Sahuarita FARMS

APPENDIX F: RIVER MASTER PLAN

FICO

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TOWN OF SAHUARITA

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HYDROLOGY & GEOMORPHOLOGY, INC

Sahuarita Farms River Master Plan Report

Submitted in conjunction with the Sahuarita Farms Specific Plan

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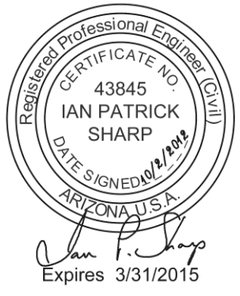


Executive Summary

Introduction

The Santa Cruz River is the geographic heart of both the Town of Sahuarita and the FICO property. For many decades the residents of this region have envisioned opportunities to transform the river corridor into a recreational and natural asset that benefits both existing and future generations. Previous planning studies by the Town of Sahuarita and Pima County reflect a comprehensive roadmap for a river-centered community. Growth pressures, exerted from current and future development projects adjacent to the FICO property, require thoughtful and farsighted long-range planning of land use, infrastructure and regional flood control. This River Master Plan (RMP) creates a long-term management strategy for the Santa Cruz River corridor that complements the Town's current land use and infrastructure plans.

FICO land along the Santa Cruz River corridor extends over 14 linear miles, stretching from Canoa Ranch to Pima Mine Road. This RMP addresses only the portion of the FICO lands located within the Town of Sahuarita, which comprise a reach of approximately 10 river miles, and which is known as Sahuarita Farms. FICO's long-term vision for Sahuarita Farms is consistent with previously approved Town and County plans which envisioned a narrower floodplain and the transition to non-agricultural land uses. This vision can only be realized through the implementation of a regional flood control strategy that will better manage flooding and reduce the footprint of the floodplain. The flood control elements of the RMP are integral to the Town's and FICO's overall vision for the area.

Problem Statement

Over the last century the Santa Cruz River has significantly degraded between the City of Tucson and Pima Mine Road. This degradation is due primarily to headcutting, which is a form of erosion that progressively migrates upstream. ***If left uncontrolled, headcutting will eventually threaten the entire upper Santa Cruz River and its tributaries.*** Headcutting decreases bank stability, increases flood velocities, reduces natural flood attenuation, creates hazardous bank conditions, undermines bridge foundations, damages utility crossings, and reduces the potential for natural riparian habitat to be sustained.

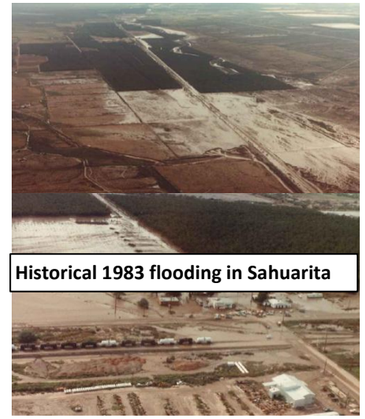
Headcutting & unstable channel banks near Pima Mine Rd.

In addition, the ***Santa Cruz River floodplain is perched and disconnected from the main channel***. During large floods, flows leave the main channel corridor and flow along Old Nogales Highway and the Railroad for miles before returning to the channel. The river no longer has a pristine, natural floodplain. Its current condition is the result of more than a century of inconsistent human intervention, historical changes in the watershed, activities in the river corridor near Tucson, and a patchwork of localized solutions to individual flood and erosion problems.

Several large floods over the past few decades caused extensive flood damages to public infrastructure and private property, and highlighted the need for a comprehensive river master plan. **Without a comprehensive River Master Plan, not only will the Santa Cruz River continue to degrade, the opportunity to protect the River and to create a lasting amenity will become more expensive and more difficult to achieve.**

RMP Concept

The Sahuarita Farms RMP is a fresh approach to river corridor management; one that takes advantage of the unique opportunity provided by a singular owner of over __ miles of the Santa Cruz River and the vision for the Sahuarita Farms development. This RMP is not constrained by many of the challenges that existed during the planning of the numerous river corridors in other areas of the Tucson Basin, which limited engineering solutions to steep soil cement banks with few recreational opportunities and low value riparian habitat. Instead, the Sahuarita Farms RMP includes an improved floodplain that will have a direct connection to the main channel, with channel and terrace features more consistent with the character of the Sonoran Desert. The RMP provides a comprehensive solution that treats the river as an amenity, not just a drainage channel, and will mitigate the existing threats to the river in a manner compatible with the community's economic, environmental, and public safety goals.



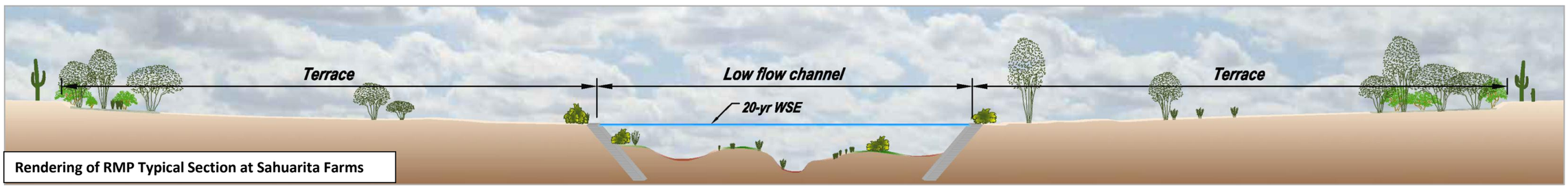
Historical 1983 flooding in Sahuarita

The RMP will create the terraced river cross section illustrated below. This terraced cross section will reconnect the river and its floodplain, safely convey floods and store flood water, provide erosion protection, prevent continued headcutting, and provide a template for habitat and environmental restoration. The low flow channel will have an average width of 500 feet, which is more than twice the width the Santa Cruz River at Congress Street in Tucson, and will fully contain flows up to the 20-year event. The geometry of the low flow channel will be designed with a thalweg, bars and shallow floodplain surfaces that mimic the natural channel features in more stable "reference" reaches of the Santa Cruz River. This natural channel design will help assure sediment continuity and minimize the need for river maintenance. Where development is proposed within 500 feet of the low flow channel, it will be bounded by 5-foot high soil cement (CSA) bank protection to prevent lateral migration. CSA bank protection will be constructed with 2:1 side slopes to facilitate wildlife passage and minimize its aesthetic impact.

Healthy channel & floodplain cross section on Santa Cruz River.

The low-flow channel segment will be flanked by 200 to 500 foot wide flood terraces that will convey the portions of the 100-year flood not carried in the low flow channel. Flood flows on the terraces will be infrequent, have short durations and will be carried at low, non-erosive flow depths and velocities. These terraces will provide opportunities to enhance the river corridor as a regional amenity. Potential uses of the terraces include flood storage, passive and active recreational uses areas, habitat reestablishment areas, wetland/natural recharge areas, and gateway areas to connect to the Town. Together, the low flow channel and terraces comprise a total corridor width of up to 1,300 feet, except at existing narrower bridge crossings.

The RMP outlines a phased construction plan for the RMP corridor, to be implemented in conjunction with development of Sahuarita Farms, other adjacent private development, and construction of nearby public infrastructure.



Rendering of RMP Typical Section at Sahuarita Farms

Benefits

The benefits of a comprehensive RMP for this area extend far beyond the FICO property and the immediate area of influence adjacent to the Santa Cruz River. The scope of the RMP concept is "generational" relative to the lasting positive impacts that it will have on the Sahuarita community. The most significant of these benefits are:

- Public safety
- Regional flood control
- Public open space and recreation – passive & active
- Enhancement of habitat and wildlife corridors
- Regional access and connectivity to and from the river
- Water conservation & aquifer recharge
- Creation of wetlands, open water features and associated habitat
- Reduced public infrastructure cost for bridges, utilities, and transportation
- Removal of existing properties from the 100-year floodplain
- Minimize flood damage potential
- Allows space for natural channel process of erosion, sediment transport, vegetative growth
- Provides a solution to regional headcutting

Environmental & Regulatory Compliance

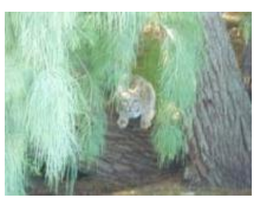
The RMP will meet all applicable environmental and resource agency requirements, such as the Clean Water Act (Section 404 permitting) and the National Environmental Protection Act (NEPA). Early coordination with the US Army Corps of Engineers (USACE) regulatory staff and environmental groups indicates no significant concerns with the RMP plan. In addition, the RMP concept meets federal and local floodplain requirements including no adverse impacts to adjacent properties. Implementation of the RMP will decrease 100-year water surface elevations and flood inundation on adjacent lands.

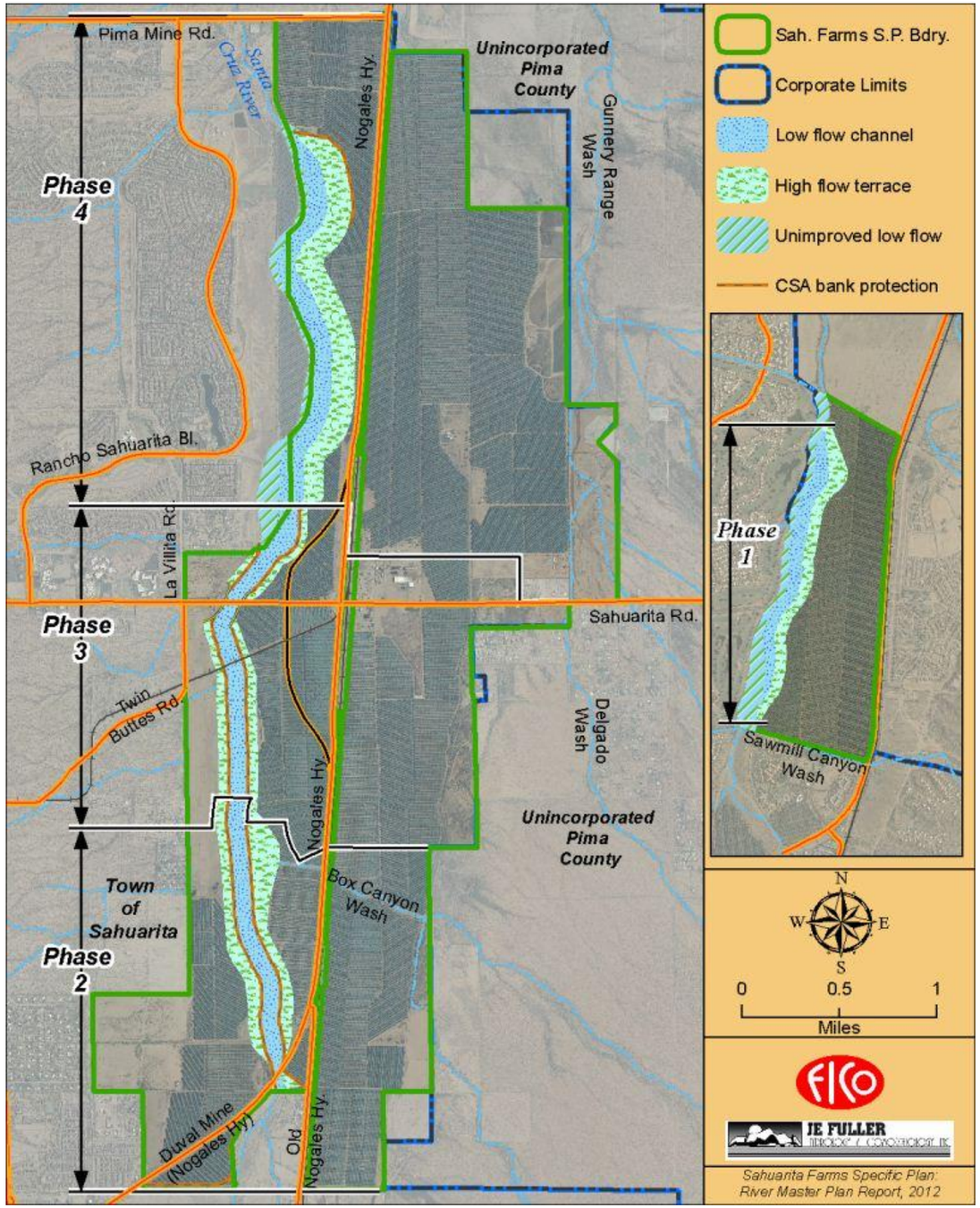
RMP Report

The RMP is a planning document, although sufficient technical analyses have been carried out to assure the feasibility of the proposed plan. Technical documents are attached to the RMP that demonstrate the current existing floodplain conditions, the sediment transport conditions, and to document the RMP design itself. The RMP has been analyzed with detailed modeling to establish water surface elevation profiles, to determine with-project sediment transport, to assure no adverse impacts to adjacent parcels, and also to document with-project flood attenuation to assure that downstream communities will not encounter adverse impacts from this project.

Summary

The Sahuarita Farms RMP provides a unique opportunity to work with a landowner seeking to responsibly develop floodplain lands while restoring a damaged watercourse. Implementation of this RMP will provide a lasting and desirable amenity to the region, while simultaneously providing a centerpiece and foundation for defining the future of the Town of Sahuarita.



Sahuarita Farms RMP Overview.

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List of Selected Acronyms and Definitions

20-year flood
: Flood that has a 5 percent chance of being equaled or exceeded in a single year.

100-year flood
: Flood that has a 1 percent chance of being equaled or exceeded in a single year. The 100-year flood has a 1 in 100 probability of occurrence in a given year. FEMA calls this the Base Flood.

Bio-engineered plantings
: Bio-engineered plantings employ a combination of biological (plants) and mechanical (grading) concepts. Erosion will be prevented through prudent placement of plants and through grading.

cfs: Cubic feet per second.
: Measurement of water flow rate. 1 cfs equals 449 gallons per minute.

CSA: Cement stabilized alluvium.
: Composed of a mixture of native soils, Portland cement, and water compacted to a high density.

EHS Erosion hazard setback.
: Regulatory tool used by agencies such as Town of Sahuarita. Structures with walls and roofs are not allowed within the EHS.

FEMA: Federal Emergency Management Agency.

FICO: Farmers Investment Co.
: FICO owns 7,000 acres of agricultural land in the Sahuarita Area including the "Continental Farms" and the "Sahuarita Farms". The Sahuarita Farms is the northern of the two farms and is entirely within the Town of Sahuarita. The Continental Farms is the southern of the two farms and is partly within the Town and partly within unincorporated Pima County.

Freeboard:
: Additional space provided in a channel to allow for additional capacity and account for uncertainties.

RMP: River Master Plan.
: River Master Plan refers to enhancements and improvements to the Santa Cruz River channel and floodplain within Sahuarita Farms. RMP improvements are proposed within all of the Sahuarita Farms SP area.

GCS: Grade Control Structure.
: Hardened structures spaced intermittently within the low-flow channel designed to prevent long term channel degradation.

Sahuarita Farms
: Sahuarita Farms refers to the 6,000 acres (approx.) of land that FICO owns within the Town of Sahuarita. This includes all of the Sahuarita Farms and the northern portion of the Continental Farms.

SP Sahuarita Farms Specific Plan.
: The Sahuarita Farms Specific Plan is a comprehensive planning and regulatory document that covers all of FICO's Sahuarita Farms and the portion of the Continental Farms within the Town of Sahuarita.

USACE: United States Army Corps of Engineers.

WSE: Water surface elevation.

List of symbols used in figures

Current ownership, corp. limits, & subdivisions
- Corporate Limits
- FICO's Sahuarita Farm
- FICO's Continental Farm
- Existing subdivisions
- San Xavier Dist./Tohono O'odham Nation
- Private land
- State trust land

Existing transportation features
- Major streets
- Minor streets
- Railroad
- Interstate

Current regulatory drainage features
- PC Defined washes
- PC Defined washes > 2,000 cfs
- Existing bank line
- Existing erosion hazard setback
- Updated existing floodplain
- Effective Floodway
- Effective Zone AE
- Offsite watersheds
- Non-contributing watershed areas

Aerial Imagery
2010. Source: http://gis.apfo.usda.gov/arcgis/services

Planned FICO S.P. land uses
- Sahuarita Farms S.P. Boundary
- Non-specific land use
- AC
- EC
- IP
- RCD
- RP
- UN
- VN
- S.P. Road Corridors

Planned Town features
- Channel stabilization
- Realigned Nogales Highway

Planned FICO S.P. drainage features
- Low flow channel
- High flow terrace
- Unimproved low flow
- With-project floodplain
- Tributary corridors
- Grade control
- Grading limit (low-flow)
- CSA bank protection
- RMP EHS baseline
- EHS with RMP in place

Section 1 INTRODUCTION

1.1 Introduction

Farmers Investment Co. (FICO) is developing a master plan for a portion of its land called "Sahuarita Farms." FICO plans to transition Sahuarita Farms from an exclusively agricultural operation to a blend of urban, public, open space, and agricultural uses. The Santa Cruz River, which flows through Sahuarita Farms, is an important asset and the most significant natural feature within the Town of Sahuarita; shaping its topography, history, surrounding infrastructure, and the future development of the land. The river is also a liability, because it is a source of flooding, with three very large floods in the last 40 years.

One of FICO's goals is to enhance the river's natural assets by enhancing and preserving the features and habitat that once characterized the river, while simultaneously minimizing the flood risks. To achieve this goal, a plan to manage, enhance, improve, and manage the Santa Cruz River through Sahuarita Farms is necessary. This document outlines a River Master Plan (RMP) for the Sahuarita Farms reach of the Santa Cruz River, and summarizes the supporting technical documents attached as Appendices.

JE Fuller Hydrology/Geomorphology Inc. (JEF) has prepared this report on behalf of FICO and the Sahuarita Farms project team. The purpose of the RMP is to present the framework for river improvements and long-term enhancements of the Santa Cruz River within the Sahuarita Farms area. This RMP report is submitted to the Town of Sahuarita (Town) in conjunction with the Sahuarita Farms Specific Plan (SP). The SP and RMP provide the vision for future land uses on FICO's property within the Town.

1.2 Project Location

Sahuarita Farms is located within eastern Pima County, entirely within the Town's incorporated limits (Figure 1-1). FICO owns approximately 7,000 acres of agricultural land within and near the Town. FICO's land includes contiguous parcels called "Continental Farms" and "Sahuarita Farms," as shown on the insets on Figure 1-1. The Sahuarita Farms area is located entirely within the Town and the SP boundary, while only a portion of Continental Farms is within the Town and the SP boundary. Together, the Sahuarita Farms and the northern 573 acres of the Continental Farms make up the Specific Plan area.

With an area of approximately nine square miles, Sahuarita Farms accounts for nearly one-quarter of the Town's total land area. Nogales Highway and the UPRR divide the project area from east to west. The historic intersection of Nogales Highway and Sahuarita Road is within Sahuarita Farms, placing this project within the heart of the Town of Sahuarita.

1.3 RMP Limits

The Sahuarita and Continental Farms areas are both located along the Santa Cruz River, but are separated from each other by approximately two miles of mostly undeveloped land. Approximately eight miles of the Santa Cruz River flows through the Sahuarita Farms planning area. Approximately two river miles are in the Continental Farms area. The RMP will modify the river through all of FICO's lands within the Town of Sahuarita, including all of Sahuarita Farms and the northern part of Continental Farms.

The southernmost road crossing the Sahuarita Farm is labeled on most area maps as Nogales Highway east of and at the river on most maps, and as Duval Mine Road to the west of the project. On some local maps, it is labeled as Duval Mine Road at the river. In this report, to avoid confusion between Nogales Highway and Old Nogales Highway, we refer to the road at the river as Duval Mine Road.

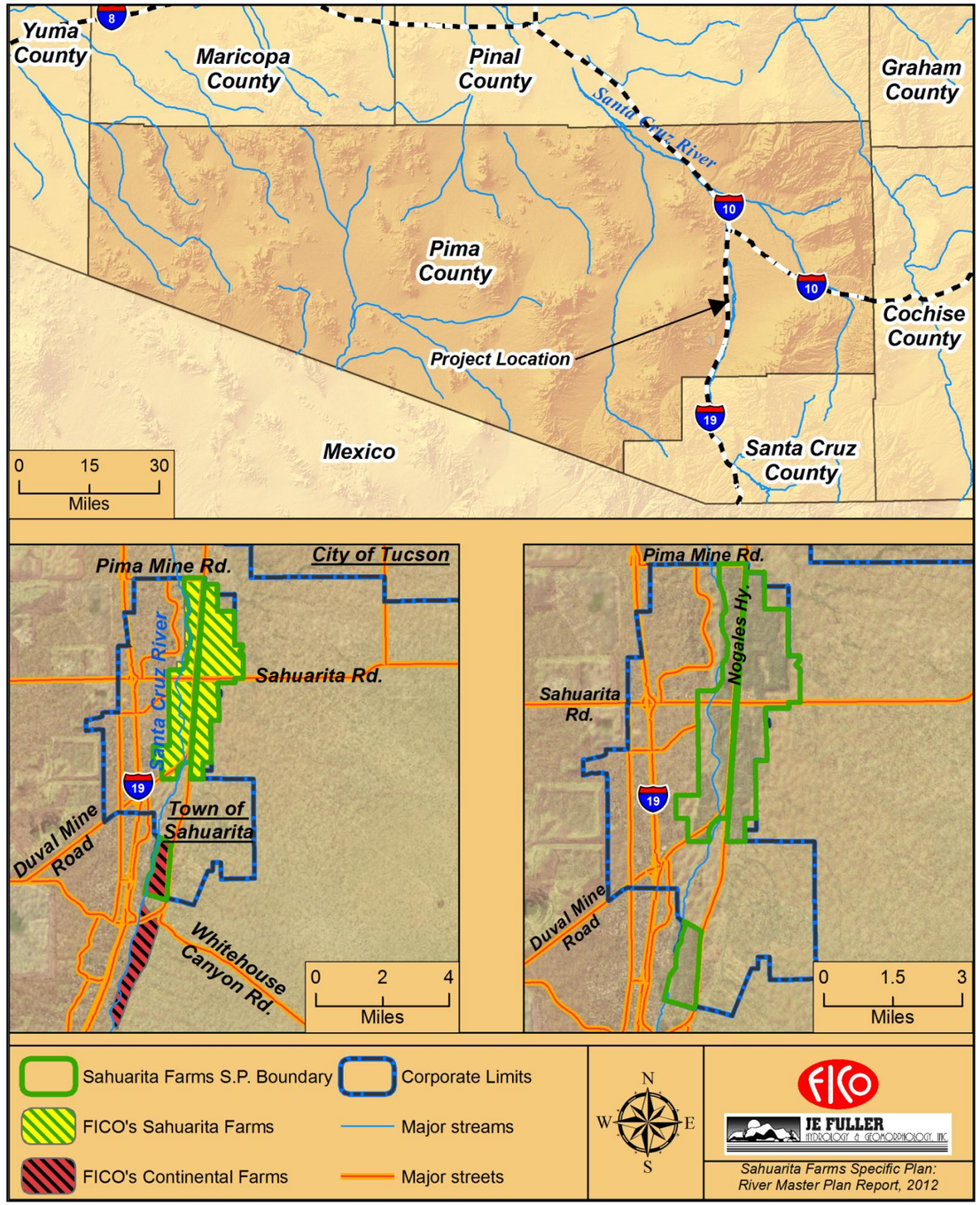


Figure 1-1. Sahuarita Farms Specific Plan location map showing Sahuarita Farms and Continental Farms.

1.4 Specific Plan Overview

The Specific Plan will take Sahuarita Farms from an agricultural land use to a mix of uses in keeping with the Town's General Plan. The Specific Plan proposes the development of a wide variety of land uses occurring over a long period, possibly as much as 50 or more years. Future land uses proposed in the Specific Plan include residential, commercial, office space, and light industrial, along with public uses, open space, and river corridor (Figure 1-2). The RMP report describes the river corridor portion of the Specific Plan (shown as Low-Flow Channel and High-Flow Terrace in Figure 1-2).

1.5 River Master Plan Overview

Sahuarita Farms will be developed gradually, with developed areas removed from the FEMA floodplain as discussed in Section 3.6. Improvements to mitigate existing flood and erosion hazards are necessary to allow for safe development of Sahuarita Farms, and will be accomplished by following the River Master Plan, which is outlined in Section 4. The RMP prescribes enhancements to the river which consist of a low-flow channel with high-flow floodplain terraces. The low-flow channel will convey the most frequent, hazardous, and erosive flows, and will protect Sahuarita Farms infrastructure from frequent flood damage. The high-flow terraces will convey and contain the portion of the largest floods that exceed the low-flow channel flow capacity. The high-flow terraces will be inundated infrequently, and will experience low velocities and depths, allowing for a variety of uses on the terraces that will further enhance the river and provide an amenity for the Town and the surrounding communities. The uses of the terraces are described in more detail in Section 8 of the RMP, but include passive and active recreation, habitat reestablishment, wetlands, and natural recharge, as well as gateway areas to connect the river corridor to adjacent land uses throughout the Town.

Implementation of the RMP will achieve the following benefits to the community:

- Prevention upstream migration of headcutting that threatens the existing river corridor.
- Protection of existing public infrastructure currently at risk from flood and erosion damage.
- Reduction of flood risks and flood protection costs required for future public infrastructure.
- Reduction of long-term, on-going flood hazards for existing homes and private lands.
- Enhancement of natural habitat and river function in the highly disturbed Santa Cruz River.
- Provision for connected wildlife corridors and habitat along the river and tributary corridors.
- Provision for open space, passive and active recreation, trails and other amenities.
- Provision for sufficient space for overbank flood storage and natural low flow channel migration.
- Creation of areas that can be used for groundwater recharge and/or wetlands.

These benefits and opportunities cannot occur without the development of Sahuarita Farms. Thus, the Specific Plan and the River Master Plan are linked.

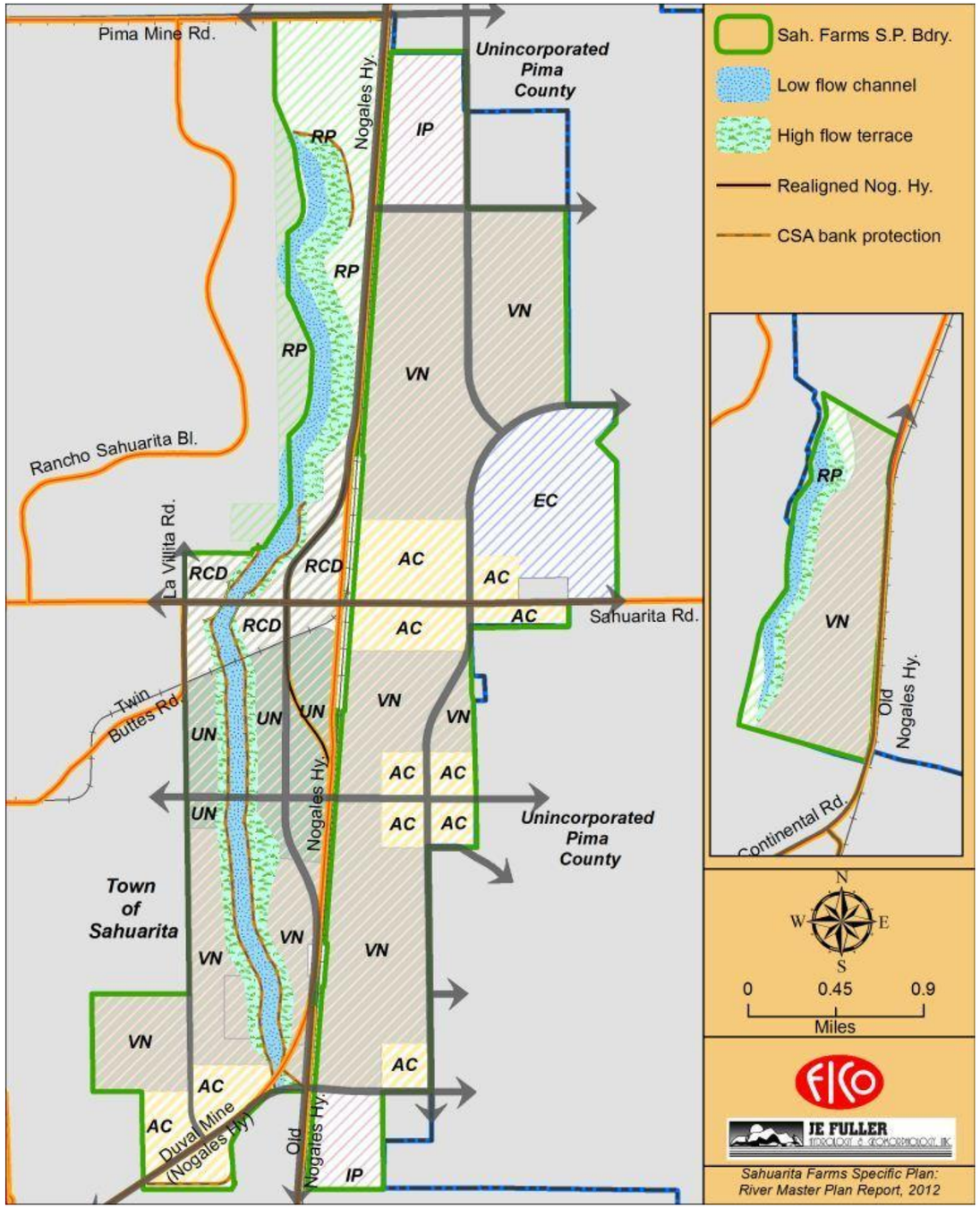


Figure 1-2. Sahuarita Farms Specific Plan (SP) proposed land uses.

Section 2 PROJECT AREA AND LAND USES

2.1 Adjacent Land Use and Ownership

Sahuarita Farms is surrounded by a mix of land uses and property ownership (Figure 2-3). In recent years, the Town has experienced significant growth on both sides of the I-19 corridor, some of which abuts Sahuarita Farms' western perimeter. Only a few areas have been developed along the eastern boundary of Sahuarita Farms, with the exception of residential development along Sahuarita Road and the new Walden Grove High School.

The northern boundary of Sahuarita Farms at Pima Mine Road abuts the Tohono O'odham Nation. East of the Nogales Highway and the Tohono Nation, there is an existing sand and gravel mining operation on unincorporated Pima County land. The Santa Cruz River exits the Sahuarita Farms parcel just south of Pima Mine Road, crosses private land, and then enters the Tohono O'odham Nation (Figure 2-1)

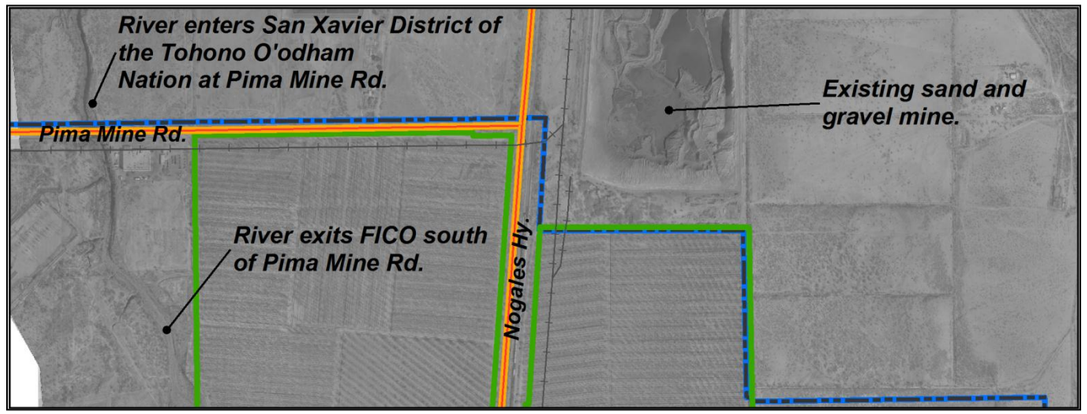


Figure 2-1. Aerial photo of the northern Sahuarita Farms boundary showing adjacent land uses.

The south side of Sahuarita Farms is bounded by undeveloped State Trust Land, land controlled by Pima County, another sand and gravel operation located east of Old Nogales Highway, and low density residential development along the west side of Old Nogales Highway (Figure 2-2). The river enters Sahuarita Farms at Duval Mine Road.

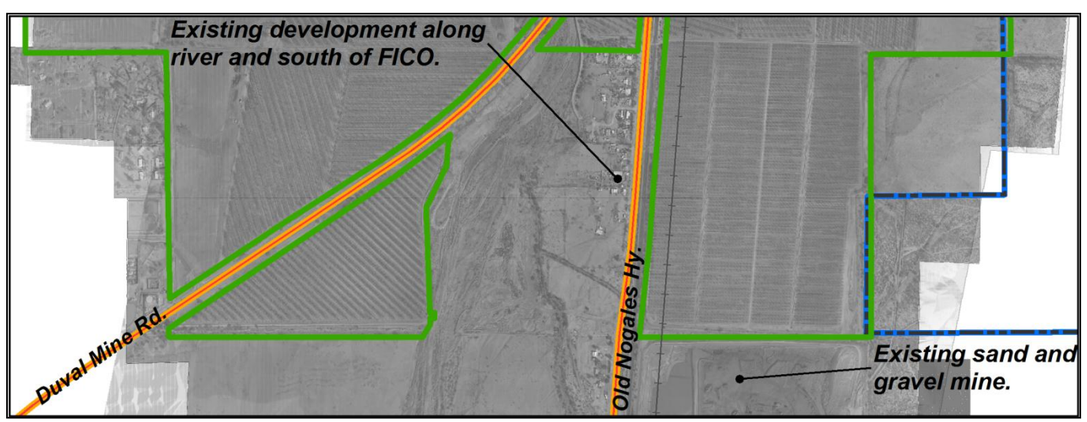


Figure 2-2. Aerial photo of the southern Sahuarita Farms boundary showing adjacent land uses.

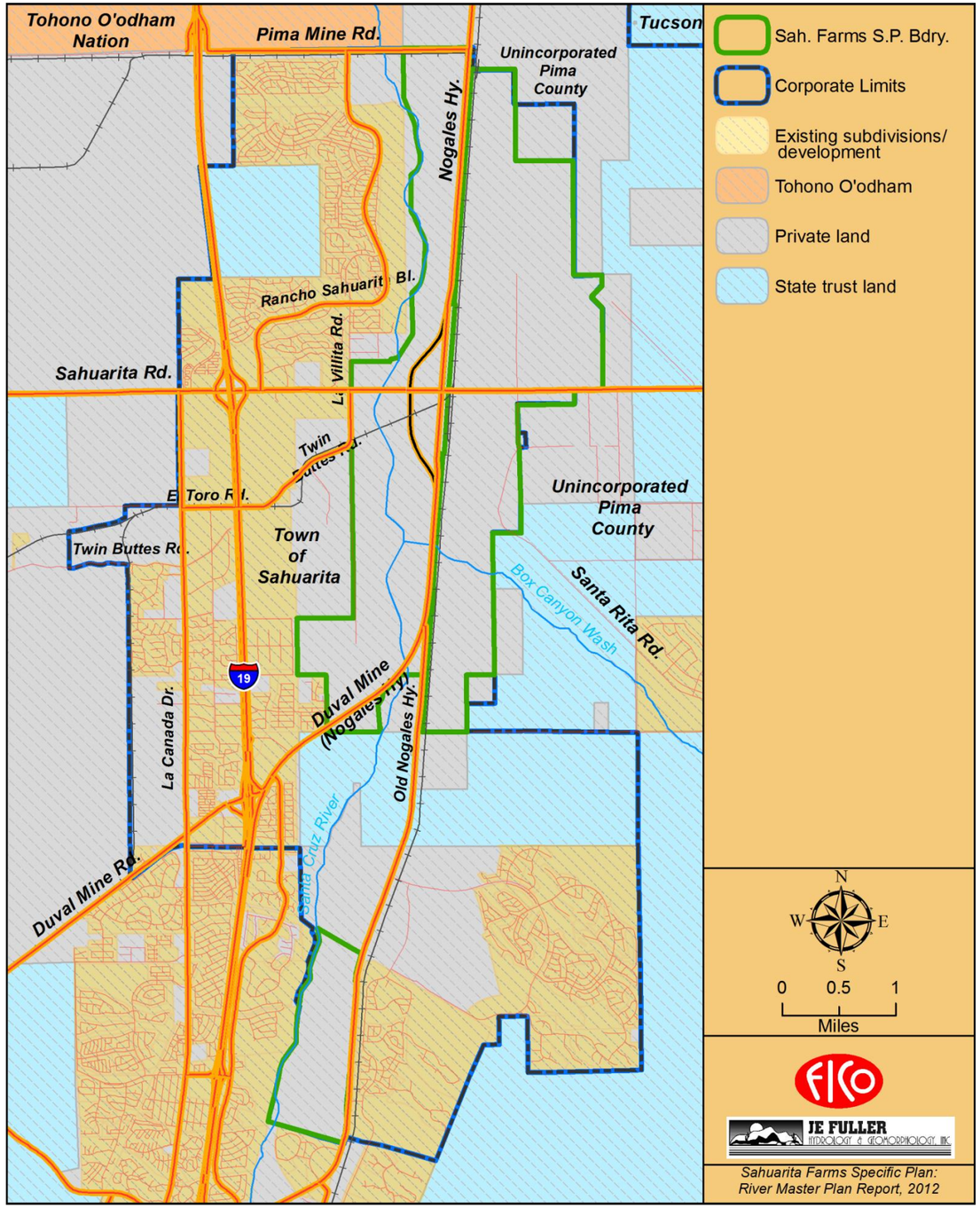


Figure 2-3. Land management and ownership near Sahuarita Farms.

2.2 Existing Sahuarita Farms Land Use

Sahuarita Farms is comprised mostly of Pecan orchards and a Pecan processing facility. The other portions of Sahuarita Farms are fallow, are part of the river channel, or are open rangeland. Figure 2-4 is an aerial view of the project area.

Current Drainage Conditions

The Santa Cruz River flows through Sahuarita Farms. The local drainage naturally flows toward or parallel to the river. However, because the Pecan orchards are primarily gravity irrigated (Photo # 1), the leveled and contoured orchards now drain along the irrigation contours, with much of the local runoff retained on-site.

Photo # 1. Existing pecan orchards with irrigation ditches.

Photo # 2. Alternating pecan row directions.

Local washes draining through the property to the river now have berms along their banks to protect the fields from flooding. Photo # 3 (below) shows Box Canyon Wash, looking east toward its confluence with the Santa Cruz. Note the straight alignment with berms on either side. Photo # 4 looks north along FICO's eastern boundary. The row of vegetation on the mid-left side of the frame is growing on an existing berm that prevents offsite flow from entering FICO lands. The berms in these photos were built many decades ago, are visible on 1936 aerial imagery, and predate the current land ownership.

