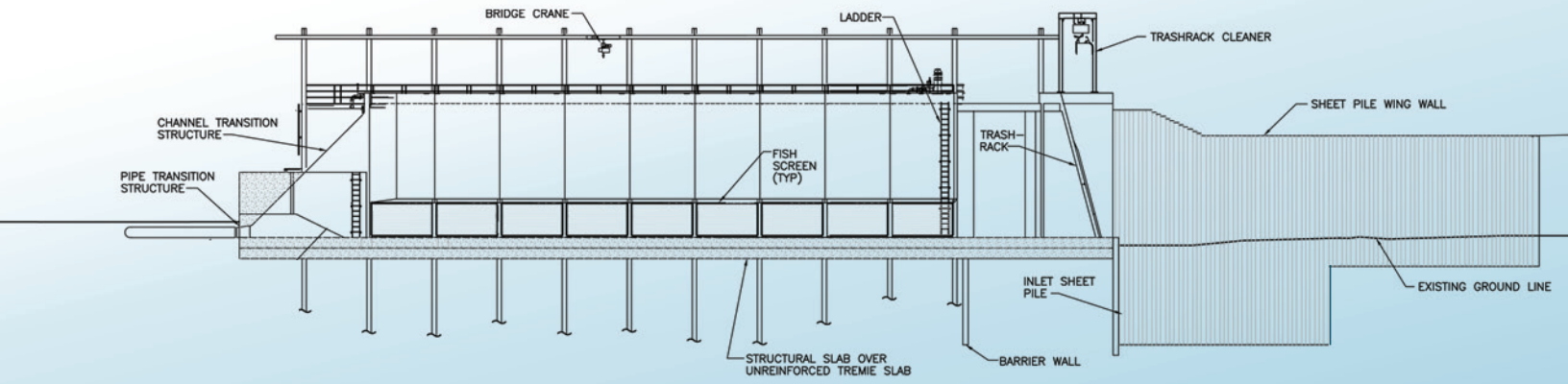
PREPARED FOR
West Stanislaus
Irrigation District

West Stanislaus Irrigation District Fish Screen Project

Final Fish Screen Feasibility Study

December 2010



Profile V- Shaped Intake Facility

FINAL FEASIBILITY STUDY

MWH®
BUILDING A BETTER WORLD

West Stanislaus Irrigation District

Final Fish Screen Intake Feasibility Study

December 2010

Prepared by

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ABBREVIATIONS AND ACRONYMS

BMPs	Best Management Practices
CCIC	Central California Information Center
CDFG	California Department of Fish and Game
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
District	West Stanislaus Irrigation District
DMC	Delta Mendota Canal
EFH	Essential Fish Habitat
FESA	CESA and/or Federal Endangered Species Act
HEC-FFA	HEC Flood Frequency Analysis
MDB&M	Mount Diablo Base and Meridian
NAHC	Native American Heritage Commission
NMFS	National Marine Fisheries Service
NTU	nephelometric turbidity units
PWRPA	Power & Water Resource Pooling Authority
Qdp	Dos Palos alluvium
Qf	alluvial Fan Deposits
RM	River Mile
SJNWR	San Joaquin Natural Wildlife Refuge
SJRNWR	San Joaquin River National Wildlife Refuge
SLF	Sacred Lands File
USCS	Unified Soils Classification System
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	U. S. Geological Survey
Va	river flow approach velocity, normal to the screen face
Vs	river sweeping velocities
WAPA	Western Area Power Administration

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EXECUTIVE SUMMARY

The West Stanislaus Irrigation District (District) was established in 1920 for the purpose of providing water for area farmers to grow crops in the San Joaquin Valley. The District has a water right to divert 262 cfs for irrigation from the San Joaquin River between Mendota Pool and Vernalis in accordance with their License Number 3957 (Permit 2758, Application 1987). The District's Point of Diversion is described as north twenty nine degrees fifty minutes east (N29d50E), nineteen thousand two hundred ninety (19,290) feet from W 1/2 corner of Section 28, T4S, R7E, Mount Diablo Base and Meridian (MDB&M), being within the SE 1/ NE 1/ of Section 10, T4S, R7E MDB&M. The District's Point of Diversion is located at the beginning of the 2.2 mile existing conveyance channel. This channel is also the sole conveyance for the United States Fish and Wildlife Service (USFWS) riparian supply.

In addition, the District is obligated by a 1939 agreement to divert at its diversion point on the San Joaquin River, 45 cfs of riparian water for irrigation of riparian land adjacent to the District, known as the White Lake Mutual Water Company. That agreement is still binding between the parties, and imposes upon the District the continuing obligation to dedicate 45 cfs of pumping capacity to the adjacent riparian lands. This was confirmed by a State Water Resources Control Board September 11, 1941 Memorandum of Field Visit stating: ". . .the district is obligated to supply up to 45 cfs to the Burkhard property by an agreement since 1928 and merely acts as a transporting agent for this water which is under riparian and an old appropriative right."[1]

The District also receives Central Valley Project water annually from the Delta Mendota Canal (DMC) per their contract 14-06-200-1072-LTR. The contract provides for delivery of 50,000 AF of project water used to supplement crop delivery requirements. The crops grown in the District Service area are primarily row crops, including alfalfa, almonds, apricots, beans, and tomatoes. The average farm size in the District is about 160 acres. The District serves irrigation water to 20,166 acres within its service area. Refer to **Figure ES-1** for a map of the northern portion of the San Joaquin Valley and location of the District's service boundary.

Financing for this study was provided by the District, and by the Federal Anadromous Fish Screen Program using Central Valley Project Improvement Act (CVPIA) funds, to evaluate the feasibility of intake alternatives with positive barrier fish screens for the protection of anadromous fish and other species. These species include Chinook salmon and steelhead trout which are listed as threatened or endangered by State and Federal agencies.

[1] The White Lake Mutual Water Company was formed on September 11, 1941 and represents the Burkhard Properties by virtue of its Articles of Incorporation and Bylaws.

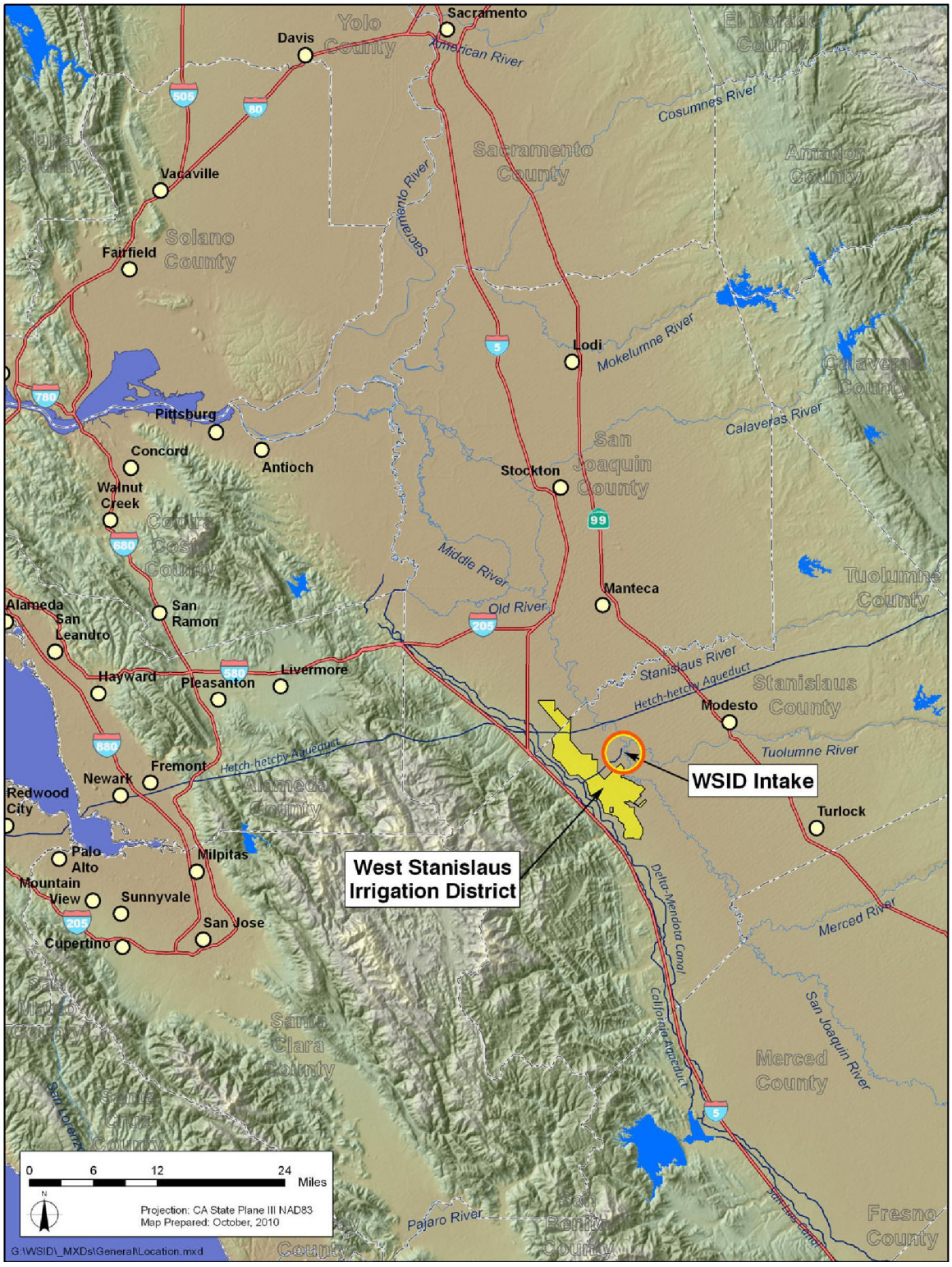

Figure ES-1
Regional Map of San Joaquin Valley

A preliminary hydraulic analysis was performed for the San Joaquin River using data obtained from the U.S. Geological Survey (USGS). Flow and stage data were obtained from the USGS Newman Gage Station, located roughly 20 miles upstream of the project site. River rating and exceedence curves were developed for the gage station, with the 90%, 10% and 100-year exceedence flows determined to be at a flow of 160 cfs, 15,000 cfs and 45,000 cfs respectively. Rating curves were then established to determine the water surface elevation at the Newman Gage. Projection of water surface elevations for the various alternatives ranged from 18 to 32 feet msl. A more in depth discussion of the project site existing conditions is covered in Section 2.

Project design criteria used for a conceptual fish screen structures are based on the District's operational requirements, published criteria for fish passage facilities established by the California Department of Fish and Game (CDFG) and the National Marine Fisheries Service (NMFS). Current industry practice and experience at similar facilities along both the San Joaquin River and Sacramento River were also used to develop the design criteria. Section 3, Design Criteria, describes the criteria developed for this project.

Site 1 Alternatives 1A and 1B - New In-Channel Vertical Flat Plate Screen Intake Facility at San Joaquin River Mile (RM) 81.6

Alternatives 1A and 1B provide for a new intake facility with a capacity of 347 cfs. The new facility includes a In-Channel Vertical Flat Plate Screen Intake as described in Section 4 which is located at the existing District Point of Diversion on the west side of the San Joaquin River within the existing inlet channel at RM 81.6. This alternative would require a total of sixteen 12-foot long symmetrically opposing vertical flat plate wedge-wire screens inside a V-shaped structure with steel members, a fish bypass pump station and pipeline, and an access bridge/platform.

An automated mechanical brush screen cleaning system and pressurized sediment suspension system would be included along each side of the V-shaped screening structure for cleaning of the screens and removal of any accumulation of sediment near the screens.

Alternative 1A would convey water to the existing District's Lift Station No. 1 via two new 96" or larger diameter parallel pipes installed and buried within the existing channel. Alternative 1B would require some improvements to the channel and water would be conveyed within the existing channel.

Site 2 Alternatives 2C, 2D, 2E, and 2F - New Vertical Flat Plate Screen Intake Facility at San Joaquin River Mile (RM) 83.6

Alternatives 2C through 2F also provide for a new intake facility with a capacity of 347 cfs; however, the new facility will instead include a vertical flat plate wedge-wire screen described in Section 4 located along the west bank of the San Joaquin River at RM 83.6. This alternative would require sixteen 12-foot long vertical flat plate wedge-wire screens along the front face of a concrete sump structure, new parallel discharge pipelines, and access roadway.

An automated mechanical brush screen cleaning system and pressurized sediment suspension system would be included along the screen face for cleaning of the screens and suspension of any accumulation of sediment around the screens.

Alternatives 2C and 2E would convey water via two new 78" or larger diameter parallel pipes routed below grade from the Intake Facility to discharge midway along the existing channel. Both of these alternatives would require improvements to a portion of the upper section of conveyance channel.

Alternatives 2D and 2F are similar to Alternatives 2C and 2E, except the new 78" or larger diameter parallel pipes would be constructed along the alignment of the existing conveyance channel to the existing District's Lift Station No. 1. The parallel pipes along the conveyance channel alignment would be installed and buried within the existing conveyance channel prism. For these alternatives, turnouts would be required to allow USFWS to obtain the water service required for their existing pumping facilities; and modifications to each of the USFWS facilities will likely be required.

Site 3 Alternatives 3G and 3H - New Vertical Flat Plate Screen Type Intake Facility at San Joaquin River Mile (RM) 84.3

Alternatives 3G and 3H provide for the same type of intake facility and cleaning system as for the alternatives for Site 2 above, located along the west bank of the San Joaquin River at RM 84.3.

Alternative 3G would convey water via two new 96" or larger diameter parallel pipes routed below grade from the new Intake Facility and discharge approximately two-thirds of the way down the existing conveyance channel, and conveyance would continue in the lower third of the conveyance channel to the existing District's Lift Station No. 1.

Alternative 3H is similar to Alternatives 3G, except the new 96" or larger diameter parallel pipes would continue along the alignment of the existing channel all the way to the existing District Intake Facility. The parallel pipes along the channel alignment would be installed and buried within the existing channel. For this alternative, turnouts would be required to allow USFWS to obtain the water service required for their existing pumping facilities; and modifications to each of the USFWS facilities will likely be required.

