.

In general, the cuts and fills within a given river reach will be cautiously designed to maintain the hydraulic conveyance capacity of the river. Drastic changes to any river reach, either increasing or decreasing the conveyance capacity can have adverse effects on the stability of that reach and subsequent reaches, either upstream or downstream.

The typical concept for grading is illustrated by two cross sections that were selected to illustrate the effect of applying the site plan to the existing topography. The cross section profile shows how the proposed infrastructure fits on the existing features. One major challenge during the design phase will be to configure the proposed roads, canals, and wetlands so they require a minimum of grading and still operate effectively and meet the habitat goals of the project. Canals need to gravity flow along the terrace and overbank, but the uneven nature of the existing ground will make it challenging to design. The cross section shows that excavation will be required along the north overbank as the canal passes through a high area on the riverbank. Also, the wetland on the north terrace will require new embankment. The purpose of showing the cross section in this report is to demonstrate that the conceptual site plan will require adjustments during design to better fit the topography (see Figure 4-1).

A second cross section shows that new embankment may be required to make canals gravity flow through some low lying areas. This cross section demonstrates that the LFC dominates this reach leaving only a narrow corridor for the wetland to be constructed (see Figure 4-2).

The proposed vegetation, once mature and established, will be somewhat damaged during frequent to moderate flows (such as the 5- and 10-year design discharges of approximately 23,500 cfs and 57,000 cfs, respectively), but with acceptable loss of habitat. Lost habitat should be naturally replenished by the remaining vegetation.

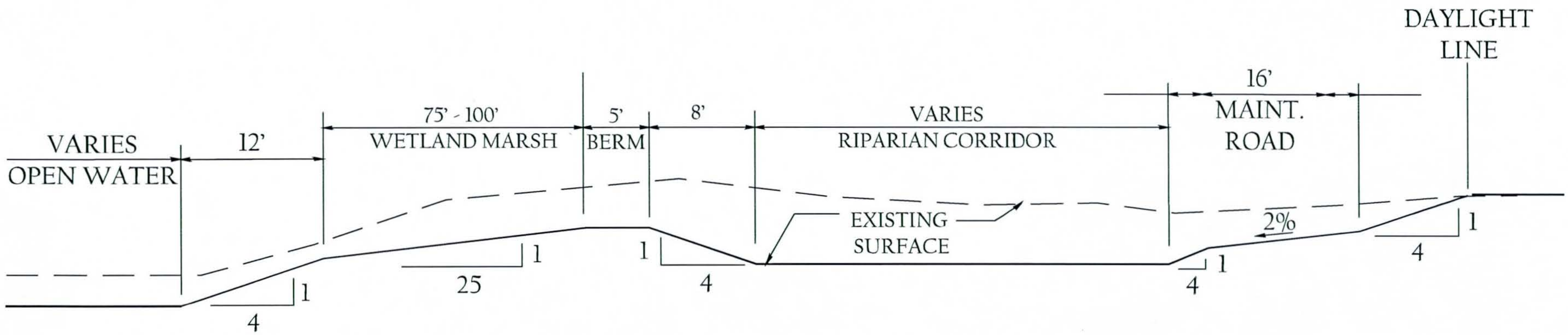
As flood flows become larger in magnitude and/or duration, the proposed habitat becomes more threatened. However, loss of vegetation is dependent not only on magnitude and duration of the flooding, but on the timing of the flood event relative to construction. For example, newly planted vegetation may be more susceptible to damage, even at low to moderate flows, than mature, established vegetation experiencing moderate to large flood events. For additional discussion regarding hydraulic modeling for the Phase 3 Project, refer to the Phase 3 Hydraulic Analysis Report, provided under separate cover.

4.3 Roadway Culverts

The ability to successfully restore the critical riparian and wetland habitats along the project reach requires the flow of water through the reconstructed channel system. Maintaining flow through the new system will require the installation of new storm drain culverts across Old 115th Avenue and El Mirage Road.

El Mirage Road currently has three separate culverts across the roadway, one bank of culverts on the southern end that convey the majority of flow, a set on the north side of the existing landfill, and the recently constructed culverts on the north side that provide an outfall for the interior drainage behind the Phase 1B levee. The southern culverts are outside of the project limits and convey the majority of the low flows in the channel. The invert elevations of the 2 sets of north culverts prohibit their use in maintain flow to the new channel system. To promote low flows to use the new braided channel system along the north side of the river, a new set of culverts is proposed along El Mirage Road. The culverts will consist of 2 30-inch diameter reinforced concrete pipes. The invert elevation will match that of the existing culverts on the south side of the roadway. The lowered invert elevation will assist in maintain a steady low flow through the new channel system.