Photo # 3. Aerial view of Box Canyon Wash confluence with Santa Cruz River.

Photo # 4. Aerial view of FICO's eastern boundary with new Walden Grove High School.

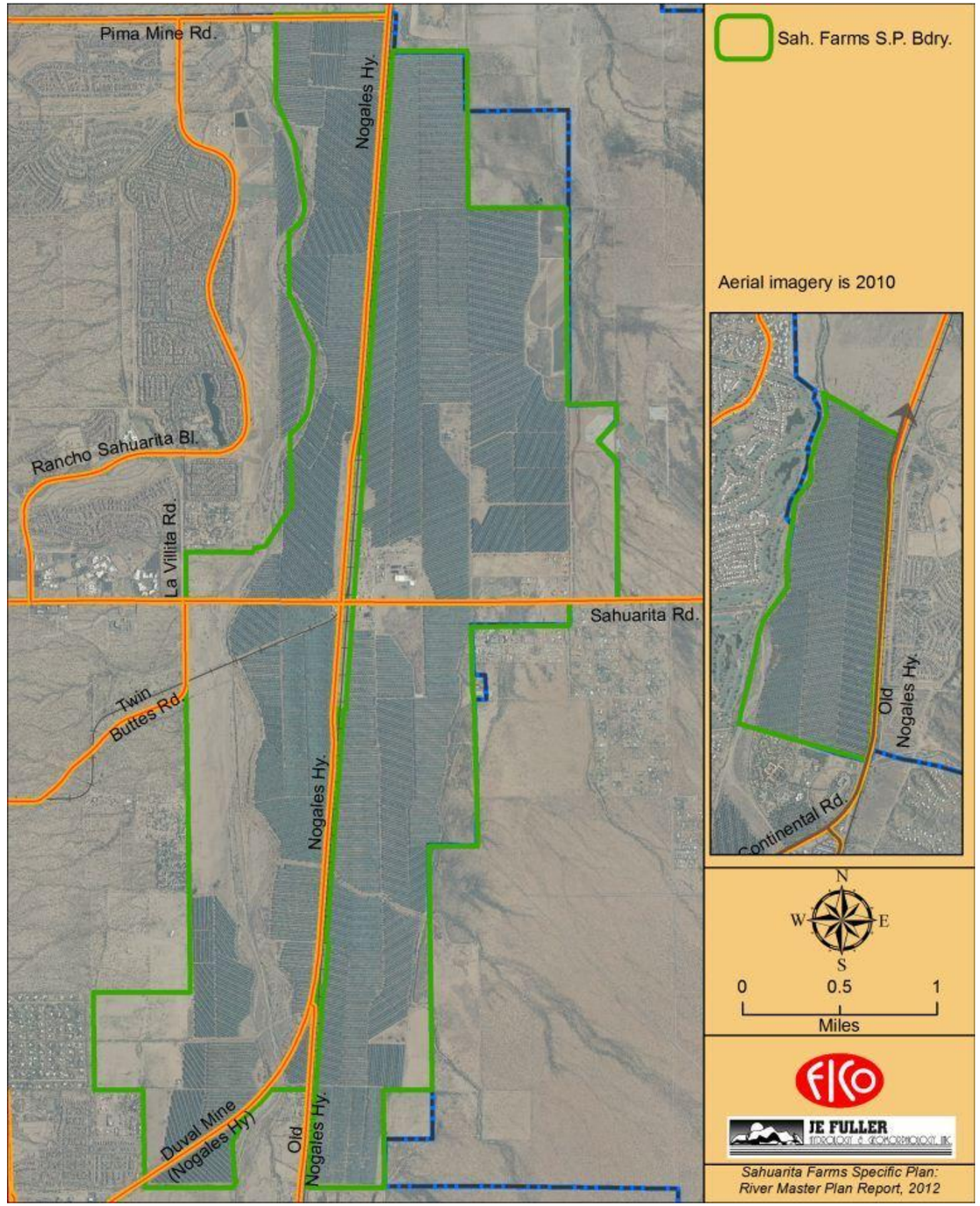


Figure 2-4. Current aerial overview map.

Section 3 SANTA CRUZ RIVER

3.1 Santa Cruz River

The Santa Cruz River originates in the San Raphael Valley in southern Arizona. From there it drains south into Mexico, then turns west and north to reenter Arizona, flowing north through the Town. The Santa Cruz River is an uncontrolled river with a total drainage area of approximately 1,662 square miles, as measured at Continental Road.

The Santa Cruz River at Sahuarita Farms flows only in response to large precipitation events or during brief periods of snowmelt runoff from the upper elevations of the watershed. Historically, the Santa Cruz had reaches of ephemeral and perennial flows, although this reach has been ephemeral for at least the past 100 years. Today, the river is normally dry, due to declining ground water tables and other watershed changes that have decreased the frequency and duration of low water flows.

3.2 Current River Conditions Within FICO

The condition and characteristics of the Santa Cruz River channel change significantly from Pima Mine Road to Continental Road. At the upstream end of FICO's land on Continental Farms, the main channel is relatively wide, shallow, and stable, which is strikingly different from the highly incised, narrow, degraded channel that exists at Pima Mine Road. This stark contrast in river conditions occurs because of historical headcutting and degradation on the Santa Cruz River that is migrating upstream from Tucson over the past 150 years. This headcutting has reached a point just upstream of Pima Mine Road, and now threatens to migrate through the river segments within the Town.

River at Pima Mine Road

Near Pima Mine Road, the river channel is incised to a depth of nearly 30 feet, with a width of less than 50 feet, and is characterized by steep, unstable banks and minimal riparian habitat. Historical topographic and elevation data at Pima Mine Road (Figure 3-1) indicates that the channel invert dropped by about 10 feet between 1969 and 1998, and possibly up to 30 feet between 1936 and 1998 (Photos #5-10). This historical degradation is the result of headcutting migrating up the river system, and should be expected at other crossings upstream in the future, although similar data document no recent degradation at Sahuarita Road, Duval Mine Road, or Continental Road. If left uncontrolled, it is likely that the headcutting will further incise and degrade the river beyond Duval Mine Road.

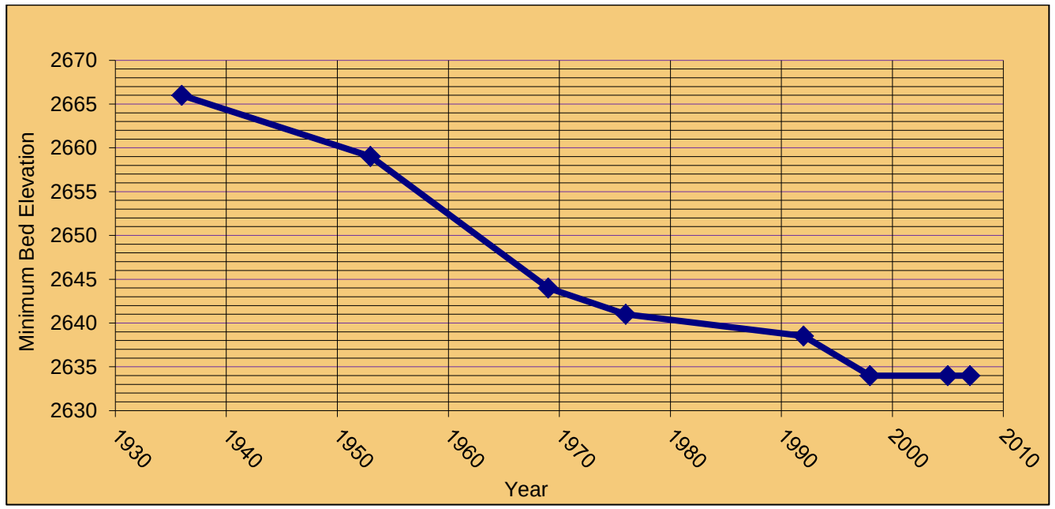


Figure 3-1. Historic bed elevation at Pima Mine Road showing up to 32 feet of headcutting since 1936.

Photo # 5. River channel at Pima Mine Road.
Photo looks downstream from Pima Mine Rd. Bridge at the incised channel, and steep unstable channel banks.

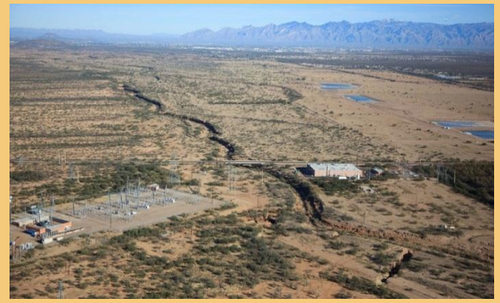


Photo # 6. Downstream facing oblique at Pima Mine Rd.
Note how the deeply incised, narrow channel extends downstream beyond field of view.

Photo # 7. River channel at Pima Mine RR Bridge
Looking upstream from Pima Mine Road at incised channel.

Photo # 8. Looking upstream at Pima Mine Road Bridge
The arrow points at the top of a 16 ft. survey rod.

Photo # 9. Close up of west pier of Pima Mine Rd. Bridge
The pier pile shafts are exposed due to scour and long-term streambed degradation. The pier base was 6 feet below the channel bed when the bridge was built in ~1969.

Photo # 10. Eroded unstable bank upstream of Pima Mine Rd.
Note the highly incised channel bank with scalloped, deeply rilled banks and poor vegetative cover.

River Between Pima Mine Road and Sahuarita Road

Between Pima Mine Road and Sahuarita Road, the headcut terminates and the river channel changes from the deeply entrenched channel at Pima Mine to a wider, more stable channel. Within this reach banks become more stable and somewhat vegetated, although the river bed itself has little to no vegetation and is fairly flat across the floor of the channel corridor.

Photo #11. River channel between Pima Mine & Sahuarita Rds. View looking upstream mid-way between Pima Mine Road and Sahuarita Road.

Photo #12. River bed between Pima Mine & Sahuarita Rds. View looking downstream within the main channel showing the sandy, flat river bottom.

River Between Sahuarita Road and Duval Mine Road

While the main channel is nearly 30 feet deep and 50 feet wide at Pima Mine Road, just three miles upstream at Sahuarita Road, it is only 10 feet deep and about 200 feet wide. The channel at Sahuarita Road has a skewed approach and is located on a bend which has caused sediment to accumulate in the bridge section and reduce its capacity. Construction of the Town's new bridge may remove the sediment deposition, but without further upstream and downstream river enhancements, future sedimentation is likely.

Photo # 13. River channel near Sahuarita Road. View looking downtream toward the Sahuarita Rd. Bridge. Note that a hgih-flow terrace occupies the east 2/3 of the bridge.

Photo # 14. Oblique view of channel at Sahuarita Rd. View looking upstream at the channel through the Sahuarita Rd. and UPRR bridges.

The UPRR Spur Bridge is a relatively low structure that crosses the river at a high skew angle. This structure has been damaged by recent floods, including the 1993 event. The photos below provide some documentation of the existing bridge conditions.

Photo # 15. UPRR Spur bridge. This picture shows two segments of the bridge. The bridge was destroyed during the 1993 flood.

Photo # 16. UPRR Spur bridge from channel This photo shows how low the spur bridge is relative to the floodplain terrace.

The photos below show the channel bottom between Sahuarita Road and Duval Mine Road.

Photo # 17. River channel at UPRR Spur Bridge. This picture faces downstream from the Twin Buttes RR spur. The existing low-flow channel is on the east (right) side.

Photo # 18. River Channel downstream of Duval Mine Rd. This photo was taken one-half mile downstream of Duval Mine Road.

River at Duval Mine Road

The Duval Mine Road Bridge is shown in the photos below. The bridge is at a severe skew to the river and the opening is choked from sediment accumulation. Just upstream of the bridge there is an existing spur dike on the east bank that guides flows into the bridge. The existing structures on the back side (east) of the dike are within the floodplain.

Photo # 19. Duval Mine Road bridge.
This photo looks from the east bank facing north (downstream.) The east side of the bridge is relatively free of sediment accumulation while the west (left) side is choked with sediment and vegetation. Arrows indicate flow direction and the match point on Photo #20.

Photo # 20. Oblique view of Duval Mine Road bridge.
This photo faces southeast and shows the skewed alignment of the bridge to the channel.

Photo # 21. River bed upstream of Duval Mine Road
This picture looks upstream from within the channel. The spur dike is on the left side of the frame.

Photo # 22. River channel upstream of Duval Mine Road
This photo is facing downstream (north) from the river channel near Duval Mine Road. At the top left of the frame is FICO's southernmost Pecan Orchard within Sahuarita Farms.

River near Continental Road

Eleven miles upstream of Pima Mine Road, the channel is about eight feet deep and about 600 to 800 feet wide. The channel has established a low-flow channel with its high-flow terraces, with vegetated banks. The channel bottom also has some vegetation and bars. Near Continental Road the river channel appears to be much healthier than at Pima Mine Road. The photos below demonstrate current conditions between Quail Creek Road and Continental Road.

Photo # 23. River channel near Quail Creek Road
This picture looks downstream and is taken just upstream of the Quail Creek Road alignment.

Photo # 24. River channel downstream of Continental Road
This photo is facing upstream (south).

Photo # 25. River channel at Continental Road.
This picture looks upstream from the right bank south of Continental Road.

Photo # 26. Aerial view of channel south of Continental Rd.
This photo is facing upstream (south). The channel at this location is much broader and less incised than the channel at Pima Mine Road. Blue arrow indicates Continental Rd.

3.4 Potential for Flood and Erosion Damage Along the River

Pima County requires that new structures (walled and roofed buildings) have a minimum "erosion hazard setback" of 500 feet from the nearest bank of the Santa Cruz River, as shown on Figure 3-2. This is prudent, considering that the Santa Cruz River is capable of moving hundreds of feet in a single large flood. The risk of bank erosion is also present in more common floods. For example, erosion damage to FICO's pecan orchards often occurs when the river floods. Usually, this damage is localized and limited to the outside bank of river bends where the unconsolidated native soils are unprotected. The photographs below show examples of this type of erosion.

Photo # 27. Aerial view of bank erosion w/in FICO.

Photo # 28. Ground view of bank erosion w/in FICO.

In addition to the localized bank erosion and headcutting described above, flood inundation has also caused significant damage to public infrastructure, to FICO's farming operation, and to other private land and structures. In the three largest floods (1978, 1983, 1993), significant public and private property losses were incurred at bridges and residential structures (photographs below).

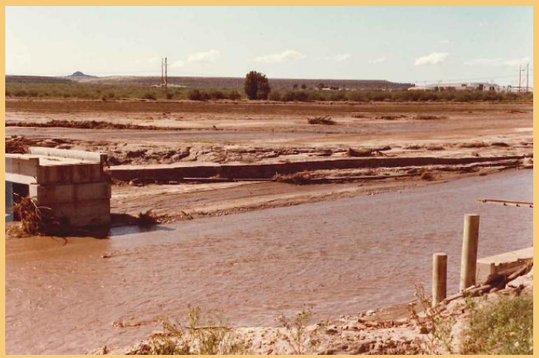


Photo # 29. 1993 bridge damage at UPRR spur crossing.

Photo # 30. 1993 bridge damage at Sahuarita Rd. Bridge.

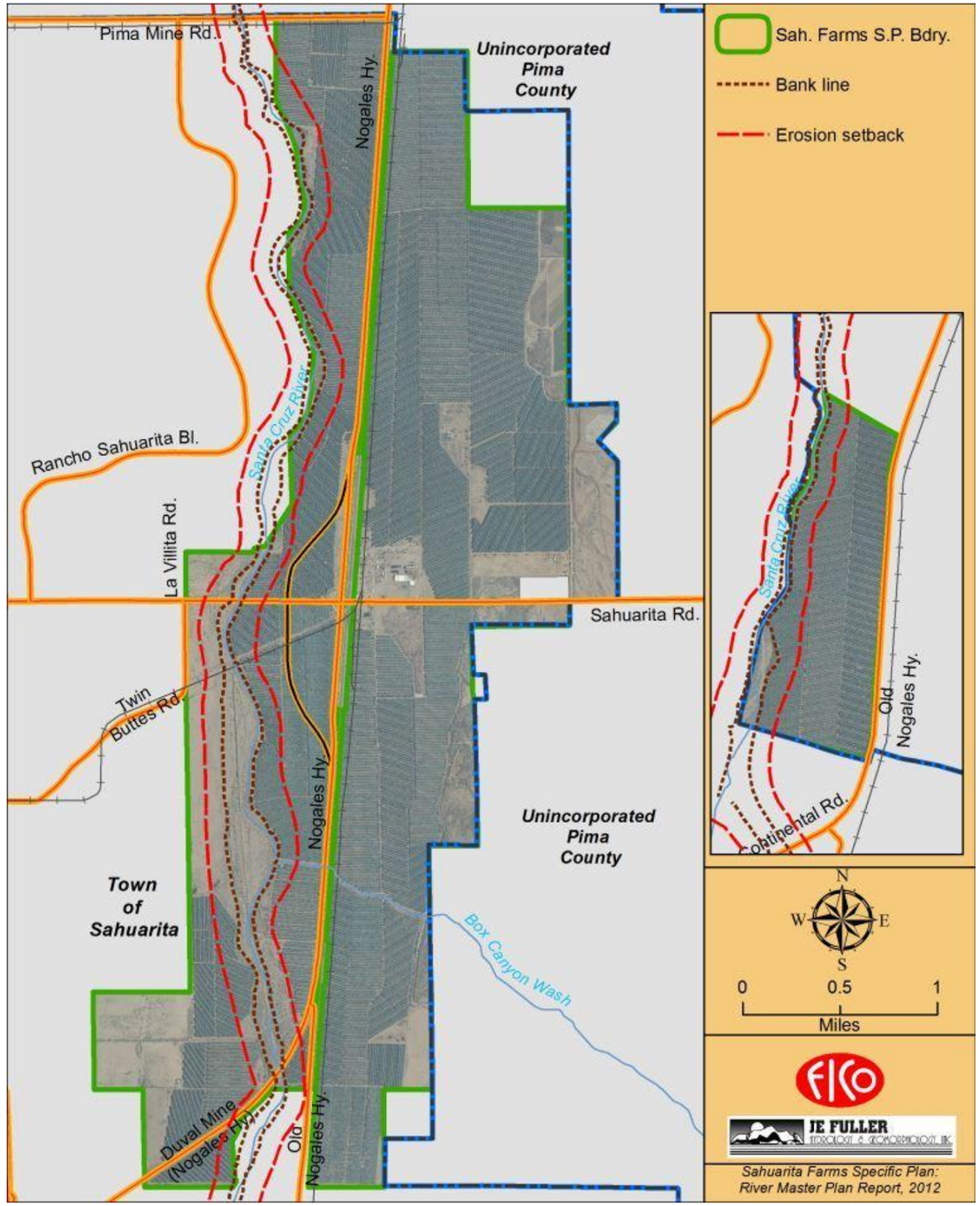


Figure 3-2. Existing bank position and related erosion hazard setbacks.

3.5 Flooding Along the River

While the river is normally dry throughout the year, it flows occasionally in response to intense local storms or large volume regional rainfalls. During the largest events, flooding has overflowed the main channel and has inundated large portions of the historical floodplain within Sahuarita Farms. The historic floodplain is relatively flat, with little lateral relief across the valley, and has a longitudinal (down-river) slope of about 0.3 percent. Consequently, when floods overtop the main channel, much of Sahuarita Farms can be inundated.

Recent flooding on the Santa Cruz River is well documented. Significant flooding occurred in October 1977 (26,500 cfs), October 1983 (45,000 cfs, the flood of record recorded at Continental Road), and January 1993 (32,400 cfs). In addition, there have been 10 events in the past 70 years that have exceeded 10,000 cfs (approximately the 10-year event discharge). The photographs below show aerial views of past flooding events.

Photo # 31. Sahuarita Farms during 1983 flood event.

This photo is looking upstream, facing south/southwest. Note headcut erosion scars in the foreground at Pima Mine Road.

Photo # 32. 1983 Santa Cruz River flood at Box Canyon Wash

This photo is facing west and shows the Box Canyon Wash draining into the river.

Photo #33. 1983 flooding at Sahuarita Road/Nogales Highway. This photo is facing west/northwest and shows the flooding that occurred to Sahuarita Road, the UPRR, and FICO during the 1983 event.

Photo #34. 1993 flooding at Sahuarita Road/Nogales Highway. This photo is facing west/southwest and shows the flooding that occurred to Sahuarita Road, the UPRR, FICO, and west of FICO during the 1993 event.

A large percentage of Sahuarita Farms is located within the regulatory floodplain (Figure 3-3) of the Santa Cruz River. The Federal Emergency Management Agency (FEMA) mapped the 100-year floodplain in the vicinity of the project as Zone AE with a 2,200-foot wide floodway. It is noteworthy that a number of existing residential parcels are located within the floodplain along the west side of the river, with several more in the floodway west of Old Nogales Highway.

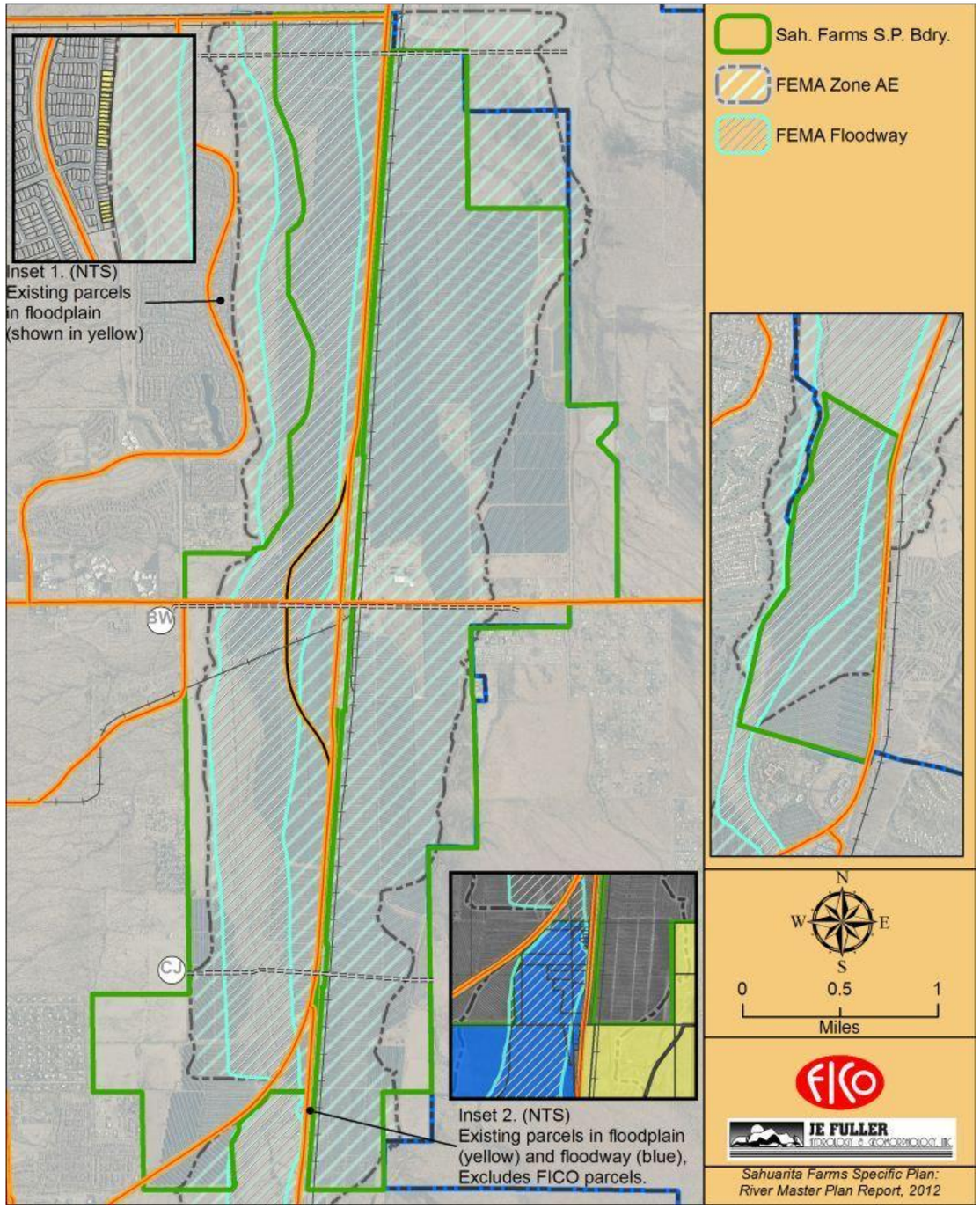


Figure 3-3. Effective FEMA flood zones (Study date: 1999).

3.6 Current Floodplain Conditions

The existing conditions Santa Cruz floodplain has been modeled using more detailed topographic and aerial mapping of the river through the FICO property than was available in the mid 1990's when the effective FEMA model was prepared. This modeling effort was necessary in part because the effective FEMA model is over 15 years old and does not accurately reflect the existing condition of the river due to the following reasons.

- Physical river changes including scour, headcutting, and local aggradation have reshaped the channel since the effective mapping was prepared.
- Topographic mapping has advanced in recent years. Much greater detail is available with the use of digital terrain and elevation models versus the printed maps used in the 1990's. Review of the effective mapping shows some locations where the floodplain may be inaccurately mapped compared to the current maps.
- Modeling procedures have changed in recent years. Software and computer hardware advances allow for more detailed modeling to be performed beyond the limitations of 1990's era models. Today's models can be prepared with much greater resolution with elevation data extracted with software as opposed to earlier models relying on the user to scale a map and hand enter elevation data into the model.
- FEMA's criteria for modeling and delineating floodplains have evolved since the effective maps were prepared. The updated model reflects current FEMA modeling guidelines regarding modeling non-levee embankments. The result of this is a slightly wider floodplain on the west side of the river near Sahuarita Road.

Three example cross sections are shown in Figure 3-4 (alignments shown on Figure 3-3, left). These are typical; the northernmost cross sections exhibit extensive channel degradation, while the floodplain elevations are often higher. Further south, the cross sections are a better match, mostly because headcutting has not yet extended this far south.

Figure 3-5 shows the updated floodplain which has been used for internal purposes, primarily as a standard of comparison for the project design. The updated modeling has not been submitted to FEMA, nor is there a plan to do so this time. Note that the floodplain may be slightly narrower at Sahuarita Road after construction of the new bridge.

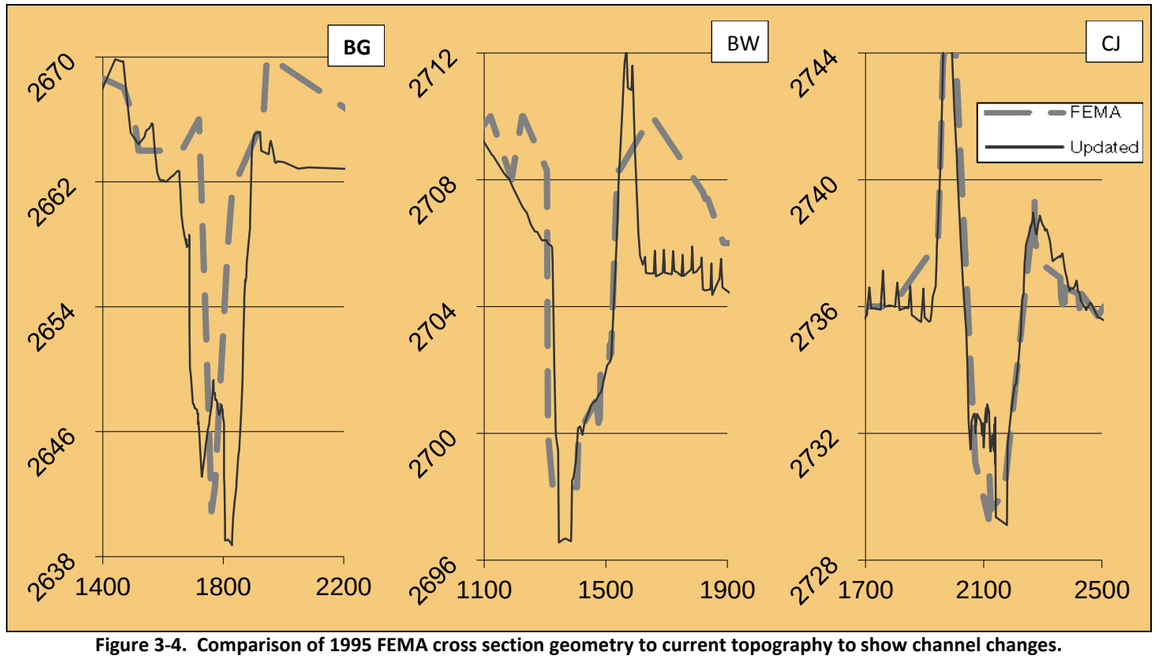


Figure 3-4. Comparison of 1995 FEMA cross section geometry to current topography to show channel changes.

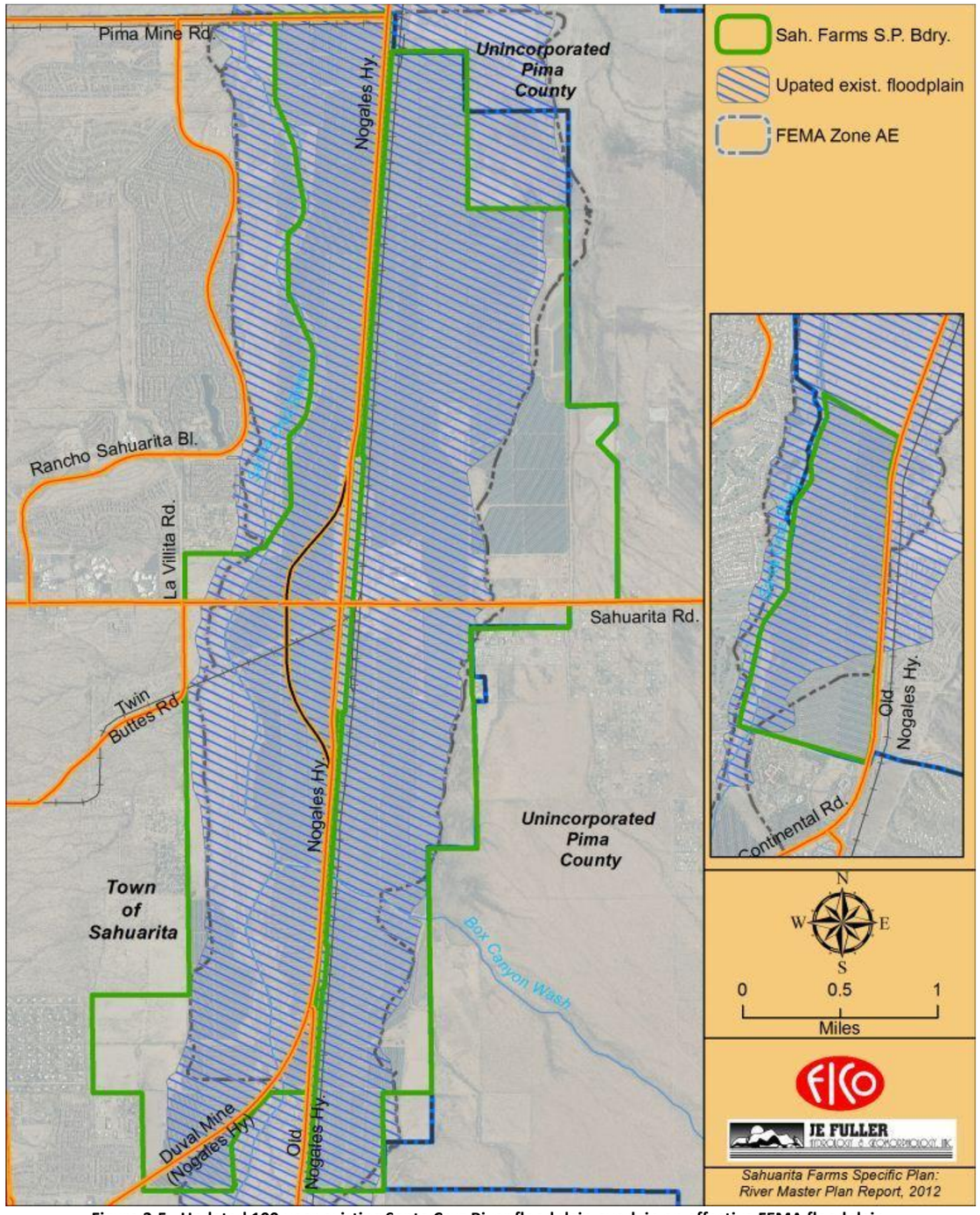


Figure 3-5. Updated 100-year existing Santa Cruz River floodplain overlain on effective FEMA floodplain.

Section 4 RIVER MASTER PLAN

4.1 Background of River Master Plan Concept

The Sahuarita Farms RMP concept is based upon years of experience in observing how natural channel systems evolve and how urbanized channel systems operate. Lessons learned from past projects on the Santa Cruz River and its tributaries, as well as other river systems in the arid west, have been applied to the RMP design concept. In addition, the RMP benefitted from the insights of FICO's owners, who have been working with the river since the 1940's.

Many alternatives to accommodate development of Sahuarita Farms were proposed and examined. These alternatives included full bank protection and/or channelization for the 100-year discharge, differing river alignments, and/or levees along the existing main channel. While these concepts have worked elsewhere, the owners of Sahuarita Farms decided on a RMP concept that best met their objectives for river and habitat enhancement, preservation and integration of the built and natural environment, and provision of community amenities. The following are a few of the guiding principles that shaped the proposed RMP concept.

Rivers are shaped by their surroundings. Natural, sustainable channels are part of a larger system that shapes and is shaped by the river. Key system elements include: the frequency, duration, magnitude of flow, natural soils and geologic formations that confine vertical and horizontal movement, sediment inflow, down-valley slope, climate, vegetation, and human influences.

Natural rivers are sinuous. Rivers dissipate energy by varying slope, sinuosity, and geometry within the constraints imposed by the natural and human environment. Straightening a river usually has long-term adverse consequences.

Prismatic channel sections designed to contain the 100-year are not sustainable. Natural rivers develop a low-flow channel /floodplain cross section geometry to efficiently convey frequent low-flows (main channel), as well as the rare floods (floodplain and flood terraces). In addition, a healthy river will develop a complex geometry that includes slope breaks, riffles, braids, bars, meanders, floodplains, and terraces.

Floodplains reduce flood peaks. Floodplains and flood terraces efficiently store runoff volume and attenuate flood peaks. In arid regions like Pima County, the ratio between the discharge inundating the floodplain terrace and the dominant, channel forming discharge is higher than in most humid or mountain regions. Still, frequent inundation of the lower floodplains and less frequent inundation of flood terraces is required to store flood waters and prevent unacceptable losses of flood attenuation.

River corridors create meaningful open space. Natural river corridors provide habitat and recreational opportunities.

The RMP concept was developed to mimic these guiding principles to the extent possible while still achieving the development goals for Sahuarita Farms.

4.2 River Master Plan Goals

The RMP concept began with the goal to contain the floodplain within a corridor that resembles a healthy, natural watercourse, which would include a low-flow channel, floodplains and high-flow terraces. This type of cross section requires a larger footprint than the typical trapezoidal channel cross section that has been used elsewhere on the Santa Cruz River. For example, the proposed RMP river corridor is up to 1,300 feet wide, much wider than the 200-foot wide channel at Congress Street in Tucson where the regulatory (design) discharge is 33% higher. The wider RMP corridor more closely mimics natural river corridor geometry, allows for inclusion of river amenities, community benefits, and preserves and enhances much of the river channel's natural form and function. In addition to allowing for the safe development of Sahuarita Farms, the RMP goals include:

- Limit construction footprint to FICO property.
- Contain the 100-year discharge within a corridor.
- Prevent adverse impacts to surrounding lands.
- Allow space for amenities & habitat enhancement.
- Explore opportunities for groundwater recharge.
- Minimize future maintenance requirements.

RMP Elements

To achieve the RMP goals, a design concept was formulated that consisted of the following elements:

Low-flow Channel. The proposed "low-flow channel" will allow sufficient space for a natural thalweg and floodplain to develop. The overall low-flow channel segment will widen the existing, incised cross section of the Santa Cruz River. This widened section will contain the most frequent "bankfull" discharges, as well as floods up to the 20-year event within the low flow channel. The low-flow channel will experience the highest flood velocities and depths. The low flow channel area will also include a naturally shaped, more frequently inundated floodplain.

Bank stabilization. CSA will be provided at the margins of the low-flow channel to prevent future erosion damage. Bank stabilization will be limited to approximately five feet high to mimic natural bank heights in undisturbed portions of the river, to allow for wildlife movement (maximum 2:1 side slope), and to minimize aesthetic impacts. *Bank stabilization may be omitted if development is set back a minimum of 500 feet from the low-flow channel.*

Floodplain terrace. A floodplain terrace will be created adjacent to and above the low-flow channel. The "terrace" will be inundated when moderate to large floods overtop the main channel. Flooding on the terrace will be limited to low depths and velocities to minimize potential flood damage and to allow for flood storage. The terrace will be built with a low cross slope to allow drainage toward the low-flow channel and to correct the adverse slope condition that exists in the current floodplain. This cross slope will minimize flood depths and velocities at the margins of the RMP corridor and allow opportunities for other uses on the terrace, such as habitat enhancement, trails, and recreation.

Grade control. Hardened structures spaced intermittently within the low-flow channel will prevent further upstream migration of the headcutting that has so severely degraded the river to the north of Sahuarita Farms.

The final design of the RMP, including the corridor cross section and layout will be conducted as part of later design phases of the RMP. Final design should include a detailed geomorphic assessment of the low flow channel geometry required to maintain stability and sediment continuity.

4.3 River Master Plan Concept Cross Section

An artist's rendering of the RMP concept is shown in Figure 4-1. This cross section shows the low-flow channel flanked by high flow floodplain terraces. The low-flow channel in this rendering is protected by CSA (soil cement).