Site 4 Alternatives - New Vertical Flat Plate Screen Type Intake Facility at San Joaquin River Mile (RM) 84.9

Alternatives for Site 4 would provide for the same type of intake facility and cleaning system as for the alternatives for Site 2 and 3 above, located along the west bank of the San Joaquin River at RM 84.9. However, due to the increased length of pipe, the need to change the point of diversion, required land acquisition, coordination with USFWS for required easement, and overall costs, no further analysis has been made for alternatives for this site.

Initially, a total of nine alternatives were evaluated for this project. A pre-screening of alternatives based on river bank stability, distance to existing District Intake, access, water quality, water right, extension of electrical power, cost of construction and environmental impact

reduced the total number of alternatives for full evaluation to three. Refer to Section 4 for complete descriptions of all alternatives. The three final alternatives are briefly summarized below from a construction cost, and annual operations and maintenance cost:

Cost Estimates for the Three Final Alternatives

Alternative	Estimated Project Cost	Estimated Annual O&M Cost
Alternative1B	$24,880,000	$80,772
Alternative 2C	$28,200,000	$63,772
Alternative 3G	$39,000,000	$63,772

The three final alternatives were analyzed with respect to the following criteria:

- Resource Protection/Potential Environmental Impacts
- Geomorphology/Sediment/Scour & Bank Stabilization
- Water Supply
- Operation and Maintenance
- Estimated Cost

Based on evaluation of the alternatives using the above criteria, Alternative 1B has been selected as the preferred alternative.

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SECTION 1 – INTRODUCTION

PROJECT BACKGROUND

The West Stanislaus Irrigation District (District) was established in 1920 for the purpose of providing water for area farmers to grow crops in the San Joaquin Valley. The District diverts up to 262 cfs per their water right for irrigation from the San Joaquin River between Mendota Pool and Vernalis in accordance with their License Number 3957 (Permit 2758, Application 1987), refer to Appendix A. The District's Point of Diversion is described as north twenty nine degrees fifty minutes east (N29d50E), nineteen thousand two hundred ninety (19,290) feet from W 1/2 corner of Section 28, T4S, R7E, Mount Diablo Base and Meridian (MDB&M), being within the SE 1/ NE 1/ of Section 10, T4S, R7E MDB&M.

The District serves an area that is located west of the San Joaquin River, northwest of the City of Patterson, and includes the unincorporated communities of Westley, Grayson and Vernalis as shown in **Figure 1-1**. A small portion of the District extends into San Joaquin County. The crops grown in the District service area are primarily row crops, including alfalfa, almonds, apricots, beans, and tomatoes. The average farm in the District is about 160 acres. The District's boundary includes approximately 21,676 acres. The District provides its customers with irrigation water for agricultural purposes. This total amount of water is provided by several sources. The primary supply is from their single point of diversion described in their permit as from the Tuolumne and San Joaquin Rivers (refer to Appendix A). In addition, supplemental supplies include groundwater from four deep wells within the District's boundary, and imported water from the Central Valley Project (described below).

In addition, the District is obligated by a 1939 agreement to divert at its diversion point on the San Joaquin River, 45 cfs of riparian water for irrigation of riparian land adjacent to the District, known as the White Lake Mutual Water Company (refer to Appendix A). That agreement is still binding between the parties, and imposes upon the District the continuing obligation to dedicate 45 cfs of pumping capacity to the adjacent riparian lands. This was confirmed by a State Water Resources Control Board September 11, 1941 Memorandum of Field Visit stating: ". . .the district is obligated to supply up to 45 cfs to the Burkhard property by an agreement since 1928 and merely acts as a transporting agent for this water which is under riparian and an old appropriative right."

Additional supplemental supply of irrigation water is available through groundwater to the District. The District has a total of four wells capable of approximately 4 cfs each depending on time of year and depth of water. The average depths of water for these wells varies between 15 to 40 feet below the ground surface.

The District also receives Central Valley Project water annually from the Delta Mendota Canal (DMC) per their contract 14-06-200-1072-LTR. The contract provides for delivery of 50,000 AF of project water used to supplement crop delivery requirements.

The District's water delivery system originates at the conveyance channel shared by the District and the United States Fish and Wildlife Service (USFWS) which ends at the District's Lift Station No. 1. The unlined conveyance channel extends 2 miles southwesterly from the point of

Diversion just upstream of the confluence of the Tuolumne and San Joaquin Rivers to the District's Lift Station No. 1. In addition District facilities include 3 miles of concrete lined main lift canal, 45 miles of concrete lined laterals, 14 miles of unlined laterals, 22 miles of concrete pipe sub laterals and approximately 4,000 feet of concrete pipe connecting to the DMC turnout. The District has 6 pump lifts within their system for moving water throughout the service area.

Along the District's conveyance channel, which ends at the District's Main Lift Station No. 1, there are four small pumps with capacities of 10 cfs each owned and operated by the USFWS to irrigate the riparian habitat maintained on the San Joaquin River National Wildlife Refuge (SJRNWR). Refuge lands within and near the project area consist of a mature riparian corridor within the San Joaquin River flood control levee and former agricultural lands being restored back to floodplain riparian forest. USFWS and the District have worked together with MWH to provide information in order to make decisions regarding future operations and impacts to all interested parties.

AUTHORITY

Financing for this feasibility study is provided by the District, and by the Federal Anadromous Fish Screen Program operated by the Bureau of Reclamation and U. S. Fish and Wildlife Service. Federal funding has been provided using the authority under Section 3406 b(21) of the Central Valley Project Improvement Act (CVPIA) to contribute up to 50 percent of the cost of efforts to avoid losses of juvenile anadromous fish resulting from unscreened diversions on the Sacramento and San Joaquin Rivers.

STUDY AND PROJECT OBJECTIVES

The primary objective of this feasibility study is to evaluate the engineering feasibility, environmental constraints, project costs and potential benefits to screen the District's diversion and to recommend a preferred alternative. Review and evaluation of an alternate location for an intake is based on criteria including geology, hydrology, water quality, geomorphology, topography/bathymetry, environmental issues and operations and construction costs. The feasibility study includes surveying, geotechnical investigations, environmental documentation and alternative analysis of suitable locations for the fish screens and types of fish screens to be used.

The project objectives are to improve passage conditions for anadromous fish species in the lower San Joaquin River, maintain the District's existing water supply, and improve aquatic and wildlife conditions in the project area. The existing District pumps diverting San Joaquin River water are unscreened and therefore fish entrainment at the site represents a source of mortality for anadromous fish inhabiting the San Joaquin River. Anadromous fish species such as fall-run Chinook salmon, steelhead, shad, and striped bass use the area as a seasonal migration corridor, spawning habitat, and for juvenile rearing. Because of the size and location of this diversion along an important migration route for juvenile anadromous salmonids, the Anadromous Fish Screen Technical Team has identified the District's diversion as a candidate for screening. This project also provides opportunities for enhancing existing wildlife values on the SJRNWR, which is currently bifurcated by the District's Main Canal leading to their pumping plant. The USFWS would like to see some of the lands in the vicinity of the Main Canal be reconnected in

order to provide wildlife migration routes, and to improve fish and wildlife habitat by allowing water during high river flows to flood the refuge lands.

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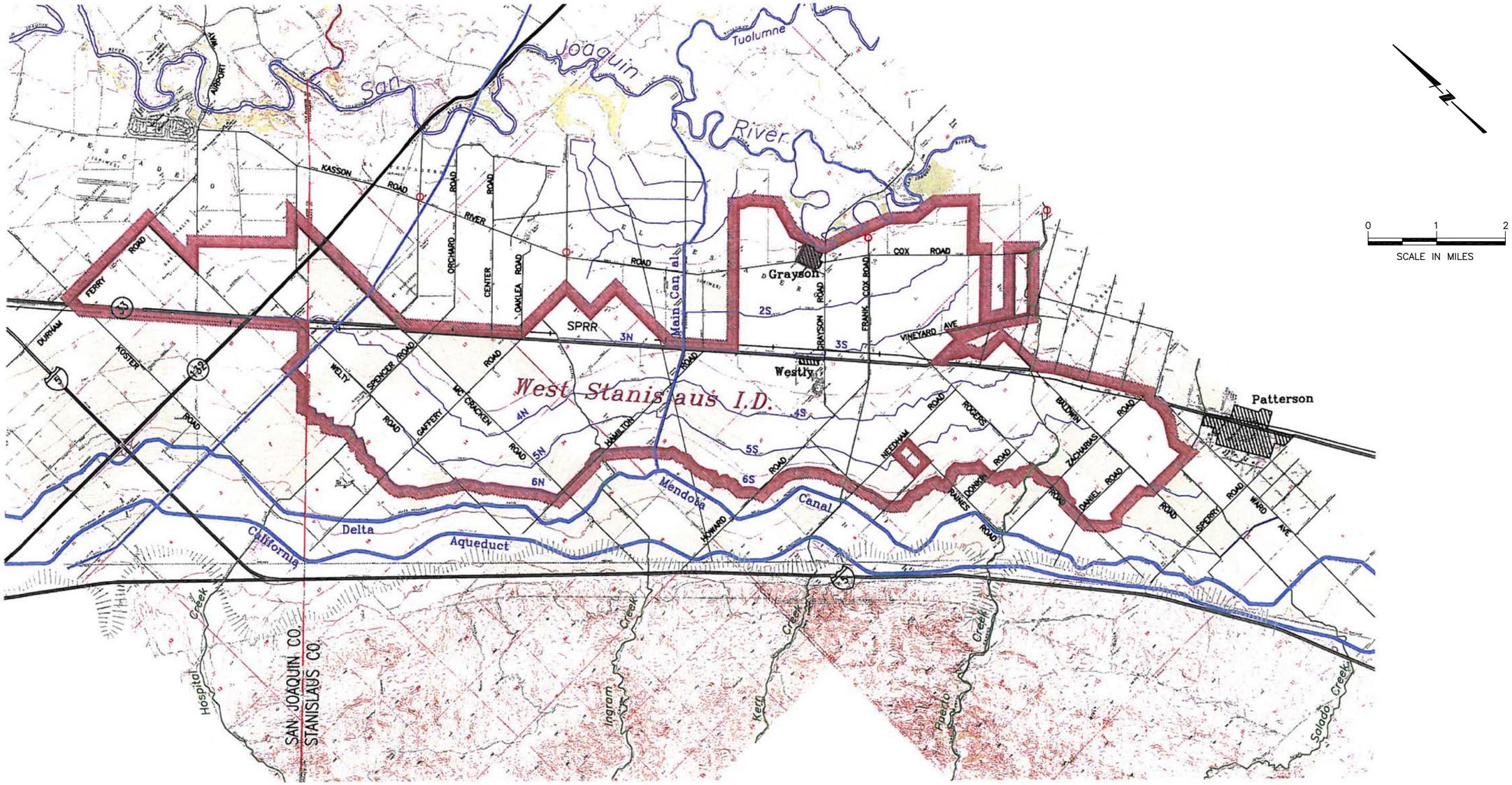

ORIGINAL MAP PROVIDED BY:
WEST STANISLAUS IRRIGATION DISTRICT

SCALE:	WARNING			
AS SHOWN	0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.	MWH	WEST STANISLAUS IRRIGATION DISTRICT	SAN JOAQUIN RIVER DIVERSION DISTRICT BOUNDARY MAP

FIGURE
1–1

SECTION 2 – EXISTING CONDITIONS

EXISTING SURFACE WATER PUMPING FACILITIES

The District and USFWS share a diversion channel which extends from the San Joaquin River to the District's Lift Station No. 1, refer to **Figure 2-1**.

The Ownership Easement was granted to District by the Burkhard Investment Company on September 1, 1942 and recorded on October 29, 1942. The legal easement description consists of "....a right of way extending from the west boundary of the Burkhard properties to the San Joaquin River."

"The center of said right of way, which is identical with the centerline of the proposed Main Canal, coincides with the Burkhard Main Canal from the S. P. Railroad to the River Road, thence paralleling the Burkhard Canal to the Russian Slough, thence paralleling the power line to the river."

Additionally, the Ownership Easement states, "The right of way to be sufficient in width for the canal, road and power line of the West Stanislaus Irrigation District together with the right of ingress and egress for the use, maintenance, repair, improvement, and enlargement thereof."

All irrigation water from the San Joaquin River is conveyed to the District's water users through the District's Lift Station No. 1 to the District's Main Canal. Six separate pump lifts are used to pump irrigation water to the highest elevation lands within the District's service area. Lift Station No. 1 from the river into the Main Canal is approximately 41 ft. Each of the additional lifts is about 11 to 14 feet.

For a summary of the District's Lift Stations and flow conditions, refer to **Table 2-1**.

Table 2-1
Existing Lift Station Design Capacity

Lift Station No.	Number of Pumps	Number of VFDs	Total Flow (cfs)	TDH (ft.)
1	5	1	310	42.5
2	6	1	256	28.6
3	7	1	262	28.6
4	6	1	256	28.5
5	2	0	81	29.3
6	1	0	47	29.2

The District is part of a utility called Power & Water Resource Pooling Authority (PWRPA). This was organized by several water districts to pool their Western Area Power Administration

(WAPA) contracts and buy supplemental power on the market in order to get competitive power rates.

Daily operations for the District consist of changes in delivery at both 6:00 AM or 5:00 PM where gains or reductions in diversions in each lift pool are made by operating a radial gate structure at the head works of each lateral. There are two laterals per pool, one lateral serves the areas north of the Main Canal and the other serves the areas to the south.

EXISTING IRRIGATION WATER DISTRIBUTION FACILITIES

The District's facilities include the following for distribution of irrigation water to their customer base:

- 3 miles of concrete lined main lift canal.
- 45 miles of concrete lined laterals.
- 14 miles of unlined laterals.
- 22 miles of concrete pipe sub laterals.
- Approximately 4,000 feet of concrete pipe to connect to the DMC turnout.