Only one set of existing storm drain culverts are located across Old 115th Avenue. These culverts are located adjacent to the main open water body on the east side of the roadway and are on the southern portion of the river. A new set of culverts is proposed to be located along the north side of the river to facilitate flow in the new channel system. The new culvert system will promote the capture and conveyance of outflows from the Overbank Wetlands through the new channel system. The culverts will have a similar size and configuration as the new culverts at El Mirage Road.



Typical Design Section

Figure 4-1

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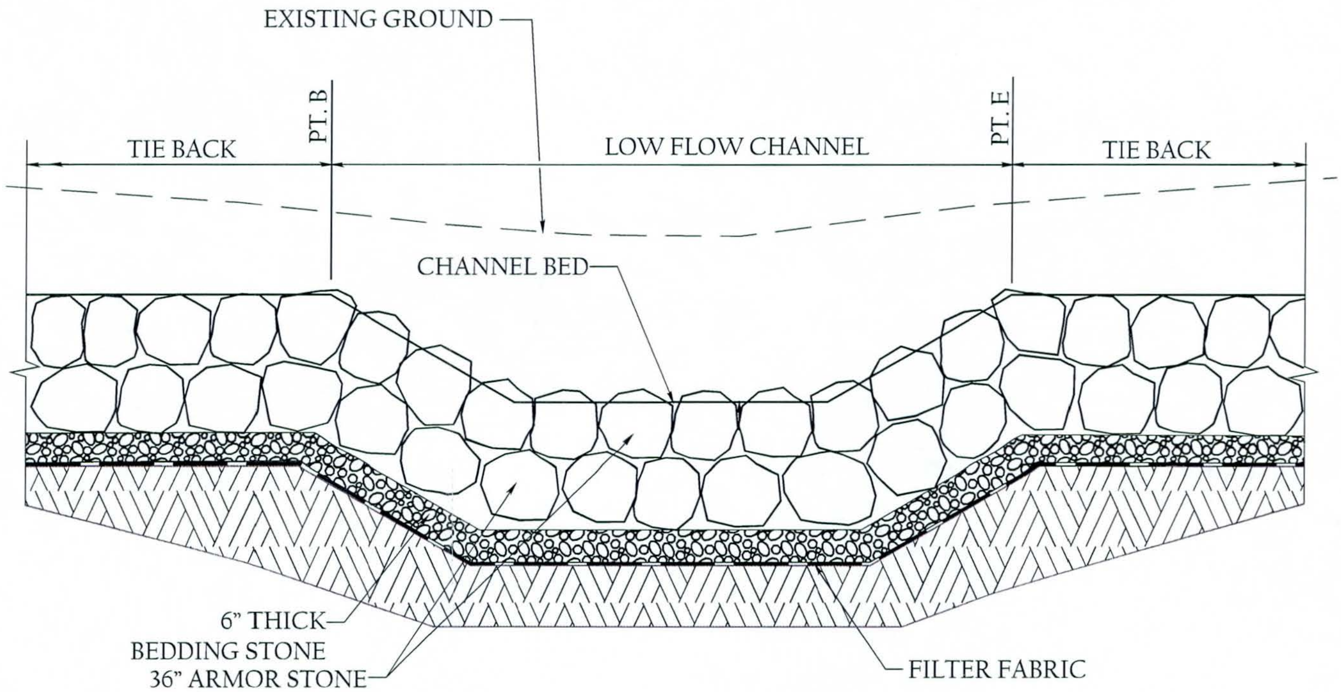