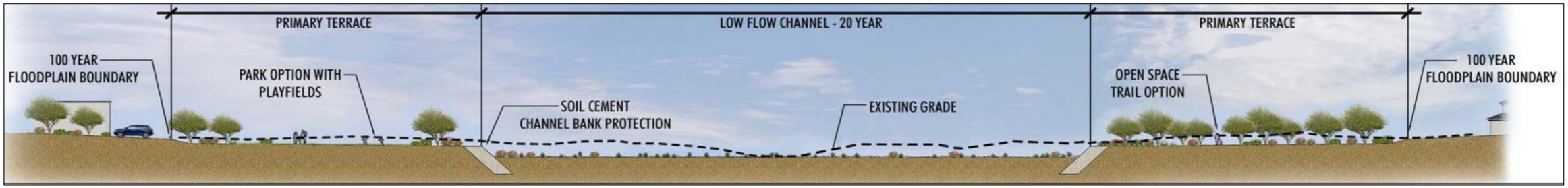


Figure 4-1. Artist's rendering of River Master Plan concept cross section

4.4 River Master Plan "Typical" Cross Section

Figure 4-2 shows the low-flow channel and terraces in a typical cross section. The central low flow channel will convey the 20-year discharge. The 100-year discharge will be contained within the terraces. The widths of the low-flow channel and terraces vary throughout to simulate realistic river floodplains and to match existing features.

While the sketch in Figure 4-2 is drawn with straight lines for illustration purposes, the final design anticipates that the low-flow channel will evolve into a more natural thalweg/floodplain cross section that mimics the less incised reaches of the Santa Cruz River. An approximation of what this may look like is shown in Figure 4-3.

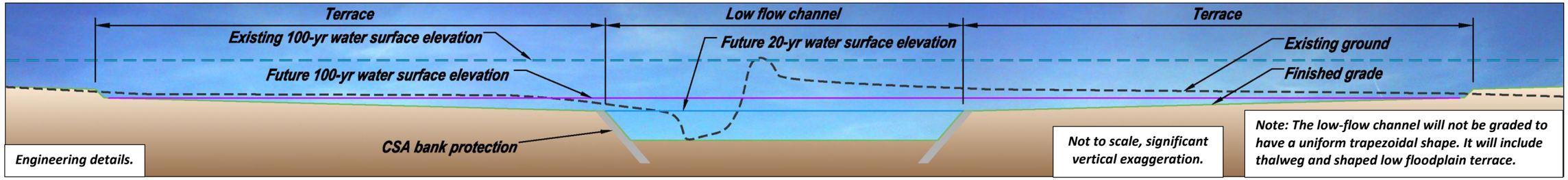


Figure 4-2. River Master Plan low-flow channel and terrace concept: Plan Condition.

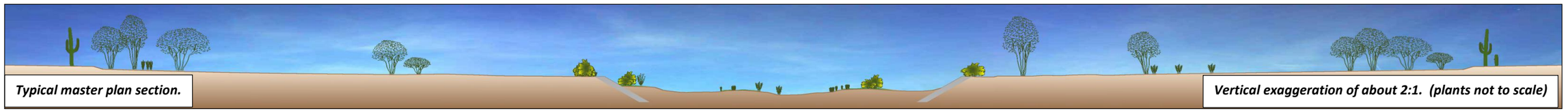


Figure 4-3. River Master Plan low-flow channel and terrace concept: Future Condition.

Low-Flow Channel Design Discharge

The low-flow channel is designed to contain the 20-year flood which has a peak of approximately 17,000 cubic feet per second (cfs). (See Table 4-1 for other discharges.) The 20-year discharge was used for a number of reasons, including:

- The low-flow channel capacity of the stable reach near Continental Rd. is about the 20-year discharge. (The low-flow capacity at Duval Mine Road is about the 10-year; at Pima Mine Road it is about the 100-year.)
- The 20-year low-flow channel design discharge prevents the terraces from being exceedingly wide (as would be the case with a 10-year low-flow channel design).
- Containing the 20-year discharge keeps terrace depths and velocities low during the 100-year event.
- The terraces will not experience significant flow on a routine basis, allowing for a greater level of flood protection for the terrace amenities. Observations made during the 1983 flood, the largest flood on record for the Santa Cruz River, indicate that the 1983 flood hydrograph only exceeded a magnitude of 17,000 cfs for about 12 hours. Therefore, the duration of flow on the terraces is likely to be short, further limiting the potential damage.

Table 4-1. Peak discharge vs. recurrence interval – Santa Cruz River at Continental Road.

Source	500-yr	200-yr	100-yr	50-yr	20-yr	10-yr	5-yr	2-yr
	Peak discharge (cfs)							
FEMA FIS	72,000	Not listed	45,000	22,000	NL	11,000	Not listed	Not listed
USACE	115,000	72,000	45,000	30,000	17,000	12,000	7,300	3,500

River Master Plan Single-Terrace Cross Section

To the north of Sahuarita Road, FICO does not own both sides of the river. In some locations FICO only owns the east side of the existing channel. In these reaches, the typical cross section detailed in Figure 4-2 is modified to alter the east side of the channel only. Furthermore, this area has no land development adjacent to it on the east side, allowing for the CSA bank protection to be eliminated. An artist's rendering is shown below.

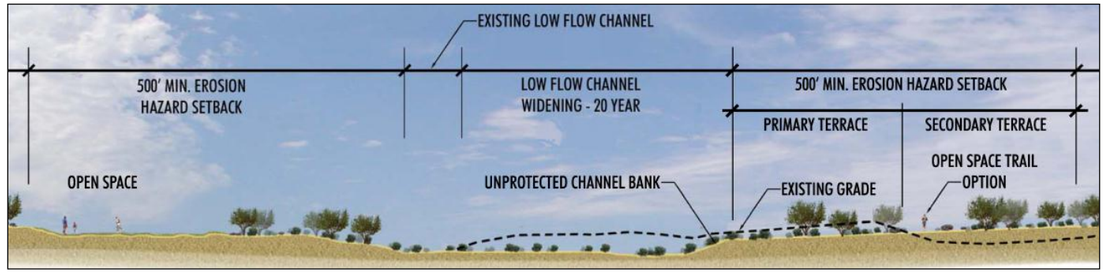


Figure 4-4. Artist's rendering of River Master Plan concept single-terrace cross section

Note: Because the proposed RMP cross section is over 1,000 feet wide and only 8 feet deep, it is difficult to show the cross section without significant vertical exaggeration to convey the concepts and details of the RMP cross section. Vertical exaggeration distorts the cross section and makes the vertical elements appear larger than reality.

4.5 River Master Plan Components

The extent of the Sahuarita Farms River Master Plan (RMP) is shown in Figure 4-5. The RMP is divided into four sub-reaches. Details regarding each sub-reach are provided in subsequent sections. The RMP was designed so that all improvements will be located on FICO lands, and are intended to prevent adverse impacts to adjacent lands.

Reach 1: Inlet

The most upstream and southern reach is Reach 1. This reach collects perched overbank flooding and directs it to the RMP corridor. Reach 1 components include river improvements, floodplain modifications, and collector channels.

Reach 2: Dual Terrace Reach

Reach 2 conveys flow through a corridor consisting of the low-flow channel flanked by terraces on both sides (as in Figure 4-1). The low-flow channel envelops, but is not centered on the existing thalweg. The low-flow channel corridor is designed with sinuosity and with sufficient space to allow further meanders to develop. The low-flow channel includes CSA bank protection at the channel/terrace interface. The CSA bank protection is needed to maintain the channel alignment through the three existing bridges within this reach and to protect proposed urban land uses near the corridor. The CSA will extend to about five feet high in most locations, but slightly higher at the bridges.

Reach 3: Single Terrace Reach

In Reach 3, the western side of the historical floodplain is not entirely within FICO lands, as well as some parts of the main channel. Therefore, the Reach 3 cross section has only one terrace on the east side. Additionally, the low-flow channel is widened only east from the existing channel, instead of on both sides. The east bank will have CSA for the southernmost 1,600 feet to protect the Nogales Highway. The rest of Reach 3 continues the one-sided terrace cross section, but excludes the use of CSA bank protection since no development is proposed adjacent to the corridor, and the terrace is at least 500 feet wide.

Reach 4: Outlet

This reach is designed to transition flow from the RMP corridor to the pre-development condition within the Sahuarita Farms project limits. The transition will be accomplished by gradually reducing the terrace and low-flow channel widths and by placing a hardened weir structure along the east bank, which will allow flow to return to the floodplain.

The Southern Reach

The Southern Reach is located at the current southern limits of the Town of Sahuarita, just north of the La Posada development on the eastern side of the Santa Cruz River floodplain. The RMP concept in the Southern Reach consists of a low flow channel and terrace on the east side of the river. New development will be located outside of the 500-foot erosion hazard setback zone. No new CSA bank protection will be constructed within the Southern Reach. This reach contains similar cross sectional geometry to Reach 3. Flow coming from the south of this reach is contained on the east by existing CSA bank protection. This reach will take this flow and convey it safely through the reach to near the northern limit of this southern parcel. Flow expansion will occur within the project, similar to Reach 4, returning flow to existing conditions at the northern end. This reach will also lower the 100-year water surface elevations and flow velocities, relieving potential floodplain issues affecting parcels to the east of the railroad.

Sahuarita Road and Old Nogales Highway

The Town of Sahuarita plans to rebuild Sahuarita Road and the Sahuarita Road Bridge over the Santa Cruz River in the near future. The new bridge will be wider than the current bridge and will include a grade control structure. Sahuarita Road will be elevated from its current profile to accommodate the large bridge structure. The Town also plans to realign Nogales Highway and move its intersection with Sahuarita Road to the west, closer to the river. The RMP has been designed to work with the proposed new roads and bridge.

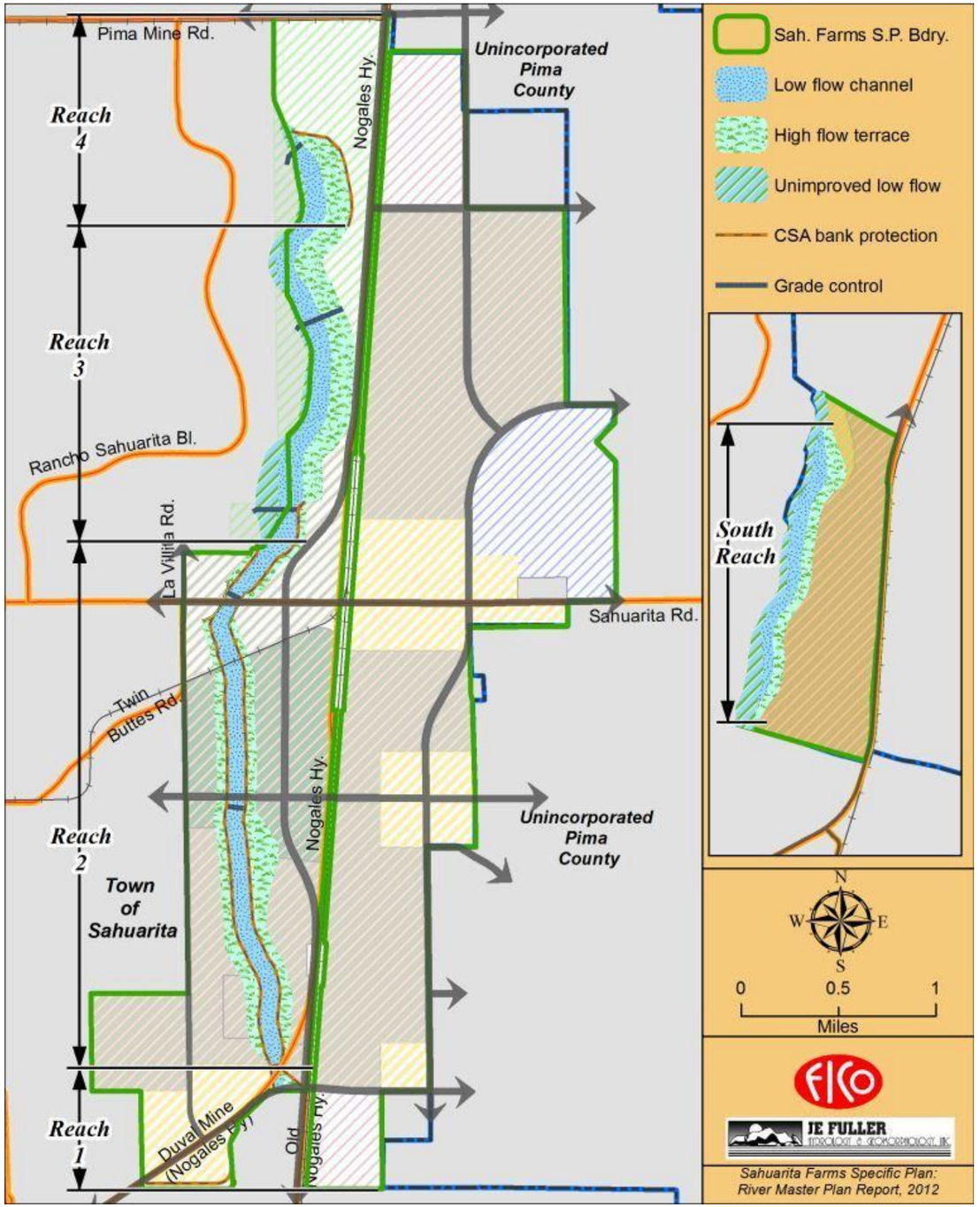


Figure 4-5. River Master Plan reaches.

Grade Control

Several grade control structures will be included in the RMP to arrest on-going severe head cutting. These structures will be placed perpendicular to flow across the low-flow channel, and will be toed-in to prevent flanking. The downstream face of these structures will be designed to facilitate pedestrian, equestrian and wildlife movement.

Cement Stabilized Alluvium (CSA)

CSA (a.k.a., soil cement) is routinely used as a bank protection material in Southern Arizona. CSA is preferred over riprap because suitably sized rock is not typically available locally. CSA is composed of a mixture of native soils, Portland cement, and water compacted to a high density. For the RMP, it would be constructed in 8-inch lifts, 8 feet wide, with a maximum 2:1 side slope (exposed). CSA is highly durable and capable of withstanding velocities much greater than those present in the river.

Estimated Cut and Fill

Even though the RMP project will lower the water surface elevations significantly throughout Sahuarita Farms, implementation of the RMP will require significant grading along the river corridor to create the RMP cross section, low flow channel and terraces. Preliminary estimates of cut and fill requirements are shown in Table 4-2, which indicates a net export of fill. The cuts and fill areas are shown in Figure 4-6. Cut areas are located primarily along the low flow channel and terrace portions of the river corridor. Fill areas will be laterally extensive, and may be up to several thousand feet wide, and may provide the foundation for homes, streets, trails, parks, open space and/or other features. Normal engineering requirements for fill should be applied during final design. Fill requirements can be reduced by replacement of the Duval Mine Road Bridge and continuation of the RMP concept upstream and off FICO lands. Fill requirements will be evaluated in detail in the future as part of the normal platting and planning process.

Table 4-2. Estimated cut and fill volumes for the RMP corridor.

Phase	Length	Volume		
		River Excavation	Fill within RMP Corridor*	Fill on Adjacent Lands
	(ft)	(CY)		
1	8,143	1,411,344	75,907	1,985,550
2	8,744	1,741,134	29,738	422,044
3	10,640	2,718,242	39,630	332,294
South	7,962	979,031	0	48,996
Total	35,488	6,849,751	145,275	2,788,884
		Total Fill		2,934,159
		Balance		3,915,592

*Note that some fill is necessary along the terraces.

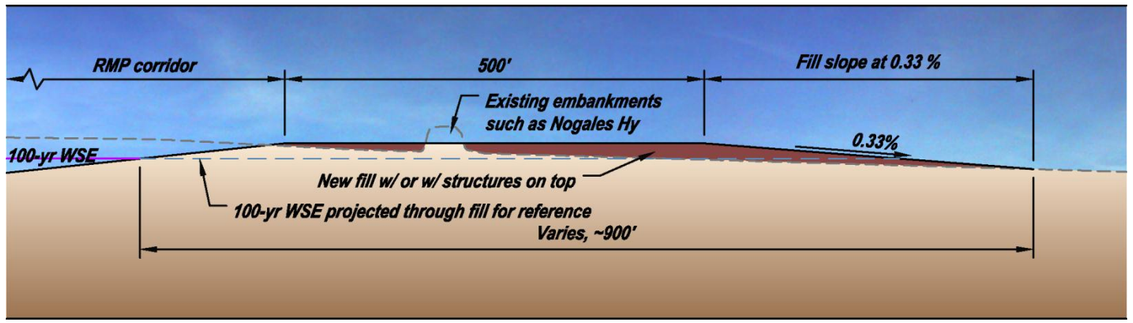


Figure 4-6. Cut and fill locations within Sahuarita Farms.

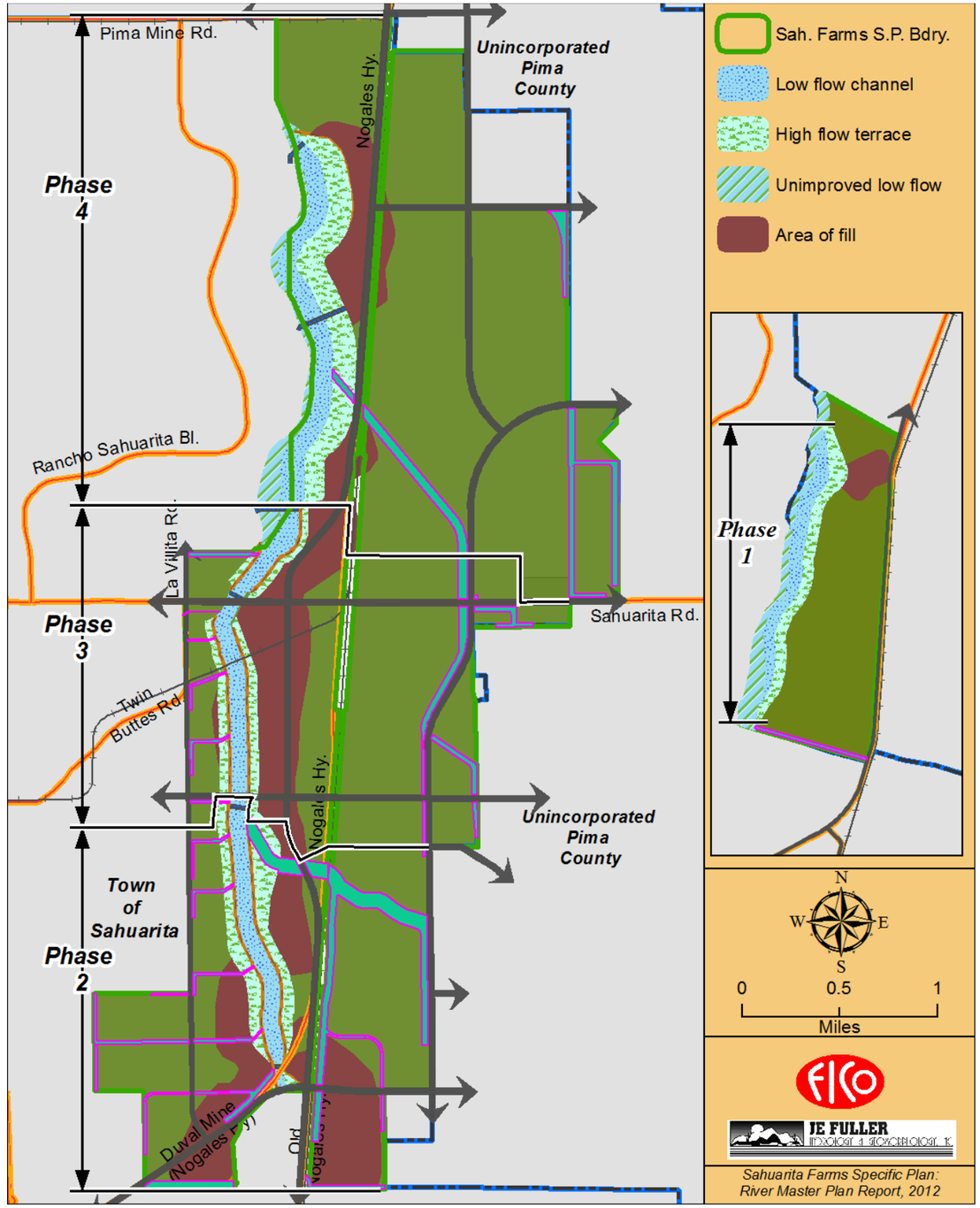


Figure 4-7. Fill adjacent to RMP Corridor.

4.6 Reach 1: Inlet

Reach 1 is a short reach, consisting of approximately 3,000 feet of the river upstream of and including Duval Mine Road. The RMP in this reach includes river channel improvements to draw the water surface profile down, and floodplain improvements to guide flow into the RMP corridor. Figure 4-8 shows the existing conditions and Figure 4-9 shows the various design elements for Reach 1. The effective floodplain will be revised after construction of the project. Alternative inlet designs may be considered if adjacent landowners elect to participate in the RMP.

Existing Conditions

As shown on Figure 4-8, the existing 100-year flow conditions are complex, with as little as half of the 45,000 cfs 100-year discharge passing through the existing Duval Mine Road Bridge, and the remainder overtopping both Duval Mine Road and Old Nogales Highway. Flow begins to overtop Old Nogales Highway upstream of FICO's ownership of the river in an area with existing homes and businesses that are currently in the floodplain, potentially inundating them by over three feet during a 100-year flood. The existing Duval Mine Road Bridge is relatively narrow (~225 feet perpendicular to flow) and is silted in, creating a significant flow constriction. Upstream of the bridge there is an existing levee-like spur dike on the east bank of the river. This dike is not FEMA-certified and does not capture the entire floodplain, but instead guides only the flow in the main channel through the bridge, leaving up to 20,000 cfs behind (east of) the dike flowing along or over Old Nogales Highway.

Note: The description above and figure below are based upon current conditions and assumes no scour of the channel through the bridge, which will most likely occur during a significant flow event. This scour could allow more flow through the bridge with less flooding and less overtopping (both existing and design condition). However, local and FEMA modeling requirements dictate "fixed-bed" models that ignore scour be used for flood studies.

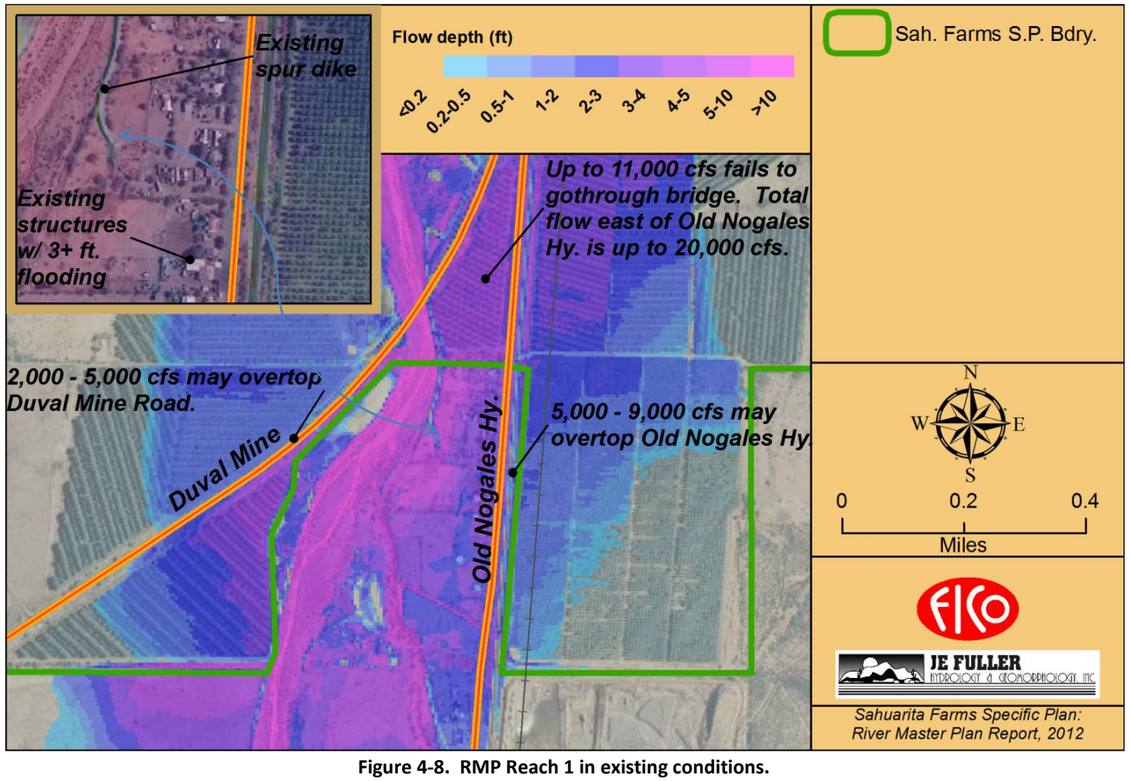


Figure 4-8. RMP Reach 1 in existing conditions.

Design Conditions

Several design elements are included in Reach 1, as shown on Figure 4-9.

Bridge Opening: The existing Duval Mine Road Bridge will remain and be cleared of the accumulated sediment that is currently choking the river through this structure. The sediment removal will increase the bridge capacity and lower water surface elevations upstream of the bridge. Additional detailed modeling of sediment continuity and deposition potential at the Bridge section will be performed in conjunction with later design phases.

River Main Channel: Sediment removal will extend upstream of the bridge within the river channel to the southern limit of FICO's ownership. This, in addition to downstream Reach 2 improvements and bridge improvements, will significantly lower the water surface profile in this reach and prevent adverse impacts to the adjacent lands.

West Overbank: According to the RMP models, Duval Mine Road is overtopped even with the proposed channel improvement and sediment maintenance. Flow that overtops Duval Mine Road will be captured in an overflow channel and directed back to the river. FICO is continuing to explore alternatives to this element that will prevent overtopping, protect Duval Mine Road from lateral erosion, and eliminate the need for the channel north of Duval Mine Road. Currently, all plan elements are located on FICO lands. Future alternatives will include off-site options. One such alternative is to replace the bridge cwith a 100-year structure. This would eliminate overtopping of the roads, reduce fill requirements, and alleviate flooding on existing lands.

Far-East Overbank: The land to the east of Old Nogales Highway will be elevated above the 100-year water surface elevation to remove it from the floodplain. This elevated area will be surrounded on the south by a collector channel and the west by an overflow channel. This overflow channel will convey offsite tributary flow and flow from the Santa Cruz River that crosses Old Nogales Highway. The overflow channel drains north to Box Canyon Wash (not shown on Figure 4-9), which will then convey it to the river.

Near-East Overbank: The second design element along the east side of the river is situated between the river, Duval Mine Road, and Old Nogales Highway. Here, the existing levee-like spur dike will be lowered (top elevation reduced) to allow flood water trapped between the river and the Old Nogales Highway to be directed back towards the river by a combination of fill and bank protection. Future studies will include more detailed analysis of this situation.

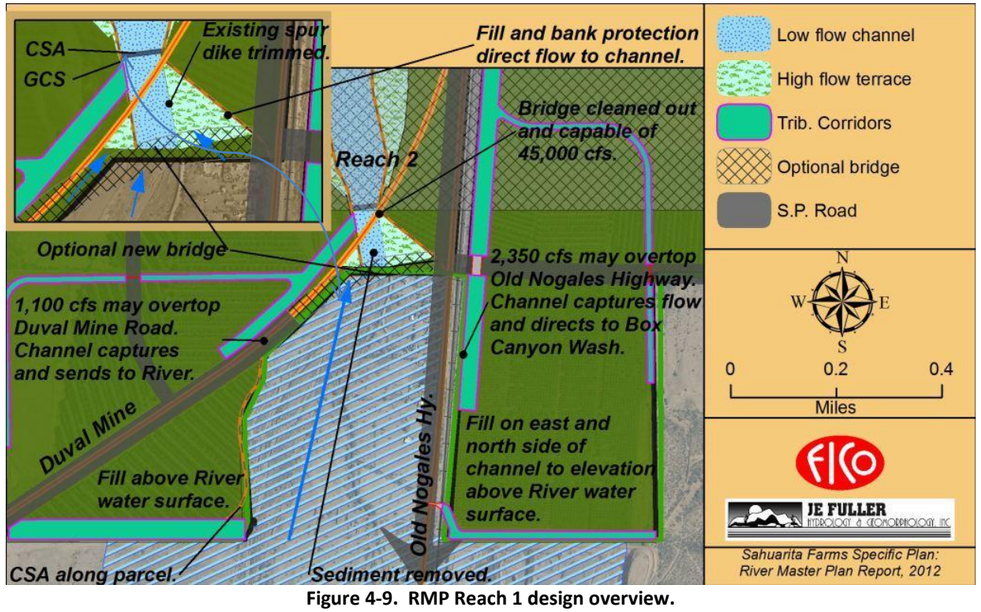


Figure 4-9. RMP Reach 1 design overview.

4.7 Reach 2: Dual Terrace Reach

Reach 2 extends three miles from Duval Mine Road through the UPRR Spur and Sahuarita Road, as shown in Figure 4-10. The corridor alignment in Reach 2 is influenced by these three existing bridges, as well as by the Town's new Sahuarita Road Bridge (currently under construction). Reach 2 includes a low-flow channel and terraces on both sides of the river. A conceptual cross section for Reach 2 is shown in Figure 4-11.

Flow in the RMP Cross Section

In Reach 2, the low-flow channel contains 17,000 to 18,000 cfs before terrace flow begins. During a 100-year event (45,000 cfs), about five percent of the flow will be conveyed on the terraces (combined), even though the terraces contain 15 to 20 percent of the cross section area. This apparent disparity is due to the much lower velocities on the terrace (<2.5 ft/sec) compared to the main channel (~10 ft/sec), and will also allow significant hydrograph attenuation during large floods. Note that velocity of 3 feet per second is generally considered non-erosive for alluvial materials. Furthermore, the terrace velocity is at a maximum nearest the channel, but approaches zero at the outer margin, as discussed in Section 4.13. Because the velocity at the edge of the terrace is so low, there is no need for a bank protection at the outer terrace margins, thus providing a more natural appearance to the floodplain. In addition, bioengineering measures will be used at the outer terrace margins to increase the local resistance to erosion.

Other Design Elements

There are several key design features in Reach 2. The first is Box Canyon Wash, the largest of the Santa Cruz River tributaries located within Sahuarita Farms. Box Canyon Wash will serve as a key drainage corridor for off- and on-site runoff, and will confluence with the Santa Cruz main channel across the terrace in Reach 2. The second is the existing UPRR Bridge. This UPRR Bridge is undersized and will need to be lengthened to accommodate the 100-year discharge. Because it is difficult to modify a railroad profile, the RMP design passes the 100-year flood without raising the railroad. The RMP assumes that the existing UPRR Bridge will be replaced with a 500-foot structure that spans the entire low-flow channel. Finally, the existing Sahuarita Road Bridge is currently being be replaced by the Town of Sahuarita. The new bridge has been designed for the 100-year event and is aligned to accommodate existing conditions. The alignment of the bridge approach within the RMP channel introduces a 45-degree deflection from the upstream alignment through the railroad spur. The proposed bridge width is less than 400 feet, which is narrower than the low-flow corridor in the remainder of the RMP reach. Therefore the RMP turns, narrows, and deepens at the road. Downstream of the bridge the RMP expands to 600 feet to counter the effect of the narrow channel through the bridge.

The existing longitudinal profile of the river bed in this reach is not smooth, having been altered by human influences. The RMP design profile has been smoothed and in locations the planned bed of the low-flow channel will be slightly below the existing thalweg elevation. This design provides for more consistent and predictable flow conditions, as well as a more sustainable, natural channel design.

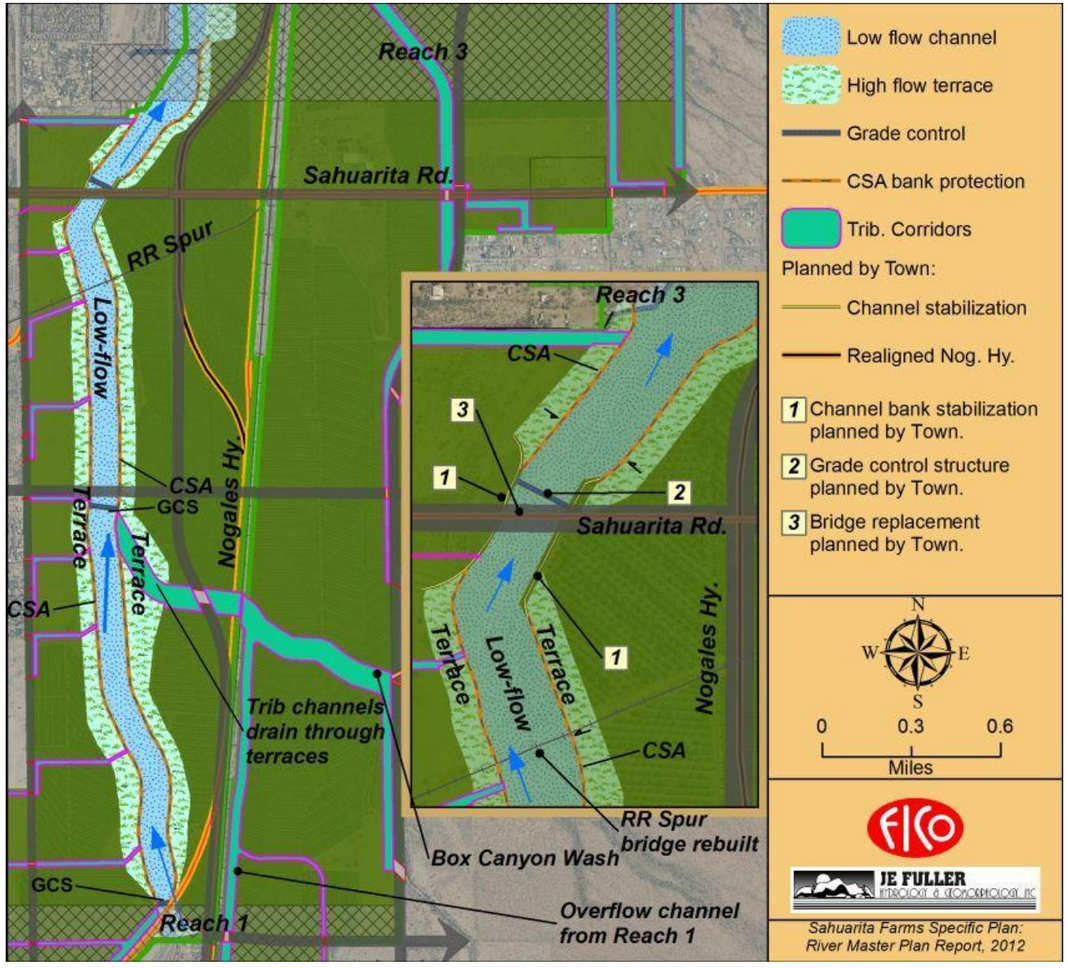


Figure 4-10. RMP Reach 2 design overview.

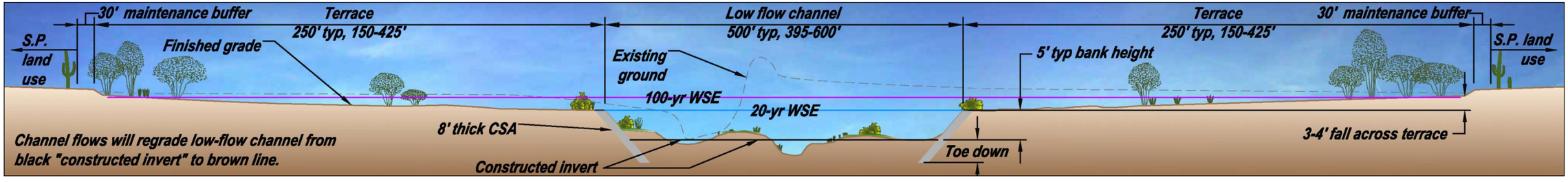


Figure 4-11. RMP Reach 2 typical dual terrace detail.

4.8 Reach 3: Single Terrace Reach

Reach 3 transitions the RMP concept from the more urbanized Reach 2 through an area with lower development densities, an area in which FICO generally owns only the east side of the river. The change in adjacent land use and the one-sided ownership influences the design of the reach. In Reach 3, the low-flow channel and single terrace will both be created along the east side of the existing thalweg, as shown in Figure 4-12 and Figure 4-13.

A single terrace is included on the east side of the river while the west side remains in its current state. Because the RMP corridor will contain the regulatory discharge, there will be no adverse floodplain impacts to properties to the west.

Flow in the Cross Section

Except for a short segment at the southern end, this reach does not include CSA bank protection, allowing the low-flow channel freedom to migrate. River migration within the erosion hazard setback in this reach is acceptable because no development is proposed on the adjacent lands. Similar to Reach 2, the low-flow channel will be capable of conveying the 20-year discharge, and will also convey the majority of the 100-year discharge. The overall low-flow channel width is wider than Reach 2, resulting in slightly lower flood velocities in the main channel, and therefore somewhat less erosion potential. 100-year low-flow channel velocities are generally between 8 and 9 feet per second, with average terrace velocities less than 3 feet per second. A minimum of one foot of freeboard is provided in this cross section. The hydraulic modeling performed for the RMP indicates that the flood flow velocities in this reach will decrease, lowering the existing erosion hazard. In addition, the low flow channel and thalweg alignments will be establish to decrease the existing impingement angles on adjacent properties in this reach.