EXISTING USFWS FACILITIES

The SJRNWR is comprised of over 6,500 acres of riparian woodlands, wetlands, agricultural lands and grasslands that are managed to provide habitat for a diversity of wildlife native to California's Central Valley. The SJRNWR was established in 1987 under the authorities of the Endangered Species Act and Migratory Bird Conservation Act. It has played a major role in the recovery of Aleutian cackling geese, and is currently a focus area in the riparian brush rabbit recovery program. The Refuge is one of California's largest riparian forest restoration projects: 400,000 native trees have been planted across 1,700 acres of river floodplain. This major task is being done by contract through River Partners, a non-profit organization committed to restoring riparian habitat for wildlife; and with the funding and implementation assistance of numerous partners. Completion and success of the SJRNWR also required significant coordination and assistance from USFWS.

The following is a summary of the major refuge facilities which could potentially be affected by this project (refer to **Figure 2-2**).

- Three main irrigation pipelines exist south of the shared District and USFWS channel. Those pipelines are all concrete pipe. The larger is 24 inch and there are two 18 inch pipes. The pipes connect the two respective lift pumps located on the south bank of the shared channel.
- One Agricultural well.
- One Domestic well.
- One two inch PVC pipeline (thin blue line) extends from the domestic well and feeds drip line plantings on the east side of the main levee near the river.
- Refuge roads generally follow the perimeter of each existing fields which can be seen on the map. All are dirt roads, with the exception of the levee top road which has an all-weather gravel surface.

Site 1
Existing WSID Point of Diversion on San Joaquin River
WSID Water Right App#: 1987, Permit 2758, License
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Tuolumne River
San Joaquin River
West Stanislaus Main Canal
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Site 2
Pumped Diversion (USFWS)
Pond
Site 3
Site 4
Well
West Stanislaus Irrigation District Pumping Plant No. 1
Pumped Diversion (USFWS)
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
04N 07E 09
04N 07E 10
04N 07E 11
04N 07E 02
04N 07E 01
04N 07E 16
04N 07E 15
04N 07E 14
04N 07E 13
04N 07E 21
04N 07E 22
04N 07E 23
S.JRNWR
North twenty-nine degrees fifty minutes east (N29d50'E), nineteen thousand two hundred ninety (19,290) feet from W1/2 corner of Section 28, T.4 S, R.7 E, MDB&M, being within the SE1/4 of NE1/4 of Section 10, T.4 S, R.7 E, MDB&M.
Stockton
Manteca
Stanislaus River
Modesto
Tuolumne River
Turlock
Merced River
Merced
WSID Intake
San Joaquin River

Figure 2-1
West Stanislaus Irrigation District San Joaquin River Diversion Alternative Site Locations

Feature of Interest
Flood Control Levee
General Area of Potential Intake

San Joaquin River NWR Landuse
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Refuge Boundary

0 600 1,200 2,400 3,600 Feet

N

Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 17, 2010

MWH

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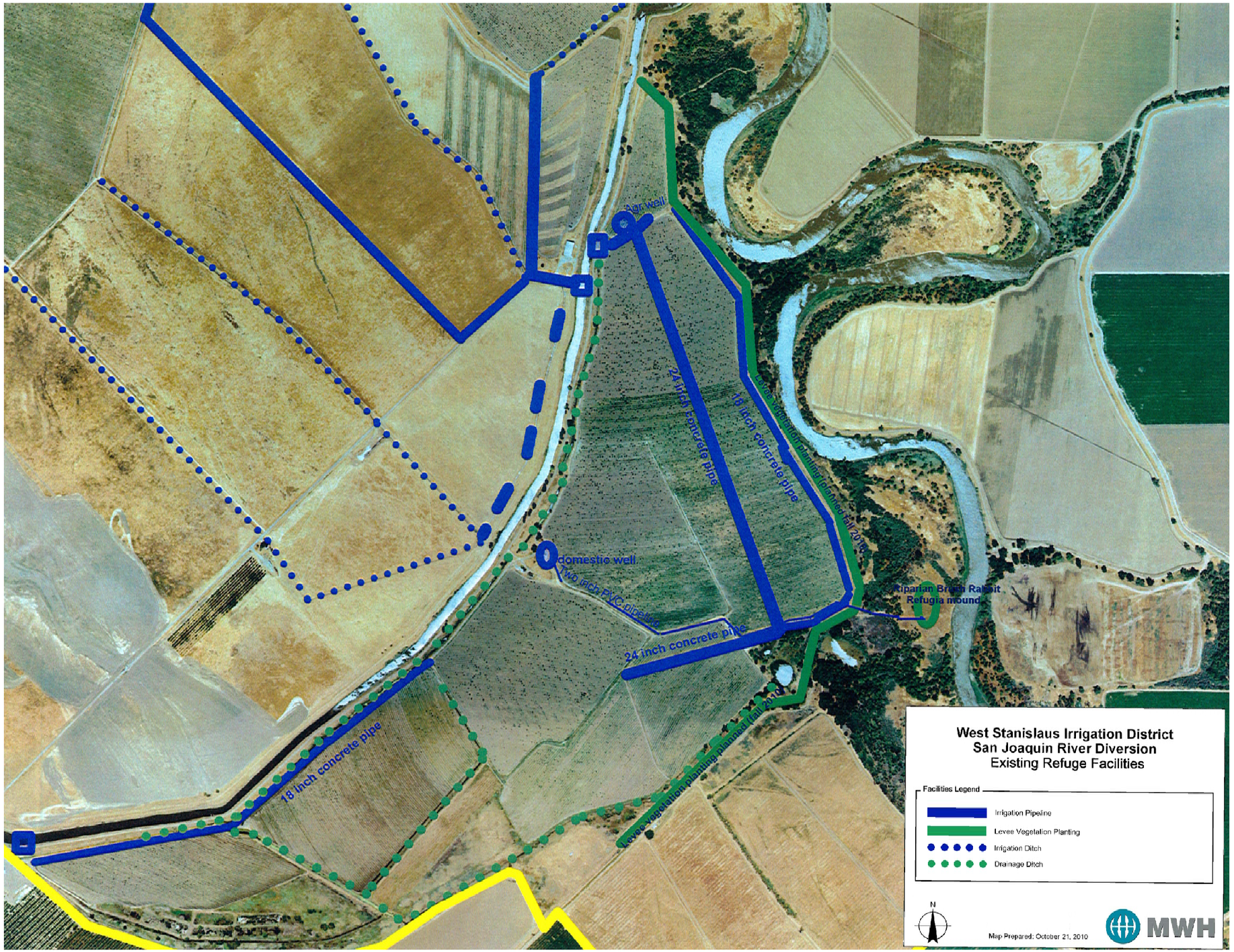

ORIGINAL FIGURE PROVIDED BY:
U.S. FISH & WILDLIFE SERVICE – SAN LUIS NATIONAL WILDLIFE REFUGE COMPLEX

SCALE:	WARNING			FIGURE
1"=300'	0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.	MWH	WEST STANISLAUS IRRIGATION DISTRICT	SAN JOAQUIN RIVER DIVERSION USFWS SAN JOAQUIN RIVER NATIONAL WILDLIFE REFUGE INFRASTRUCTURE	2–2

- Drainage ditches (indicated with dotted lines)
- An elevated earthen mound is constructed as "flood refugia" for riparian brush rabbits and other small mammals.
- North of the shared channel, a concrete-lined water delivery canal (indicated with dashed line), and earthen water delivery ditches (dotted lines) are indicated on the map.

ENVIRONMENT

Aquatic Habitat

The San Joaquin River basin has a dry summer Mediterranean climate with approximately 90% of the annual precipitation occurring between November and April (Schneider et al. 2003). The proposed intake and screened diversion would be located in the area immediately upstream of where the San Joaquin and Tuolumne Rivers join and will be situated within the boundaries of the San Joaquin Natural Wildlife Refuge (SJNWR).

The primarily aquatic habitat within the San Joaquin River is relatively shallow (typically less than 20 feet deep) with a relatively uniform bottom comprised to silt, sand, peat, and other organic matter with little submerged aquatic or emergent vegetation. Aquatic habitat conditions in the area are impacted by a variety of factors that include water storage and releases from upstream impoundments, mining within the upstream watersheds, levee construction and land reclamation, water diversions from the river, and upstream watershed agricultural and urban development. Rip rapped levees have reduced seasonally inundated floodplain habitat and high flow velocities have reduced instream emergent and submerged aquatic vegetation. A variety of physical structures provide cover for non-native predatory fish such as striped bass, largemouth and smallmouth bass. Because of the limited emergent and submerged vegetation within the river channel there is little cover and foraging habitat in the proposed project reach. The mainstem channel in the proposed project reach is characterized by reduced habitat diversity and hydrologic variability. Although the river supports a variety of resident fish, the mainstem river channel in the proposed project area serves as a migration corridor for upstream passage of adult fall-run Chinook salmon and Central Valley steelhead and downstream passage of juvenile salmonids. The San Joaquin River serves as Essential Fish Habitat (EFH) for Pacific salmon and has been designated as critical habitat for Central Valley steelhead.

The primary habitat value currently provided to anadromous fish species of concern by the overall project area is limited to migration pathways associated with the San Joaquin River main channel and side channels. However, ongoing floodplain restoration actions by the USFWS and approved management plans will incorporate using surrounding Refuge lands as anadromous fish rearing habitat during flood and high water events.

Species of Concern

The most abundant fish inhabiting the lower reaches of the San Joaquin River in the vicinity of the proposed project sites include striped bass, threadfin shad, white catfish, fall-run Chinook salmon, and largemouth bass. Anadromous fish species such as fall-run Chinook salmon, steelhead, shad, and striped bass, use the area as a seasonal migration corridor, spawning habitat, and for juvenile rearing.

Existing conditions, combined with the presence of a suite of non-native predatory fish (smallmouth bass, largemouth bass, striped bass, and others) represent a high level of disturbance and alteration to the native habitat and fish assemblages. Among the fish species inhabiting the area that have been listed for protection under the CESA and/or Federal Endangered Species Act (FESA), longfin and delta smelt inhabit areas of the Delta downstream of the proposed project locations. Winter-run and spring-run Chinook salmon are produced in the Sacramento River system and do not occur in the San Joaquin River in the vicinity of the proposed project site. Central Valley steelhead are predominantly produced on the Sacramento River system, however, steelhead are also produced within the San Joaquin River system and would occur seasonally in the vicinity of the proposed project site. Steelhead spawning and juvenile rearing occur in upstream reaches of major tributaries and hence no steelhead spawning or oversummer rearing by juvenile steelhead would be expected in the project area. Adult and juvenile steelhead use the area of the San Joaquin River in the vicinity of the proposed project sites as a seasonal migratory corridor. Although not listed under the ESA the San Joaquin River basin tributaries produce fall-run Chinook salmon that are an important native fish species that supports commercial and recreational harvest.

WILDLIFE HABITAT AND SPECIES OF CONCERN

Wildlife Habitat

Special-status wildlife species that are associated with cropland, valley foothill riparian, irrigated managed wetland, freshwater emergent wetland, lacustrine, riverine, wetland (riparian and seasonal) and annual grassland habitats may be present due to the presence of these habitats within the study area. The refuge is managed for a wide suite of threatened and endangered species, migratory birds, and wildlife/plant communities that occur naturally in the area.

As a part of the wildlife habitat evaluation, wildlife are categorized by their related movement into and out of certain areas and types of habitat. Movements of wildlife generally fall into three basic categories: a) movements along corridors or habitat linkages associated with home range activities such as foraging, territory defense, and breeding; b) dispersal movements—typically one-way movements (e.g., juvenile animals leaving their natal areas or individuals colonizing new areas), and; c) temporal migration movements—these movements are essentially dispersal actions which involve a return to the place of origin (e.g., deer moving from winter grounds to summer ranges and fawning areas).

The study area is utilized by dispersing, migrating, or foraging wildlife with the San Joaquin River main and side channels providing a corridor of aquatic and riparian habitat. This corridor is used primarily by fish as a migration corridor but is also used by terrestrial wildlife species as a movement corridor or linkage between habitats. The river and study area is bounded by lands which are subject to high intensity agricultural which is similar in nature to land uses within the greater study area vicinity. Land uses located beyond the immediate study area boundaries are composed of both open space and agricultural lands. Although terrestrial wildlife are not restricted to this corridor an abundance of similar land uses is located in the vicinity of the study area, movement pattern may be influenced by the existing canal which bifurcates the refuge.

Although wildlife movement patterns have not been studied, it is likely that the existing canal alters wildlife movement patterns. The natural flood regime of the river is altered by the canal as it prevents natural flood waters from flowing into the northwest area of the refuge. The absence of these flows determines the type and extent of habitat existing in that area which in turn determines which wildlife species will occupy the area.

Those portions of the study area that are located within the SJRNWR are managed according to a comprehensive conservation and refuge management plan that is being undertaken in large part by the USFWS. Goals of the plan include implementing passive restoration by allowing periodic flood events to inundate and maintain natural river functions and contributing to the recovery of threatened, endangered and special status wildlife and their habitat. Achieving these goals will involve the preservation and restoration of wetlands and riparian floodplain habitat.

It is presumed that the existing canal inhibits wildlife movement and flood water flows which would support those habitats used by special status wildlife. Thus, alternatives which propose to remove all or a portion of the existing canal would have a beneficial effect to wildlife as it would improve upon the ability of wildlife to move throughout the study area and utilize wetland and riparian habitat that would otherwise be unsustainable. Conversely, those project alternatives that do not bury the existing canal would not further constrain wildlife movement patterns as they would simply maintain existing conditions.

Species of Concern

The surrounding areas in the general vicinity of the San Joaquin River at the confluence of the Tuolumne River has the following special-status species:

- burrowing owl (Athene cunicularia),
- California red-legged frog (Rana aurora draytonii),
- Delta button-celery (Eryngium racemosum)
- giant garter snake (Thamnophis. Gigas),
- Least Bell's vireo (Vireo bellii pusillus),
- Loggerhead shrike (Lanius ludovicianus),
- riparian brush rabbit (Sylvilagus bachmani riparius),
- San Joaquin Valley woodrat (neotoma fuscipes riparia),
- Swainson's hawk (buteo swainsonii),
- San Joaquin kit fox (Vulpes macrotis mutica),
- tricolored blackbird (Agelaius tricolor),
- valley elderberry longhorn beetle (Desmocerus californicus dimorphus),
- greater sandhill crane (Grus canadensis tabida),
- Aluetian Canada geese (Branta Canadensis leucopareia), and
- western pond turtle (Actinemys marmorata).