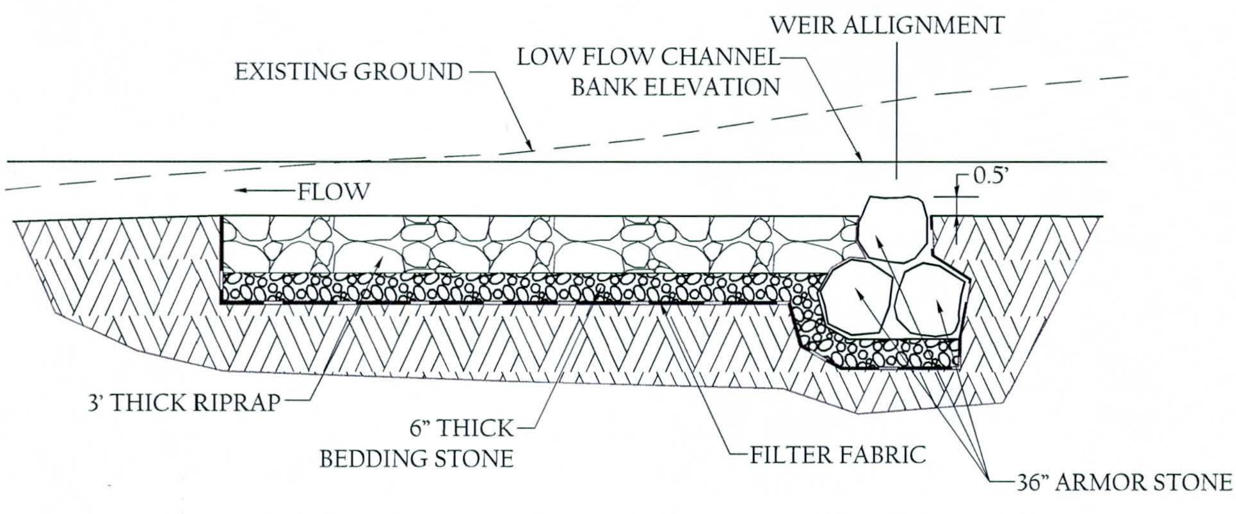

LFC Elevation Section

Figure 4-2

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4.4 Old 115th Avenue Grade Control Improvements

The proposed project relies on the grade of the existing Old 115th Avenue roadway to provide significant open water areas to the east of the roadway. The existing roadway section acts as a grade control structure and appears to be made up of a combination of compacted fill and asphalt paving. The existing culverts under the roadway are only capable of conveying low flows, and large storm flows overtop the roadway surface. The roadway surface and embankment are no longer maintained and have experienced significant erosion in recent years. Breaching of the existing roadway embankment would result in a significant drop in the upstream water surface elevations of approximately 1-2 feet, and result in a large reduction in the open water areas of the project.

To maintain these open water areas over the life of the project, improvements are proposed to reinforce the existing roadway embankment. Due to the highly erosive nature of large flow events in the river, a roller compacted concrete (RCC) spillway type section is proposed to cap the existing roadway embankment. The RCC section is proposed to consist of two 12-inch lifts of compacted concrete. A cutoff wall is proposed on the upstream side to prevent erosion and undercutting of the section, and riprap revetment is proposed on the downstream side for erosion control. Riprap is proposed on the downstream side in lieu of extending the RCC section due to the high ground water table. A cross section of the proposed grade control section is shown on Figure 4-3.

4.5 Riprap Bank Protection and Cross-Vane Weirs

Riprap stone protection is included in the project to provide protection at the existing landfill, roadway culverts, and for the cross-vane weirs and grade control structure at Old 115th Avenue. The use of riprap features was limited to the maximum extend practical. The locations and details of the riprap features shall be shown on the plans. The riprap was sized using the USACE criteria based on the results of the with-project hydraulic modeling. The required sizes and gradations shall be shown on the plans and in the project specifications.

Riprap bank protection is proposed along the northern boundary of the existing landfill on the east side of El Mirage Road. The proposed grading will result in improved open water, wetland, and riparian corridors along the northern boundary of the landfill, and riprap bank protection is provided prevent erosion along the existing embankment.

Cross-vane weirs are provided in two locations west of Old 115th Avenue to control the flow of water which leaves the project boundary in the existing low flow channels. In the rivers current configuration, a significant portion of the daily low water flows leave the project site in an existing channel that flows south towards the Phoenix International Raceway (PIR), west of Old 115th Avenue. Two cross-vane weirs are proposed along this channel system, within the project boundary, to balance the low water flows between the existing channel and the new corridors to be constructed along the north side of the river.

Cross sections of the riprap bank protection and cross-vane weir are shown on Figures 4-4 and 4-5.

4.6 Debris Removal

As stated previously, there are significant amounts of debris. Site visits were undertaken to locate and distinguish between the isolated and areal types of debris in the Tres Rios corridor. Isolated areas are areas where a single piece of debris is located. For example, some areas contained

The site preparation contractor will remove only the surface debris. Specific depth limitations will be decided during final design of the site preparation task. The specifications for the site preparation task will define the limitations of removal and how to backfill or grade the area of removal.