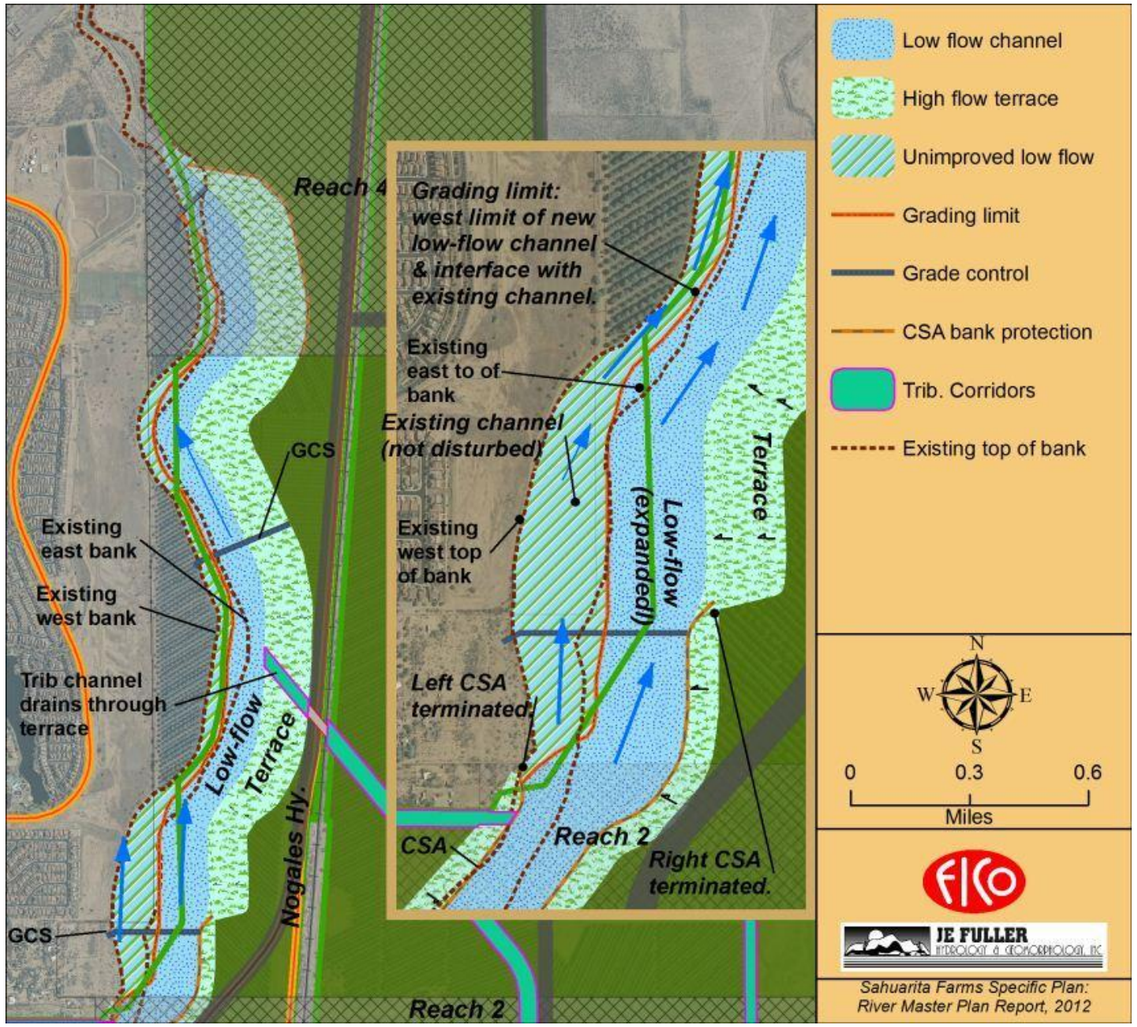


Figure 4-12. RMP Reach 3 design overview.

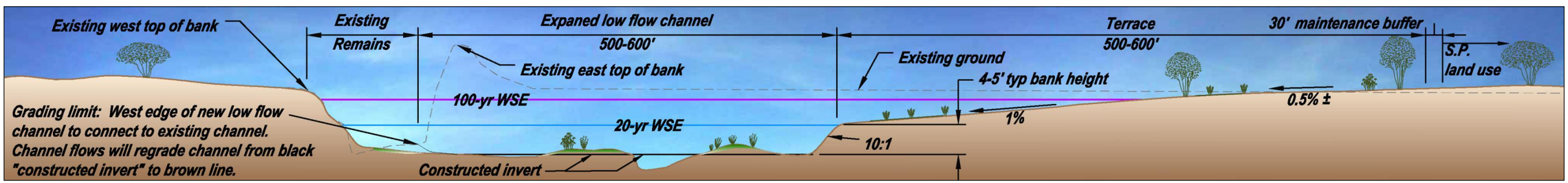


Figure 4-13. RMP Reach 3 typical single Terrace detail.

4.9 Reach 4: Outlet

Reach 4 contains a short segment of the RMP that duplicates the Reach 3 design, after which the RMP corridor is designed to return the Santa Cruz River to the pre-development condition, as shown on Figure 4-14. About one mile upstream of Pima Mine Road, flow will be transitioned from the channel to the right overbank. The edge of the terrace will be hardened with CSA and will act as a weir, controlling the flow rate leaving the channel. The flow will be allowed to return to the existing floodplain between the end of the RMP and Pima Mine Road. The area where flow expands back to the floodplain will be bioengineered to protect against erosion and to provide a natural appearance.

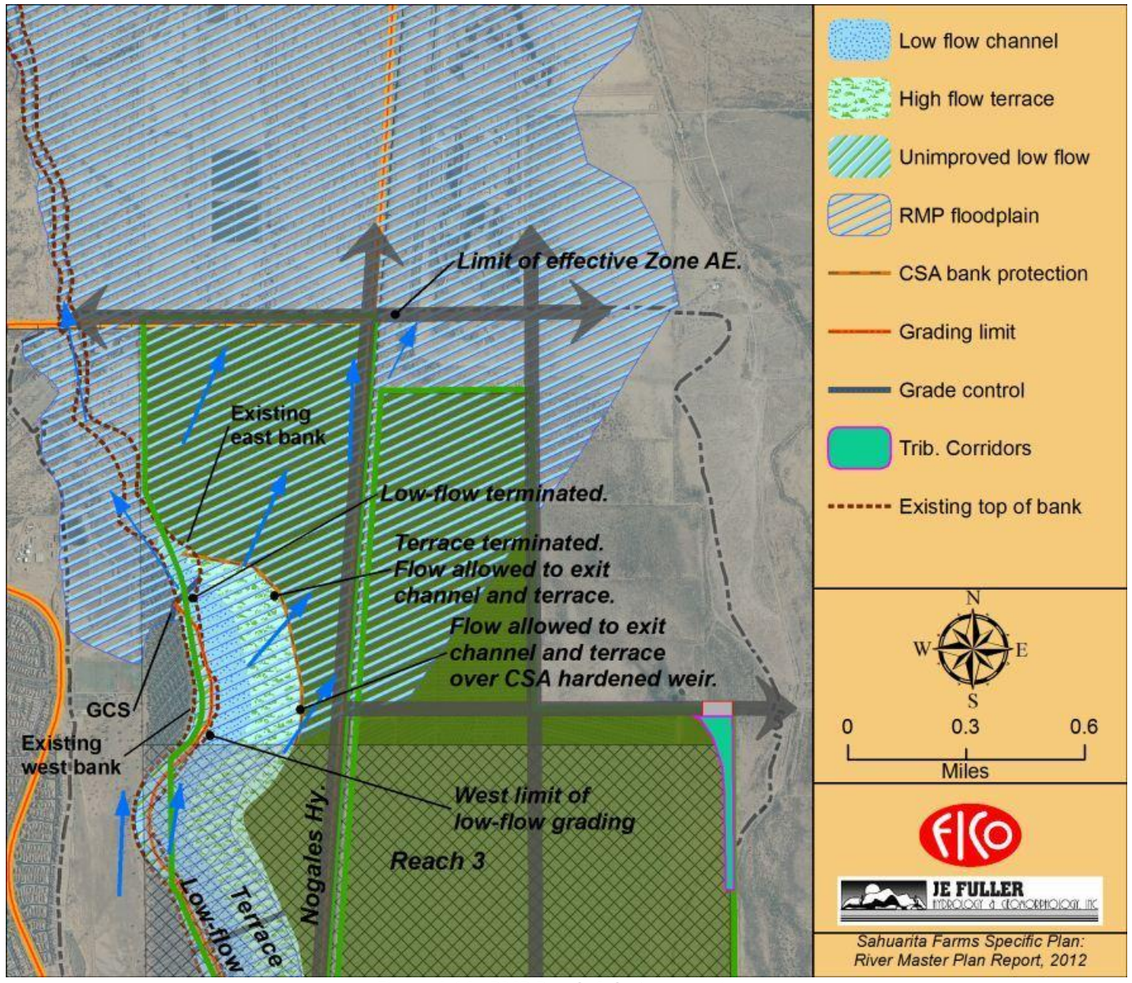


Figure 4-14. RMP Reach 4 design overview.

Outlet Velocity

An analysis of the flow velocity exiting the RMP has been performed to estimate the impacts upon FICO's lands and adjacent parcels. This was done in part to determine if vegetation could be allowed near the RMP outlet, possibly including the existing pecan groves. The model indicates that flow velocities on the existing floodplain are below 3 feet per second which is typically considered non-erosive. Furthermore, if the existing pecans remain, they will act to retard and expand flows at the outlet. Figure 4-15 below demonstrates the predicted flow velocities.

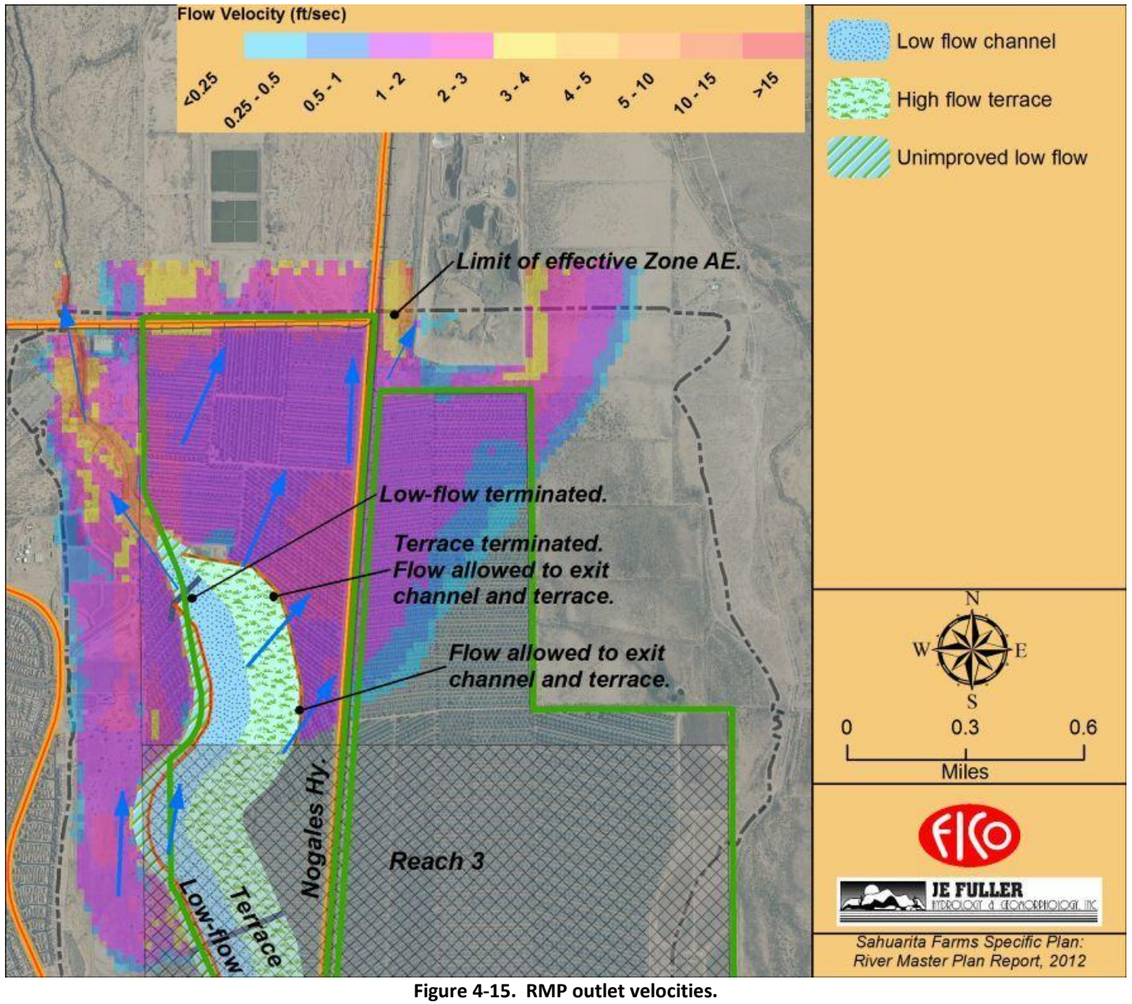


Figure 4-15. RMP outlet velocities.

4.11 The Southern Reach

The Southern Reach is a smaller-scale version of the combined northern four reaches. This reach captures offsite flow, conveys it through a stretch of the project within a corridor, and then releases it at the downstream end.

At the southern (upstream) end of the Southern Reach, the river is fully contained by existing CSA bank protection which was constructed for the La Posada Development. The RMP within this reach will accept that flow and expand it into a single terrace and low-flow channel cross section. This low-flow channel section expands the existing cross section of the Santa Cruz River, which is relatively narrow and deep at this location. The low-flow channel component may be constructed with an intermediate "island" of higher terrain, introducing geometry that will prevent an over-widened channel. The precise dimensions of the low flow channel geometry will be determined during later stages of the RMP design process, in conjunction with geomorphic analyses to determine the configuration that will best preserve channel stability and assure sediment continuity. The proposed cross section will contain the most frequent floods the west of the island, while allowing larger flood to flow around and expand to the east.

The terrace in the Southern Reach will begin to convey flow at around the 20-year discharge. Most of the flood events above that threshold will be contained about mid-terrace. Because bank protection is not provided in this reach, an erosion hazard setback will be utilized. The baseline, or the point from which the EHS is measured, is placed about 100 feet into the terrace at a grade break. It is at this point that the 50-year discharge is contained and the product of depth and velocity-squared is below 18, a commonly used value for estimating levels of greater erosion and flood force danger. The erosion hazard setback of 500-feet extends past the terrace. This area will not allow for structures and should be used for natural features.

Flow is returned to the existing floodplain at the northern end of this reach. This occurs by expanding the terrace while narrowing the channel. Flow will return to pre-development conditions before reaching the property line. Future coordination with downstream property owners may allow for connection and continuation of this RMP design through the next reach of the river to the north, and possibly to the Duval Mine Road Bridge.

A benefit of the design of the Southern Reach is that it reduces the 100-year water surface elevations, benefiting properties both to the west of the river as well as to east of the railroad embankment. In the current condition, it is possible that some of the existing homes east of the project are at risk of flooding from extreme events. This reach would contain the regulatory discharge, preventing such flooding from occurring.

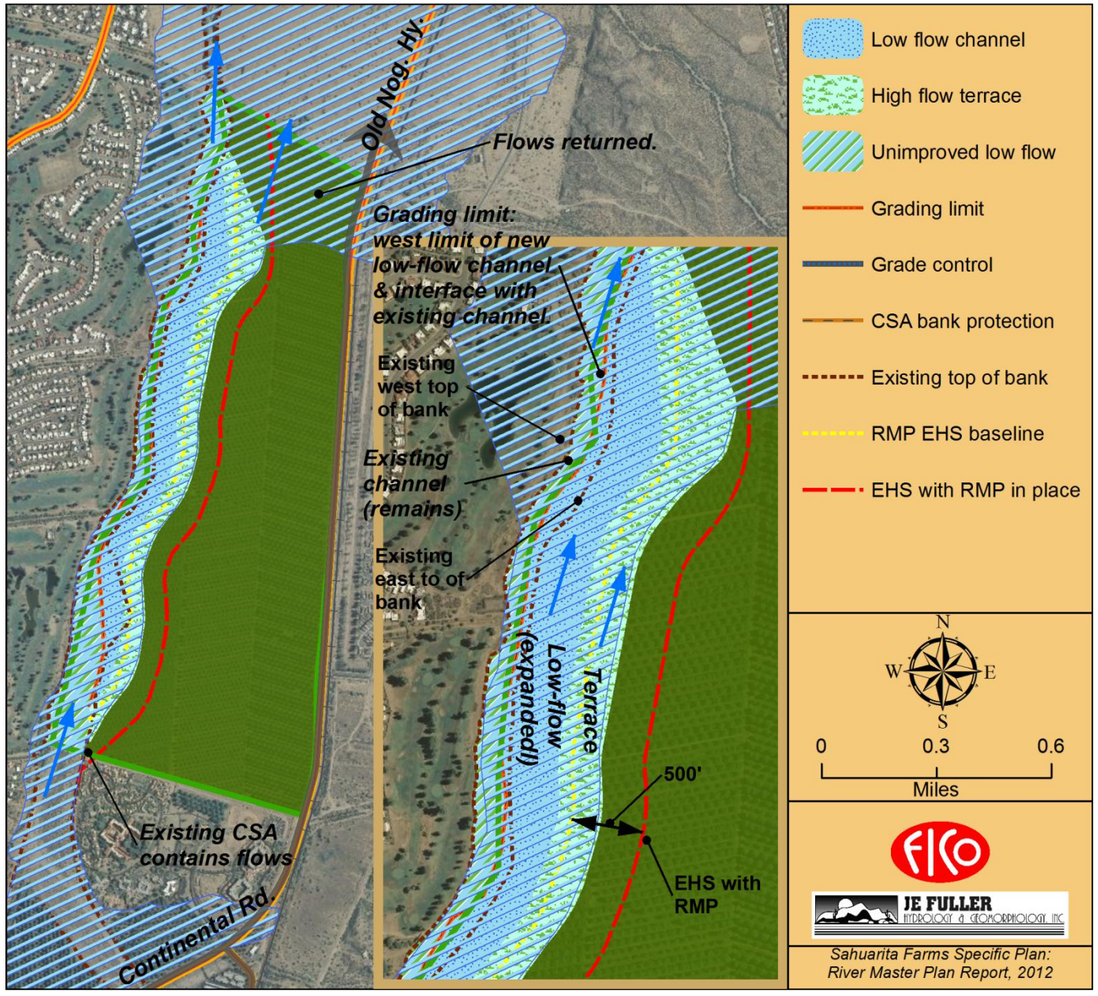


Figure 4-16. RMP Reach 3 design overview.

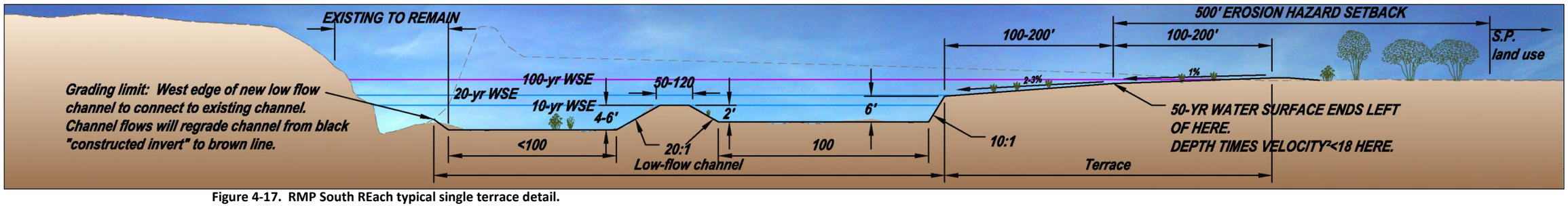
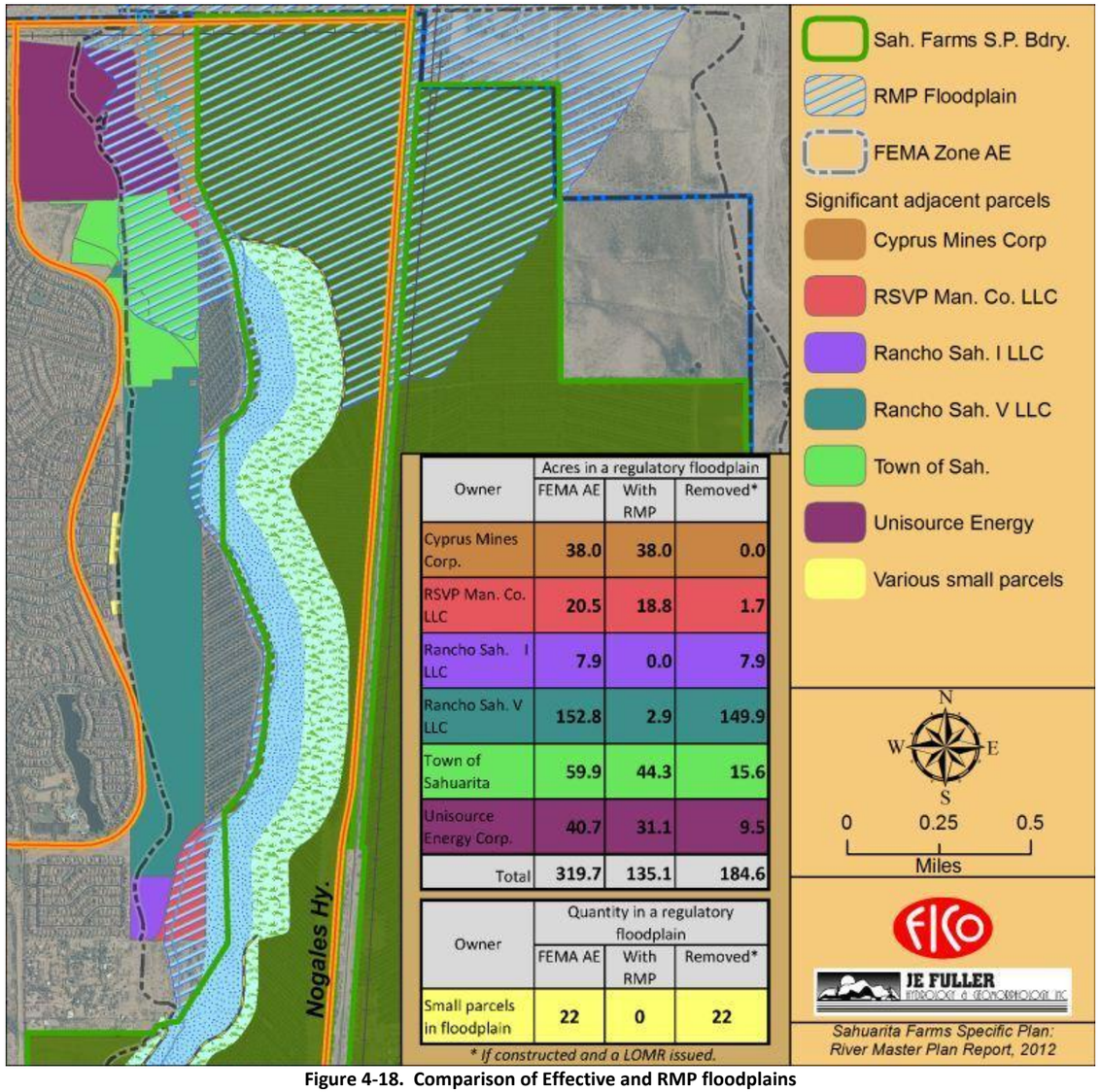


Figure 4-17. RMP South REach typical single terrace detail.

4.12 Final Floodplain Conditions

The with-project 100-year floodplain is shown in Figure 4-19. There are no places where the floodplain area or 100-year water surface elevation is increased due to the RMP design. The flood limits upstream of the project will be narrowed due to the river improvements. Furthermore, the western floodplain limit will be narrowed upstream of Sahuarita Road, where several existing homes are mapped very close to or within the effective regulatory floodplain. An analysis of floodplain area on several large, adjacent parcels was performed with the results shown on Figure 4-18. None of the parcels will have an increase in flood area and most will have a significant decrease.



Owner	Acres in a regulatory floodplain		
	FEMA AE	With RMP	Removed*
Cyprus Mines Corp.	38.0	38.0	0.0
RSVP Man. Co. LLC	20.5	18.8	1.7
Rancho Sah. I LLC	7.9	0.0	7.9
Rancho Sah. V LLC	152.8	2.9	149.9
Town of Sahuarita	59.9	44.3	15.6
Unisource Energy Corp.	40.7	31.1	9.5
Total	319.7	135.1	184.6

Owner	Quantity in a regulatory floodplain		
	FEMA AE	With RMP	Removed*
Small parcels in floodplain	22	0	22

** If constructed and a LOMR issued.*

Figure 4-18. Comparison of Effective and RMP floodplains

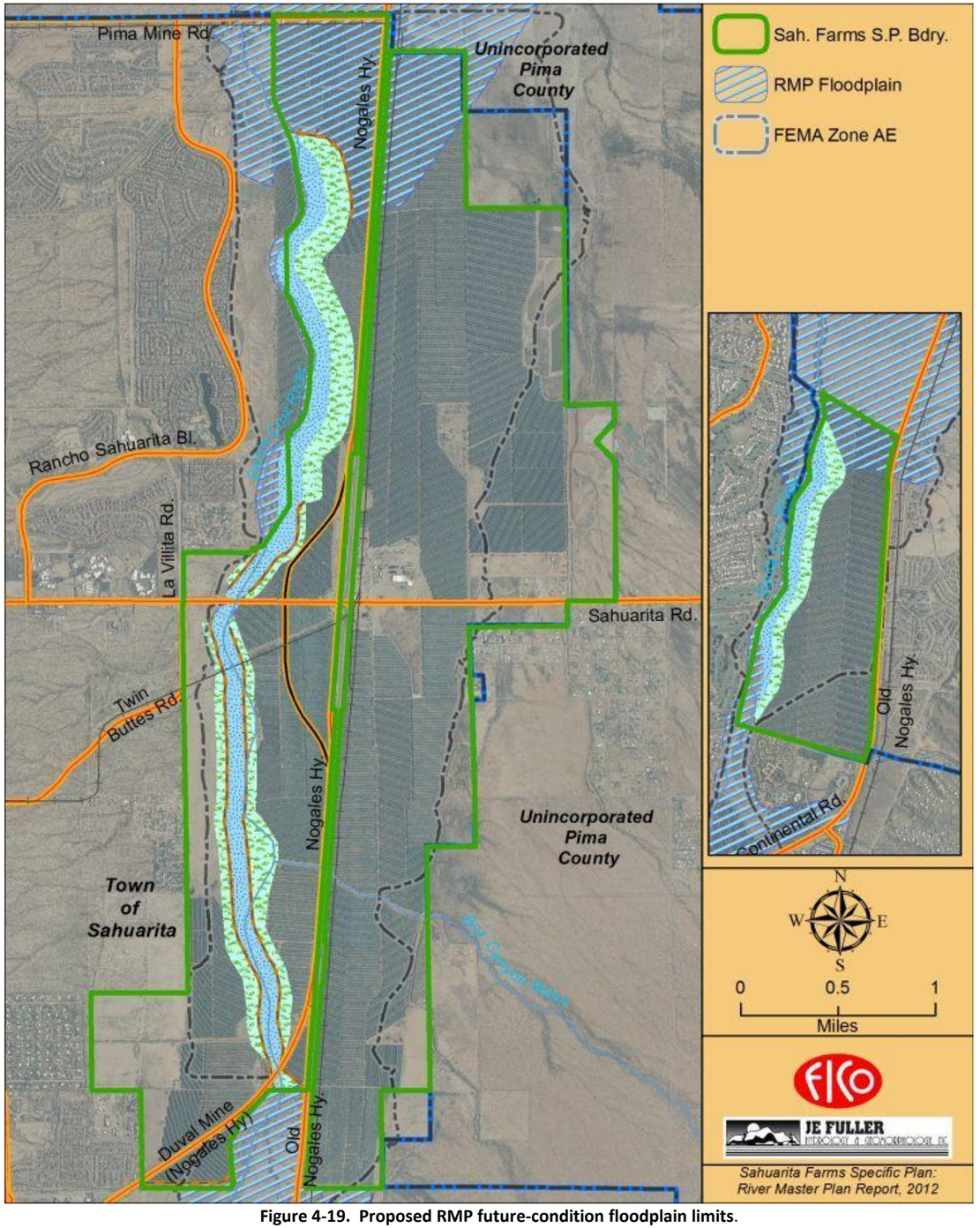


Figure 4-19. Proposed RMP future-condition floodplain limits.

4.13 Flow Modeling Summary

Detailed hydraulic modeling was performed in support of the RMP and to delineate the future floodplain (Figure 4-19). The various hydraulic models are discussed in a report included within Appendix C with results summarized in Figure 4-20 for Reaches 2 and 3. While the RMP has been designed for 45,000 cfs, a model with 55,000 cfs has been run to analyze how the terraces will behave in more extreme events.

Figure 4-20 summarizes the flow area contribution by the terraces and low-flow channel for the array of discharges. The results indicate that the low-flow channel will do the majority of the work in conveying most floods, while the terraces provide an increasing proportion of the flow area as the discharge increases, allowing for floodplain storage and flow attenuation. Based upon the results below for the 55,000 cfs discharge, the terraces should be stable in all of the modeled events.

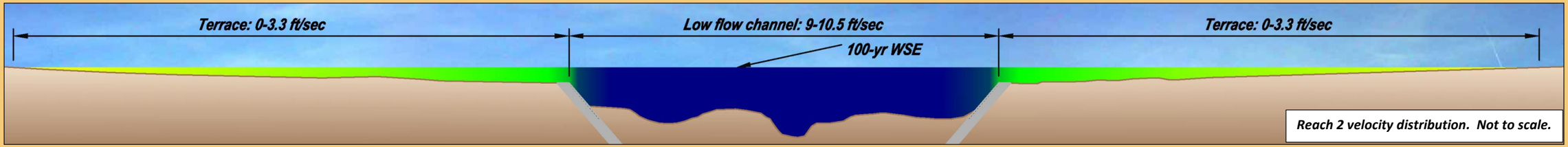
Figure 4-20 shows the typical velocity distribution for an RMP cross section with a dual (left and right) or single (right) terrace. Note how the velocity on the terraces for the 100-year event is below 3 feet per second on average but varies across the terrace with a near-zero velocity at the outer margin. Based upon these velocity profiles for the peak of a flood hydrograph, the terrace should have little to no erosion in the 100-year event and the margins should have little risk of lateral erosion hazards.

Average Flow Values in Reach 2

Event	Discharge				Average Velocity			Percent of Flow Area	
	Total	West Terrace	Low-flow	East Terrace	West Terrace	Low-flow	East Terrace	Low-flow	Total Terrace
2-yr	4,000	0	4,000	0	0.0	3.9	0.0	100.0%	0.0%
10-yr	11,000	0	11,000	0	0.0	5.9	0.0	100.0%	0.0%
20-yr	16,500	0	16,500	0	0.0	6.9	0.0	100.0%	0.0%
	20,000	8	19,989	8	0.7	7.4	0.7	99.2%	0.8%
~50-yr	25,000	74	24,889	72	1.3	8.1	1.3	96.5%	3.5%
	35,000	395	34,309	387	1.9	9.1	1.9	90.6%	9.4%
100-yr	45,000	986	43,200	971	2.4	10.0	2.3	84.6%	15.4%
	55,000	2,112	49,907	3,414	2.8	10.3	2.7	67.5%	32.5%

Average Flow Values in Reach 3

Event	Discharge				Velocity			Percent of Flow Area	
	Total	West Terrace	Low-flow	East Terrace	West Terrace	Low-flow	East Terrace	Low-flow	Total Terrace
2-yr	4,000	N/A	4,000	0	N/A	3.6	0.0	100.0%	0.0%
10-yr	11,000	N/A	11,000	0	N/A	5.2	0.0	100.0%	0.0%
20-yr	16,500	N/A	16,495	7	N/A	6.0	0.5	99.6%	0.4%
	20,000	N/A	19,969	42	N/A	6.3	0.9	98.6%	1.4%
~50-yr	25,000	N/A	24,868	132	N/A	6.8	1.1	97.3%	2.7%
	35,000	N/A	34,424	576	N/A	7.6	1.7	93.4%	6.6%
100-yr	45,000	N/A	43,693	1,307	N/A	8.4	2.2	89.9%	10.1%
	55,000	N/A	52,762	2,238	N/A	9.0	2.4	86.5%	13.5%



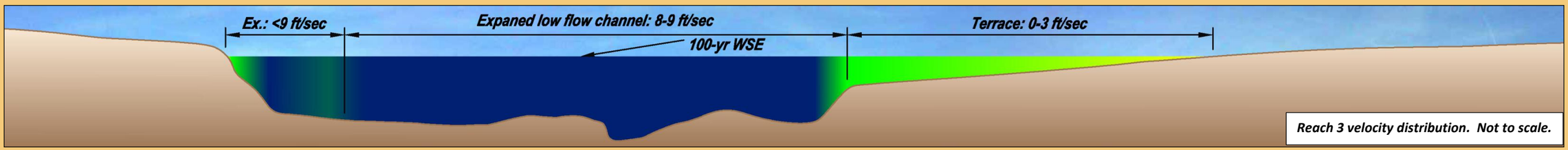


Figure 4-20. Average flow conditions and velocity distribution in River Master Plan cross section.

4.14 RMP Phasing Plan

The River Master Plan improvements may either be constructed in their entirety or in logical phases as shown on Figure 4-21 as funds are available. The proposed phasing plan is oriented from upstream to downstream to allow for adjacent development to be removed from the floodplain. The following outlines the proposed RMP phasing:

Phase 1: Southern Reach. The Southern Reach is located at the current southern limits of the Town of Sahuarita, just north of the La Posada development on the eastern side of the Santa Cruz River floodplain. Phase 1 will be constructed as a single element, and will include grading to shape the river section and transition it to existing conditions at the northern end. No CSA or grade control structures are required.

Phase 2: Duval Mine Road to Box Canyon Wash. The second phase constructs all of Reach 1 and 7,500 feet of Reach 2. Phase 2 includes the following elements:

1.A. RMP low-flow channel, CSA, and terraces from Duval Mine Road to Box Canyon Wash.

1.B. Box Canyon Wash improvements to convey flow back to the river.

1.C. Overflow channels along Duval Mine Road and Old Nogales Highway.

Phase 3: Box Canyon Wash past Sahuarita Road. This phase completes the dual terrace portion of the RMP (Reach 2) and the portion of the single terrace RMP with CSA bank protection. Phase 3 includes:

2.A. RMP low-flow channel, CSA, and terraces from Box Canyon Wash to 3,000 feet north of Sahuarita Road.

2.B. Replacement of the UPRR Spur Bridge with a wider bridge.

2.C. It is assumed that the Sahuarita Road Bridge will have been replaced.

Phase 4: Sahuarita Road to Pima Mine Road. The last phase takes the RMP to Pima Mine Road and includes:

3.A. RMP low-flow channel and terrace from north of Sahuarita Road to south of Pima Mine Road.

3.B. Return flow grading near Pima Mine Road.

Interim Conditions

An interim condition will exist between the construction of subsequent phases of the RMP. This will require that temporary features be constructed to allow the river flows to exit the constructed channel and return to the floodplain without adversely impacting adjacent parcels and while allowing for continued operation of FICO's current Pecan operation, if necessary. Each phase will be addressed with a design report to demonstrate how the interim condition will operate and will be submitted for agency review and approval.

Tributaries

The phasing plan excludes definition of how the tributaries will be constructed because these will be addressed as a part of the master drainage plan for the Sahuarita Farms Development. Currently, the design of channels for offsite tributary channels and future onsite channels is preliminary and does not include the level of analysis provided in the RMP design. However, at the time of the RMP construction, much more will be known regarding how these tributaries will be constructed and where they will drain into the river. Therefore the tributaries will be phased along with the RMP improvements as appropriate with plans and reports submitted for agency review and approval. Tributary drainage is discussed in more detail in Section 6 and in the technical appendixes.

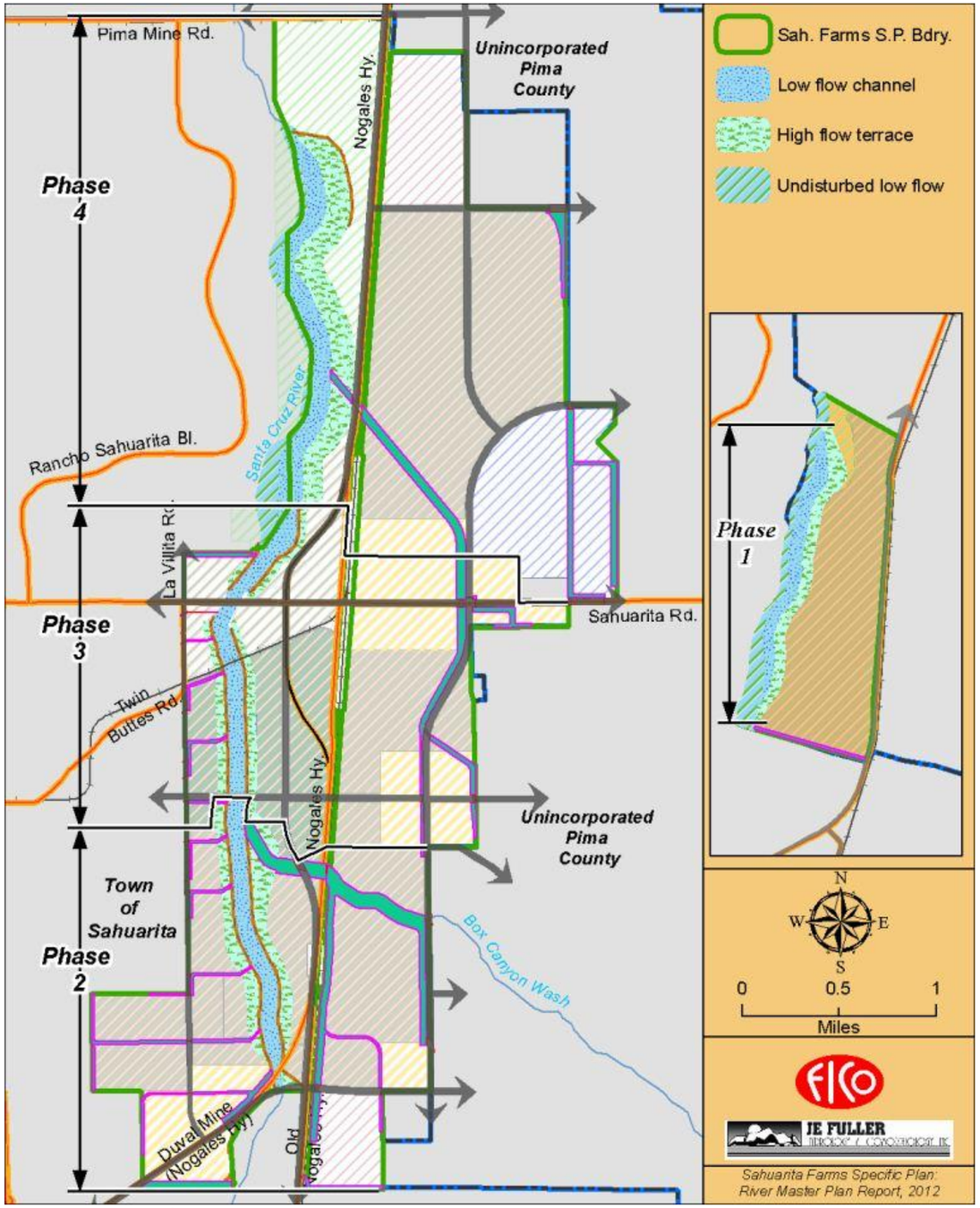


Figure 4-21. RMP phasing.

Section 5 FREQUENTLY ASKED QUESTIONS ABOUT THE RIVER MASTER PLAN

Why is the river being modified and not simply left alone?