The San Joaquin River National Wildlife Refuge (SJRNWR) Comprehensive Conservation Plan and the San Joaquin River Management Plan describe the primary function of the refuge as that which protects and manages Aluetian Canada geese. This plan was expanded to include protection of wildlife that are dependent on wetlands and riparian floodplain habitat and

restoration of this habitat and its ecological processes. The goal is to restore riparian habitat and hydrologic function and provide alterative methods of flood control.

The plan also includes a goal to contribute to the recovery of threatened, endangered and special status wildlife and their habitats. Ongoing restoration efforts to reestablish the riparian brush rabbit population began in the early 2000's and include a captive breeding program and protection and planned restoration of the existing riparian habitat. Protection and restoration of riparian habitat was made a management priority when the San Joaquin Valley woodrat was observed on the refuge as they also occupy riparian habitat.

Bifurcation of the refuge by the existing canal has eliminated natural flood patterns that would sustain wetlands and riparian habitat in areas located northwest of the canal. Alternatives which propose to bury all or a portion of the existing canal would improve the ability to restore and maintain riparian habitat in these areas thereby improving rabbit and woodrat habitat and the potential for reestablishment of their populations. These alternatives would aid in the USFWS's goal to contribute to the rabbit and woodrat recovery. Conversely, alternatives that propose to keep the canal in place would not change the current land management and associated challenges.

CULTURAL RESOURCES

A records search was conducted at the Central California Information Center (CCIC) of the California Historical Resources Information System at California State University, Stanislaus on August 11, 2009 (CCIC File # 7464N). Seven cultural resources investigations have been conducted within a 1/2-mile radius of the project area, including one within the project area. Two prehistoric archaeological sites have been recorded within a 1/2-mile radius of the project area. No other cultural resources, including historical archaeological sites or historic architectural resources (buildings, structures, or objects) have been previously recorded within a 1/2-mile radius of the project area. No cultural resources have been previously recorded within the project area itself. The location of an ethnographic village site, Mayemes, was noted as being within 1/2-mile of the project area, though no source citation was available.

The Native American Heritage Commission (NAHC) was contacted on August 10, 2009 to request that a Sacred Lands File (SLF) records search be conducted for the project and that contact information be provided for Native American groups or individuals that may have concerns about the project. The SLF search did not indicate the presence of Native American cultural resources in the project area. The NAHC provided a list of Native American contacts that might have further knowledge of the project area with respect to cultural resources. Each person or organization identified by the NAHC was contacted by letter on March 19, 2010. Follow-up letters were sent on April 28, 2010 after the project alternatives had been narrowed to their present forms. To date, no responses have been received.

Cultural resources surveys of the proposed project areas were conducted on September 10, 2009 by architectural historian Kathy Anderson, M.A., and on May 3, 2010 by archaeologist Candace Ehringer, M.A., RPA. Three cultural resources, consisting of two historic architectural resources (West Stanislaus Main Canal and DISTRICT Pump House) and one historic-era archaeological

resource (concrete pad), were identified during the course of the surveys, (refer to Appendix B for the Cultural Constraints Report).

HYDRAULIC CONDITIONS

Water Usage

The District was organized in 1920 and has a year-round water right on the San Joaquin River for 262 cfs to irrigate up to 20,166 acres surrounding the city of Westley, California. The crops grown are primarily row crops including alfalfa and some permanent tree crops. The average farm in the District service area is about 160 acres. The District also receives Central Valley Project (CVP) water from the Delta-Mendota Canal. The contract provides for annual delivery of 50,000 AF of project water. A combination of these water supplies is used to meet crop delivery requirements.

WHITE LAKE MUTUAL WATER COMPANY WATER RIGHTS

In 1928 the District entered into an agreement with Burkhard Investment Company as amended June 7, 1939, wherein the parties acknowledged that the Burkhard lands had installed diversion and irrigation works to divert 45 cfs of riparian water for irrigation of riparian land. In that agreement, the District agreed to "pump the said water to which the [Burkhard land] is entitled. . ." for irrigation. That agreement is still binding between the parties, and imposes upon the District continuing obligation to dedicate 45 cfs of pumping capacity to the Burkhard riparian lands. This was confirmed by a State Water Resources Control Board September 11, 1941 Memorandum of Field Visit stating: ". . .the district is obligated to supply up to 45 cfs to the Burkhard property by an agreement since 1928 and merely acts as a transporting agent for this water which is under riparian and an old appropriative right."

Table 2-2 lists historical monthly diversion information from the San Joaquin River for District usage. The information is based on the Water Account Record data as recorded by the USBR for 1998 through 2009. These diversions have been contingent on river levels, availability of DMC water, cropping patterns and diversion channel hydraulic constraint.

Table 2-2
District Historical Monthly Diversions
(Acre-Feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1998	0	0	274	2035	3483.8	4572	8482	8584	6228	2359	275	68	36,361
1999	400	89	2819	4863	9732	9584	11013	8638	3789	925	1188	1984	55,024
2000	1501	0	587	7040	8098	8655	9686	6421	3339	903	539	627	47,396
2001	481	376	787	5320	9456	8116	9203	7561	3268	653	374	125	45,720
2002	54	308	861	7117	10418	6410	7016	8126	3778	1090	154	0	45,332
2003	0	0	185	3769	9356	7222	9141	5664	1960	539	483	111	38,430
2004	91	2	1094	7793	8130	7583	8647	6997	4592	1796	215	142	47,082
2005	0	0	0	2944	9424	8595	10955	5351	1691	350	175	0	39,485
2006	0	444	140	285	6144	7061	8732	7442	3670	984	496	199	35,597
2007	989	375	2537	8504	8545	3075	6086	5241	4022	2220	1622	478	43,694
2008	0	0	2749	8073	9388	6671	6370	7184	4599	3284	1342	1223	50,883
2009	609	325	3669	8931	9635	9535	8172	8998	5423	1321	1379	361	58,358

Supplemental supplies from the Delta Mendota Canal are used to blend with river water to improve water quality during early crop stages.

San Joaquin River Hydrology

Flow Duration Hydrology

Evaluation of the San Joaquin River hydrology was completed to estimate the water surface elevations at each of the sites for various river flow conditions. Those conditions included high flows and very low flows for comparison between the sites under evaluation.

Daily flow data for the USGS San Joaquin River near Newman, CA gage (11274000) were used to determine design flows for the sites under consideration. The period of record for the gage begins in 1912 and goes to the present date. Only flows starting in 1966 were used in the analysis because flows prior to that date do not include the effects of regulation at New Exchequer on the Merced River on flows in the San Joaquin River near Newman.

Figure 2-3 is the flow exceedence for the period of record used. Flow exceedence is defined as the flow level that is equaled or exceeded for a given percentage of the period. As shown in **Figure 2-4**, for yearly data the 10- and 90-percent exceedence values are 5,000 cfs and 280 cfs respectively.

Additional statistical analyses were done on the flow data (1966-2002) from the gage near Newman to determine the 10- and 90-percent exceedence levels for each month as shown in **Table 2-3**. As shown in the table, the maximum monthly 10-percent exceedence value is in the month of February with 15,300 cfs, and the minimum monthly 90-percent exceedence value is in the month of October with 160 cfs. These two values are more conservative than the annual 10- and 90-percent exceedence numbers referred to previously.

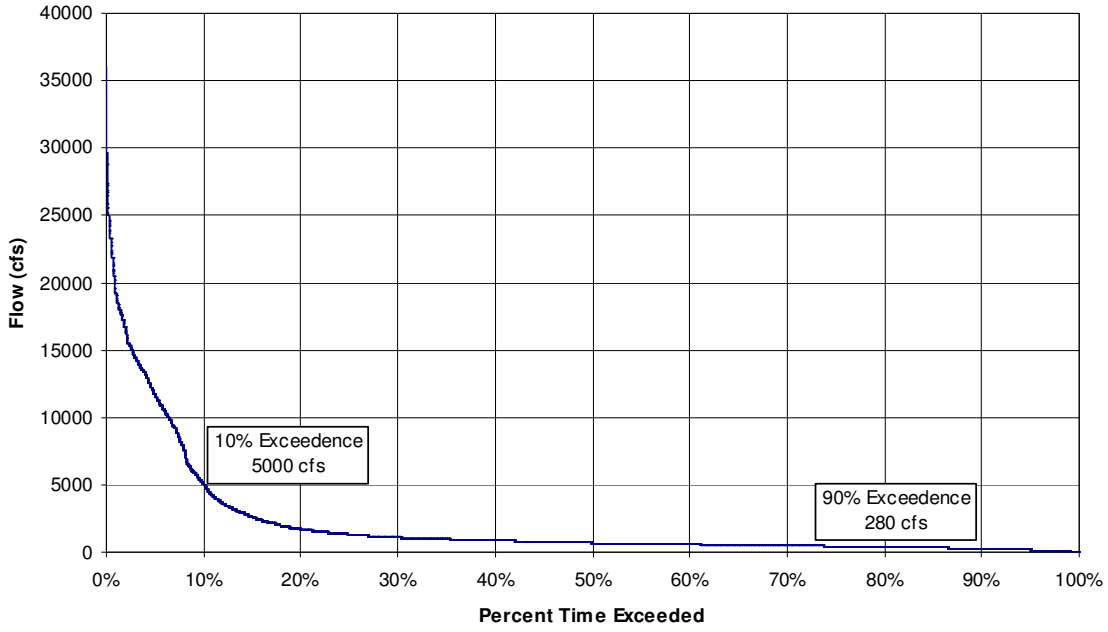

Figure 2-3
Annual Flow Exceedence – San Joaquin River Near Newman, CA
Data from 1966 to 2002

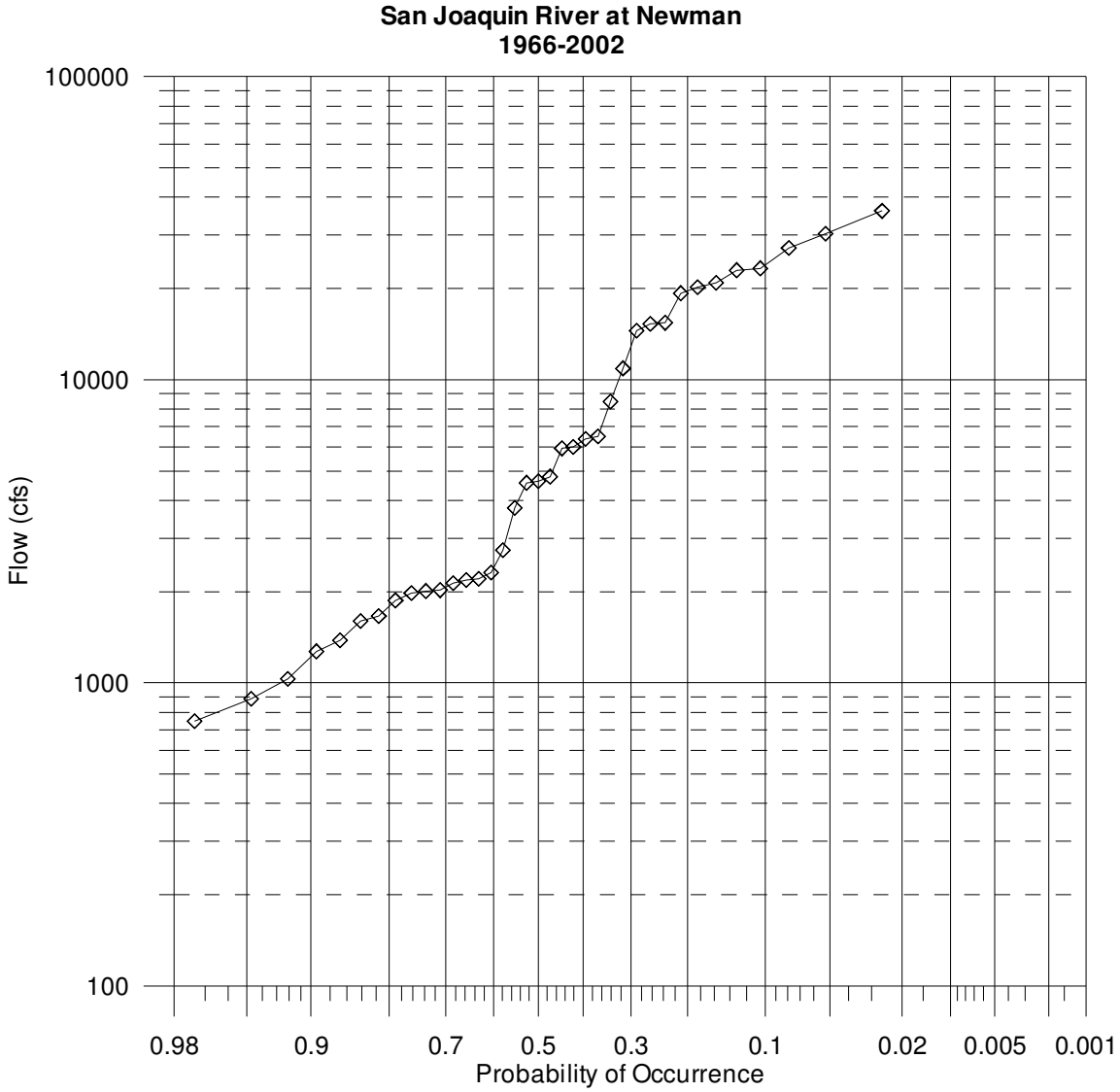

Figure 2-4
Flow Frequency Curve at Newman Gage

Table 2-3
Flow and Water Surface Elevations at
Four Potential Diversions Sites

Month	10% Exceedence					90% Exceedence				
	Flow (cfs)	WS Elev Site 1 (ft msl)	WS Elev Site 2 (ft msl)	WS Elev Site 3 (ft msl)	WS Elev Site 4 (ft msl)	Flow (cfs)	WS Elev Site 1 (ft msl)	WS Elev Site 2 (ft msl)	WS Elev Site 3 (ft msl)	WS Elev Site 4 (ft msl)
Oct	2,100	24.23	25.02	26.29	26.36	**160**	**18.44**	**21.71**	**22.07**	**22.94**
Nov	1,700	23.32	24.22	25.52	25.75	310	19.30	22.04	22.56	23.40
Dec	2,550	25.23	26.04	27.19	27.29	330	19.40	22.08	22.62	23.45
Jan	7,400	32.24	33.34	34.03	34.39	480	20.00	22.31	23.01	23.79
Feb	**15,300**	**35.46**	**36.83**	**37.62**	**38.17**	560	20.27	22.39	23.19	23.95
Mar	14,100	35.12	36.48	37.28	37.82	470	19.97	22.29	22.99	23.77
Apr	13,650	35.00	36.35	37.16	37.68	390	19.69	22.20	22.80	23.60
May	12,050	34.55	35.89	36.71	37.21	280	19.16	21.98	22.47	23.32
Jun	9,150	33.41	34.66	35.44	35.88	210	18.82	21.84	22.26	23.14
Jul	4,600	29.76	30.64	31.29	31.52	190	18.69	21.79	22.19	23.07
Aug	1,150	22.06	23.15	24.47	25.02	180	18.61	21.77	22.15	23.02
Sep	1,550	22.98	23.93	25.23	25.55	170	18.52	21.74	22.11	22.98
Annual	**5,000**	**30.64**	**31.54**	**32.09**	**32.35**	**280**	**19.16**	**21.98**	**22.47**	**23.32**
100-Year	**45,000**	**38.95**	**40.26**	**41.55**	**42.53**					