4.7 Waste Removal

Waste will certainly be encountered during construction. Depending upon where it is found, for example beneath structures, reservoirs, etc., its depth and thickness will determine how much excavation is required. A decision tree will be developed during final design as to what procedures should be followed depending upon where and what type of waste is encountered. The final decision on what to do during construction will need to be made by the USACE site construction staff in concert with the COP and other regulatory agencies.

4.8 Operations/Maintenance Considerations

Care must be taken in the site grading to avoid steep slopes in areas subject to saturation.

- Embankment slopes in the vicinity of the wetlands and canals will require regular inspection to evaluate the condition of the liners under these features. Plant growth, storm flows and settlement all can disturb a soil liner and weaken its integrity. A leaky liner can go undetected for a considerable time, saturating and weakening soils, leading to slope failure or further settlement.

Erosion of soils around Project features adjacent to stormwater outfalls, river embankments, or the LFC may occur over time. Regular inspection of these facilities needs to occur.

- The side slopes of the LFC will be subject to erosion because the slopes are steep (variable from 1:1 to 3:1). If concentrated flows are allowed to drain down the side of the LFC it will most likely create deep erosion cuts in the bank. The final grading plan will ensure that concentrated flows do not reach the LFC banks in an unprotected location. Regular maintenance of the outfall channels, canals and other infrastructure can prevent the diversion of flows to unprotected locations.
- The stormwater outfalls will be designed to carry the 10-year storm runoff. If storm events in excess of the design storm occur then erosion adjacent to these outfall channels is likely.

Timely repair and maintenance of any damaged areas will prevent further damage and limit costs.

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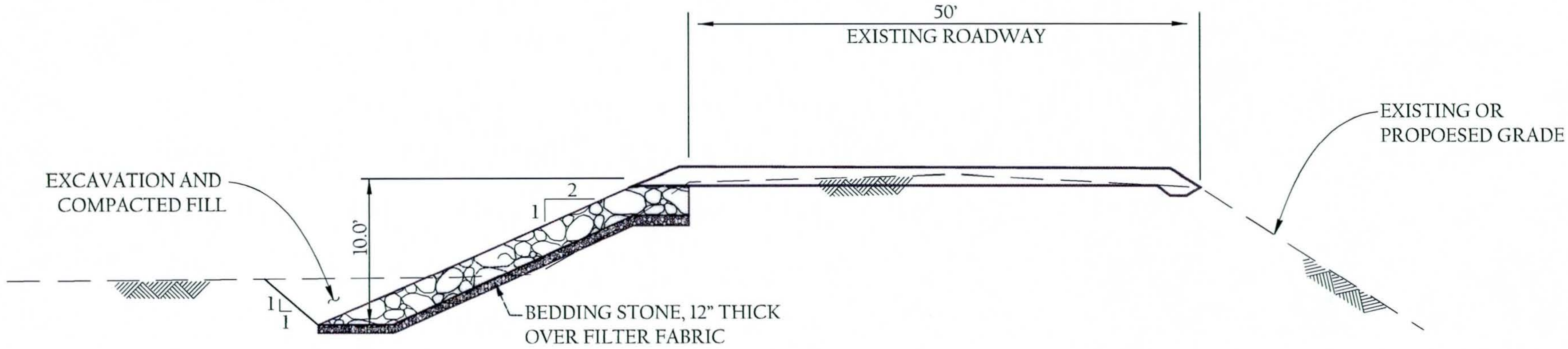