The Santa Cruz River is no longer a pristine, undisturbed river. The river's current condition is the result of more than a century of inconsistent human intervention, historical changes in the watershed, activities in the river corridor near Tucson, and a patchwork of localized solutions to individual problems. Because of some of man's activities in the watershed and downstream of Sahuarita, the Sahuarita Farms area has a severe risk that headcuts will migrate upstream through the property and significantly alter the river. Headcutting decreases bank stability, increases flood velocities, reduces natural flood attenuation, creates hazardous bank conditions, and reduces the potential for natural riparian habitat to be sustained. Also, the current floodplain is perched (disconnected from the main channel) and is highly disturbed. It is not a pristine, untouched, natural floodplain. The RMP provides a comprehensive solution that treats the river as an amenity, not just a drainage channel. The RMP's improved floodplain will have a direct connection to the main channel, with channel and terrace features more consistent with the Sonoran Desert.

In addition, the Santa Cruz floodplain is very broad, covering most of Sahuarita Farms. Recent and historical flooding was damaging not only to FICO, but also to adjacent landowners and public infrastructure, and resulted in significant public expenditures. The RMP provides an opportunity to mitigate most of these existing threats to the river in a manner than is compatible with the community's economic, environmental, and public safety goals.

FICO also recognizes that the current agricultural operation may not be compatible with the land uses indicated in the Town's General Plan, and that as time progresses the surrounding land uses will be less compatible with farming. Few of the Town's projected future land uses are sustainable without the kind of floodplain improvements proposed in the RMP. Therefore, FICO is proactively planning for the future by accommodating needed river improvements and flood hazard mitigation measures that transition the river from its current disturbed condition into a sustainable river corridor that is a regional resource. The proposed river enhancements provide increased floodplain protection as well as space for public amenities within an improved river corridor.

Will soil cement (CSA) bank protection be needed along the entire river corridor?

No. Cement stabilized alluvium (CSA) bank protection is provided only where needed to protect development and public infrastructure. No bank protection will be provided in reaches where existing and proposed development is located outside the required erosion set back. In addition to offsetting the significant cost of the bank protection, its removal allows for less hardscape in the northernmost reach of the project. Where CSA is proposed, it will have a relatively low impact and will integrate well with the surrounding features due to its low height (~5 ft), composition of native channel materials, and moderate side slopes (2:1 or less). The bank protection will be designed to facilitate wildlife movement, as well as pedestrian and equestrian activities.

In all cases, implementation of the RMP channel corridor will reduce the 100-year velocities and will result in reduced erosion hazard. Furthermore, provision of grade control structures will prevent long-term degradation that leads to increased bank erosion. To meet environmental goals, and to achieve a more natural river corridor, bank protection was not included in the portions of the RMP corridor where it was not needed to protect development or critical public infrastructure. In reaches where no low flow bank protection is proposed, development will be set back at least 500 feet from the channel bank. In addition, placing bank protection along the entire reach would substantially increase the maintenance and inspection costs. In limiting the bank protection to only those areas where it is necessary to protect development or critical infrastructure, fiscal resources are protected and any money spent goes directly towards the public well-being. An important goal of the RMP is to provide an environmentally sensitive design that minimizes hard scape features.

Will this project cause adverse impacts to adjacent properties?

No. The RMP must meet strict requirements set forth by the Town of Sahuarita floodplain ordinance, as well as by FEMA. The proposed RMP project is not allowed to increase the regulatory flood depths on adjacent lands by more than one-tenth of a foot and cannot increase velocities by more than the 1 foot per second or 10-percent, whichever is less. This project will meet both of these standards, and in most cases, will have lower flood water surface elevations and velocities.

The proposed design pays special attention to assuring that the already significant flooding potential to existing structures upstream of Duval Mine Road, and downstream of Sahuarita Road on the west side of the floodplain, is not worsened. In both cases, the 100-year flood depth is lessened due to increased capacity of the river corridor.

Is the RMP consistent with the Town's General Plan?

Yes. The Town's General Plan and other adopted plans anticipate and plan for river improvements in conjunction with future non-agricultural uses.

How has the river changed since FEMA's effective mapping was prepared?

The shape and elevations of the river and floodplain have changed since the effective model was prepared. These changes include the headcutting that is present north of Sahuarita Road, bank erosion throughout the reach that has widened the main channel, meandering of the thalweg, and some localized areas of aggradation and sediment deposition. All of these changes impact the shape of the floodplain, as well as how floods are carried within the river corridor.

In addition, the way floodplains are modeled has changed since FEMA last mapped the floodplain. In 1995 the program of choice was HEC-2, a DOS-based program developed by the Corps of Engineers. The program required the user to hand enter station/elevation data for a series of cross sections to model a river channel and its floodplain. These station/elevation points were interpolated by hand from a paper copy of a topographic contour map. Today, the HEC-2 program has been replaced by HEC-RAS, a Windows-based program with a graphical user interface allowing the user to better understand the data entered into the model.

The model resolution has significantly improved due to computer hardware and software advances. The station and elevation data can now be extracted from a digital terrain model using computer software, allowing much more detail at each cross section. Previously, the six mile reach of the river from Duval Mine Road to Pima Mine Road was represented by approximately 36 two-mile wide cross sections with about 40 or so station/elevation points each. This same reach has now been modeled with over 90 cross sections each with several hundred station/elevation points. Computer software now also assists the user in delineating the floodplain, allowing for much greater resolution when producing flood maps.

FEMA's regulatory mapping requirements have also changed since the mid 1990's when the original FEMA maps were prepared. These changes affect how many of the agricultural and development-related features are modeled, resulting in changes in the regulatory floodplain limits.

The FEMA floodplain maps will be updated as required when the RMP is implemented and prior to development as subdivision plats are completed in the future.

Why will the existing river channel be disturbed?

It is necessary to rework the existing river channel in order to contain and control regulatory flood flows, and to create a more sustainable, stable river corridor. The proposed RMP design modifies the existing river channel while meeting regulatory and engineering guidelines. All of the applicable provisions of the Clean Water Act will be met by the proposed RMP design, which will include restoration of any lost habitat and enhancement of the existing degraded habitat.

Can the RMP concept be extended beyond Sahuarita Farms?

Yes. The RMP can be extended to create a continuous river corridor. The key to extending the RMP is cooperation between various stakeholders and landowners. Developing the RMP through FICO has been challenging but is simplified by single ownership. If the Town foresees future development to the south of FICO, a similar RMP can be developed following the pattern laid out in this RMP. Considering the impact of planning for and improving a river not only as a flood control measure but a public open space, recreation and environmental amenity prior to development, it makes good sense to plan for such improvements today. Furthermore, a similar RMP can be developed to the north to rehabilitate the river, should this be deemed important

What will be in the low-flow channel?

The low flow channel will only have what Mother Nature puts there. The RMP proposes that no structures or improvements be placed within the low-flow channel. Over a short amount of time, vegetation will become established in the low-flow channel, and the geometry of the channel will be shaped and changed by low-flows and floods. The RMP concept allows for this natural evolution of the low-flow channel over time. The wide channel provided for in the RMP design will allow the river to create its own equilibrium form within the low-flow channel portion of the corridor.

This RMP design is based on experience gained from many river projects, including studies of the Santa Cruz River and the Rillito Creek. This experience indicates that although channels may be designed and constructed as smooth, trapezoidal sections, they eventually evolve, deposit sediment, develop vegetated bars, and form channel meanders. In projects where such "evolutionary" processes are not accounted for, a managing jurisdiction must on occasion remove channel material at a monetary cost to the taxpayers and an environmental cost to the river. To avoid this, the hydraulic model prepared for the Sahuarita Farms RMP design accounted for this natural evolution. Hydraulic models use a coefficient to define "roughness", a reflection of vegetation, obstructions, irregularity, etc. In this project, the roughness values used were 25 percent higher than those often used in downstream reaches of the river in past FEMA submittals. This allows for suitable freeboard to account for future vegetative growth and local sediment deposition. Therefore, the answer to the question of what will be in the low-flow channel is whatever the river system develops naturally, including braids, vegetated bars, meanders, and in-channel terraces.

How will the low-flow channel be designed?

The low flow channel portion of the RMP cross section will include a thalweg and low floodplains that bound the thalweg. The thalweg channel will carry the most frequent flows, and will be shaped to mimic the natural channel and low floodplain geometry of stable reference reaches in nearby portions of the Santa Cruz River. This geometry will help provide sediment continuity that will increase the stablity of the thalweg and minimize the potential for lateral erosion. A detailed geomorphic analysis of the low flow channel geometry will be conducted as part of the final RMP design process. Costs to maintain and inspect the terraces after major floods that inundate the terraces should be included in long-term budgeting for the project.

What will be on the terraces?

The terraces are a low-impact design feature and may include trails, parks, landscape treatments, habitat enhancements, recharge facilities, and open space for recreation, creating a unique opportunity for a regional river park. All of the terrace uses will be compatible with a river-oriented community. Because the terraces will be subject to occasional low-velocity, low-depth flooding, some flood inundation and sedimentation should be expected, and any constructed uses should be designed to withstand such conditions or be easily maintained after such an event.

What happens to the terraces in big events?

The RMP terrace areas are intended to be part of the floodplain, and as such retain some potential for natural floodplain sedimentation processes during the rare floods that will reach and inundate the terraces. The velocities, impact forces, and statistical probability of any point on the terrace being inundated were evaluated using engineering models. The terraces will only be impacted during floods that exceed the 20-year level. Even during the 100-year event, the maximum average velocities will not exceed 2.5 feet per second. The threshold for erosion is generally considered to be above 3 feet per second. Furthermore, flood velocities will decrease even more with distance from the low-flow channel, and will be mitigated with vegetative plantings and other bioengineering techniques. It is likely that some deposition of fine-grained sediment will occur on the terraces during large floods, with some potential for local scour in isolated places.

Where no bank protection is constructed between the low-flow channel and the terrace, there is potential for lateral erosion to remove some of the terrace area during very large floods. The presence of grade control structures which prevent headcutting and creation of a more natural low-flow channel will mitigate some the potential for lateral erosion.

Has the RMP concept been used elsewhere?

Yes. The RMP concept has been used elsewhere in Arizona, and is commonly used by the Corps of Engineers for river restoration/flood mitigation projects. Rivers have been managed using a variety of strategies for centuries. In the Tucson region, river master plans for the larger streams, such as the Santa Cruz River, Pantano Wash and Rillito Creek, were prepared and implemented after urbanization encroached upon their floodplain. Because these river master plans were retrofits in an existing urban setting, the most practical engineering solution was to contain these streams with narrow, prismatic sections to reduce floodplain encroachment and impacts to the adjacent existing uses. The Sahuarita Farms RMP differs from these past Tucson area designs primarily because urban encroachment has not yet occurred in the floodplain – which severely limits softer, more environmentally desirable options that typically require a wider river corridor. The Sahuarita Farms RMP design, however, is not new. The RMP's low-flow channel/ terrace concept is found on most natural river systems. Locally, a similar design was used on a reach of the Santa Cruz River at Irvington Road, where a CSA-lined low-flow channel and relatively narrow non-armored floodplain terraces are used. The RMP low-flow channel at Sahuarita Farms will be only 5 feet deep (vs. ~20 ft. at Irvington Rd.) and the RMP terraces will be much wider and more aesthetically pleasing.

The Continental Ranch reach of the Santa Cruz River in the Town of Marana used a similar channel/terrace design concept, with several important differences. First, effluent flow introduced to the low-flow channel near Marana has scoured the channel and undermined the low flow CSA, which has for the most part maintained its integrity. The Sahuarita Farms RMP does not intend to introduce treated effluent into the low-flow channel to prevent these kinds of impacts. Secondly, the outer terraces margins at Continental Ranch are also bank protected. The RMP bioengineered design does not require this secondary CSA construction. Finally, the RMP corridor will function more as a public amenity than the armored channel and vacant floodplain at Continental Ranch.

Section 6 TRIBUTARIES

6.1 Watersheds

Several tributaries drain to Sahuarita Farms. Offsite watershed modeling was prepared as part of the Sahuarita Farms development plan to document the discharges generated from the tributary washes. Offsite hydrology and tributary design are discussed in the Drainage Master Plan Report.

Figure 6-1 shows the overall extent of the area draining to the Sahuarita Farms Specific Plan area.

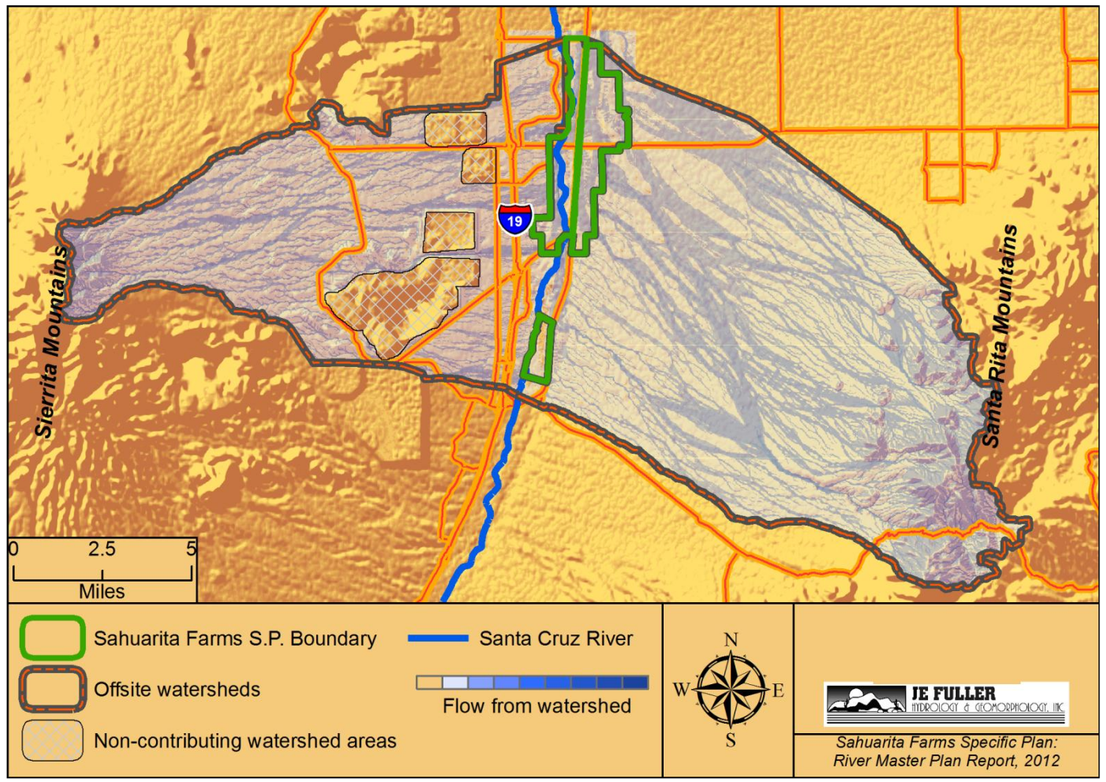


Figure 6-1. Contributing watersheds.

Figure 6-2 shows the flow depths in detail along with the alignment of the washes that have been defined by Pima County. While the only such wash that flows through the project is the Box Canyon Wash, there are large areas with sheet flooding. Note that there is little if any offsite flow and no regulatory flow (other than the river) that is conveyed through the southern portion of the Sahuarita Farms area.

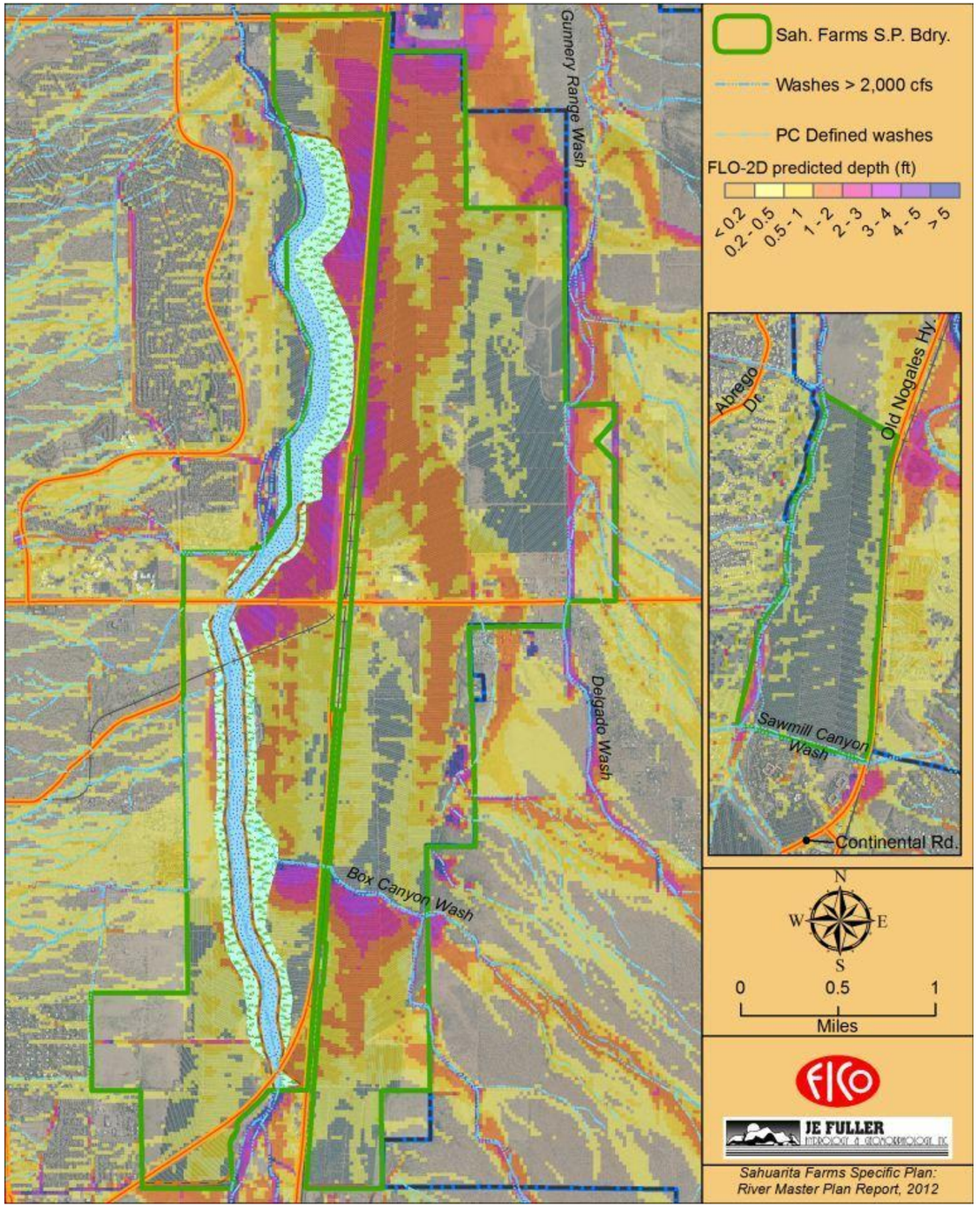


Figure 6-2. RMP with local washes and flow depths.

6.2 Tributary Channel Design

Other than the Box Canyon Wash, there are few competent drainage paths within Sahuarita Farms. What is there is easily overwhelmed by the 100-year discharge and therefore all of the existing tributary channels and flow paths will be modified in some form to accommodate drainage in and around Sahuarita Farms. The design of channels for offsite tributary channels is preliminary at this point, is described in the Sahuarita Farms Drainage Master Plan Report, and is summarized below. Where collector channels are used to capture off-site flows, appropriate collector channel design standards will be used in the design phases of the on-site drainage system.

Several channels were designed to convey the offsite flow through the Sahuarita Farms project. These channels were aligned to convey flow along existing flow paths within tributary channel corridors (shown at right). These corridors have the following characteristics:

- Most channels are prismatic with rip rap banks sloped at 3:1 (H:V). Most channel bottoms are earthen, but some channels, such as Box Canyon Wash, may be built as a compound channel with a low-flow channel and terrace, similar to the RMP.
- Channels that collect flow along the project margin will have concrete lined banks where flow enters the channel. Channel corridors include enough width to site the channel and a 16 foot maintenance road. In addition, a buffer was added to the above width to account for grading and to allow for future revisions.
- All channels have been sized to have 1.5 feet of freeboard. 100-year flow depths of between 3 and 4 feet were preferred and most depths are below 5 feet. Shallow depths were necessary to prevent the need for excess fill on the site due to the extremely flat prevailing slopes.

The Box Canyon Wash currently crosses the Nogales Highway and Railroad corridor through a series of undersized culverts. In the present conditions, if a 100-year event were to occur within the Box Canyon Wash, a sizeable percentage of the flow would not make it through the culverts but would instead follow the railroad and highway to Sahuarita Road. Two options exist for this area. The first is to mimic this with a design to convey this flow to and through Sahuarita Road and outlet at the north end of the property. The second is to rebuild the culverts and convey flow to the river. The second option has been selected and future coordination with local jurisdictions and the railroad will be necessary to convey this flow back to the river.

The Town is currently designing Sahuarita Road through Sahuarita Farms. JE Fuller has obtained preliminary plans for the road and its drainage infrastructure. The tributary corridors were aligned to accommodate the drainage design by the Town, however, there are some areas where future design changes by the Town may require some revision to the corridor alignments. These issues will be addressed as both designs progress.

Because there is no regulatory offsite flow draining through the southern portion of the project, no channels are proposed in this area. Sawmill Canyon Wash confluences with the Santa Cruz River just south of the Southern Reach of the RMP, but no development is proposed within the floodplain or erosion hazard setback of that watercourse, as described in the Sahuarita Farm Drainage Master Plan Report. Some channels may be necessary for conveyance of onsite drainage. These will be identified as the project progresses to future subarea drainage master plans and/or subdivision plats.

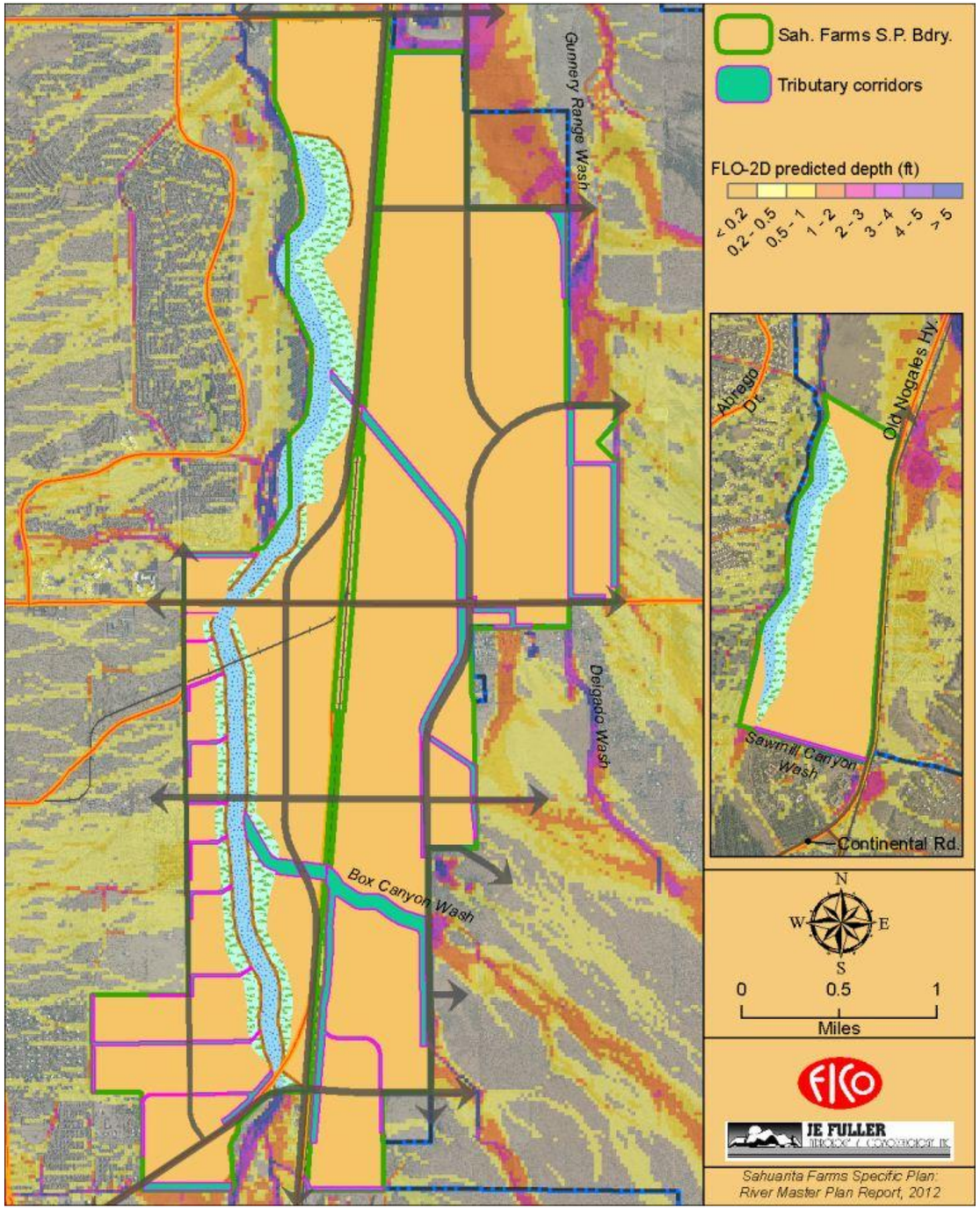


Figure 6-3. Overview of Drainage Master Plan.

Section 7 SUMMARY OF EXTERNAL AGENCY COMMUNICATION AND REQUIREMENTS

Ultimately, this project will be subject to local, state, and federal agency requirements during the final design and construction phases. This section briefly explains some of the most significant requirements, how they affect the project, and communication that has occurred with the agencies. As is typical, formal environmental and other regulatory permitting will be initiated during later design phases of the development review process, and are not a requirement of the specific plan. However, environmental and biological considerations have been included in this project; please see Appendix D for a detailed Environmental Overview as well as Biological and Cultural Resource Considerations.

7.1 Section 404 Permits

Section 404 of the Clean Water Act (CWA) regulates the discharge of fill material to waters of the U.S. The U.S. Army Corps of Engineers (Corps) enforces the Section 404 requirements through the 404 permit program. Prior to undertaking construction activities that will result in placement of dredge or fill material within waters of the U.S., a 404 permit must be obtained.

To determine the nature and extent of the Corps' jurisdiction within the project area, a preliminary jurisdictional delineation was prepared and submitted to the Corps for review. Approximately 61 acres of potentially jurisdictional waters were identified within the Sahuarita Farms area, with 55 acres being in the river and 6 in Box Canyon Wash. There were no special aquatic sites or wetlands within the Sahuarita Farms project area. The envisioned improvements to address flood and erosion protection will likely exceed the ½ acre threshold for nationwide permits and an Individual Permit will be required. Prior to issuing an Individual Permit several supporting reports will have to be prepared, including a Alternative Analysis to ensure that the actions proposed are the least damaging practicable alternatives that meet the project's purpose and need, a habitat mitigation and monitoring plan, and state water quality certification. In addition, the Corps must also comply with the substantive requirements of the National Historic Preservation Act, the Endangered Species Act, and the National Environmental Policy Act.

Preliminary meetings were held with Corps representatives to discuss the project and identify any potential opportunities or constraints with the design. Based upon the discussion and cross sections provided, a Corps representative identified no significant concerns that would prevent this project from progressing. In addition, it was mentioned that the Corps themselves have applied similar designs to other rivers.

7.2 National Environmental Policy Act

NEPA sets forth the country's basic environmental policy and requires with some limited exceptions, all federal agencies in the executive branch have to comply with the process and procedures required by NEPA that provide for public involvement in the Federal planning process and the full disclosure of anticipated federal project impacts. Compliance triggers that initiate the substantive elements of NEPA include, but are not limited to, federal approvals of non-federal actions such as grant proposals, licenses and permits. For the activities contemplated in the RMP the CWA Section 404 permit program is the principal federal nexus for the project that would trigger NEPA obligations. Based upon our current understanding of the resources within the project area and the anticipated beneficial effects of the RMP we anticipate that National Environmental Policy Act compliance will be satisfied with an Environmental Assessment, thought ultimately the Corps will make the final determination as to whether an Environmental Assessment or and Environmental Impact Statement would satisfy their obligations under NEPA.

7.3 FEMA Requirements

The Santa Cruz River is a federally mapped watercourse with a 100-year floodplain (Zone AE designation with a floodway). Construction within the FEMA floodplain and floodway is subject to federal regulations. Because the RMP design will change both the floodplain and the floodway, these will be remapped after construction of the project through a Letter of Map Revision (LOMR) process. In addition, a Conditional Letter of Map Revision (CLOMR) will be requested by FICO during the preparation of design plans to assure FICO, the Town, and other interested parties that FEMA will accept the proposed changes. FEMA has no other method to obtain an opinion or certification that a project will be in compliance with their regulations. However, because this is such a substantial project, communication between the FICO team and FEMA has occurred to identify significant concerns. None were identified.

7.4 Local Requirements

In addition to federal requirements, local ordinances and codes dictate how a floodplain may be developed. The Town of Sahuarita is the local floodplain administrator and their "Title 14 (Floodplain and Erosion Hazard Management) of the Sahuarita Town Code" applies to this project. The requirements in this document are more stringent than and supersede FEMA's requirements. These state that this project may not adversely impact adjacent parcels. In summary:

- This project may not increase velocities by 10 percent or 1.0 feet per second, whichever is less.
- This project may not increase water surface elevations by more than 1 tenth of a foot.

The above 2 requirements have been investigated and based upon the models prepared; this project will not adversely impact adjacent properties.

(Note, Sections 7.1 and 7.2 were provided by Westland Resources Inc.)

Section 8 RIVER MASTER PLAN AMENITIES

8.1 Landscape Aesthetics and Recreational Improvements

The River Master Plan will include a wide variety of aesthetic features, improvements, and amenities. The recreational and aesthetic amenities will provide the river corridor with a unique and identifiable character portrayed through the use of improvement "zones" that will allow for varied levels of landscape and environmental enhancements. The goal is a well balanced mix of uses that complement the natural environment while allowing end users to have opportunities for a wide range of outdoor recreational activities. Landscape enhancements in these use zones will also vary according to location along the corridor and proximity to adjacent land use intensity. These may include elements found in traditionally inspired park settings or natural habitat enhancement areas.

8.2 Corridor Features

Recreational users within the river Corridor will have access to a network of community and regional trails linked with the major offsite tributary corridors. These will operate as pedestrian circulation routes, connecting the various use areas along the corridor and providing connectivity to the adjacent residential, commercial, employment, and recreational uses. Varying levels of trail improvements will be used dependent on the environmental sensitivity of the area as well as the types of activities appropriate to the zone. Trails and paths may be constructed as paved or un-paved natural surfaces and designed for non-motorized uses, and will be separated from wildlife corridors.

FICO has long held that the Santa Cruz River and similar desert watercourses are precious amenities to be celebrated, providing linkages and refuge for humans, flora and fauna alike. As a part of the overall master plan concept within the RMP, drainage, recreational, environmental and aesthetic enhancements and amenities are proposed along the river corridor. These proposed improvements can be categorized into four distinct "improvement zones" within the River Park/Open Space areas. The goal is to provide the Sahuarita community with a well-balanced mix of improvement types that complement the natural environment while establishing opportunities for a wide range of both passive and active recreational outdoor activities. The specific phasing, amenity programming and physical extents of each improvement zone will be refined with each Village Subarea Plan as each applicable river segment is designed for construction. The improvement zones include:

- Primary River Drainage Open Space
- Active River Open Space
- Passive River Open Space
- River Transition Open Space

Each of these improvement zones is described in more detail below.

Primary River Drainage Open Space: This improvement zone includes the portion of the Santa Cruz River corridor between and including the lower terrace bank protection structures and/or the low flow channel as defined in the RMP document. These areas will include a re-contouring of the low-flow channel and its adjacent floodplains to increase the river's capacity so that it can convey the 20-year flood without overtopping. This zone will also include soil cement bank stabilization in some areas to prevent erosion along the lower banks of the river corridor. Grade control structures will also be provided approximately every half-mile to prevent headcutting . The area within this zone, once constructed, will generally be left in a natural state except for periodic maintenance activities.

Active River Open Space: This improvement zone will include active public recreational amenities within portions of the upper terrace areas of the Santa Cruz River corridor. The primary use within this improvement zone will include public trails on both sides of the river, including the Anza Trail and other community trails or pathways. In addition to public trails, a variety of other recreational improvements can occur within this zone, including but not limited to trail head facilities, equestrian facilities, ramadas, picnic areas, seating areas, disc golf, par/exercise courses, ball fields, sport courts, skateboard parks, play structures, parking and staging areas, community gardens, amphitheaters, and landscape enhancements directly associated with recreational amenities.

Public accessibility to the Santa Cruz River is a key objective of the river improvement program. The river corridor is intended to serve as a regional amenity for the Sahuarita community and will have multiple opportunities for public access points. In general, gateway/trailhead areas can be established at key locations along both sides of the river, typically in conjunction with major transportation corridors and/or high-intensity land uses. Gateway areas may include amenity improvements that will provide access to the river corridor, interpretive information and areas to accommodate parking, public assembly and equestrian staging. Typical improvements in gateway/trailhead areas may include trailheads, restrooms, staging facilities and interpretive/wayfinding signs, maps and educational information. Improvements may also include shade structures and seating, outdoor assembly areas, parking and equestrian facilities and access. Enhanced landscape treatments can be used to promote the natural identity of the river corridor with the use of indigenous plants and native materials for walls, signage and pedestrian features. Historically significant design elements of the region may also be employed to provide educational opportunities for users.

The total acreage within the Active River Open Space will vary depending on the amount and extent of recreational amenities within the limits of the upper terrace areas, but at a minimum, it is anticipated that 11 miles of trails, including both sides of the river will be provided for the length of the property. If additional recreational improvements are provided, the acreage within this zone will increase and the acreage within the Passive River Open Space zone will reduced proportionately.

Passive River Open Space: This improvement zone is also located entirely within the upper terrace areas of the Santa Cruz River, and is intended to provide a more tranquil open space experience with emphasis on a natural open space environment. Improvements within this zone will include amenities such as habitat enhancements, wetland ponds, seating areas, shade ramadas, picnic tables, and other passive open space improvements. Utilization of indigenous vegetation within this zone, including lower Sonoran Palo Verde and Mesquite plantings supplemented with native grasses and shrub species will be re-introduced and/or enhanced. Indigenous xeroriparian habitat such as Mesquite, Cottonwood and Willow species may also be introduced in areas where active or standing water elements are provided, such as wetland ponds using either CAP water or treated effluent. Wetland ponds can provide cool oasis zones during the hot summer months and will support aquatic habitat and groundwater recharge. The re-establishment of riparian habitat will enhance the aesthetic quality of the river corridor and increase habitat value for wildlife. Defining a suitable balance between protected natural habitat areas and human-accessible areas will require thoughtful implementation to ensure these dual-use objectives are sustainable and align with best management practices.

River Transition Open Space: This open space zone is located at the north edge of the property where the Santa Cruz River floodplain will be returned to the pre-improvement condition upon exiting the Sahuarita Farms property. This zone may include clusters of pecan trees in an agricultural preserve, and/or a slow transition to a more native plant palette. A portion of this zone is also designated as a potential future site for a regional wastewater treatment facility located south of Pima Mine Road.

Section 9 RIVER MASTER PLAN ALTERNATIVE ANALYSIS

In addition to the recommended River Master Plan described in Section 4, a number of other design alternatives were also considered and evaluated. The other RMP alternatives considered included the following:

- Channelization
- Levees
- Regional Detention
- Floodplain Fill.
- No Development/No Action

Evaluation Criteria. All of the RMP alternatives were evaluated to the level of detail required either to demonstrate the existence of a fatal flaw or to the level needed to rate the alternative relative to other alternatives. The alternatives which passed the fatal flow analyses were evaluated by the entire project team for their ability to achieve the overall project goals and objectives, and the recommended alternative was selected. The following criteria were used to evaluate the RMP alternatives:

- Floodplain Management. The recommended alternative must fully contain the 100-year flood and erosion hazards within a defined corridor and provide an area for safe development adjacent to the river corridor.
- Regulatory Compliance. The recommended alternative must be able to meet applicable local, state and federal development and regulatory requirements.
- Off-Site Impacts. The recommended alternative must not have any unacceptable adverse impacts on adjacent property owners. If possible, the recommended alternative should reduce flood hazards on adjacent lands.
- Flood Hazard Reduction. The recommended alternative should reduce flood and erosion damages to existing and proposed public infrastructure.
- Multiple-Use Opportunities. The recommended alternative should provide opportunities for recreational and open space uses in the floodplain, as well as for recharge, habitat enhancement, trails, wildlife corridors, and natural floodplain functions.
- Cost. The recommended alternative should minimize capital and life-cycle costs
- Off-Site Drainage. The recommended alternative should account for and be compatible with existing and future off-site drainage corridors.
- Environmental Enhancement. The recommended alternative should provide opportunities for enhancement of the existing riparian environmental along the Santa Cruz River corridor.
- Environmental Permitting. The recommended alternative should be able to meet Section 404 and NEPA environmental permitting requirements.
- River Stability. The recommended alternative should create a sustainable river corridor that reduces or prevents the expansion of existing, historical instabilities in the Santa Cruz River.
- Aesthetics. The recommended alternative should create an aesthetically pleasing corridor that is an amenity for the surrounding communities.

The recommended alternative was presented at numerous agency coordination meetings, stakeholder meetings, and public meetings, as well as at a public/private design charrette, and feedback was solicited on how to optimize the RMP conceptual design.

Channelization. A wide spectrum of alternative channelization designs with various channel widths, depths, cross section geometries, and bank stabilization methods were considered. At one end of the spectrum, a channelization plan similar to the designs used for most of the Santa Cruz-Rillito-Pantano-Canada Del Oro river systems in metropolitan Tucson was considered. Although this narrow, trapezoidal, soil-cement protected design would create the largest footprint of developable land, it was rejected because it did not meet most of the non-engineering evaluation criteria. Other channelization alternatives considered included a cross section that avoided impacts to potential "waters of the United States" (404 jurisdictional areas). This alternative was rejected primarily because of concerns raised by local floodplain administrators, since avoiding potentially jurisdictional channel areas created a perched flood elevation condition and complicated connections with off-site tributary runoff. The final recommended alternative represents a balance between floodplain cuts and fill, containment of the 100-year flood, and creation of a sustainable river corridor footprint.