Notes:
(1) **Bold numbers indicate Maximum and minimum**
(2) Data are from years 1966 – 2002
(3) Elevation data are feet NAVD 88

Flood Hydrology

The daily data from 1966 to 2002 at the USGS San Joaquin River near Newman, CA gage were used to develop the flood hydrology. The period 1966 to 2002 is a subset of the entire period of record at the Newman gage, which starts in 1912. It was used because the New Exchequer Dam on the Merced River began operation in 1966 and changed the flow frequency statistics for the Merced River which enters the San Joaquin River just upstream of the Newman gage. The flood hydrology was developed using the methodology from USGS Bulletin 17B, "Guidelines for Determining Flood Flow Frequency." The analysis required for this method is performed by the HEC Flood Frequency Analysis (HEC-FFA) computer program. The peak flow for each year of record is extracted from the daily flow records and is used as input to the model. The model uses a Log Pearson Type III analysis to determine the flood percent probability of occurrence. The plot of flow versus probability of occurrence is given in **Figure 2-4**. For the San Joaquin River near Newman, the 1 % flood flow was developed by plotting a best-fit line through the data points for all flows that exceeded a 3-year flow. The flood that has a 1 % chance of occurring in any given year is commonly called the 100-year flood because over a long period of time, it will occur on average every 100 years. The 1 % flood at the Newman gage, as determined using the methodology described above, is 45,000 cfs.

RIVER HYDRAULIC ANALYSIS

An HEC-RAS computer backwater model was also developed to help determine the water surface elevation at the proposed diversion sites. Cross section data for the reach of the San Joaquin River from the Newman gage to the confluence with the Tuolumne River (RM 115.88 to RM 81.49), from the U.S. Army Corps of Engineers Sacramento and San Joaquin River Basins Comprehensive Study, were used as the basis for the model geometry.

It is very important to note that the datum used for the Comprehensive Study cross section data is NGVD 29, whereas the datum used for the future topographic mapping for design of a new diversion structure will likely be NAVD 88. The difference between the two in this area is around 2.4 feet, meaning that for a given point, the elevation from the Comprehensive Study will be 2.4 feet lower than the elevation from the design topography. All table and figure data in this TM have been adjusted to the NAVD 88 datum.

The Manning's n values in the model were calibrated to match the river stages at the Newman gage for a given flow in the river. This required the use of n values that vary with stage in the river. Typically, the n values increase with stage as flows begin to interact with revetment and vegetation along the rivers edge.

Rating Curve Development

The HEC-RAS model described above was used to develop rating curves at each of the four potential diversion sites. The rating curves include flows that cover the range of lowest probable flow to higher than 100-year flow. The rating curves for each of the sites are given in tabular form in **Table 2-4**.

Table 2-4
Rating Curves at Potential Diversion Sites
(NAVD88)

Flow (cfs)	Site 1 (RM 81.6) Water Surface Elevation (ft)	Site 2 (RM 83.6) Water Surface Elevation (ft)	Site 3 (RM 84.3) Water Surface Elevation (ft)	Site 4 (RM 84.9) Water Surface Elevation (ft)
100	17.95	21.55	21.82	22.68
200	18.77	21.82	22.23	23.11
400	19.74	22.22	22.83	23.63
1000	21.72	22.86	24.18	24.82
2000	24.01	24.8	26.09	26.15
5000	30.64	31.54	32.09	32.35
10000	33.98	35.3	36.13	36.6
20000	36.77	38.18	38.94	39.57
35000	37.73	39.07	40.34	41.32
50000	39.56	40.86	42.15	43.13

Water Quality

Water quality in the San Joaquin River at the pumping plant site is generally good during the winter high-flow periods. However, during times of low flow or extended droughts, several chemical constituents affect the water quality (State Water Resources Control Board 1995). During low-flow periods, the turbidity of the San Joaquin River is high due to the presence of suspended clays, silts, and organic matter. The presence of high concentrations of various minerals, trace elements, and Total Dissolved Solids is mainly due to the large amounts of agricultural return flows from surface runoff and subsurface drainage (U.S Bureau of Reclamation 2000).

Based upon monitoring data obtained by the U.S. Geological Survey on the San Joaquin River at the Patterson Bridge near Patterson, California (1985-1994 records), pH ranges from about 7.3 to 8.2. The average concentration of suspended sediment is 100 mg/L.

The Regional Water Quality Control Board has established water quality objectives to protect existing beneficial uses in the Central Valley Region. These objectives state that the suspended sediment load, suspended sediment discharge rate of surface waters, and the turbidity shall not be altered in such a way to cause a nuisance or adversely affect beneficial uses. The RWQCB states that where natural turbidity is between 1 and 5 nephelometric turbidity units (NTU), increases shall not exceed 1 NTU (Regional Water Quality Control Board 1998).

River Sand, Silt and Debris

The existing location of the beginning point of the shared conveyance channel is on the inside of a bend in the San Joaquin River. The opposite side of the river experiences higher velocities and the side of the river that flows into the shared channel has lower velocities. In addition, the confluence of the Toulumne River is just downstream which can create a backwater condition in the San Joaquin River dependent on river flows. This configuration is conducive to sands and silts settling out in front of the channel and reducing the hydraulic capabilities on the side of the river that flows into the channel that delivers flow to the District's Lift Station No. 1.

GEOTECHNICAL CONDITIONS

A draft preliminary geotechnical study was performed by AGS Engineering in April of 2010. The report presents the results of the subsurface investigation and subsequent analyses of the soil conditions at the project site. A copy of this report is provided in Appendix C. The following sections summarize the results of this report.

Geology

As described in Mussetter (2000), the San Joaquin River occupies the southern portion of the Great Central Valley, which is a synclinal trough whose axis is offset to the west side of the basin. The San Joaquin River lies between the crests of the Sierra Nevada and the Coast Range and the basin lies within parts of the Sierra Nevada, California Coast Range and the Great Central Valley geomorphic provinces. The Sierra Nevada is composed primarily of crystalline igneous rocks (granite, quartz monzonite, quartz diorite) with some metamorphic, volcanic and metavolcanic rocks. The Coast Range is composed of folded and faulted sedimentary rocks. The

valley floor is underlain by relatively unconsolidated sediments. Based on a map compiled by Wagner et al. (1991), the main geologic formations traversed by the proposed project alignment are Dos Palos alluvium (Qdp) and alluvial Fan Deposits (Qf). The Dos Palos Alluvium formation consists of Holocene age fine grained floodbasin deposits. Alluvial fan Deposits are Holocene deposits generally consisting of gravel, sand, silt and clay.

The San Joaquin River is a highly sinuous meandering river system throughout its course. The morphology of the river between the foothills and the delta are controlled by the tectonic uplift of the Sierra Nevada range, subsidence of the San Joaquin Valley, and surface erosion of the watershed. Tectonically-driven subsidence rates are approximately 0.25 mm/yr, and this subsidence is partially counterbalanced by sediment deposition of alluvial fans from the San Joaquin River and tributaries draining from the Sierra Nevada and Coast Range (Janda 1965). Stream gradient is very low in all reaches, with steeper reaches in the foothills less than 0.1 percent, and remaining reaches less than 0.05 percent. Below the Friant Dam, the channel bed material consists of sand.

The United States Department of Agriculture (USDA) Soils Conservation Service has produced a number of maps of West Stanislaus County, including the project area. These maps have attempted to differentiate soils mainly based on parent materials, exposure, and development of soils profiles. The West Stanislaus Soils Survey (USDA 2002) shows the project area is underlain by soils of several different series, particularly fine sandy loam, Merritt silty clay loam, Dos Palos and Bolfar complex soils, Veritas sandy loam and Clear Lake clay. Based on the Unified Soils Classification System (USCS) corresponding soils would be well-graded or poorly graded sand with silt or clay, and either silty or clayey sand.

Faults and Seismicity

The nearest historically active fault is the Great Valley (Segment 7) Fault, located approximately 7 miles southwest of the project location. The largest earthquake, based on deterministic seismic hazard analysis could occur is a 6.7 moment magnitude at the Great Valley Fault.

The project location is within an area of low historical seismic activity. Since the 1930s, no major earthquake (magnitude greater than 6.0 on Richter Scale) has occurred within 19 miles of the location.

Groundwater

Site specific groundwater level information was not available for the project. In general, groundwater levels are expected to rise and fall with respect to water levels in the river and the depth to groundwater is anticipated to increase with increased distance and elevation respective to the main river channel.

Wells located in the vicinity of the District's Lift Station No. 1 indicate that groundwater is at approximately 20 to 22 feet below existing grade. The presence of groundwater is seasonal and dependent on the location related to the river, there are areas that could have groundwater depths as shallow as 3.5 feet below existing grade.

Existing Site Conditions

Site 1

Site 1 was directly accessed using the maintenance road along the south side of the District channel, and was also viewed from the end of the north side maintenance road, in the vicinity where the District channel meets a large backwater slough of the San Joaquin River.

Site 1 occupies the northwest facing side of a sandbar, just south of a large backwater slough. Since the site lies west of the main river channel, there seemed to be little current when compared to Sites 2, 3, and 4, which lie along the main river channel. At Site 1 the sandy soils do not form a continuous slope but have instead formed dune slopes, except for a short terrace near the edge of the water and at some of the road cuts along the south side of the maintenance road that extends northeastward beyond the end of the District channel. Slopes are locally as steep as 2H: 1V. At the time of the visit on April 23 the water level was very high, and the water level was only 2 feet below the grade of the access road. The top of the sand bar was estimated to be approximately 10 to 12 feet above water level, approximately 8 to 10 feet lower than the bank height next to the District channel. The bank slopes and river terrace were observed to be almost entirely covered by scrub brush such as mustard, fennel, and annual grasses, with no tree canopy.

Site 2

Site 2 is located on a bend of the main river channel. At the time of the site visit on April 23 there was considerable current, but because of the channel configuration the bank was not observed to be undercut by river scour. At Site 2, the bank rises approximately 20 feet over a nearly uniform slope from the river edge to the top of the levee road. The bank was not very steep and was estimated to be approximately 3H: 1V. The lower portion of the slope, near the river edge, was covered with river cobbles, apparently to stabilize the bank.

The bank was covered by a variety of vegetation, including arroyo willow, mugwort, thistle, and stinging nettle. A few small trees occur along the bank, with scattered larger oaks and other trees near the top of the levee.

Site 3

Site 3 is located toward the upstream end of a bend in the river that is centered approximately 2,400 feet southeast of Site 2. The site is also subject to the main channel river current, and apparently lies along the northern edge of the aggrading part of the bend, where a sand bar has formed. At the time of the site visit on April 23, only a short near vertical bank along the river edge, approximately 2 to 3 feet high was observed. Above the bank is a river terrace which gradually slopes upward toward the main floodplain at a shallow gradient of less than 4H: 1V. Along the river edge, just downstream of Site 3, there are approximately 8 to 10 foot high, nearly vertical banks. At Site 3, the bank and river terrace is covered by mixed riparian vegetation, including mustard, thistle, stinging nettle, various types of grasses, arroyo willow, and scattered small trees.

Site 4

Site 4 is located near the middle of the bend in the main channel of the river upstream of the confluence with the Tuolumne River, in an area of moderate river scour.

At the time of the site visit, near vertical banks rose approximately 7 feet above the river edge. West of the bank is a river terrace that sloped gradually upward toward the adjoining fields to the east at a shallow gradient of less than 4H:1V. At the site the bank and river terrace were covered by various types of riparian vegetation, including stinging nettles, thistle, and trees such as arroyo willow, and box elder. A few larger cottonwood trees occur near the top of the river terrace.

GEOMORPHOLOGY

General

Mussetter Engineering (2000) provides an extensive description of the geomorphic and sediment baseline conditions of the San Joaquin River from the Delta to the confluence with the Merced River. The San Joaquin River is a meandering river system between the foothills and the delta controlled by the tectonic uplift of the Sierra Nevada range, subsidence of the San Joaquin Valley, and surface erosion of the watershed. They characterize this reach as meandering with a relatively low gradient (0.5 to 1.2 feet/mile) and having numerous cutoff channels.