FIGURE 4-3 CONCRETE AND RIPRAP GRADE CONTROL STRUCTURE
NOT TO SCALE

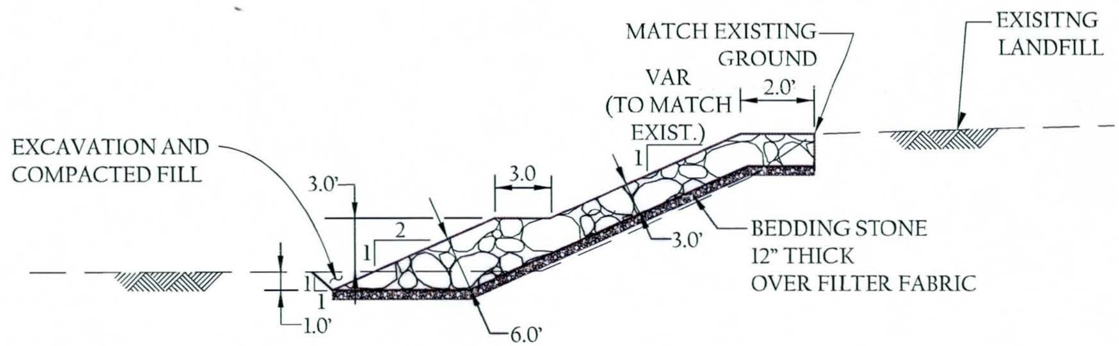

FIGURE 4-4 RIPRAP BANK PROTECTION
NOT TO SCALE

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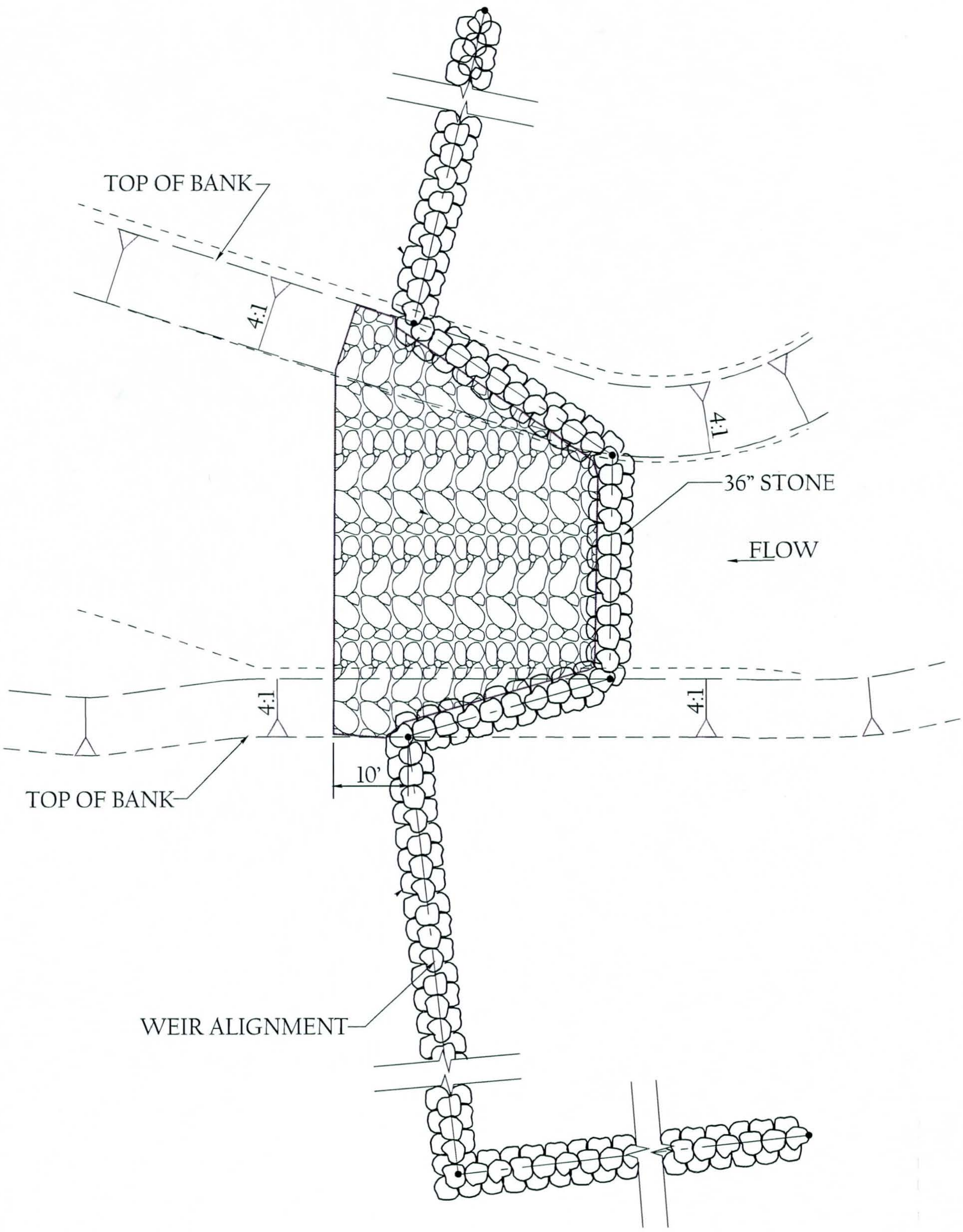

Cross Vane Weir

Figure 4-5

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References