Floodplain Fill. Elevating structures on engineered fill is a common means of developing in the floodplain, and was considered as an RMP alternative, but was rejected as the sole solution for the majority of the project area for the following reasons: (1) use of widespread fill would not solve existing flood problems at the UPRR, the Nogales Highway and at various bridge crossings, (2) filling the floodplain would not solve existing river instability and headcutting problems that threaten the long-term health of the study reach, (3) creation of isolated development fill pads would not provide the all-weather access required by local development codes, and (4) the volume of fill required was not readily available without significant excavation of the floodplain. Use of engineered fill in conjunction with channelization is part of the recommended RMP alternative for the Sahuarita Farms parcels. In addition, elevation on fill was the recommended alternative for Continental Farms portion of the project in unincorporated Pima County.

Levees. Early RMP alternatives considered the use of levees to contain the 100-year floodplain along the existing main channel of the Santa Cruz River. Levees have been successfully used as a flood control measures throughout Arizona and the United States for many decades. However, the proposed RMP levee design would have resulted in embankments elevated significantly above the surrounding floodplain, effectively cutting off access and views of the river corridor, and eliminating most opportunities for public access, recreation and multiple-uses in the floodplain. In addition, there were potential fatal flaws at existing bridge crossings and tributary confluences. Finally, since the epic levee failures in New Orleans during Hurricane Katrina, there are significant regulatory barriers to constructing and maintaining new levees. Therefore, levees were not considered as part of the recommended RMP alternative.

Regional Detention. Flood peak reduction through regional detention or flood storage was rejected as a viable flood control alternative because of the magnitude of floods on the Santa Cruz River. No practical detention sites with sufficient storage volume are available in or near the FICO property.

No Development/No Action. Some modification of the existing regulatory floodplain is required to allow the types of future development envisioned by the Town's General Plan for the FICO parcels. Similarly, definitive actions along the river corridor are required to stop the headcutting that originated in Tucson and now is beginning to migrate upstream through FICO lands. If unchecked, this headcutting will significantly degrade the riverine environment along the Santa Cruz and will threaten public and private infrastructure along the river corridor. Therefore, the no action alternative was rejected as the recommended RMP alternative because no action will result in adverse consequences to the river and the public.

Flow Collection Alternatives. After the RMP channelization concept was selected, it was necessary to evaluate and select alternatives for capturing flooding at the upstream end of the Sahuarita Farms reach at Duval Mine. A range of alternatives were evaluated based on their ability to meet the following criteria: (1) no adverse impacts to adjacent properties, (2) construction of all structural elements on property controlled by FICO, and (3) compatibility with the other goals and objectives of the RMP. Early concepts included flood gates, levees, collector channels, and channel excavation. As described earlier in this Report, the recommended flow collection design included placement of fill to direct flow towards the river corridor and a series of collector channels on FICO lands that direct runoff toward the main channel of the river. It is recommended that the potential for optimizing the flow collection system be explored with potential funding partners as one of the RMP implementation processes.

Section 10 RMP OPERATIONS & MAINTENANCE PLAN

One of the benefits of the RMP is that it will reconnect the Santa Cruz River with its floodplain, and by reducing its footprint, will substantially reduce the amount of public and private infrastructure requiring maintenance due to flood damage. The RMP will also reduce flood damages and maintenance associated with lateral erosion on adjacent properties, flood inundation along Old Nogales Highway and the UPRR, and most importantly, headcutting. Like all flood control facilities, periodic maintenance of the RMP corridor will be required. There presently is public and private infrastructure within the Santa Cruz River floodplain, such as roads, bridges, railroads, bank protection, grade control structures, utility lines, and farm levees that require regular inspection, maintenance, repair, and eventual replacement. Although the RMP introduces no new types of infrastructure, soil cement bank protection will increase, and it is likely that new recreational and environmental enhancement features will be constructed on the terraced portions of the RMP cross section. Just like the existing infrastructure, any new RMP facilities will require an operations and maintenance plan.

A detailed Operations and Maintenance Plan (O&M Plan) will be developed with the detailed construction design of the RMP improvements. The O&M Plan should include the following elements:

- Ownership: The O&M Plan should clearly identify the owner of each facility.
- Maintenance Responsibility: The O&M Plan should clearly identify the entity or entities responsible for performing inspection, maintenance, repair, and replacement activities of each element of the RMP.
- Inspection: The O&M Plan should outline the frequency of regular and event-based inspections, include an inspection checklist of required activities, and identify the minimum qualifications of inspection personnel. For example, some facilities such as bridges, require annual inspection to meet Federal Highway Administration requirements, but many also benefit from inspection after significant floods to assure safety and long-term performance.
- Local Standard of Practice: The Pima County Regional Flood Control District (PCRFCD) currently maintains hundreds of flood control facilities, and routinely implements O&M Plans for these facilities. The RMP O&M Plan should utilize relevant parts of the PCRFCD O&M Plans to assure conformance with local standards and practices.
- Maintenance & Repair: The O&M Plan should identify conditions which trigger maintenance activities and/or repair for each type of structure and RMP element. For example, some level of sediment deposition is a normal process in a healthy river system, and may be expected within the low flow channel in the RMP corridor. However, while the RMP will be designed to provide sediment continuity, if excessive sediment deposition were to occur, it could potentially raise flood levels above the design targets. To address this, index cross sections at key locations could be established relative to hydraulic modeling to identify if a threshold of deposition (or scour) has occurred that would adversely impact the function of the RMP corridor.
- Replacement: Over time, most engineered facilities require eventual replacement. The O&M Plan should acknowledge the need for future replacement of engineered facilities, so that the responsible parties can budget for such costs.

Costs associated with operations and maintenance of river corridors should be accounted for in the project planning and design. Costs can be incurred due to any of the following:

- Vegetation/Irrigation: Required activities may include maintenance of terrace landscape and irrigation elements, removal of invasive species, and planting and maintenance of habitat restoration elements. Included should be a maintenance allowance for vegetation and irrigation repairs on the RMP terraces after floods greater than a 20-year event.
- Sediment Control: Removal of excessive sediment deposition, if present at levels that would affect performance of the RMP corridor during the design flood.
- Infrastructure Replacement: Potential replacement of engineered elements such as bank stabilization and grade control structures.
- Inspection: There are costs associated with regular, periodic inspection of RMP facilities, as well as the documentation of findings and actions.
- Trails Maintenance: Normal maintenance of trail surfaces, access points, and structures will be required. Trails should not be located within the low flow channel of the RMP corridor to avoid damage and on-going maintenance expenses from flows in the low flow channel.
- Parks Maintenance: Any park facilities located within the RMP will require normal park maintenance activities such as trash removal and facility maintenance. In addition, park facilities on the RMP terraces may require maintenance after floods greater than a 20-year event.

The RMP has been designed to minimize operations and maintenance costs in five important ways. First, the RMP concept minimizes the footprint and removes existing homes and infrastructure from the floodplain to prevent the types of flood damage that require maintenance and repair. Second, low flow bank protection is proposed only in locations where needed to protect existing or proposed infrastructure. Third, the design of the low flow channel element will use natural channel concepts to assure sediment continuity, minimize lateral and vertical instability, and allow for a natural, self-regulating river section. Fourth, the RMP terraces are designed to be infrequently flooded. When flooded, the RMP terrace will convey floodwaters at shallow depths and slow velocities. Fifth, the design of the tributaries will minimize introduction of post-development nuisance flows that could cause excessive vegetative growth in the RMP low flow channel conveyance zones.

Section 11 CONCLUSION

The Santa Cruz River has long been a focal point within the Town of Sahuarita and the surrounding area. The river has a very broad floodplain with a documented history of causing extensive flood damages. There have been three major floods within the last 40 years that damage private and public infrastructure. Damage from riverine erosion routinely occurs on FICO's lands during moderate floods. This River Master Plan allows for responsible development at Sahuarita Farms, enhances the Santa Cruz River Corridor, and defines the future of this valuable amenity for the Town of Sahuarita. Without the River Master Plan, these types of flooding damages will continue to occur, posing a risk to the Town of Sahuarita and properties along the river. In addition, implementation of the plan will mitigate the on-going headcutting that threatens the health and stability of the Santa Cruz.

The Sahuarita Farms RMP extends from Duval Mine Road to Pima Mine Road and will be constructed entirely on land owned by FICO. The River Master Plan includes a unique terraced river corridor design. The design contains the most hazardous portion of flood flows within a low-flow channel, and allows less frequent flooding on the adjacent floodplain terraces. Where FICO owns both sides of the River, the RMP will include dual terraces. Where FICO owns only the east side of the river north of Sahuarita Road, the RMP calls for one terrace on the east and low-flow channel improvements along the east side of the existing channel.

The low-flow channel is designed to contain the 20-year discharge without overtopping. Higher discharges up to the 100-year event will be contained within the adjacent terrace. The terraces will include a variety of amenities compatible with occasional flooding. Average 100-year velocities on the terrace will be a non-erosive three feet per second or less.

The Sahuarita RMP includes an inlet (Reach 1) and outlet (Reach 4) designed to transition the floodplain into and out of the corridor without adversely impacting adjacent parcels. Within Sahuarita Farms, the RMP includes the low-flow channel and terrace configuration. The upstream (southern) reach (Reach 2) extends from Duval Mine Road to 1,600 feet north of Sahuarita Road through the most urbanized portion of Sahuarita Farms. Reach 2 is 800 to 1,300 feet wide and includes a bank protected low-flow channel flanked on either side by the dual terraces. The downstream reach (Reach 3) extends through an area where the land use plan includes open space along the River Corridor and where FICO only owns the east side of the River. Reach 3 is about 1,200 feet wide and includes a non-bank protected low-flow channel coupled with a single terrace on the east side of the low flow channel.

Implementation of the Sahuarita Farms RMP is proposed as three phases, to be constructed as funds are available. Construction will occur from upstream to downstream (south to north) with Phase 1 beginning at Duval Mine Road and extending to north of Box Canyon Wash. Phase 2 will extend the River Master Plan north of Sahuarita Road to finish the dual terrace part of the plan. Phase 3 will construct the single Terrace part of the plan, taking the River Corridor to near Pima Mine Road and finishing the project. Temporary features will be constructed during interim condition to return the floodplain flows to their pre-development condition at the property limits.

The RMP has significant flood control benefits, including the following:

- Public Safety. The River Master Plan will reduce flooding risks to the public and will provide for enhanced safety along the river.
- Flood Control. The River Master Plan's flood control measures will reduce flood damages and associated costs.
- Public Infrastructure. Existing and future bridge and utility river crossings will be protected from flood damages. Future bridges over the river will span a narrower river than the mile-wide floodplain that currently exists.
- Reduced Floodplain Limits. The 100-year floodplain will be reduced from a nearly mile-wide area to a smaller corridor allowing recovery of former floodplain properties.
- Opportunity to extend RMP limits. The River Master Plan presented in this report covers the Sahuarita Farms reach of the river. However, the RMP limits may be extended further south to include the other lands, both public and private. An extension of the RMP to tie into the already improved river at Continental Road will provide additional regional flood control benefits.

This River Corridor will also provide many amenities that are often excluded in flood control projects, but which are important to the community and will connect urbanized natural areas, and provide for recreation, habitat enhancement, and education opportunities. The amenities provided by the river corridor will include:

- Primary River Drainage Open Space
- Active River Open Space
- Passive River Open Space
- River Transition Open Space

The proposed River Master Plan is an opportunity to restore the Santa Cruz River, provide public and wildlife amenities, and allow for further development of the Town of Sahuarita in accordance with the Town's General Plan. This opportunity is made possible by a large tract of contiguous land ownership. FICO has farmed its land for decades while the Town grew around it, and now wishes to plan for and ultimately develop the land responsibly. The River Master Plan will safely mitigate flood hazards, will substantially reduce flood risks to the Town, and will form the foundation for future Santa Cruz River improvements and enhancement.

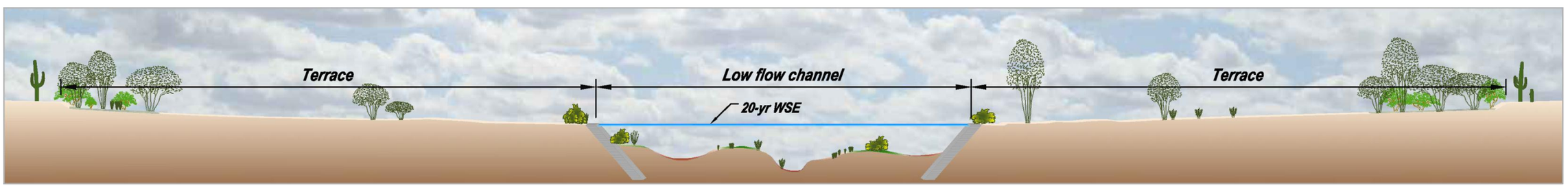
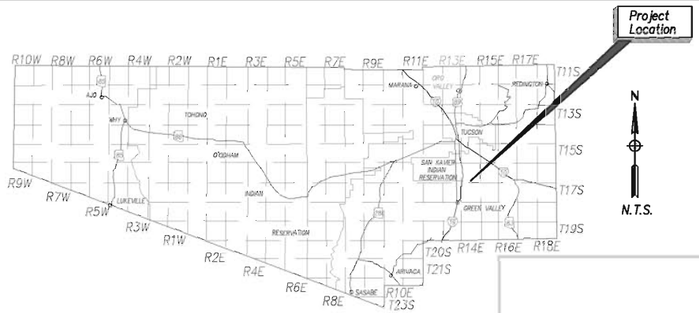


Figure 11-1. Rendering of FICO's River Master Plan typical cross section through Sahuarita Farms

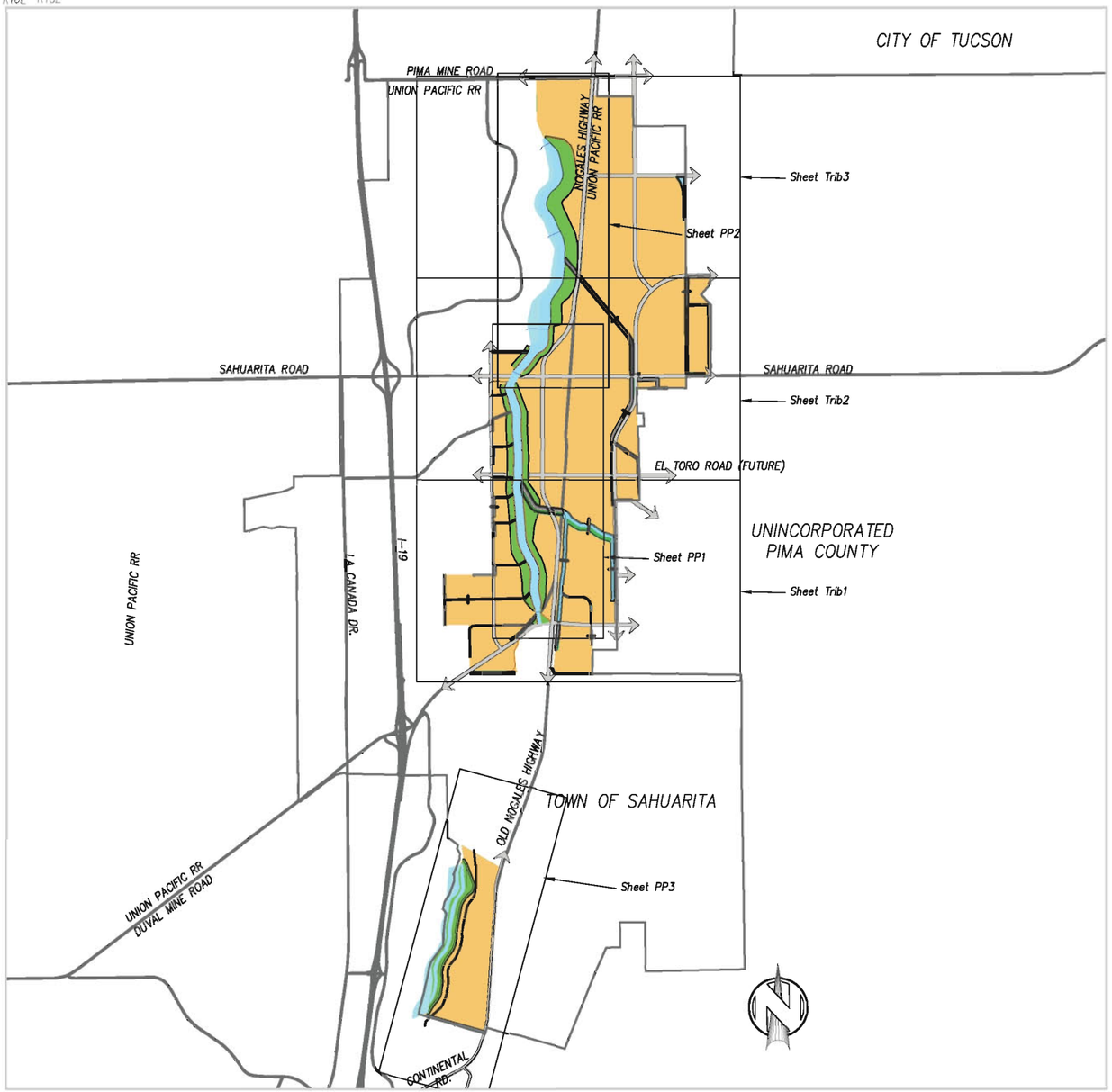
Appendix A. Preliminary Plan, Profile, and Details for the River & Drainage Master Plans

Prints of preliminary plans for the River Master Plan and the Drainage Master Plan are included here. These plans show an overview of how the River Master Plan is oriented in both plan and profile view and also include cross sections. The Drainage Master Plan is illustrated with tributary corridors, preliminary invert elevations, and cross section dimensions. These prints are not to scale as they are reduced size reproductions of 24" by 36" prints. The 24" by 36" plans have been submitted separately for agency review.



FICO
SAHUARITA FARMS SPECIFIC PLAN
RIVER AND DRAINAGE MASTER PLANS

SEPTEMBER 2012



SHEET INDEX

SHEET NO.	NAME	DESCRIPTION
1	COVER	COVER SHEET
2–3	D–	DETAIL SHEETS
4–6	PP–	PLAN AND PROFILE OF RMP
7–9	TRIB–	PLAN OF TRIBUTARY DRAINAGE
10–11	CS–	CROSS SECTIONS

NO.	REVISIONS	DATE	BY	CHK.

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Registered Professional Engineer (Civil) CERTIFICATE NO. 43848 IAN PATRICK SHARP DATE SIGNED ARIZONA U.S.A. Expires: 9/30/2013

FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

COVER SHEET

SCALE:	NTS
NAME	COVER
SHEET NO.	1
OF:	11

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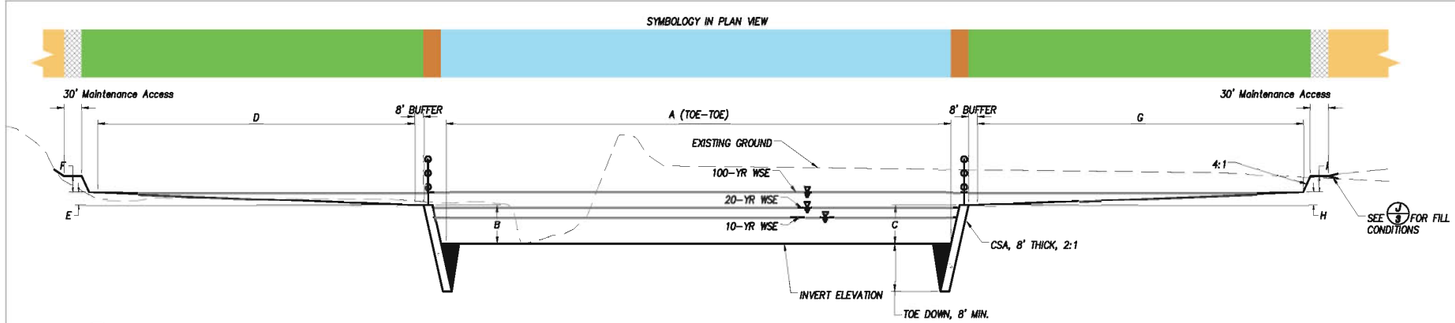


A STRUCTURAL RMP TERRACED RIVER TYPICAL SECTION: STA 441+75 - 594+00

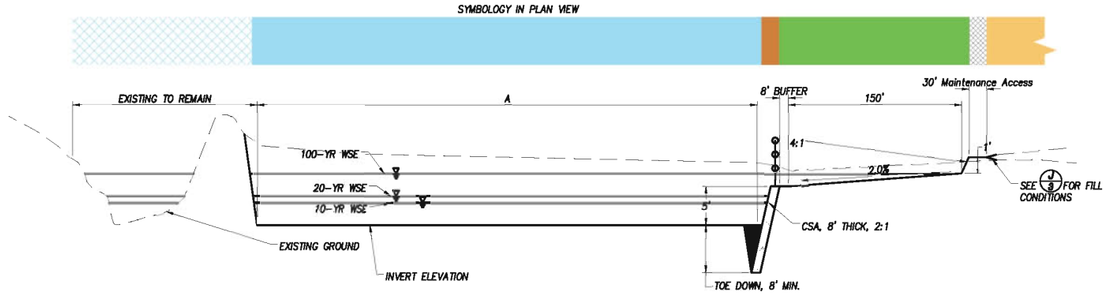
NOT TO SCALE

Low Flow Channel Bottom Width Table			
Station			A (ft)
44175	-	44500	240 (Match ex. thru bridge)
44600	-	45200	Trans: 240-500
45200	-	55600	500.00
55600	-	55800	Trans: 500-550
55800	-	56400	550.00
56400	-	56600	Trans: 550-500
56600	-	57300	500.00
57300	-	58200	None
58200	-	59400	500.00

Low Flow Channel Bank Height Table					
Station			B (ft)	C (ft)	
44150	-	44350	Trans: 6-13	Special Det.	
44350	-	44400	Trans: 13-15	Special Det.	
44400	-	44600	17 (Ex.)	17 (Ex.)	
44600	-	44750	Trans: 17-15	17 (Ex.)	
44750	-	44950	Trans: 15-6	Trans: 17-10	
44950	-	45200	6	Trans: 10-6	
45200	-	45470	Trans: 6-5	Trans: 6-5	
45470	-	55575	5	5	
55575	-	56000	Trans: 5-7	Trans: 5-7	
56000	-	57300	7	7	
57300	-	58200	None	None	
58200	-	58700	Trans: 7-6	Trans: 7-6	
58700	-	59400	6	6	

Left Terrace Table					
Station			D (ft)	E (ft)	F (ft)
44175	-	44400	Trans: 180-0	Trans: 1-0	0
44400	-	44950	0	0	0
44950	-	45500	Trans: 0-275	Trans: 2-4	1
45500	-	46250	275	4	1
46250	-	46750	Trans: 275-375	4	1
46750	-	47025	375	4	1
47025	-	47250	Trans: 375-325	4	1
47250	-	47800	325	4	1
47800	-	48050	Trans: 325-375	4	1
48050	-	48350	375	4	1
48350	-	49100	Trans: 375-225	4	1
49100	-	55800	225	4	1
55800	-	56000	Trans: 225-150	Trans: 4-3	1
56000	-	57200	150	3	1
57200	-	58200	None	None	None
58200	-	59200	Trans: 150-100	3	1
59200	-	59400	Trans: 100-150	3	1

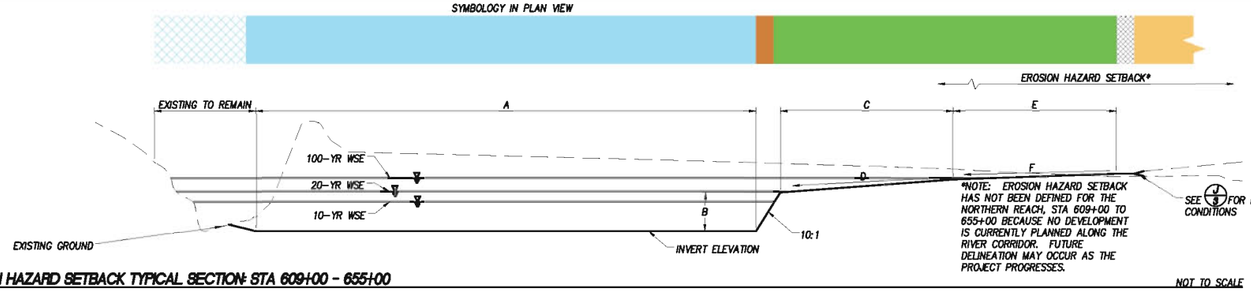
Right Terrace Table					
Station			G (ft)	H (ft)	I (ft)
44150	-	44950	0	0	0
44950	-	45470	Trans: 0-180	Trans: 2-4	1
45470	-	46000	Trans: 180-325	4	1
46000	-	46750	325	4	1
46750	-	47250	Trans: 325-225	4	1
47250	-	48600	225	4	1
48600	-	49600	Trans: 225-425	4	1
49600	-	50600	Trans: 425-225	4	1
50600	-	55800	225	4	1
55800	-	56000	Trans: 225-150	Trans: 4-3	1
56000	-	57425	150	3	1
57425	-	58000	None	None	None
58000	-	58450	Trans: 0-150	Trans: 0-3	1
58450	-	59400	150	3	1



B STRUCTURAL RMP 1/2 TERRACED RIVER TYPICAL SECTION: STA 594+00 - 609+00

NOT TO SCALE

Low Flow Channel Bottom Width Table			
Station			A (ft)
59400	-	59900	Trans: 500-600
59900	-	60900	600.00



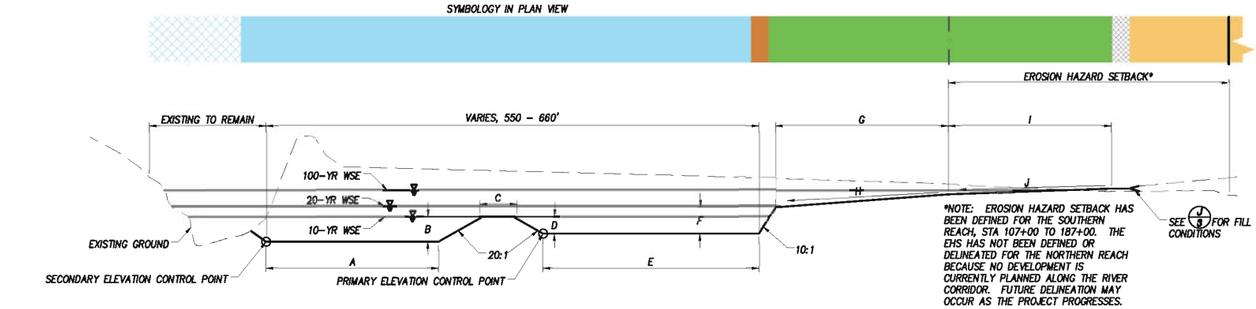
C EROSION HAZARD SETBACK TYPICAL SECTION: STA 609+00 - 655+00

NOT TO SCALE

Low Flow Dimension Table					
Station			A (ft)	B (ft)	
60900	-	61150	Trans: 500-600	5	
61150	-	62600	600	5	
62600	-	62800	Trans: 600-500	Trans: 5-4	
62800	-	65500	500	4	

Primary Terrace Dimension Table					
Station			C (ft)	D (%)	
60900	-	61800	200	1.5	
61800	-	62100	Trans: 200-300	1.0	
62100	-	62600	300	1.0	
62600	-	62800	Trans: 300-400	1.0	
62800	-	65500	400	1.0	

Secondary Terrace Dimension Table				
Station			E (ft)	F (%)
60900	-	61150	Trans: 0-300	0.33
61150	-	61800	300	0.33
61800	-	62100	Trans: 300-200	Trans: 0.33-0.5
62100	-	64600	200	0.50
64600	-	65100	200	0.75
65100	-	65500	200	0.50



D EROSION HAZARD SETBACK TYPICAL SECTION: STA 655+00 - 714+25 and 107+00 - 187+00

NOT TO SCALE

West Low-Flow Channel Table				
Station			A (ft)	B (ft)
65500	-	68900	200	3
68900	-	69400	600	Trans: 3-6
69400	-	70600	200	6
70600	-	70800	200	Trans: 6-8
70800	-	71100	200	8
71100	-	71700	Trans: 200-0	Trans: 8-4
10700	-	11700	0	0
11700	-	17000	Var: 0-100	4
17000	-	18000	70	6
18000	-	18700	Tran: 70-0	Trans: 6-0

Mid-Channel Island and East Low-Flow Channel Table						
Station			C (ft)	D (ft)	E (ft)	F (ft)
65500	-	65900	50	2	Trans: 200-250	4.0
65900	-	69700	50	2	250	4.0
69700	-	70000	50	2	250	Trans: 4-5
70000	-	70300	50	2	Trans: 250-200	5.0
70300	-	71400	50	2	200	5.0
71400	-	71700	50	2	Trans: 200-100	5.0
10700	-	12800	Trans: 0-50	Trans: 0-2	100	Trans: 3-5.5
12800	-	14500	Var: 50-70	2	100	5.5
14500	-	16200	70	2	100	6.0
16200	-	16700	120	2	100	6.0
16700	-	18500	70	2	100	6.0
18500	-	18700	Trans: 70-0	Trans: 2-0	Trans: 100-0	6.0

Primary Terrace Dimension Table				
Station			G (ft)	H (%)
65500	-	67600	400	1.000
67600	-	68700	400	1.250
68700	-	68900	Trans: 400-450	1.220
68900	-	71700	450	1.220
10700	-	11700	100	2.000
11700	-	16200	100	2.500
16200	-	18200	100	3.000
18200	-	18700	200	2.500

Secondary Terrace Dimension Table				
Station			I (ft)	J (%)
65500	-	69700	200	0.5
69700	-	70000	Trans: 200-0	0.5
70000	-	71700	N/A	N/A
10700	-	11200	100	1.0
11200	-	13000	150	1.0
13000	-	16800	150	0.7
16800	-	17700	Trans:150-400	1.0
17700	-	18700	Trans: 400-0	Var.: 1-10

NO.	REVISIONS	DATE	BY	CHK.

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Registered Professional Engineer (USA) CERTIFICATE NO. 43848 IAN PATRICK SHARP DATE SIGNED ARIZONA, U.S.A. Expires: 9/31/2015

FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

River and Tributary Channel Details

SCALE: NTS
NAME: D1
SHEET NO.: 2
OF: 11

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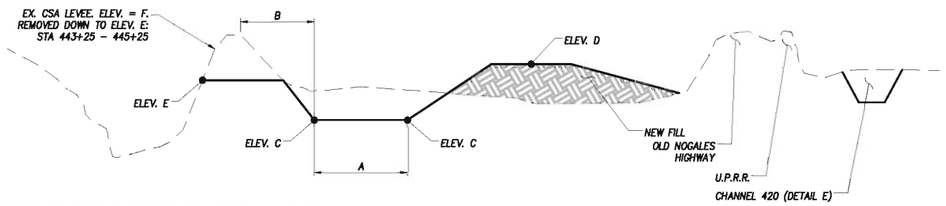
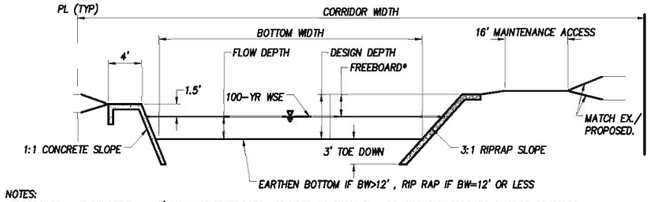
Rt. Bank Special Detail Table						
Station	A (ft)	B (ft)	C (ft)	D (ft)	E (ft)	F (ft)
44150	585	50	2750.0	N/A	N/A	2756.5
44250	440	50	2750.0	2757.4	N/A	2756.3
44300	405	50	2749.8	2757.2	N/A	2756.1
44350	355	50	2749.6	2757.0	2750.0	2755.8
44400	245	50	2749.4	2756.6	2749.4	2755.7
44500	100	50	2749.2	2756.6	2749.4	2755.7
44600	0	0	-	2754.2	N/A	2757.6



E RIGHT BANK SPECIAL DETAIL: STA 441+50 – 444+00

NOT TO SCALE



Trib. I.D.	Bottom Width (ft)	Flow Depth (ft)	Design Depth (ft)	Corridor Width (ft)
E130	80	3.45	4.95	160
E320C	30	3.00	4.50	100
E320D	30	3.00	4.50	100
E340B	60	3.75	5.25	140
E340C	60	3.40	4.90	140
E420B	100	4.00	5.50	190
E440B	8	2.00	3.50	65
W405C	8	1.70	3.20	60
W510D	12	2.50	4.00	75
W510E	16	2.30	3.80	75
W610A	45	4.20	5.70	130
W620C	8	2.35	3.85	70
W710A	110	3.90	5.40	200

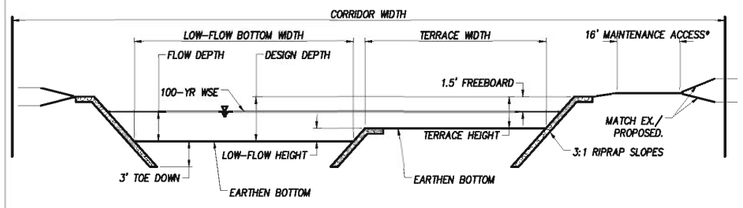
NOTES:
*FREEBOARD = FLOW DEPTH. 1.5' MINIMUM FREEBOARD INCLUDED IN CHANNEL. REMAINING FREEBOARD MAY BE PROVIDED IN ADJACENT ENGINEERED BERM (NOT SHOWN AT THIS TIME).

FLOW DEPTH AND BOTTOM WIDTH ARE DEFINED IN THE TABLE AND ARE BASED UPON PRELIMINARY NORMAL DEPTH MODELING.

THE TOTAL WIDTH OF THE CORRIDOR SHOWN ON THE PLANS INCLUDES ROOM FOR THE 16' MAINTENANCE ACCESS, THE TOP WIDTH OF THE CHANNEL, PLUS AN ADDITIONAL 20%+/– TO ALLOW FOR GRADING AND OTHER USES.

G TRIBUTARY COLLECTOR CHANNEL DETAIL

NOT TO SCALE



Trib. I.D.	Low Flow Width (ft)	Flow Depth (ft)	Design Depth (ft)	Low Flow Bank Height (ft)	Terrace Width (ft)	Terrace Bank Height (ft)	Corridor Width (ft)
E315	80	4.50	6.00	2.00	60	4.00	245
E410A	250	4.35	5.85	2.00	120	3.90	420
E410B	250	4.40	5.90	2.00	120	3.90	420
E410C	250	4.10	5.60	2.00	120	3.60	420

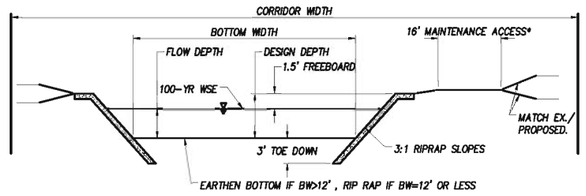
NOTES:
DESIGN DEPTH=100-YR FLOW DEPTH + 1.5' FREEBOARD
FLOW DEPTH AND BOTTOM WIDTH ARE DEFINED IN THE TABLE AND ARE BASED UPON PRELIMINARY NORMAL DEPTH MODELING.

*MAINTENANCE ACCESS MAY BE PLACED ON EITHER SIDE.

THE TOTAL WIDTH OF THE CORRIDOR SHOWN ON THE PLANS INCLUDES ROOM FOR THE 16' MAINTENANCE ACCESS, THE TOP WIDTH OF THE CHANNEL, PLUS AN ADDITIONAL 20%+/– TO ALLOW FOR GRADING AND OTHER USES.

H TRIBUTARY CONVEYANCE CHANNEL DETAIL - COMPOUND SECTION

NOT TO SCALE



Trib. I.D.	Bottom Width (ft)	Flow Depth (ft)	Design Depth (ft)	Corridor Width (ft)
E110A	120	3.70	5.20	200
E110B	80	3.55	5.05	155
E110C	30	3.30	4.80	95
E120	25	3.05	4.55	90
E310	130	4.60	6.10	220
E320A	80	3.60	5.10	155
E320B	80	3.50	5.00	155
E330A	80	3.40	4.90	155
E330B	8	2.50	4.00	65
E330C	8	2.75	4.25	70
E340A	60	2.40	3.90	125
E420A	100	3.85	5.35	180
E430	90	4.00	5.50	170
E440A	8	2.00	3.50	65
E510	25	2.50	4.00	85
W120	40	4.35	5.85	115
W220	8	2.35	3.85	65
W305A	8	2.50	4.00	70
W305B	8	3.00	4.50	70
W310A	20	3.60	5.10	85
W310B	20	4.25	5.75	90
W310C	8	3.10	4.60	70
W320	16	3.20	4.70	80
W325A	16	3.80	5.30	85
W325B	12	2.30	3.80	70
W330A	16	4.00	5.50	85
W330B	12	2.80	4.30	70
W405A	12	2.70	4.20	70
W405B	8	2.30	3.80	65
W510A	25	3.10	4.60	90
W510B	25	2.00	3.50	80
W510C	25	1.90	3.40	80
W620A	8	2.35	3.85	65
W620B	8	1.90	3.40	65

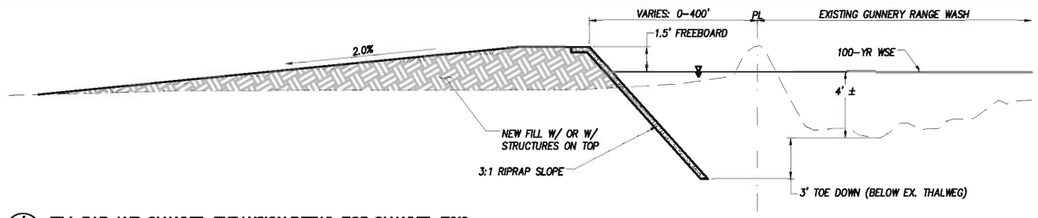
NOTES:
DESIGN DEPTH=100-YR FLOW DEPTH + 1.5' FREEBOARD
FLOW DEPTH AND BOTTOM WIDTH ARE DEFINED IN THE TABLE AND ARE BASED UPON PRELIMINARY NORMAL DEPTH MODELING.

*MAINTENANCE ACCESS MAY BE PLACED ON EITHER SIDE.

THE TOTAL WIDTH OF THE CORRIDOR SHOWN ON THE PLANS INCLUDES ROOM FOR THE 16' MAINTENANCE ACCESS, THE TOP WIDTH OF THE CHANNEL, PLUS AN ADDITIONAL 20%+/– TO ALLOW FOR GRADING AND OTHER USES.