PWA (2004) reports that the geomorphology of the San Joaquin River has changed significantly over the last century due to dramatic changes in hydrologic and sedimentologic conditions. River engineering projects, including dams, bypasses, levee construction, and bank protection, have reduced the magnitude and frequency of flood peaks, increased the magnitude and frequency of the lower flows and increased the magnitude and duration of the moderate flows. Analysis of the San Joaquin River related to the movement was conducted with the following conclusions for each of the proposed intake locations (refer to Appendix D):

Site 1 – Stable

Site 2 – Most stable site

Site 3 – Actively eroding and migrating

Site 4 – Actively eroding and migrating

In terms of sediment, channelization and levee construction along with dam operations have resulted in increased stage, sediment starvation, and elimination of overbank (floodplain) sediment storage space.

The current USGS 7 1/2' topographic quadrangle map from 1994 is actually based upon 1978 aerial photography. The project maps in use for this investigation are based on 2008 aerial photography.

The Mussetter report further divided the river into 4 sub-reaches based upon hydrologic and geomorphic characteristics. The DISTRICT diversion sites falls within Sub-reach 3 {RM83.8 (Tuolumne River mouth) to RM99.5} which has an average slope of 0.00017, a sinuosity (ratio of channel length to valley length) of 1.5, and channel width to depth ratio of 19. The lower portion of the Sub-reach is more sinuous than the upper portion. Project levees extend along the left bank from RM 84.5 to RM 86.2 and on the right bank from RM 85 to RM 88.5. The reach has considerable evidence of old and recent cutoffs. The cutoffs and resulting oxbow segments are readily apparent on the USGS 7 1/2' topographic quadrangle. Their examination indicated that about 29 percent of the banks in this Sub-reach are actively eroding.

The best assessment of the present state of channel stability can be made by comparing the 1994 map (actually 1978 photography) and the latest aerial photography. Each of the potential diversion sites was assessed in this manner.

SEDIMENT

General

The U. S. Geological Survey (USGS) has collected both suspended sediment data and bed material data at several gauging stations in this reach of the San Joaquin River. The records for the station, San Joaquin River at Patterson Bridge near Patterson, contain miscellaneous suspended sediment records from 1965 through 2002. Unfortunately, there was only one bed material sample collected during that period and it has only a partial size distribution analysis. Suspended sediment and bed material samples were collected at the San Joaquin River near Vernalis station (RM 72.5) over the same period. This station is approximately 12 river miles downstream from the diversion site and both the Stanislaus and Tuolumne Rivers enter in that reach.

Mussetter Engineering (2000) collected bed material samples in the reach of the San Joaquin from RM 63.5 to RM 117.8 and from the Merced, Tuolumne, and Stanislaus Rivers. They found the tributary bed materials to be coarser than those of the San Joaquin and that the mainstem bed was coarser downstream from the tributary entries. They collected samples at RM's 73.5, 76.6, 83.6, 84.2, and 117.8. The size distributions for the reach from RM 83.6 to 117.8 were very consistent with significantly coarser material downstream.

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SECTION 3 – DESIGN CRITERIA

This section contains the design criteria that will be used for the planning, design, and operation of a gravity river diversion with positive barrier fish screens for each alternative. The criteria used for the development of the alternatives presented in this report are based on the District's operational requirements, current published criteria for fish passage facilities established by CDFG (2000) and NMFS (1997), current industry practice, and experience at similar facilities. The design criteria are identified below.

PROJECT FLOWS AND WATER ELEVATIONS

- Current District San Joaquin River diversion capacity can approach the Main Canal design capacity of approximately 307 cfs, per their water right (Permit 2758, Application 1987). This amount includes 45 cfs of riparian water for irrigation of riparian land adjacent to the district, known as the White Lake Mutual Water Company.

- Actual District monthly water supply data (USBR Water Account Record for 1973 to 2001) are used to represent typical demands.

- USFWS has an entitlement to water from the San Joaquin River to irrigate riparian land; USFWS historical diversions have been approximately 40 cfs for this purpose, which is divided into four separate pumping facilities.

- In order to provide flow for the District, White Lake Mutual Water Company, and USFWS from the Joaquin River, the designed diversion capacity will be 347 cfs.

- Discharge pipeline sizing will be based on a maximum velocity of 5 fps to control total headloss and reduce pumping requirements. To minimize sedimentation in the pipelines, flow velocity will be kept above 2 fps.

- A minimum San Joaquin River elevation between 16 to 21 feet msl would be used for sizing the pump units and fish screens depending on alternative.

- All project elevations are to be based on the NAVD88.

- Facilities will be designed to be protected from the 100-year flood elevation between 39.56 and 43.13 feet msl depending on alternative.

- Based on the San Joaquin River gage information at Newman Gage Station from 1912 to 2000, the 90% and 10% exceedance flows are 160 cfs and 15,300 cfs, respectively.

FISHERIES

- Project design will be based on protection of fall and spring-run chinook salmon and steelhead fish for each alternative District point of diversion on the San Joaquin River.

- The target species and life stage of concern are fall-run Chinook salmon fry.

- Other non-target fish species present at the screens, including resident fish, are assumed to be protected by the established screening criteria for the target species.

FISH SCREEN TYPES

- In accordance with the CDFG and NMFS fish screen design criteria, only "positive fish barriers" are considered.

- Behavioral barriers such as louvers, acoustics, light, air and electrical barriers are not included in this analysis because they do not qualify as "positive" barriers.

- Stainless steel wedge-wire type screen material is recommended for flat or cylindrical fish screens. Automatic screen cleaning will be provided, with a minimum 5-minute cycle time to clean all screens.

FISH SCREEN SIZING CRITERIA

- River flow approach velocity, normal to the screen face (Va), shall be a maximum of 0.33 fps. Velocity is based on the gross screen area less the area of major structural supports.

- River sweeping velocities (Vs) parallel to the screen face should be at least twice the approach velocity.

- Fish screen design shall include provisions for even flow distribution over the entire screen area in accordance with NMFS fish screen criteria (NMFS 1997).

- Screens must be configured to keep transport velocity either constant or increasing through the screen area.

- Screen opening slot must be 1.75 mm wide or less.

- Screen panels must have at least 27% open area.

- If Submerged cylinder screens are used, they must be located a minimum of three feet below the 90% exceedence level.

- The screens must be designed to meet criteria from the 10 to 90% exceedence flows in the river.

EXISTING LIFT STATION MODIFICATIONS

The existing USFWS pumps for riparian habitat may require some modification in order to maintain 10 cfs deliveries at the four locations delineated. The need for modification is contingent on the differing alternative. There are some alternatives that include buried pipe and others that use the existing channel or a combination of the two. The modifications will be further developed in future phases of the project based on the selected alternative.

TEMPORARY CONSTRUCTION PARAMETERS AND SEQUENCING

- The District must be able to obtain irrigation supplies from the San Joaquin River during the active season between, at least, March and November through the use of its existing pumping facility. If the existing diversion facility cannot be kept operational for these active seasons during construction, various construction sequencing alternatives will have to be considered. USFWS must be able to obtain diversion flows year round depending on the current planting for riparian habitat. When only lower flow rates are required it may be very feasible to provide temporary pumping to allow construction to occur within USFWS's active season, although it may be possible to sequence the construction to stay outside of the active season period. Some possible construction sequencing options are listed below.

    - Construct all facilities in one off-season.

    - Construct all facilities in off-season's over two years. This would mean stopping construction during one pumping season.

    - Begin construction of the new intake facility and any non-interfering conveyance pipelines during the pumping season and time the construction so final pipeline and channel work, and integration is completed during the off-season.

    - Install temporary means to provide water to meet USFWS demands to allow the construction window to expand by excluding USFWS season restrictions.

OPERATIONAL PARAMETERS FOR FISH SCREEN

- The facility will be provided with an all weather access road to enable District staff to maintain and operate the facility without impedance.

- The facility will provide for a means for accessing and removing the fish screens for inspection, maintenance and/or repair.

- The facility will allow both the District and USFWS to continue their pumping operations in a manner similar to their current operation procedures.

- The facility will be designed to minimize impacts on river traffic during construction and operation of the new fish screen facility.

- No bathroom or additional storage facilities will be provided on-site.

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SECTION 4 – PROJECT ALTERNATIVES

INTRODUCTION

This section presents the alternatives considered for the District Fish Screen Intake Feasibility Study in the San Joaquin River. Each of the alternatives would protect threatened and endangered fish with the installation of fish screens at the potential point of diversion sites on the San Joaquin River.

Each alternative was developed to accomplish the following:

1. Protect the District's existing water supply in all dry, wet, or normal years.

2. Comply with current NMFS and CDFG fish screen design requirements.

3. Allow the existing District and USFWS pumping facilities to operate as they have historically during construction of the new pumping and conveyance facilities.

The alternatives represent proven fish screening options which include the use of vertical flat plate wedge wire stainless steel screens. These fish screens would be designed to protect threatened and endangered fish and maintain the existing diversion capacity of 347 cfs from the San Joaquin River. Alternative technologies that were briefly reviewed but received no further consideration included: cone screens, cylindrical screens, floating pumps/screens and inclined flat plate screens. Various factors contributed to dismissal of these technologies for this application including current velocity, depth of water, and theft/vandalism.

Four site alternatives for intake locations were considered for review. Similar sites were evaluated during a Value Planning phase of this project. The value planning study was an appraisal level study conducted by a multi-agency team of experts that evaluated feasible alternatives for constructing a fish screen to provide the highest project value at the lowest cost. The information contained in the value planning study was considered in preparation of this Feasibility Study. Initially, the Value Planning Team identified six sites for location of the intake. The final alternatives considered in this Feasibility Study are generally consistent with the findings of the Value Planning Study in terms of preferred site locations and screening technologies. All alternative sites evaluated would provide long term protection of threatened and endangered fish in the San Joaquin River for the District surface water diversion.

REVIEW OF ALTERNATIVES

Site Alternatives

Suitable locations for the intake were evaluated based on a set of criteria that would provide for stability and long term reliable operation of an intake protected by a positive barrier fish screen structure.

The first location considered (Site 1) is the existing location to the shared channel that the District currently uses to convey water to their existing Lift Station No. 1, (refer to **Figure 4-1**).

Site 1 is just west of the main San Joaquin River channel. This site is comprised of sandy soil that form some dune slopes with a terrace near the water and steeper slopes of 2H: 1V. The existing location has been used for 90 years, provides water quality that the District is familiar with, lies within an existing easement for District use and is in compliance with their water right in terms of point of diversion. Based on these reasons, the District Board of Directors have supported that the new fish screen intake be constructed at this location. This site does have some issues related to siltation and sediment because it falls within an inside bend of the river that will need to be addressed for easier operation.

Site 2 is located approximately 4,000 feet upstream of Site 1 and is on an outside bend of the river with no noticeable undercut by river scour. Site 2 has been improved with the addition of cobbles to create stability and is configured with a uniform slope from the water to the access road. This location also includes several very mature oak trees along with smaller trees near the bank. This site is closer to the District's existing Lift Station No. 1 by approximately 1,000 feet.

Site 3 is also upstream of Sites 1 & 2, approximately 1.4 miles upstream of Site 1. This location is on the upstream end of a bend in the San Joaquin River. Site 3 appears to be in a transition zone with near vertical banks 6 to 12 feet high just downstream of this general vicinity. This site does not have good direct access and although posted as private property it does have significant visitation by the public.

Site 4 is upstream of all the other sites at River Mile post 84.9 and 1.7 miles from the existing point of diversion. This location is in the middle of a bend on the main river channel. The near vertical bank just downstream are approximately 7 feet above the river bank. This site is accessible and is also frequented by the public.

Intake Facility Alternatives

Alternative Screen Types Dismissed

The location being used in this evaluation and comparison is Site 1 at the current intake channel on the San Joaquin River. The site has potential sediment problems both with deposition and scour in the structure and also in the channel in front of the structure.

Cone Screens

The capacity of this diversion is 347 cfs that includes 262 cfs for the District, 45 cfs for White Lake Mutual Water Company and 40 cfs for the Federal refuge. To install cone screens that have a maximum capacity of 40-50 cfs each would provide a challenge. The installation would likely have to be in a straight line or in a staggered line down the intake channel with the first cone screen being near the center of the San Joaquin River. Then the collection assembly (box, pipes, or fabricated steel) would be long and difficult to secure along with keeping it clear of sediment. Sufficient water depth are also a challenge but a sediment suspension system could be designed to help move the sediment along and try to keep the screens fairly clear. In one other installation there are a series of pumps parallel to the flow of the river but in this case the flow would be perpendicular to the flow of the river. This would make it much more difficult to keep clear for sediment and debris. An additional problem would be the inherent impossibility of

Existing WSID Point of Diversion on San Joaquin River

WSID Water Right App#: 1987, Permit 2758, License 10

Site 1

Site 2

Site 3

Site 4

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

West Stanislaus Main Canal

West Stanislaus Irrigation District Pumping Plant No. 1

Pond

Well

North twenty-nine degrees fifty minutes east (N29d50'E), nineteen thousand two hundred ninety (19,290) feet from W1/2 corner of Section 28, T 4 S, R 7 E, MDB&M.

North twenty-nine degrees fifty minutes east (N29d50'E), nineteen thousand two hundred ninety (19,290) feet from the SE1/4 of NE1/4 of Section 10, T 4 S, R 7 E, MDB&M.

Riparian Forest (Irrigated)

Riparian Forest (Not Irrigated)

Managed Wetlands

San Joaquin River

Tuolumne River

S.JRNWR

04N 07E 09

04N 07E 10

04N 07E 11

04N 07E 02

04N 07E 01

04N 07E 16

04N 07E 15

04N 07E 14

04N 07E 13

04N 07E 21

04N 07E 22

04N 07E 23

Stockton

Manteca

Modesto

Turlock

Merced

Stanislaus River

Tuolumne River

Merced River

San Joaquin River

WSID Intake

Figure 4-1
West Stanislaus Irrigation District San Joaquin River Diversion Alternative Site Locations

Feature of Interest

Flood Control Levee

General Area of Potential Intake

San Joaquin River NWR Landuse

Managed Wetlands

Riparian Forest (Irrigated)

Riparian Forest (Not Irrigated)

Refuge Boundary

0 600 1,200 2,400 3,600 Feet

N

Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 17, 2010

MWH

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meeting CDFG and NMFS fish screen criteria using a cone screen design with respect to both sweeping flows and approach velocities.