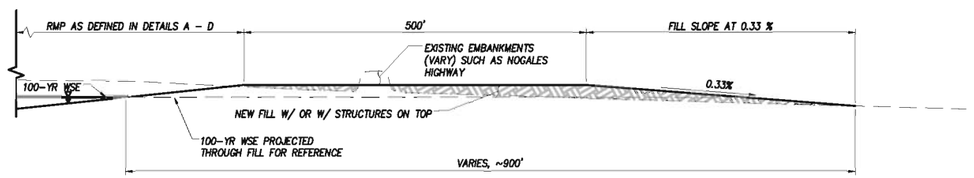
F TRIBUTARY CONVEYANCE CHANNEL DETAIL - SIMPLE SECTION

NOT TO SCALE



I FILL PAD AND CHANNEL EXPANSION DETAIL FOR CHANNEL E210

NOT TO SCALE



NOTES:
THIS DETAIL PRESENTS HOW FILL MIGHT BE PLACED WHEN FILL CONDITIONS ARE ENCOUNTERED ALONG THE RMP CORRIDOR.
FINAL DETAILS MAY VARY AS THE PROJECT PROGRESSES.

J DETAIL FOR PLACEMENT OF FILL PAD ALONG RMP

NOT TO SCALE

NO.	REVISIONS	DATE	BY	CHK.

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC
40 East Helen St.
Tucson, Az 85705
Phone: 520-623-3112
Fax: 520-623-3130

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Registered Professional Engineer (Civil) CERTIFICATE NO. 43848 IAN PATRICK SHARP DATE SIGNED: ARIZONA, U.S.A. Expires: 9/30/2015

FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

River and Tributary Channel Details

SCALE:	
NTS	
NAME	
D2	
SHEET NO.	OF:
3	11

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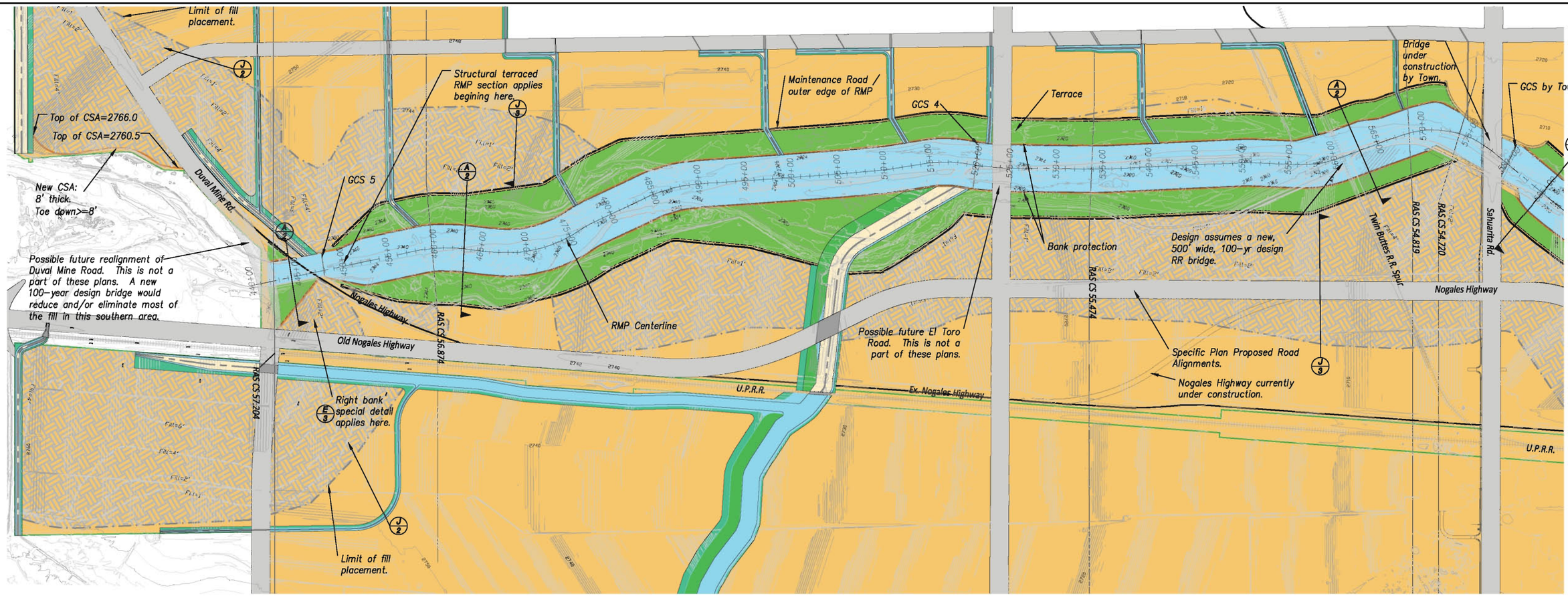

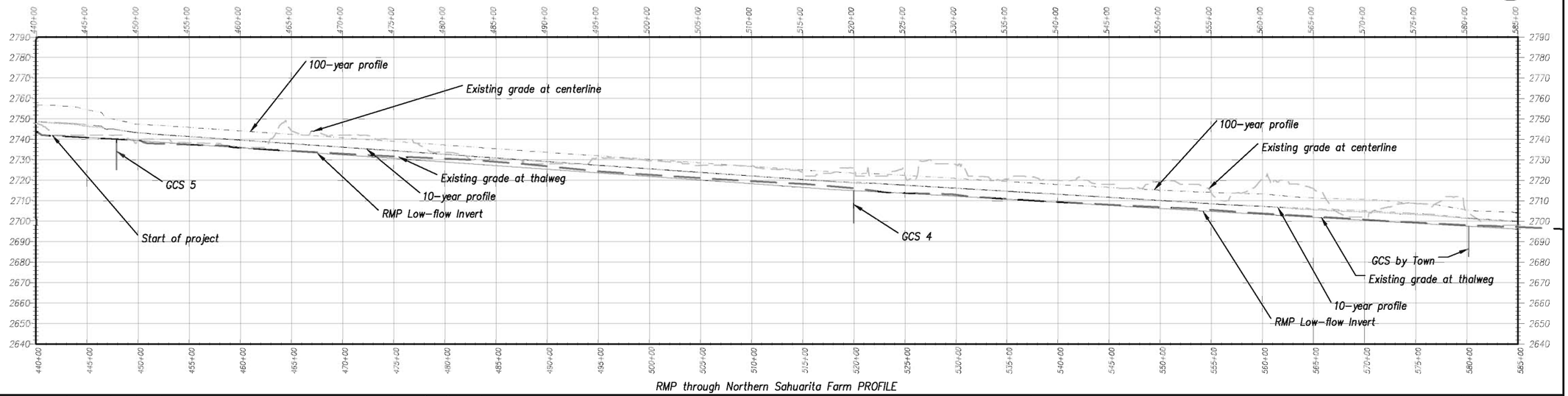

RMP through Northern Sahuarita Farm PROFILE

NO.	REVISIONS	DATE	BY	CHK.

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.
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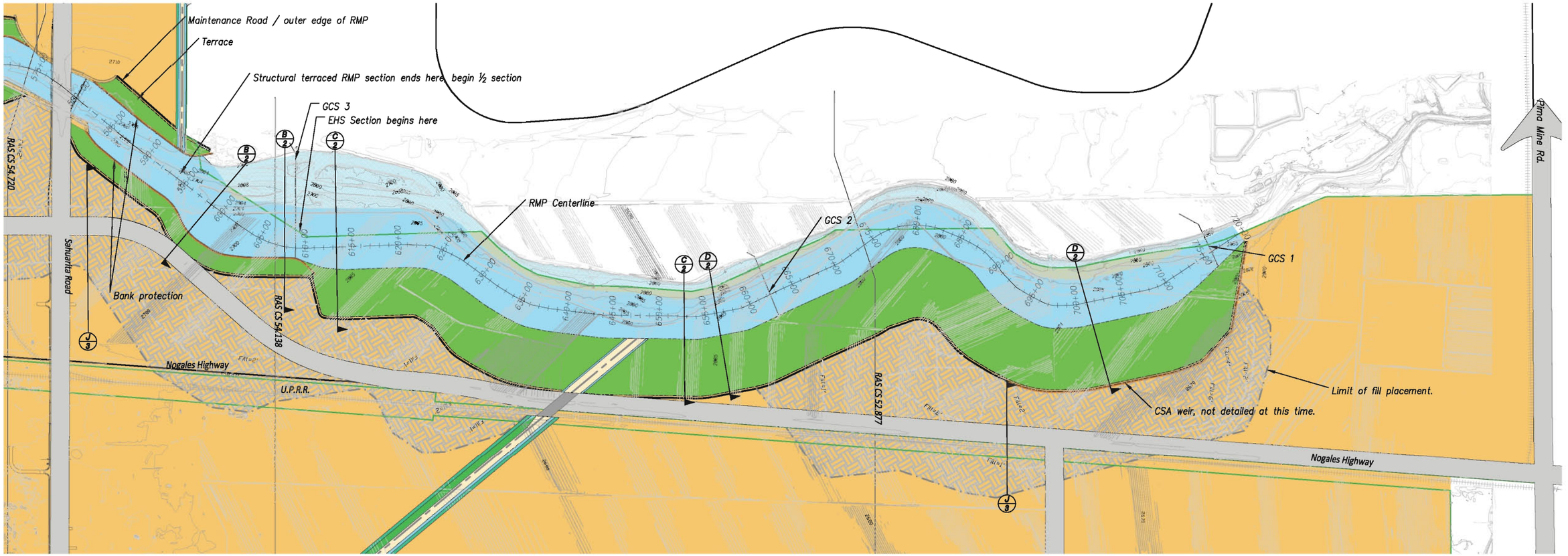
FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

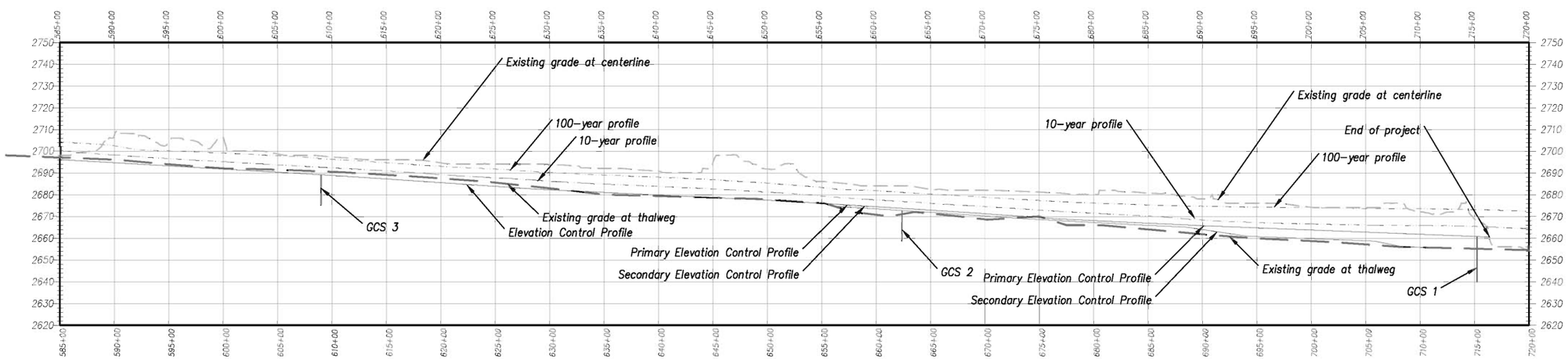
JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

RIVER PLAN AND PROFILE

SCALE:	1"=500', 2' c.i.
NAME	PP1
SHEET NO.	4
OF:	11

X:\FICO\RMP_2nd_Submittal\cad\Plans_Sep_2012\03-PP Sheets.dwg





RMP through Northern Sahuarita Farm PROFILE

NO.	REVISIONS	DATE	BY	CHK.

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.
40 East Helen St.
Tucson, Az 85705
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FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

RIVER PLAN AND PROFILE

SCALE:	1"=500', 2' c.i.
NAME	PP2
SHEET NO.	5
OF:	11

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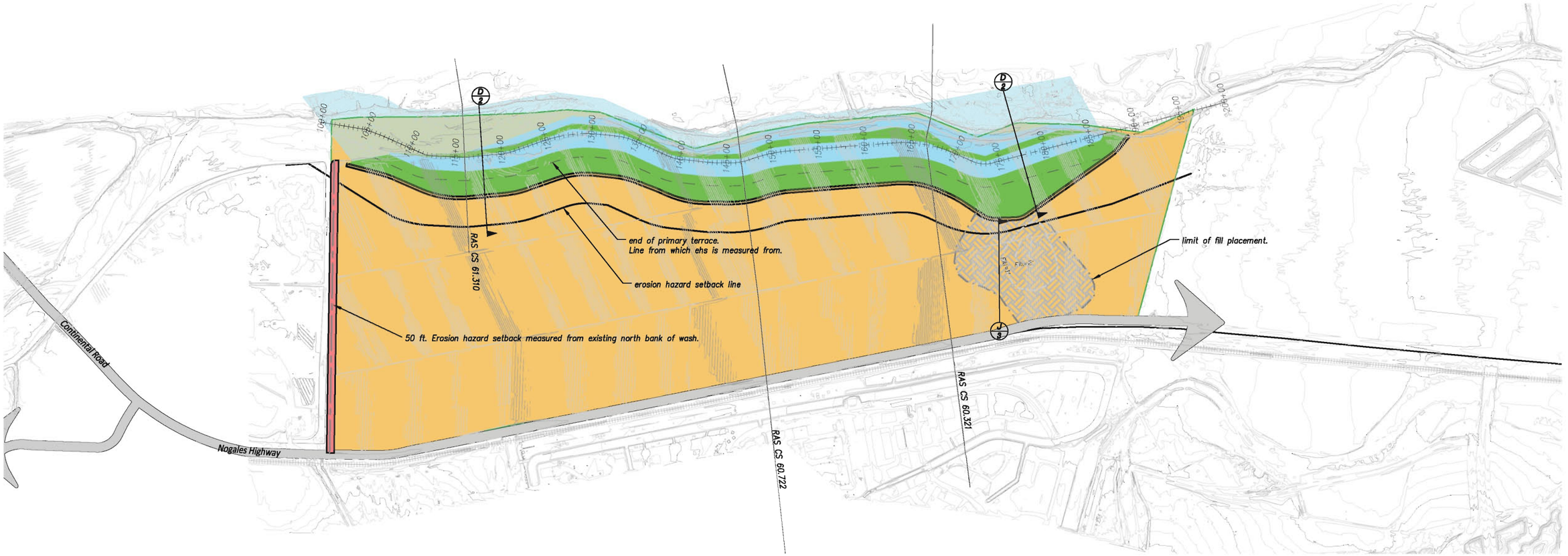

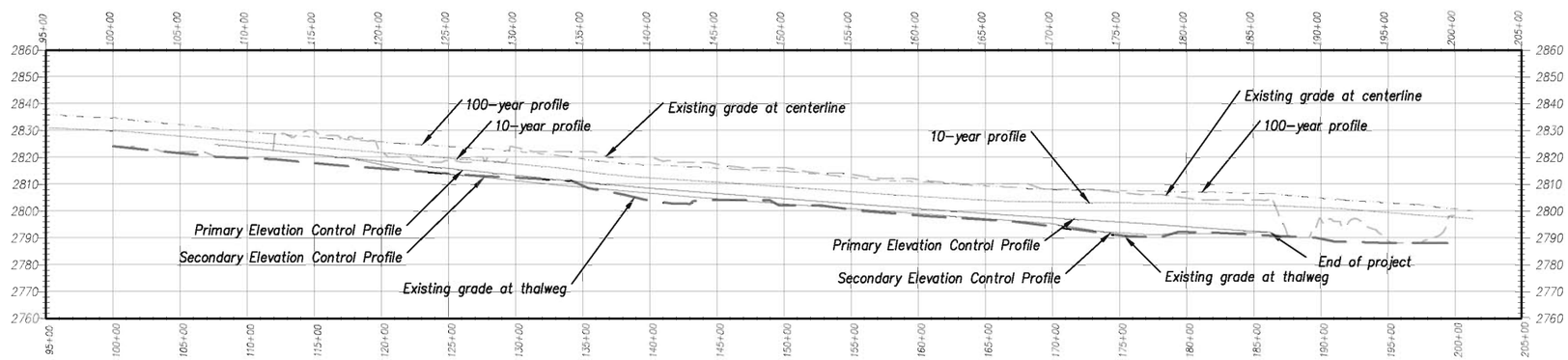

RMP through Southern Sahuarita Farm PROFILE

NO.	REVISIONS	DATE	BY	CHK.

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.
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Tucson, Az 85705
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Fax: 520-623-3130

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Registered Professional Engineer (Civil) CERTIFICATE NO. 43848 IAN PATRICK SHARP DATE SIGNED ARIZONA, U.S.A. Expires: 9/31/2015

FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
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CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

RIVER PLAN AND PROFILE

SCALE:	1"=500', 2' c.i.
NAME	PP3
SHEET NO.	6
OF:	11

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Channel W325A
Inv-us=2731.0
Inv-ds=2721.2

Culvert W325A
Q-Des=800
2-10x6X150 lf
Inv.-us=2734.0
Inv.-ds=2731.0
HW-EL=2740.2

Channel W325B
Inv-us=2737.0
Inv-ds=2731.0

Culvert W325B
Q-Des=100
1-6x4X175 lf
Inv.-us=2737
Inv.-ds=2734
HW-EL=2740.4

W325B - See Sheet CS2

Culvert W325C
Q-Des=100
1-6x4X175 lf
Inv.-us=2740
Inv.-ds=2737.0
HW-EL=2743.4

Channel W330A
Inv-us=2737.3
Inv-ds=2725.9
RMP WS-10YR=2725.9

Culvert W330
Q-Des=900
2-10x6X150 lf
Inv.-us=2740.0
Inv.-ds=2737.3
HW-EL=2746.8

Channel W330B
Inv-us=2739.4
Inv-ds=2737.3

Culvert W340
Q-Des=200
1-8x4X175 lf
Inv.-us=2740.0
Inv.-ds=2739.4
HW-EL=2744.6

Channel E410A
Compound Channel
Inv-us=2723.1
Inv-ds=2618.8
RMP WS-10YR=2719.5
(measured at outlet, typical)

Channel E410B
Compound Channel
Inv-us=2724.8
Inv-ds=2623.6

Channel E330C
Inv-us=2724.0
Inv-ds=2719.4

Culvert E410B
Q=5,600 CFS
20-10x5x35lf
Inv.-us=2725.0
Inv.-ds=2724.8
HW-EL=2730.1
RMP WSE-10=2724.7
RMP WSE-100=2729.1
FLAP GATES MAY BE REQUIRED

Collector E340C
Inv-us=2736.0
Inv-ds=2733.1

Culvert E410A
Q=5,600 CFS
20-10x5x400lf
Inv.-us=2723.6
Inv.-ds=2723.1
HW-EL=2728.5

E410C - See Sheet CS2

Culvert E330C
Q=150 CFS
1-6x4X235 lf
Inv.-us=2727.0
Inv.-ds=2724.0
HW-EL=2730.6

Culvert E410C
Q=2,300 CFS
8-10x5X220 lf
Inv.-us=2735.0
Inv.-ds=2733.0
HW-EL=2740.0

Channel E410C
Compound Channel
Inv-us=2733.0
Inv-ds=2625.0

Culvert W405A
Q=80 CFS
1-6x4X150 lf
Inv.-us=2742.0
Inv.-ds=2740.0
HW-EL=2745.0

Channel E430
Inv-us=2755.0
Inv-ds=2733.0

Channel W405B
Inv-us=2742.2
Inv-ds=2740.0

Channel W405A
Inv-us=2740.0
Inv-ds=2734.1
RMP WS-10YR=2732.8

Collector W405C
Inv-us=2760.0
Inv-ds=2742.8

Culvert W405B
Q=120 CFS
1-6x4X200 lf
Inv.-us=2742.8
Inv.-ds=2740.2
HW-EL=2746.7

Nogales Highway

E420A - See Sheet CS2

E430 - See Sheet CS2

Channel E420A
Inv-us=2744.4
Inv-ds=2725.6

Collector W510D
Inv-us=2794.0
Inv-ds=2786.0

Channel W510C
Inv-us=2786.0
Inv-ds=2767.0

Channel W510B
Inv-us=2767.0
Inv-ds=2751.9

Grade break

W510B/C - See Sheet CS2

Collector W510E
Inv-us=2792.0
Inv-ds=2786.0

Culvert W510
Q=400 CFS
3-8x4X150 lf
Inv.-us=2751.9
Inv.-ds=2751.3
HW-EL=2755.4

Channel W510A
Inv-us=2745.1
Inv-ds=2740.2
RMP WS-10YR=2740.2

Channel E440A
Inv-us=2746.5
Inv-ds=2739.3

Culvert W620
Q=100 CFS
1-6x4X150 lf
Inv.-us=2751.9
Inv.-ds=2751.3
HW-EL=2755.4

Channel W620A
Inv-us=2751.3
Inv-ds=2747.0

Culvert E440
Q=70 CFS
1-6x4X200 lf
Inv.-us=2747.1
Inv.-ds=2746.5
HW-EL=49.7

Culvert E430
Q=3,200 CFS
10-10x5X285 lf
Inv.-us=2756.0
Inv.-ds=2755.0
HW-EL=2761.4

Duval Mine Rd.

Culvert E420
Q=2,350 CFS
8-10x4X200 lf
Inv.-us=2745.0
Inv.-ds=2744.4
HW-EL=2750.0

E440B - See Sheet CS2

Channel W620B
Inv-us=2760.0
Inv-ds=2751.9

Collector E440B
Inv-us=2750.0
Inv-ds=2747.1

Collector W620C
Inv-us=2765.0
Inv-ds=2760.0

Collector W710A
Inv-us=2745.2
Inv-ds=2750.0
RMP WS-10YR=2750.0

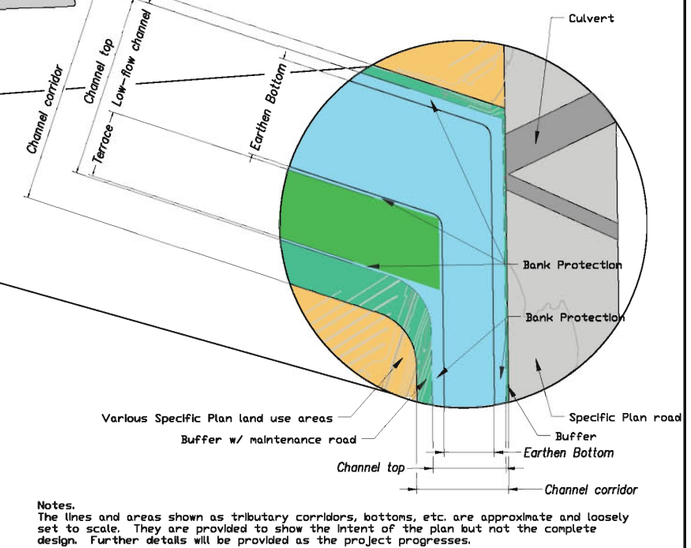
Collector E420B
Inv-us=2749.0
Inv-ds=2745.0

Duval Mine Rd.

Ex. RR Bridge
Inv.-US-2757

Channel E510
Inv-us=2764.0
Inv-ds=2757.0

Collector W710A
Inv-us=2764.0
Inv-ds=2758.0



Notes.
The lines and areas shown as tributary corridors, bottoms, etc. are approximate and loosely set to scale. They are provided to show the intent of the plan but not the complete design. Further details will be provided as the project progresses.

Explanation of Tributary Channel Symbology

NO.	REVISIONS	DATE	BY	CHK.

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.
40 East Helen St.
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FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

TRIBUTARY CHANNEL PLAN

SCALE:	1"=500', 2' c.i.
NAME	TRIB1
SHEET NO.	7
OF:	11

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Channel E110A
Inv-us=2705.9
Inv-ds=2702.6

Existing Walden Grove High School

E110A - See Sheet CS2

Channel E120
Inv-us=2713.0
Inv-ds=2705.9

Future weir will be designed to send flow north and west.

Channel E315
Compound Channel
Inv-us=2700.0
Inv-ds=2684.0

E315 - See Sheet CS2

Channel E110B
Inv-us=2720
Inv-ds=2705.9

Collector E130
Inv-us=2723
Inv-ds=2713

Channel W120
Inv-us=2714.0
Inv-ds=2697.0

Culvert W120
Q-Des=2,100
4-10x6X155 lf
Inv.-us=2715.0
Inv.-ds=2714.0
HW-EL=2722.1

Culvert E320
Q=1,800 CFS
2-10x5x200lf
Inv.-us=2702.5
Inv.-ds=2700.0
Dimensions match ToS/EEC Culvert east of Santa Rita Road

2-10x5 (by ToS/EEC)
Inv.-us=2703
Inv.-ds=2702.6

Channel E320A
Inv-us=2707
Inv-ds=2703

4-12x12 (by ToS/EEC)
Inv.-us=2720.8
Inv.-ds=2720.4

2-10x5 (by ToS/EEC)
Inv.-us=2727.4
Inv.-ds=2726.7

Nogales Highway

Sahuarita Road

Culvert W210
Q-Des=250
1-8x4X1,010 lf
Inv.-us=2722.0
Inv.-ds=2704.0
HW-EL=2727.5

Culvert E330A
Q=1,500 CFS
8-10x4x200lf
Inv.-us=2700.6
Inv.-ds=2700.0
HW-EL=2704.4

Channel E320B
Inv-us=2709
Inv-ds=2707

Culvert W220
Q-Des=250
1-8x4X175 lf
Inv.-us=2722.0
Inv.-ds=2720.0
HW-EL=2727.5

Collector E320D
Inv-us=2715
Inv-ds=2709

Channel E110C
Inv-us=2723
Inv-ds=2720

Channel W220
Inv-us=2720.0
Inv-ds=2708.0

Channel W305A
Inv-us=2717.5
Inv-ds=2709.8

Collector E320C
Inv-us=2715
Inv-ds=2709

Channel W305B
Inv-us=2720.0
Inv-ds=2717.5

E330A - See Sheet CS2

Culvert W305A
Q-Des=100
1-6x4X175 lf
Inv.-us=2721
Inv.-ds=2718.8
HW-EL=2724.4

Santa Rita Rd.

Culvert W305B
Q-Des=200
1-6x4X175 lf
Inv.-us=2722.0
Inv.-ds=2720.0
HW-EL=2727.9

Channel E330A
Inv-us=2711.2
Inv-ds=2700.6

Channel W310A
Inv-us=2721.0
Inv-ds=2714.0

Culvert 340A
Q=1,300 CFS
6-10x4X280 lf
Inv.-us=2712.0
Inv.-ds=2711.2
HW-EL=2715.8

Culvert W310A
Q-Des=200
1-6x4X150 lf
Inv.-us=2726.0
Inv.-ds=2721.0
HW-EL=2731.8

Channel E340A
Inv-us=2730.1
Inv-ds=2712.0

Channel W310B
Inv-us=2722.5
Inv-ds=2721.0

Culvert W310B
Q-Des=700
2-10x5X175 lf
Inv.-us=2728.0
Inv.-ds=2723
HW-EL=2733.7

Channel W310C
Inv-us=2724.0
Inv-ds=2722.5

Channel E330B
Inv-us=2718.8
Inv-ds=2711.2

Collector E340B
Inv-us=2732.5
Inv-ds=2730.1

Culvert W310C
Q-Des=200
1-6x4X175 lf
Inv.-us=2726.0
Inv.-ds=2724.0
HW-EL=2731.9

Channel W320
Inv-us=2726.0
Inv-ds=2718.7

Culvert E330B
Q=150 CFS
1-6x4X200 lf
Inv.-us=2719.4
Inv.-ds=2718.8
HW-EL=2724.0

Culvert 340B
Q=1,100 CFS
5-10x4X200 lf
Inv.-us=2733.1
Inv.-ds=2732.5
HW-EL=2737.4

Culvert W320A
Q-Des=500
2-8x4X150 lf
Inv.-us=2730.0
Inv.-ds=2726.0
HW-EL=2735.5

El Toro Road

Channel E330C
Inv-us=2724.0
Inv-ds=2719.4

Collector E340C
Inv-us=2736.0
Inv-ds=2733.1

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NO.	REVISIONS	DATE	BY	CHK.

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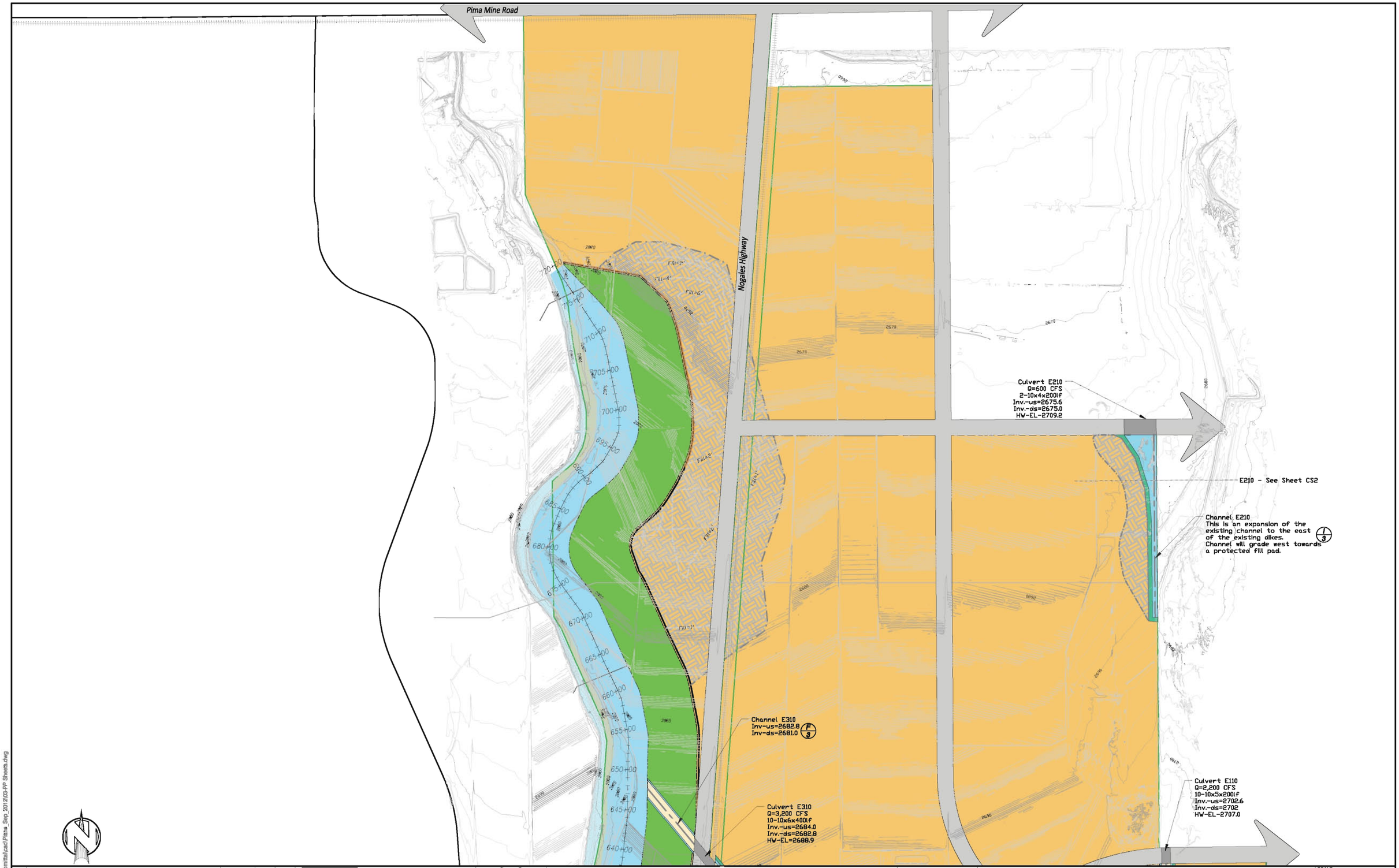
Registered Professional Engineer (Civil)
CERTIFICATE NO. 43846
IAN PATRICK SHARP
ON PERSONALLY SIGNED
ARIZONA U.S.A.
Expires 30/12/2013

FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

TRIBUTARY CHANNEL PLAN

SCALE:	1"=500', 2' c.i.
NAME	TRIB2
SHEET NO.	8
OF:	11



NO.	REVISIONS	DATE	BY	CHK.

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Registered Professional Engineer (Civil)
CERTIFICATE NO. 43846
IAN PATRICK SHARP
DATE SIGNED
ARIZONA U.S.A.
Expires: 30/12/2015

FICO Sahuarita Farms River and Drainage Master Plans
Preliminary Plan, Profile and Sections

JOB NO.	
DESIGNED BY:	IPS
DRAWN BY:	IPS
CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

TRIBUTARY CHANNEL PLAN

SCALE:	1"=500', 2' c.i.
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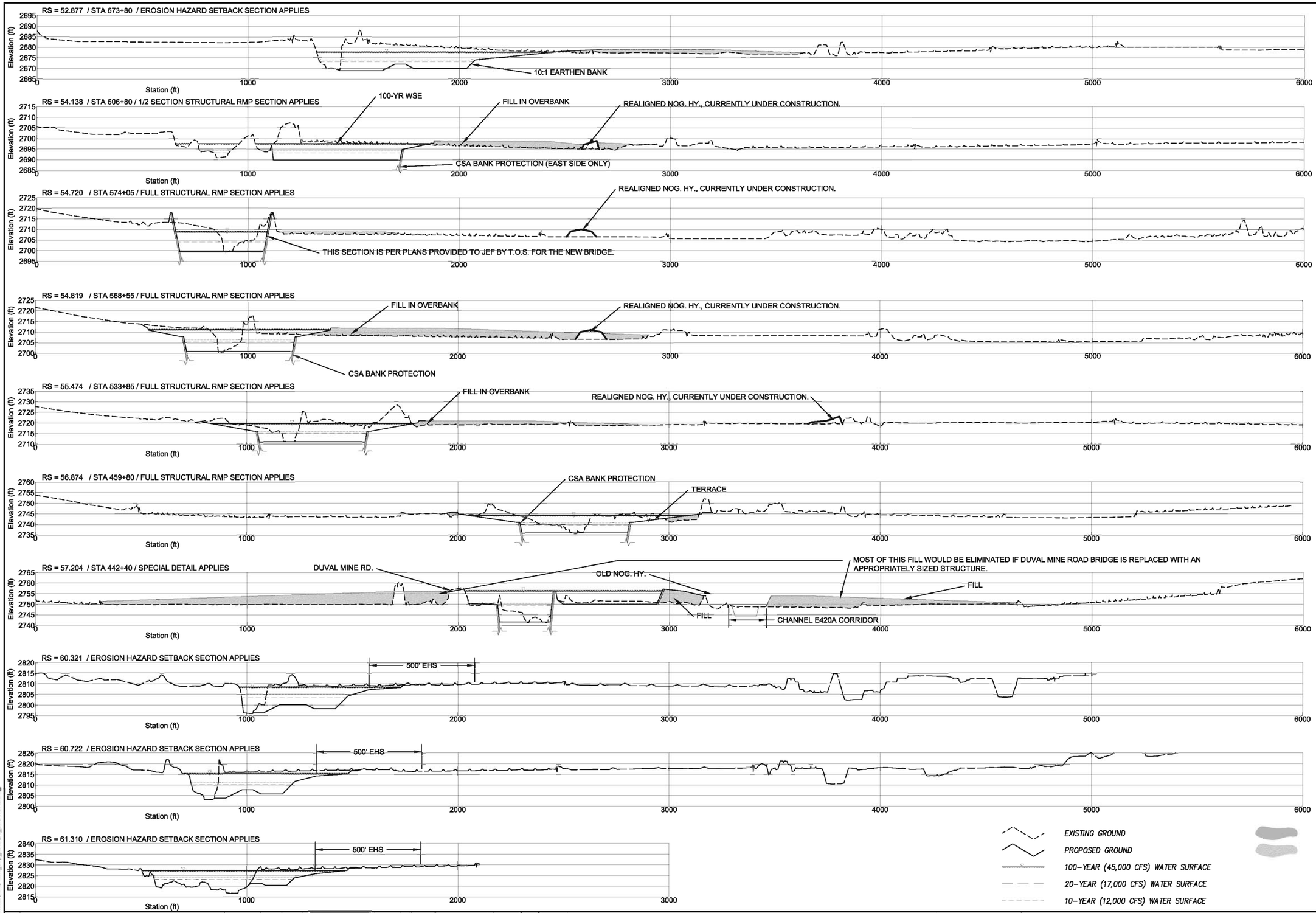

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Registered Professional Engineer (Civil) CERTIFICATE NO. 43848 IAN PATRICK SHARP DATE SIGNED ARIZONA U.S.A. Expires: 09/30/2013

FICO Sahuarita Farms River and Drainage Master Plans
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CHECKED BY:	IPS
APPROVED BY:	IPS
DATE:	September 2012

RIVER CROSS SECTIONS

SCALE:	1"=200' Horizontal 1"=20' Vertical
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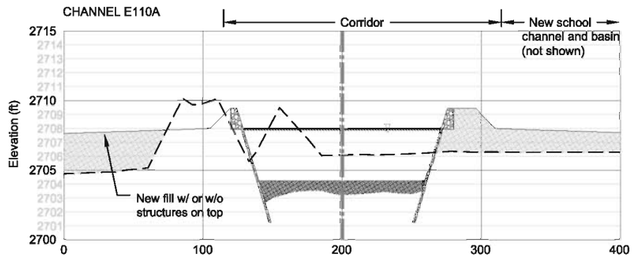