Floating Pumps and Screens

Floating pumps and positive barrier fish screens operate inefficiently in comparison to vertical turbine pumps and flat plate wedge wire screen structure installations. In this location it would be difficult to provide protection from debris and sediment and maintain accessibility to the pumps and screens. The maintenance of electric motors while floating in the water is a challenge for a permanent installation. Most of these types of pumps and motors are used in emergency situations with limited time of operation.

Inclined Flat Plate Screen

The inclined flat plate positive barrier fish screen would be costly because of the length of the structure to close off at the mouth of the channel leading to the District Lift Station No. 1. Most of the bank and streambed material in the area is composed of sand and to form a solid foundation on which to construct the structure would be expensive. The maintenance of the diversion free of sediment would be a constant challenge and quite expensive, if possible. Such an installation would be expensive and unreliable for diversion of an irrigation water supply.

Cylindrical Screens

The challenge of installing cylinder screens would relate to being able to protect and maintain these screens. The number of screens required to divert the required 347 cfs would make the task difficult. Sediment would also be a problem as with some of the other type of installations discussed above. Again a structure would have to be constructed on the left bank of the San Joaquin River to block the river flow and allow only the flow through the cylinder screens and into the channel. This installation would likely require that a supplemental pump station would have to be constructed to raise the water to a level that would flow water to Lift Station No. 1. In addition to these reasons and some in the above descriptions, the depths of water in this location provides challenges to any screen that has to be placed in the channel without a means to suspend the sediment.

Considered Alternative Screen Types

The following alternative screen technologies were further evaluated specific to the sites as described below.

In-Channel Vertical Flat Plate Screen Intake Facility

Alternatives 1A or 1B will consist of a new fish screen (V-screen) structure with submerged flat wedge-wire fish screens with a total capacity of 347 cfs located in the inlet of the existing diversion channel. The flat plate fish screens would be installed on both interior sides of the V-shaped intake structure which would allow for a shorter length facility. The structure will be equipped with a trash rack in front of the fish screen structure and mechanical cleaning system for each interior side of the V configuration that utilizes a travelling brush to provide cleaning of small debris and floating objects on the flat wedge-wire screens. A sediment suspension system

would also be required. In addition, an earth access embankment would be constructed from each bank to the structure, and an electrical control building would be constructed adjacent to the structure. There may also be a small lift station in this design.

A typical V-shaped intake facility is shown in **Figure 4-2** and only applies to Site 1.

This V-shaped intake facility alternative requires a fish pump bypass system to return fish to the San Joaquin River. Fish which migrate in the center of the structure and continue alongside the screens all the way to the back of the V are conveyed approximately 500 feet in a gravity fish recovery pipe and pumped back into the river at suitable location downstream.

The bypass system is comprised of a free flowing conveyance to low lift specially designed discharge pipes to an out-fall structure at the river. The hydraulic grade along the river is very flat; therefore pumping is required to make the fish return system feasible.

Operational Description

This alternative will pass 347 cfs through 1,152 square feet of vertical screen area to remain under the design criteria maximum approach velocity of 0.33 fps. A 3.0 fps maximum transport velocity will be maintained at low design water elevation. In general, the screen will be anticipated to be operated at higher water surface elevation conditions but low water surface has to be designed for.

The headgate system will be automatically controlled on downstream level with adjustment based on water demands, and operational needs such as periodic trash rack cleaning or system shutdown. Debris larger than 3 inches will be stopped on the trash rack at the headgate structure, smaller debris will pass through the gates to the screens which will require periodic cleaning.

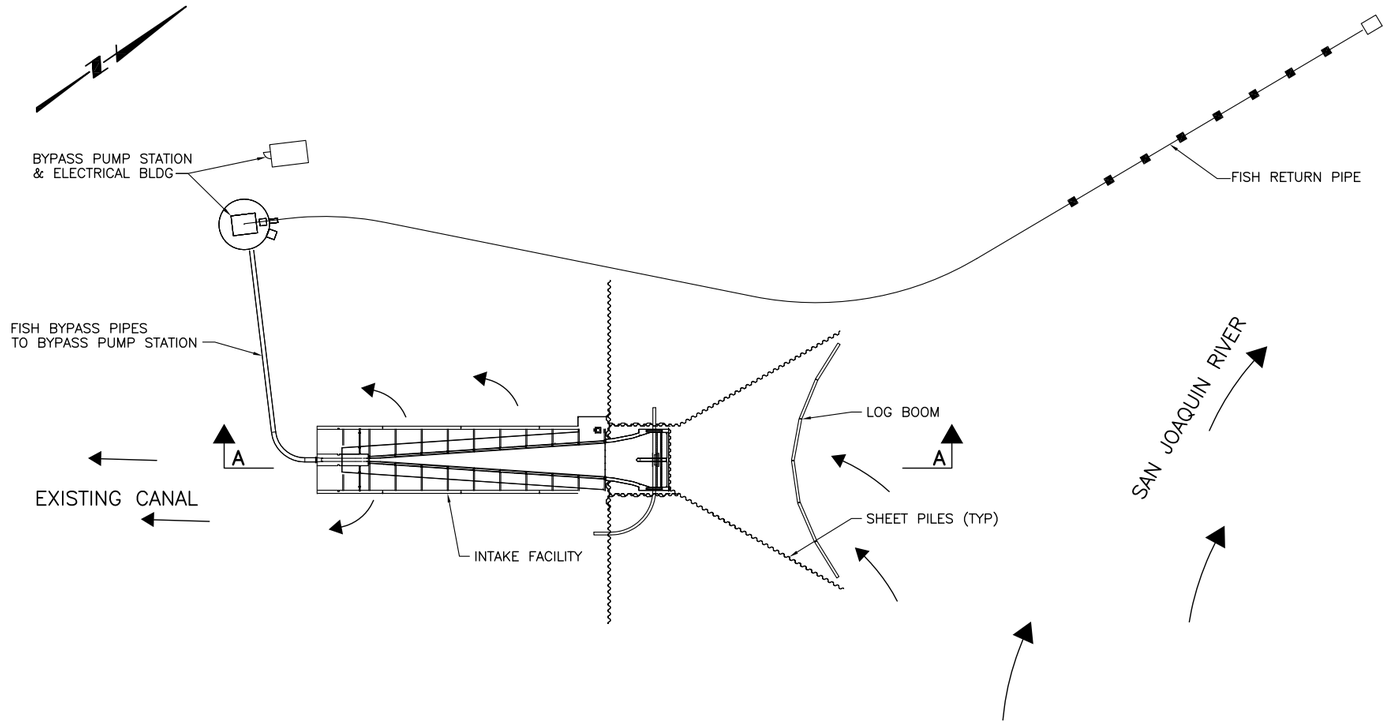
Screened Intake

Sixteen vertical flat wedge-wire panels of screen, each approximately 6 feet high by 12 feet wide, would be mounted in individual guides and lowered into place. Each screen panel would provide 72 square feet of screened area. Sixteen flat panels would provide a total of 1,152 square feet of screened area, which would meet the design criteria and limit the perpendicular approach velocity to a maximum of 0.33 ft/sec at the maximum diversion rate of 347 cfs.

The screen panels will be supported in steel fabricated guides extending from the bottom of the concrete structure to the top of the elevated deck. The screens would be positioned side-by-side along the intake side of the concrete structure. The total length of the intake structure including the sixteen screen panels and guides would be approximately 164 feet. A log boom and headgate structure in front of facility will provide protection for the screens from debris or watercraft floating in on the river.

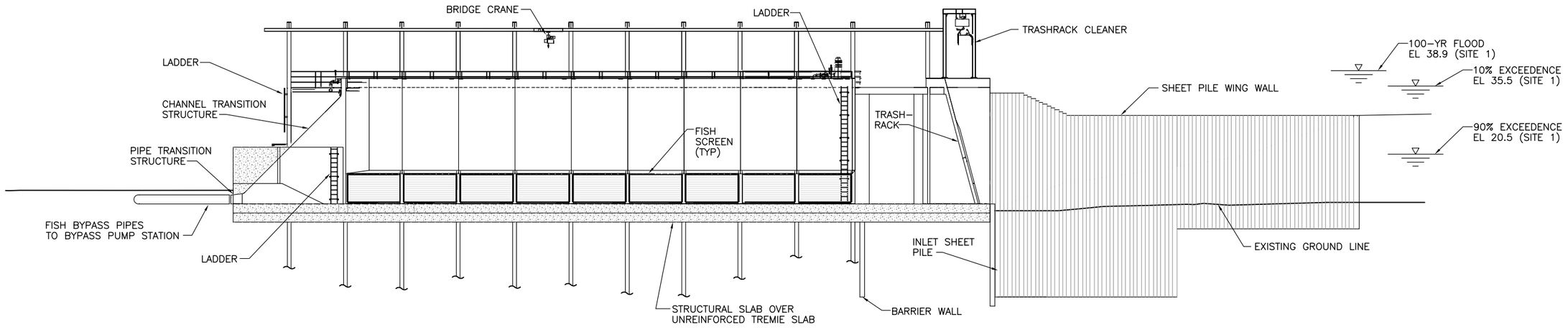
Fish Screen Cleaning System

The flat wedge-wire screens would be cleaned using an automatic travelling brush system. A brush cleaner system would consist of a track mounted brush which travels the full length of the



"V"–SCREEN TYPE INTAKE FACILITY PLAN

SCALE: 1" = 30'



SECTION A–A

SCALE: 1" = 10'

SCALE:	WARNING			
AS SHOWN	0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.	MWH	WEST STANISLAUS IRRIGATION DISTRICT	SAN JOAQUIN RIVER DIVERSION V–SCREEN TYPE INTAKE FACILITY PLAN AND SECTION	FIGURE 4–2

screen on the water side; one brush cleaner is required for each side of the Vee-type configuration.

Vertical Flat Plate On-River Screen Intake Facility

For remaining alternatives (Sites 2, 3, and 4), a rectangular concrete diversion structure with flat plate wedge-wire fish screens on the river side of the structure shall be required. The screen would be equipped with a mechanical cleaning system utilizing a travelling brush to provide cleaning of the materials on the screen. A sediment suspension system at the intake may also be required in addition to maintenance on the downstream side of the screen to ensure there is no sediment buildup. In addition, an earth dike and electrical control building would be constructed on the dry side of the structure and dike.

An example of this type of intake facility is shown in **Figure 4-3**.

Operational Description

This type of fish screen utilizes a submerged reinforced concrete rectangular intake structure to channel flow to the gravity pipelines. The intake side of the structure would face the river and access to the structure would be from the dry side. The river water would enter the concrete sump through sixteen 12-foot wide flat wedge-wire fish screens. The concrete intake structure and sump would be supported by steel pilings. Concrete walls would run from the concrete base slab to the grated steel deck above. The flow would then be sectioned into the gravity discharge piping and conveyed to the District's Lift Station No. 1.

Screened Intake

Sixteen vertical flat wedge-wire panels of screen, each 12 feet wide, would be mounted in individual guides and lowered into place. Each screen panel would provide approximately 72 square feet of screened area. Sixteen screen panels would provide a total of 1152 square feet of screened area, which would meet the design criteria and limit the perpendicular approach velocity to a maximum of 0.33 ft/sec at the maximum diversion rate of 347 cfs.

The screen guides would be fabricated from 18-inch steel wide flange W columns extending from the bottom of the sump to the top of the elevated deck. The screens would be positioned side-by-side along the intake side of the concrete structure. The total length of the intake structure including the sixteen screen panels and guides would be approximately 248 feet. The screens would be protected by a log boom system.

Fish Screen Cleaning System

The flat wedge-wire screens would be cleaned using an automatic travelling brush system. With the travelling brush system, a fixed or telescoping arm would position a brush to sweep across the face of the screen and remove debris. The brush/arm assembly would be moved by an electric motor and trolley system located above the 100-year flood event elevation. At the proposed site, the river would provide sufficient parallel sweeping velocity to exceed the minimum design criteria at all river flows for providing debris removal after brushing.

A typical process and instrumentation diagram for the Fish Screen Cleaning System is shown in **Figure 4-4**.

General Design Notes (all Alternatives)

The intake structure would be pile supported. Ladder access will be provided for interior access to the fish screens and concrete base. A bridge crane would be provided with Vee Screen Intake Facility alternative, a boom truck would be required for the Vertical Flat Plate Screen Alternative for lowering the flat wedge-wire screens into place or removing them for inspection and maintenance.

Because the facility must be constructed above the 100 year flood elevation, the intake structure would be accessible by an earth access bridge constructed from compacted fill material. The fill material would be held in place at each end of the structure by sheet pile retaining walls. The base of the sheet pile walls would require rip-rap protection to minimize scour.

Because of river bed excavation required to achieve appropriate river invert elevations at the low water level, a sediment control system will be needed to suspend sediment and avoid siltation of the intake. This system would include a vertical pump, system piping and system headers. The headers would be installed at the base of the screens to cause a burst of water that will clear any sediment that has settled in front of the screens. The systems required frequency of use would have to be determined after further sedimentation analysis of the project site conditions.