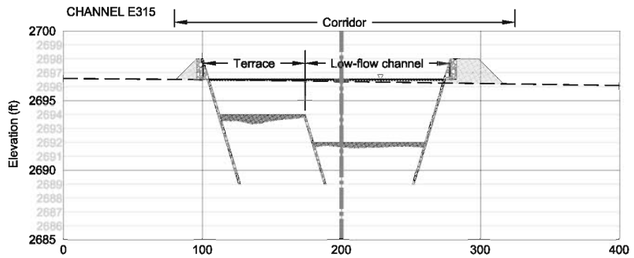

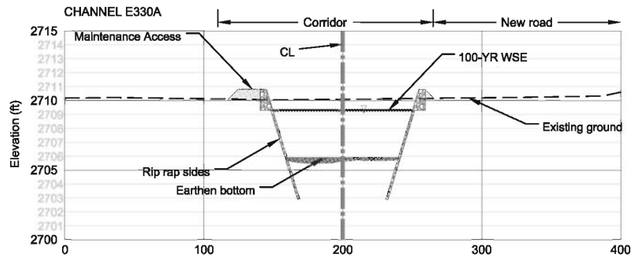

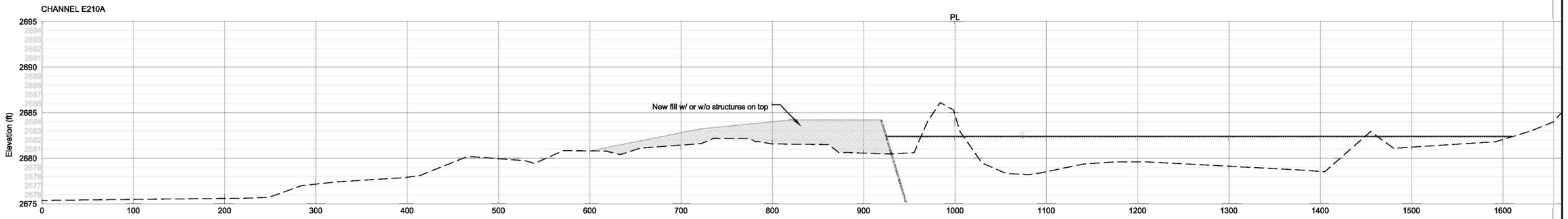

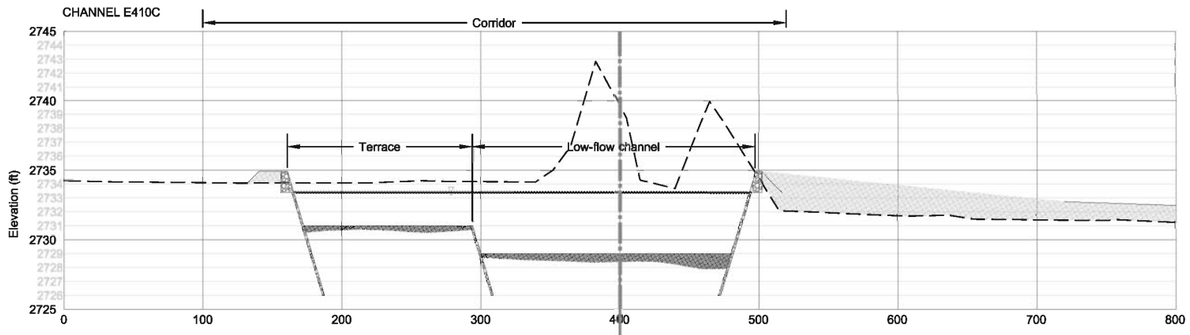

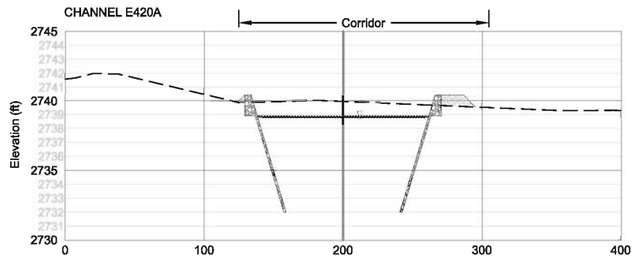

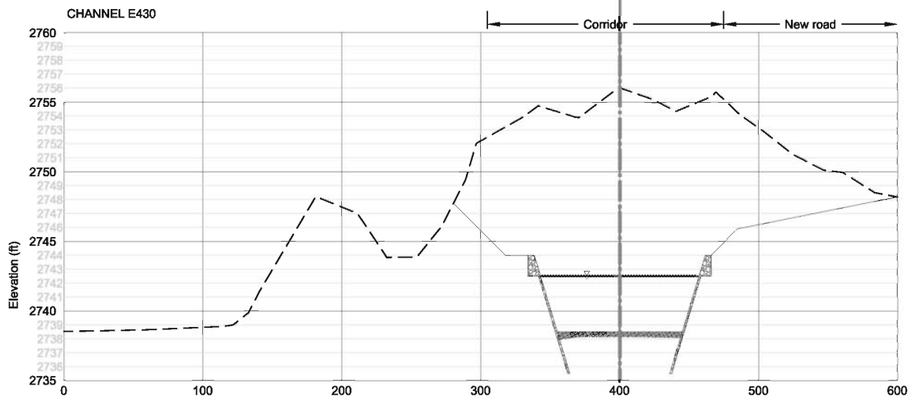

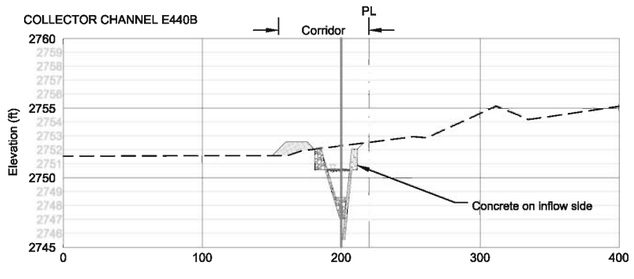

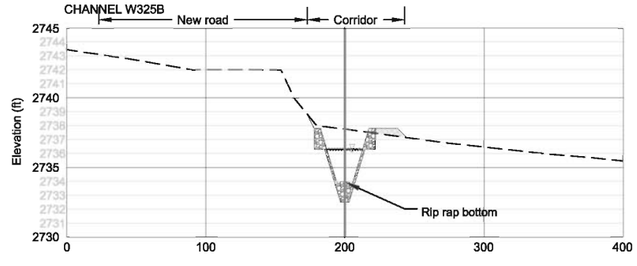

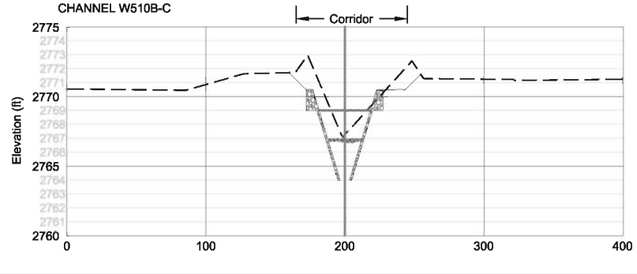

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TRIBUTARY CROSS SECTIONS

SCALE: 1"=50' Horizontal, 1"=5' Vertical
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Appendix B. Funding Sources

The following provides a list of potential sources of funding for the RMP. Most sources of funding for a project of this type and magnitude are public funding mechanisms. Typically, applying for and securing public funding requires a public entity such as a municipality or district as the local sponsor, particularly for federal funding. This list provided below in not all inclusive. Sources of funding are typically earmarked for the types of river improvement. For example, funding sources for environmental restoration are geared for habitat enhancement whereas flood control funding is specially earmarked for capital improvement projects.

Federal

1. Bureau of Reclamation (USBR) – There is potential for a long-term recharge credit or project financing if the project incorporates groundwater recharge elements, water quality mitigation, or wastewater reuse as part of the RMP. The USBR Phoenix Office Program Development Division works with communities, organizations, and states to assist them in the planning process for water supply improvements and opportunities for water reuse. Current projects in Arizona include the El Rio River Restoration Program and Tres Rios Wetlands Demonstration Project.

2. Environmental Protection Agency (EPA) *Wetland Program Development Grants* –These grants could be utilized to provide funding for RMP amenities such as wetland demonstration areas. The grants provide funds for conducting projects that promote the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to water pollution. In 2008, a total of $1,764,000 was awarded with individual grant amounts ranging from $50K to $300K.

3. Federal Emergency Management Agency (FEMA) – FEMA provides funding to reduce the risk to individuals and property from natural hazards. Hazard Mitigation Assistance (HMA) is available under five separate programs: the *Hazard Mitigation Grant Program* (HMGP), *Pre-Disaster Mitigation* (PDM), *Flood Mitigation Assistance* (FMA), *Repetitive Flood Claims* (RFC), and *Severe Repetitive Loss Pilot* (SRL) programs.

Most of these programs are not likely to be of use in funding the RMP because the existing property is mostly unimproved at this time. Of the five programs, the PDM program is the most likely candidate for receiving funding from FEMA. The PDM program is designed to assist States, Territories, Indian Tribal governments, and local communities to implement a sustained pre-disaster natural hazard mitigation program to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding from future disasters.

The HMGP is only available after a Presidential major disaster declaration. The FMA program's goal is to reduce or eliminate claims under the National Flood Insurance Program (NFIP). The RFC program is authorized with the goal of reducing flood damages to individual properties for which one or more claim payments for losses have been made under flood insurance coverage and that will result in the greatest savings to the NFIP in the shortest period of time. The SRL program is authorized with the goal of reducing flood damages to residential properties that have experienced severe repetitive losses under flood insurance coverage

Historic FEMA Hazard Mitigation Assistance Funding

	HMGP	PDM	FMA	RFC	SRL
FY09	incomplete	$90,000,000	$35,700,000	$10,000,000	$80,000,000
FY08	$1,014,615,102	$114,000,000	$34,000,000	$10,000,000	$80,000,000
FY07	$314,652,849	$100,000,000	$31,000,000	$10,000,000	$40,000,000
FY06	$232,227,932	$50,000,000	$28,000,000	$10,000,000	$40,000,000

FEMA distributes funds to the states which provide the funds to the communities. The requirements include:

- State agencies, participating National Flood Insurance Program (NFIP) communities, and qualified local organizations are eligible.
- Communities must have Flood Mitigation Plans to be eligible for project grants.
- This grant may fund up to 75 percent of the cost of eligible activities.
- Substantially reduce the risk of future damages caused by natural disasters.
- Be the most practical, effective, and environmentally sound alternative after considering a range of options.
- Solve a problem independently or be a part of a larger project that solves a problem. It must be demonstrated that the entire project will be completed.
- Include a FEMA approved all hazards mitigation plan under the rules of the Disaster Mitigation Act of 2000.
- Projects that merely identify or analyze hazards or problems are not eligible, such as flood mapping and studies.
- FEMA policy prohibits the use of funds for levee improvements.

4. Natural Resources Conservation Service (NRCS) – NRCS ***administers a broad range of programs to assist landowners, communities, and tribal nations with conserving and protecting natural resources while promoting sustainable economic development. Programs which are potential funding sources for the RMP include the following:***

   - *Watershed Protection and Flood Prevention Program* – This program provides assistance in protecting and restoring watersheds from damage caused by erosion, floodwater, and sediment; conserving and developing water and land resources; and solving natural resource and related economic problems on a watershed basis. State contacts are Dino DeSimone, Resource Conservationist, (602) 280-8786 and Don Paulus, Assistant State Conservationist, (602) 280-8780. The requirements include local and state funding contributions.

   - *Wetlands Reserve Program* – This program is part of the 2008 Farm Bill. It is a voluntary program that provides technical and financial assistance to private landowners and Tribes to restore, protect, and enhance wetlands in exchange for retiring eligible land from agriculture. The program offers three enrollment options: (1) Permanent Easement is a conservation easement in perpetuity. USDA pays 100 percent of the easement value and up to 100 percent of the restoration costs. (2) 30-Year Easement is an easement that expires after 30 years. USDA pays up to 75 percent of the easement value and up to 75 percent of the restoration costs. For both permanent and 30-year easements, USDA pays all costs associated with recording the easement in the local land records office, including recording fees, charges for abstracts, survey and appraisal fees, and title insurance. (3) Restoration Cost-Share Agreement is an agreement to restore or enhance the wetland functions and values without placing an easement on the enrolled acres. USDA pays up to 75 percent of the restoration costs.

5. US Army Corps of Engineers (USACE)
   Water Resources Development Act – Under the Water Resources Development Act, the Corps of Engineers can construct projects for the purposes of environmental protection and restoration, flood damage reduction, navigation, hurricane and storm damage reduction, and other projects within their mission. The first step in a Corps water resources development project is a study of the feasibility of the project. If the Corps has conducted a study in the area before, a new study can be authorized by a resolution of either the Committee on Transportation and Infrastructure of the House of Representatives or the Committee on Environmental and Public Works of the Senate. If the area has not been previously studied by the Corps, then an Act of Congress is necessary to authorize the study. The majority of studies are authorized by Committee resolution.
   Once authorized, the Corps first performs a reconnaissance study at Federal expense, at an approximate cost of $100,000, and typically takes one year to complete. Reconnaissance studies determine whether there is a Federal

interest in pursuing a given water resources problem or opportunity. In addition, it identifies the non-Federal interest that will participate in cost-sharing of the project. If a reconnaissance study indicates that there may be a viable Federal project and that a more detailed study should be undertaken, the Corps prepares a feasibility report, the cost of which is shared 50 percent by the Federal Government and 50 percent by the non-Federal interest.
After a feasibility study is completed, the results and recommendations of the study are submitted to Congress, usually in the form of a report to the Chief of Engineers. If such results and recommendations are favorable, the next step is authorization. Project authorizations are contained in water resources development acts, which are traditionally enacted on a biennial schedule. After a project is authorized, it would still require an appropriation of Federal funds to proceed to construction.

Civil Works Program–The most relevant program line is Flood Risk Management, with an objective to reduce the risk to public safety and risk of damages due to flooding and coastal storms through the safe operation of flood damage reduction projects. The FY 2010 budget for Flood Risk Management inland construction projects was $893,000,000. Examples include the Tres Rios Wetland Restoration and Flood Control Project in Phoenix, Arizona. Although major projects require congressional approval, some less cumbersome alternatives are available.

- *Continuing Authority Program (CAP)* – The Corps also has certain authorities to construct small projects without specific authorization from Congress. The authorities, collectively known as the 'continuing authorities program' include a number of project types with funding limits. These projects include for example, flood control projects with a Federal cost of no more than $7million. Other types of projects, with funding limits, can take care of emergency repairs to stream banks and shorelines, small beach erosion control projects, Section 107 Small Navigation Projects, projects to mitigate shore damage at federal navigation projects, small flood control projects, and snagging and clearing for flood control. The requirements include*:*

  a. Cost sharing is required. The amount will depend on the project.
  b. For the most assistance, pre-application consultation and coordination is essential.
  c. The application is simply a letter to the District Engineer, indicating clear intent to provide all required local participation.

- *Planning Assistance to the States (And Tribes) Program* – The Planning Assistance to the States (PAS) program authorizes USACE to provide technical assistance in the management of water resources problems. USACE will cooperate with States and Indian Tribes in the preparation of plans for the development, utilization and conservation of water and related land resources. Funding is subject to available appropriations, with a maximum annual amount of $500,000 to any State or Indian Tribe. Typical activities covered under this program include flood damage reduction, water resource development, water conservation, water quality, hydropower, and erosion. Requirements include the following:

  a. 50 percent cost sharing with the local sponsor.
  b. The state or tribal work request should be regional and comprehensive in scope or be part of a larger study being performed by the State or Tribe.
  c. Requests should be made through the State or Tribal water resources agency.

6. US Fish and Wildlife *North American Wetlands Conservation Act (NAWCA)* – This legislation provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife. There is a Standard and a Small Grants Program. Both are competitive grants programs and require that grant requests be matched by partner contributions at no less than a 1-to-1 ratio.

- *Standard Grants Program* – These projects must involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats. $77.2 million in total was available to fund grants in FY 2009.

- *Small Grants Program* – This program supports the same type of projects and adheres to the same selection criteria and administrative guidelines as the Standard Grants Program. However, project activities are usually smaller in scope and involve fewer project dollars. Grant requests may not exceed $75,000, and funding priority is given to grantees or partners new to the Act's Grants Program. $2 million was approved to support projects in FY 2009.

State of Arizona

1. Arizona Game and Fish Department (AGF) – AGF funding for projects such as the RMP is typically linked to environmental habitat enhancement and wildlife linkages The Landowner Relations Program has primary responsibility within AGF for working with the state's private landowners. The current program effectively implements more than $2 million annually toward a variety of habitat and land conservation projects. Several funding sources are available for developing or enhancing habitat for at-risk species. In many instances landowners and AGF combine efforts and funds with other department programs and with cost-share and grant opportunities offered by other agencies, such as the NRCS, U.S. Fish and Wildlife Service, and private nonprofit conservation groups. Most of funds target projects on private property. Some examples include wetland and riparian area restoration, vegetative manipulations, and conservation easements.

2. Arizona Department of Environmental Quality (ADEQ) *Water Quality Improvement Grant Program* – This program is available through ADEQ which allocates money from the EPA for implementation of nonpoint source management and watershed protection. ADEQ uses these federal funds to implement on-the-ground water quality improvement projects to control nonpoint source pollution. RMP improvements that enhance regional water quality such as wetlands, revegetation and incorporation of stormwater BMPs to improve water quality may be eligible for funding. The requirements include:

   - Applications must provide at least 40 percent non-federal match.
   - Projects should be completed in two years or less. ADEQ may be able to finance projects lasting up to five years if it is clearly justified that a period greater than two years is necessary.
   - A grant must be awarded and a grant agreement executed before a project can be started.
   - Projects must improve, protect, or maintain a water body in the state of Arizona by addressing a nonpoint source of pollution.
   - Projects must demonstrate acceptable water quality management principles, sound design and appropriate procedures.
   - Projects must yield benefits at a level commensurate with project costs for the benefit of the state.
   - Projects must have an on-the-ground implementation component within the state.
   - Projects must support ADEQ's Water Quality Division mission.
   - Projects must be eligible under applicable state and federal regulations, and comply with the application process described in the 2004-2007 Water Quality Improvement Grant Manual.
   - Studies, research, education, and data collection projects that are not part of an implementation project will not be considered.
   - Projects that focus primarily on water quantity issues will not be funded. An eligible project must focus on improving, maintaining, or protecting water quality. Many times, however, water quantity and water quality improvements go hand in hand.

3. Water Infrastructure Finance Authority (WIFA) – WIFA is an independent agency of the State of Arizona and is authorized to finance the construction, rehabilitation and/or improvement of drinking water, wastewater, wastewater reclamation, and other water quality facilities/projects. Generally, WIFA offers borrowers below market interest on loans for one hundred percent of eligible project costs.

4. Arizona Department of Transportation (ADOT) – ADOT's Community and Grant Services within the Multimodal Planning Division provides funding to ensure a multi-modal approach to mobility, congestion and air quality issues throughout the State. The ADOT Community and Grant Services department administers several Federal Transit Administration grant programs. ADOT funding which may be obtained for the RMP multi-use paths and associated landscape through the *Projects of Opportunity fund* or *Transportation Enhancement fund*.

5. Arizona Department of Water Resources (ADWR) *Water Protection Fund* – This fund is available through ADWR for the development and implementation of measures to protect water of sufficient quality and quantity to maintain, enhance, and restore rivers and streams and associated riparian habitats. Grants from this Fund may be used to:

   - Develop and implement capital projects or specific measures to maintain, enhance, and restore rivers and streams and associated riparian resources.
   - Acquire CAP water or effluent for the purpose of protecting or restoring rivers and streams.
   - Develop, promote, and implement water conservation programs outside of the five active management areas.
   - Support research and data collection, compilation and analysis.
   - Man-made water resource projects may be funded, if the project benefits a river or stream and creates or restores riparian habitat.

Pima County

1. Pima County Regional Flood Control District (RFCD) – The RFCD is authorized to levy secondary property taxes on parcels within its jurisdiction. Tax revenue is used to fund RFCD operations and flood control projects. Capital Improvement Program (CIP) projects include bank stabilization, detention and retention basins, bridges, drainage improvements, and river parks. Flood control improvement projects are typically funded to mitigate existing flooding issues. The removal of existing farmland from the floodplain may not be considered a viable use of county funds. However, as the farmland is converted over to a land use of residential, commercial, retail, offices, and schools, flood control funds would be viable for a joint flood control project with local public sponsors and federal sponsors.

2. Pima County Regional Wastewater Reclamation Department – Improvements associated with county wastewater facilities could include a portion of the RMP in order to provide flood protection for county facilities and/or water quality improvements for wastewater discharges to the Santa Cruz River.

3. County Bonds –Pima County has the authority to issue flood control bonds to build flood control facilities and acquire flood prone land. Most financing from government agencies is done through tax-exempt municipal bonds; however, bonds are the most complex and expensive way to borrow because of the extent of legal and other fees, administration time, and they sometimes require voter approval. Success in bond financing comes from extensive public education on the importance of flood control, a good bond rating, and a strong coalition of the community. It is important to remember that bonds must be paid off, usually through taxes or fees. The advantage is that they allow a large cost to be spread out over time.

4. Parks and Recreation – Proposed parks, trails and RMP improvements could be funded by the county Parks and Recreation CIP. RMP improvements associated with the park and trail areas may be constructed in exchange for FICO property.

5. Regional Transportation Authority (RTA) – Funded by a countywide transaction tax, the RTA manages the RTA Plan approved by voters in 2006. One component of this plan is the environmental and economic vitality element, with a budget $115 million over the 20-year plan. Developing a linear park corridor with shared use paths on the terraces of the RMP may help to fulfill the RTA Plan. The Sahuarita Area Corridor is identified in the RTA Plan as a key corridor and both Bike Lanes/Shoulders and Shared Use Paths in this area are identified in the proposed bike lanes and pathway improvements map.

Town of Sahuarita

1. General Obligation Bonds – If approved, a General Bonds could be issued by the Town to fund the RMP or a portion of it. The bond could then be paid over time by assessing an impact fee per rooftop developed in association with the RMP. The concerns described in the County Bond section above also apply to bonds issued by the Town.

2. Capital Improvements Program – The Town's CIP program could be used to fund RMP improvements.

3. Community Facilities District – The Town could fund the RMP by forming a Community Facilities District to pay for roadways, water, sewer, drainage, pedestrian ways, landscaping, lighting systems, traffic control, public buildings and sites, schools and sites, parks and sites, and public recreational facilities. The costs of the bond to be used for the improvements would be passed on to the end user of the improved property. The concerns described in the County Bond section above also apply to bonds issued by the Town for Community Facilities Districts.

4. Impact Fees – The Town can assess impact fees to equitably distribute the cost of regional public improvements that serve new development areas. The amount and type of development impact fees that are charged to new development are influenced by many factors, such as, economics, politics, and a technical benefit analysis. Many different cost allocation methods can be deployed in performing technical benefit analysis to yield significantly different development fee impact amounts.

Public-Private Partnerships

1. Union Pacific Railroad (UPRR) – The RMP will include recommendations for upgrading and replacement of multiple railroad crossings. Many of these existing structures are old and may be deficient for large storm events or modern loads. UPRR may be willing to pool resources towards improving the railroad crossings to meet current standards.

2. Pima County/Town of Sahuarita – A combination of private funds from FICO and public funds from the Town and Pima County could be utilized to construct the RMP.

3. Sand and Gravel Industry – As a cost recovery mechanism, there may be opportunity for contracting with local sand and gravel companies to excavate the desired channel in exchange for mining fees.

General Funding Guidelines

The best financing plans use a combination of grants and other sources of funding. This is because grants are very competitive and typically cover only part of the project cost. Additionally, a project is more likely to receive grant money when there is a plan in place for operation and maintenance funds. Higher priority should be given to grants offered through the state than to federal grants because federal grants are more competitive and difficult to obtain.

The purpose of this document is to identify potential sources of funding, both public and private. Private funding mechanisms with public participation in regional transportation facilities, trails, parks, and some RMP improvements seem to be the likely funding source for the project. This funding sources memo is a working document which will be revised upon meeting with potential project partners. Consideration should be given to obtaining the services of a firm which specializes in public/private development financing as this project moves forward.

Appendix C. Technical Reports

Several technical reports have been prepared by JE Fuller Hydrology and Geomorphology in conjunction with the RMP and are included digitally. Printed copies have been submitted in separate bound volumes for agency review.

Santa Cruz River Existing Conditions Floodplain Model: Downstream of Continental Road to Pima Mine Road

An existing condition floodplain model was prepared for the Sahuarita Farms, extending from north of Continental Road to north of Pima Mine Road. The topography used for this model was collected in 2007 for the project and represented the most detailed and most current data available. The floodplain modeling methodology employed in this study differed from the methodology used in the effective model, and reflects differences in engineering judgment as well as changes in FEMA's guidance for modeling levee-like embankment structures. The results of the existing condition floodplain model include a slightly different floodplain through Sahuarita Farms than is shown on the effective FIRM. However, the model and mapping are only used as a basis for the current design and have not been submitted with the intent of altering the federally mapped floodplain. In the future, this model or another may be submitted for such an effort.

Technical Data Notebook for Santa Cruz River Sediment Transport, Scour, and Long Term Analyses: Demetrie Wash to Pima Mine Road

A sediment transport and scour analysis was conducted for the Santa Cruz River to support this RMP. The analysis supported by this report included:

- Long-term aggradation/degradation potential.
- Single-event scour and erosion potential.
- Long-term adjustments to the river profile.
- Definition of hydrographs for the river.
- Documentation of sedimentation & scour problems.
- Definition of erosion hazard setback lines.

River Master Plan Modeling along the Santa Cruz River: Duval Mine Road to Pima Mine Road

This report documents the RMP design and includes the following elements:

- Hydraulic modeling used to design the river.
- Estimates of design sediment transport and scour.
- Comparison of the floodplain, at the project limits, to existing conditions.

Santa Cruz River Hydrograph Attenuation Analyses: Downstream of Continental Road to Pima Mine Road

A hydrograph attenuation analysis was completed to evaluate the impacts of the proposed RMP on peak discharges downstream of the project area. The analysis was completed to evaluate the impacts of reducing the available floodplain storage from the existing condition. The analysis included running theoretical hydrographs through models representing the existing condition and the proposed RMP conditions. This was done for the 2-yr, 10-yr and 100-yr storm events. The results of the evaluation document that the proposed RMP river improvements will not have a significant adverse impact on the downstream peak discharge. The results indicate the RMP river improvements may increase the peak discharge 0.9 miles downstream of Pima Mine Road by around 1 percent. Peak discharge increases further downstream will be even more insignificant due to the increased distance.

Drainage Master Plan

The drainage master plan is included as a parallel report to this River Master Plan Report to document offsite hydrology and onsite hydrology for the existing conditions. This was done using the FLO-2D model and is complementary to Pima County Regional Flood Control District's Lee Moore Wash FLO-2D model. This model identifies inflow concentration points (many are sheet flooding) and peak discharges. This model also predicts flow depths and velocities into and through the project.

The drainage master plan also defines tributary corridors. These corridors are planned to convey offsite flow through the site following existing flow paths to either the Santa Cruz River or existing washes and sheet flooding areas. .

Appendix D. Environmental Considerations

(The text in this Appendix was provided by Westland Resources Inc. See the attached digital disk for more information.)

Biological and Cultural Resource Considerations

During the preparation of this RMP, preliminary evaluations of the biological and cultural resources within the project area have been completed. A Class I Archaeological Records Search and an Environmental Overview have been prepared. The results of these sections are summarized below.

Biological Resources In 1775, Captain Juan Bautista de Anza, the head of the Tubac presidio, referred to his camp in the vicinity of the Sahuarita Farms project as *Punta de los llanos* or "Point of the Plains" These grassy plains, located around the flanks of the Sierrita and Santa Rita Mountain ranges, were attractive to Spanish-period ranchers and testimony given before the U.S. Court of Private Land Claims by I.E. Gonzales in 1881 described the valley as *"covered by shrubs, such as mesquite, acacia,…and very few cottonwood and willows…and also sacaton grass along the floodplain"*. The chief surveyor mapping the boundary of the Gadsden Purchase in 1854, Major William Emory, described a *"dry valley now almost exclusively occupied by mesquite."* By the end of the 1800's, the defeat of the Apache and the introduction of pump-well-irrigated agriculture allowed for the development of the valley for extensive farming and ranching.

Sahuarita Farms project area is located near a transitional zone between the Arizona Upland subdivision of the Sonoran Desertscrub biotic community and the Semidesert Grassland biotic community, as defined by Brown and Lowe. Little of the native plant communities remain and the majority of the Sahuarita Farms project area has been heavily altered from its natural state. Most of the lands comprising and immediately adjoining the project area have also been altered by historic and modern agriculture and grazing, as well as more recent residential development.

The majority of the project area is currently pecan groves, actively maintained and harvested by FICO. The pecan tree (*Carya illinoinensis)* is, by far, the most prominent plant species within the project area. Some relatively undisturbed lands on the fringes of the project area do possess more common, non-cultivar vegetation including foothill paloverde (*Cercidium microphyllum*), velvet mesquite (*Prosopis velutina*), creosote bush (*Larrea tridentata*), sotol (*Dasylirion wheeleri*), four-wing saltbush (*Atriplex canescens*), staghorn cholla (*Opuntia versicolor*), cane cholla (*Opuntia spinosior*), and Engelmann prickly pear (*Opuntia engelmannii*). Non-native disturbance species such as Russian thistle (*Salsola* spp.*)* and bermudagrass (*Cynodon dactylon*) were also observed.

The Santa Cruz River and its floodplain in the vicinity of the project area historically supported more riparian vegetation: mesquite bosques, dense sacaton (*Sporobolus airoides*), and likely scattered cottonwood (*Populus fremontii*) and possibly willow (*Salix* spp.). Beyond the historic and modern alteration of the surrounding landscape, changes in the morphology of the river and the depth of the ground water table within the valley have also altered the vegetation within the channel itself. Presently, only the margins of the constrained active floodplain possess at least some limited mature, woody vegetation characteristic of xeroriparian habitat. The active channel more regularly experiences scour and mechanical alteration to prevent erosion, and vegetation supported by the channel margins and active floodplain is mainly limited to patches of mesquite, desert broom (*Baccharis sarothroides*) and burrobrush (*Hymenoclea salsola*).

The Arizona Wildlife Linkages Assessment prepared in 2006 by the Arizona Wildlife Linkages Workgroup (AWLW) was reviewed. The AWLW worked to identify desert lowland areas that could provide linkages for wildlife movement between desert mountain ranges. Identification of the importance of a linkage to a given species indicates the species has the potential to utilize the linkage, rather than implying that the species resides in the linkage zone (AWLW 2006). The goal of the endeavor was the documentation of the connectivity value of these lowland areas and their importance to wildlife movement. The current project area is located within an area designated as Linkage 92: San Xavier-Sierrita-Santa Rita by the AWLW (2006). Linkage 92 is classified as belonging to the Sky Island and Sonoran Desert Ecoregions defined in the assessment. The assessment identifies the linkage as important to the black bear (*Ursus americanus*), cave myotis (*Myotis velifer*), giant spotted whiptail (*Aspidoscelis burti stictogrammus*), gila topminnow (*Poeciliopsis occidentalis occidentalis*), jaguar (*Panthera onca*), lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), lowland leopard frog (*Rana yavapaiensis*), mountain lion (*Felis concolor*), yellow-nosed cotton rat (*Sigmodon ochrognathus*), and western yellow-billed cuckoo (*Coccyzus americanus occidentalis*).

The USFWS list for Pima County identifies species listed as threatened or endangered, species considered to be candidates for listing, and species for whom a conservation agreement exists (Listed Species). The potential for the presence of these species to occur within the Sahuarita Farms project area was evaluated based upon: 1) field observations; 2) review of information regarding the natural history of the Listed Species; 3) evaluation of the known range and distribution for the Listed Species; 4) comparisons of this information with habitats present in the Analysis Area and general region and 5) review of information from the Arizona Game and Fish Department (AGFD) Heritage Data Management System (HDMS). Records from the HDMS were also used to determine if designated or proposed critical habitat occurs on or in the vicinity of the project area.

The Sahuarita Farms project area does not contain any proposed or designated critical habitat and there are no known records of Listed Species occurring within the project area. As outlined in greater detail in Sahuarita Farms Land/River Master Plan Environmental Overview, included as an attachment to this RMP, survey has been recommended for those limited portions of the project area that may contain suitable habitat for Pima pineapple cactus and further analysis and study is recommended for yellow billed cuckoo.

Within the land and river master plan area there are: 1) 665 acres of Important Riparian Area, 2) 431 Acres of Biological Core Management Area, 3) 354 acres of Multiple Use Management Area, and 4) 2,322 acres of Agricultural In-holdings. The bulk of these CLS designations are for lands that will be managed in accordance with the RMP.

As one of its core planning values, the project proponent has committed to compliance with the conservation principals of the Pima County Conservation Lands System (CLS). Achieving CLS conservation targets will be accomplished within the Santa Cruz River Corridor by: 1) stabilization of the degrading channel condition as outlined in the RMP, 2) the protection of wide (up to 1400 feet) interconnected open space corridor that includes passive recreation and limited active recreation, 3) extensive riparian enhancement efforts throughout the 12 miles of the Santa Cruz River corridor, and 4) the inclusion of habitat connectivity features to adjacent public lands to extent that those efforts are supported by publicly funded infrastructure to accommodate the safe movement of wildlife past the UPRR and the planned improvements to Old Nogales Highway.

Cultural Resources A Class I Archaeological Records Search was completed by Desert Archaeology, Inc. (DAI) in February 2009. The results of this investigation are provided as Appendix A of the Sahuarita Farms Land/River Master Plan Environmental Overview included as an attachment to this RMP. The records search was performed over an approximately 10,300-acre Area of Potential Effects (APE) centered on the Santa Cruz River between the San Xavier Indian Reservation to the north and the San Ignacio de la Canoa historical land grant to the south. The search included records in the AZSITE cultural resources database at the Arizona State Museum (ASM) for all previously recorded archaeological sites and completed cultural resources investigations located both within and in a 1-mile radius around the APE.

The records search identified 35 previously completed cultural resources investigations within the APE. An additional 99 were completed within the 1-mile buffer. The majority of the APE, and consequently the current Analysis Area, has not previously been surveyed for cultural resources. Additionally, most of the survey occurring within the APE was performed more than 10 years ago and by standard practice and agency policy may have to be redone.

The Class I Archaeological Records Search identified a total of 27 previously recorded archaeological sites within the APE and an additional 185 sites within the 1-mile buffer. Sites within the APE represent a wide spectrum of ages, but with clusters dating to the Hohokam Sequence (A.D. 500 -1450) and the American Period (1856 to Present). Of the 27 sites in the APE, eight were considered eligible for inclusion on the National Register of Historic Places (NRHP) by the recording archaeologist, and 13 were not evaluated for NRHP eligibility. The State Historic Preservation Office (SFPO) has not made an official determination of eligibility for any of the sites within the APE.

Cultural resources are protected by a variety of local, state, and federal regulation. For the majority of the Sahuarita Farms project area, including those actions to be governed by this RMP, the principal controlling regulation will be the National Historic Preservation Act (See Section 1.1). Considering the time frames that are likely involved with the development of the property and the features associated with implementation of the RMP, it may be most appropriate from a resource management and regulatory perspective to prepare a programmatic agreement that would include the Corps, SHPO, Pima County, Sahuarita, and interested Native American groups. This agreement would guide cultural resource compliance requirements through the life of the project. For example, it would allow for phased survey and data recovery to coincide with development phases of the project. This would avoid having to resurvey lands multiple times as the effective life of the field survey effort expires. The phased data recovery effort would avoid potentially costly implementation of mitigation obligations at the front end of the project for potential impacts that would not happen for years. It would also allow data recovery efforts that may be required later in the project life to take advantage of new technologies that may be developed in the intervening years.

Environmental Planning Goals and Concepts

The RMP has multiple objectives, not the least of which is flood and erosion protection. The Santa Cruz River, just downstream of the project area is incised and is actively degrading. This condition is moving upstream and evidence is present in the downstream reach of the Santa Cruz as it leaves the project area. Absent structural intervention and management channel degradation will continue and will further reduce habitat values in the project area. As it progresses upstream, it will eventually compromise the perennial reach of the Santa Cruz River south of this project area as well as initiate the degradation of the tributaries that report to the river within and upstream of Sahuarita Farms.

The proposed river master plan will provide for river management, enhancement, recharge, and recreation. While stabilization of the river corridor within Sahuarita Farms has far reaching and beneficial implications to regional conservation goals, the land and river management plans being proposed by FICO envision the enhancement of riparian habitat values of this reach within the context of the proposed master planned community. The following principals will guide the development of the riparian/open space corridor in the context of this RMP to further these goals.

- The river corridor is envisioned as a wildlife and recreational linkage within Sahuarita Farms and to the adjacent landscape. Specific targeted linkages connecting the public open space in the Santa Rita Mountains and the western foothills to the Santa Cruz River are contemplated at the northern end of the Analysis Area, at Box Canyon Wash near the center of the Analysis Area, and at the southern end of the Analysis Area near the Canoa Ranch. The utility of these corridors for ungulates and other large wildlife species will likely require the establishment of major wildlife crossing structures to accommodate the railroad and planned roadway features. This public benefit can be accommodated within the project master plan provided public funding is made available for the design and construction of suitable facilities to achieve desired wildlife benefits.[1]
- Local connectivity within the project will be achieved by the configuration of trails, recreational facilities, and the adjacent residential and commercial land uses to minimize conflict to the extent practical with protected natural open space areas incorporated into the river corridor.
- Lighting adjacent to the river corridor for recreational uses will be planned to minimize its intrusion into natural open space area. Lighting programs will be compatible with Pima County and Sahuarita Dark Sky ordinances.
- Within the river corridor native plant species indigenous to the Santa Cruz River will be used exclusively for landscape and habitat enhancement purposes.
- Riparian enhancement themes within the Santa Cruz River Corridor will be focused on the pre-anglo period condition of the site, to the extent creation of those habitats can be accomplished in a sustainable manner. This will favor mesquite-dominated riparian areas.
- Riparian enhancement efforts will be self-sustaining and, to the extent that effluent is available, it will be used to support oases of cottonwood, willow, and other wetland species within the larger riparian habitat enhancement area.
- Water harvesting and storm water management features will be integral components of the enhancement program and will be used to foster riparian habitat establishment and the development of more mesic habitats.
- Creating an interconnected natural open space system within the developed portions of the property is a key value and objective the RMP. To accomplish this, major tributaries to the Santa Cruz River, like Box Canyon Wash, will become integral components of the natural open space system established within the master-planned community.
- River treatments will be designed to facilitate wildlife movement, particularly ungulates. Revetment slopes will be constructed and configured in such a way that they will not be barriers to wildlife movement.

The width of the river corridor will be maximized within the context of the proposed master planned community. The primary floodway corridor of the Santa Cruz River will be approximately 500 feet wide. Upper terrace areas will be 150 to 425 feet wide. The total floodplain corridor will be from 800 to 1,400 feet wide.

[1] At Box Canyon matching road bed elevations to the existing height of the railroad crossings and lowering of the invert elevation for the underpass might allow the crossing structure to achieve the assumed minimum height requirement of 8 feet necessary for mule deer with an acceptable openness index provided that sedimentation and hydrologic requirements could be addressed.

Appendix E. Digital Files

A digital disk is included with the following elements:

1. PDF of this report.
2. PDF of the plans (Appendix A).
3. PDF of the technical reports (Appendix C).
4. PDF of the environmental reports (Appendix D).