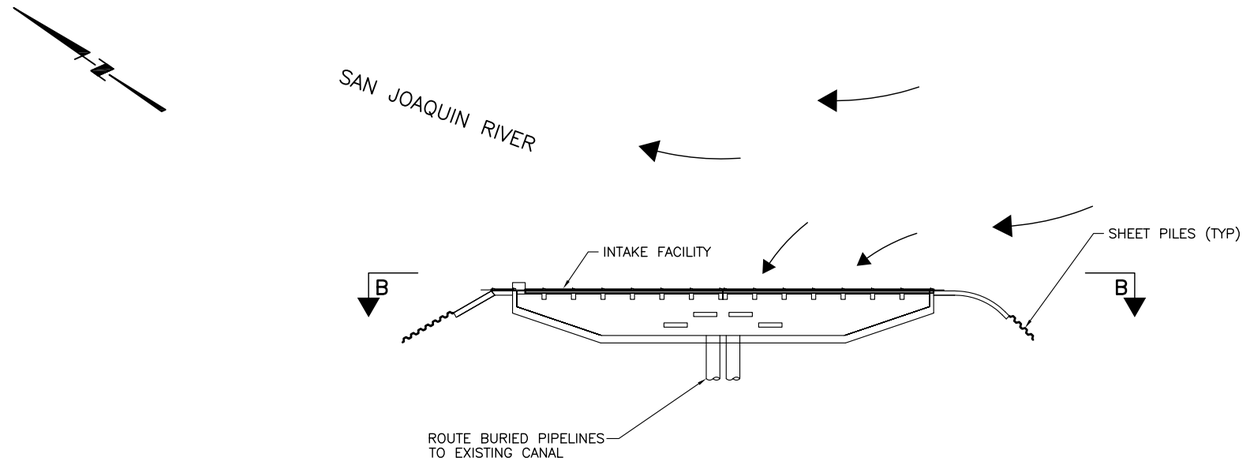
A typical process and instrumentation diagram for the Sediment Control System is shown in **Figure 4-5**.

Conveyance Alternatives

Pipeline

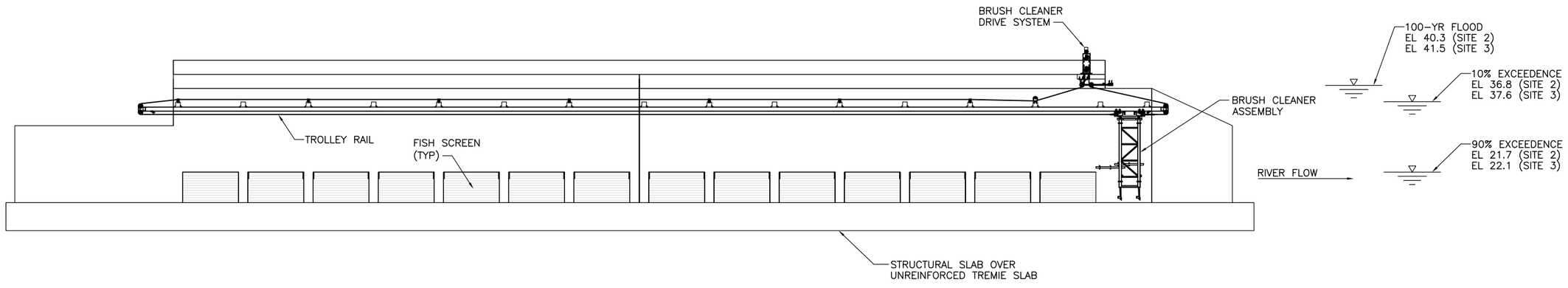
Screened water from the intake facility shall be conveyed from the intake structure to the existing District's Lift Station No. 1, several options for conveyance are presented herein. Alternatives 1A, 2D, 2F and 3H include conveyance entirely below grade. Alternatives 2C, 2E, and 3G consist of a combination of buried pipe and conveyance using a portion of the existing channel, while Alternative 1B is conveyed entirely in the channel. For alternatives with buried piping the pipeline will extend from the new intake structure to the existing Lift Station No. 1 and shall consist of two parallel large diameter reinforced concrete low pressure pipelines. Splitting the total flow among two pipelines has the following advantages:

- Reduced trench depth, and possible reduction in required depth of the wet-well at the intake facility.
- One of the pipelines may be taken out or service for maintenance needs while allowing the other pipeline to deliver up to half of the maximum required flow.
- One pipeline may be taken off-line at lower demand periods to allow higher velocities to be maintained, reducing sedimentation within the other operating pipeline.
- Reduced head loss across pipeline alignment with two parallel pipelines vs. three or more smaller diameter parallel pipelines.



VERTICAL FLAT SCREEN TYPE INTAKE FACILITY PLAN

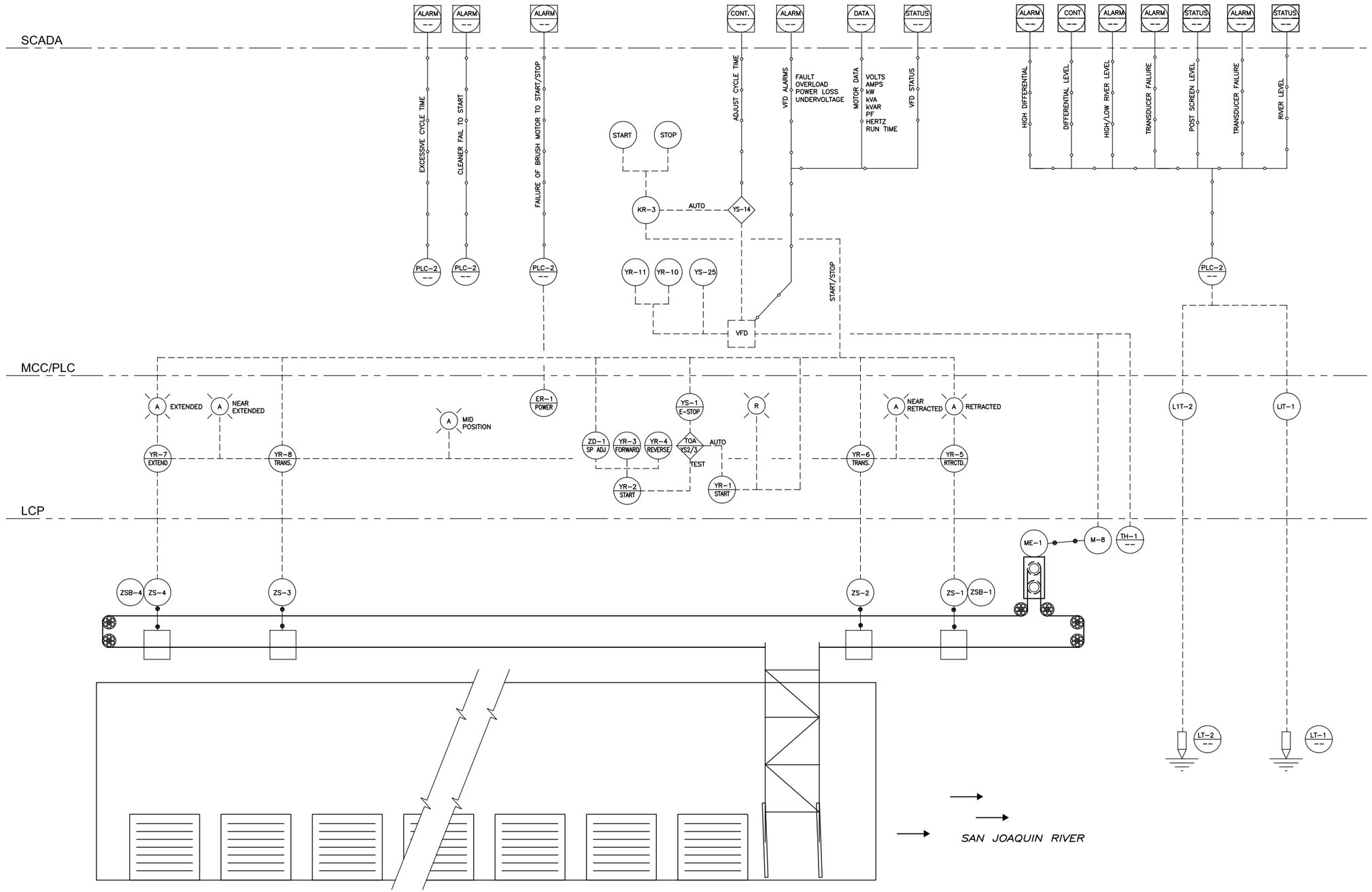
SCALE: 1" = 30'



SECTION B–B

SCALE: 1" = 10'

SCALE: AS SHOWN	WARNING 0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.	MWH	WEST STANISLAUS IRRIGATION DISTRICT	SAN JOAQUIN RIVER DIVERSION VERTICAL FLAT SCREEN TYPE INTAKE FACILITY PLAN AND SECTION	FIGURE 4–3



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SCADA

MCC/ PLC

LCP

AIR AND WATER TEMPERATURE
LOW CONDUCTIVITY
HIGH CONDUCTIVITY
LOW SUCTION LEVEL
OVERLOAD
FAULT, FAILURE TO START/STOP
VOLTS AMPS kW kVA kVAR PF RT
SSS DATA
SSS STATUS
LO/HI PRESS DELAY
LOP CONTROL POWER FAILURE
LOW & HIGH PRESSURE
SED SYSTEM PRESSURE
TIME SETTINGS/STATUS
OPEN/CLOSE (YR13,YR14)
HOA – LOCAL/REMOTE

ALARM
DATA
STATUS
CONT

PLC-2

TIT-1
TIT-2
AIT-1
LS-1
YR-50
START/STOP
HAND
AUTO
YS-4/5
G
R
OFF
ON
YR-15
OL
SSS
YR-13
YS-15
REMOTE
YR-14
KR-4
YS-16
ER-2
W
A
KR-1
KR-2
HI
LO
CLOSE
OPEN
YR-31
YR-30
YR-29
YR-28
YR-27
YR-26
YR-25
YR-24
YR-23
YR-22
YR-21
YR-20
YR-19
YR-18
YR-17
YR-16
YS-12
YS-11
YS-10
YS-9
YS-8
YS-7
YS-6
YS-5

ZS-20
ZS-19
TR-52
YR-51
V-08
YS-24
ZS-18
ZS-17
TR-48
YR-47
V-07
YS-23
S-16
ZS-15
TR-46
YR-45
V-06
YS-22
ZS-14
ZS-13
TR-44
YR-43
V-05
YS-21
ZS-12
ZS-11
TR-42
YR-41
V-04
YS-20
ZS-10
ZS-9
TR-40
YR-39
V-03
YS-19
ZS-8
ZS-7
TR-38
YR-37
V-02
YS-18
ZS-6
ZS-5
TR-36
YR-35
V-01
YS-17

M-9
PG-1
PSH-1
PSL-1
PT-1
TE-2
LE-3
TE-1
CE-1

SCALE: NO SCALE	WARNING 0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.	MWH	WEST STANISLAUS IRRIGATION DISTRICT	SAN JOAQUIN RIVER DIVERSION INTAKE FACILITY SEDIMENT CONTROL SYSTEM P&ID

FIGURE 4-5

Parallel pipelines may be used to deliver water from the new intake structure either to various points midway along the channel, or all the way to the existing District's Lift Station No. 1 intake location per the alternatives described. To reduce excavation costs and to reduce the construction impact to the general area, the pipelines may be routed in and buried in the existing channel for a portion of each alternative's alignment. Routing from the new intake facility to connect to the pipeline alignment in the existing channel will be via common open trench excavation.

The use of parallel pipelines as described in this alternative will not apply to Alternative 1B, which will utilize only the existing channel to help fulfill water delivery requirements. Refer to **Figure 4-6** for conceptual pipeline profiles for each alternative.

Channel

Some of the alternatives shall use the existing shared channel as a means for delivering water to the existing District's Lift Station No. 1. Alternatives 1B, 2C, 2E, and 3G use the existing channel for all or a portion of the overall length of conveyance.

Any portion of the Channel not used for water conveyance would be backfilled with equivalent native materials to restore the area to a similar state as was prior to the original construction of the Channel. Alternatives that utilize the full length of the existing shared channel for conveyance will include provisions for buildup of the northerly bank above the 100 year flood elevation. In addition the southern bank will have an all weather access road constructed also above the 100 year flood elevation. This construction will include bridge crossings of the channel for wildlife enhancement and USFWS riparian habitat management. These crossings will include culvert pipe to convey flood flows consistent with the USFWS riparian habitat practices. The intent of these improvements is to ensure that during a flood event fish that are to be protected by the fish screens themselves are not trapped behind the screen without being able to return to the river after the water levels recede.

Site 1 Alternatives 1A, 1B and 1C - New In-Channel Vertical Flat Plate Screen Intake Facility and Alternative of Abandonment of the existing diversion at San Joaquin River Mile (RM) 81.6

Alternatives 1A and 1B provide for a new intake facility with a capacity of 347 cfs. The new facility includes a Vee-screen type intake as previously described located in the mouth of the existing District Point of Diversion on the west side of the San Joaquin River at RM 81.6. This alternative would require sixteen 12-foot long symmetrically opposing vertical flat wedge-wire screens inside a V-shaped structure with steel members, a fish bypass pump station and pipeline, and an access bridge/platform.

An automated mechanical brush screen cleaning system and pressurized sediment suspension system would be included along each side of the screens for cleaning and removal of any accumulation of sediment near the screens.

Alternative 1A would convey water approximately 10,400 feet to the existing District's Lift Station No. 1 via two new 96" or larger diameter parallel pipes installed and buried within the existing Channel (refer to **Figure 4-7**). The twin pipelines will be constructed in the existing

channel after excavation and suitable bedding material has been placed and compacted. After placement of the pipelines the entire existing channel will be backfilled with suitable material and compacted to restore the channel to match the surrounding contours. This alternative will require modification of the existing USFWS pumping facilities to retrofit the existing pumps to the new pipeline.

Alternative 1B would be conveyed within the existing Channel (refer to **Figure 4-8**). This alternative includes three separate crossings of the channel for access and to convey flood flows. Concept drawings have been developed for these crossings and included in this study (see **Figure 4-9**). Future phases of this project will more fully develop these concepts and design to address the goals of the refuge. These crossings consist of a 12 foot wide single direction travel H20 loading bridge with an approximate span of 150 feet. The bridge construction is assumed to be a pre-engineered deck and two bridge abutments constructed on each bank. The culvert pipe will include pipe support and attachment to the bridge for conveyance of flood flows across the channel. In order to ensure that the flood flows do not trap fish behind the screen, the northerly bank of the shared channel will be built up so that it is above the 100 year flood level of elevation 38.9 feet (refer to **Figure 4-9**). The berm construction will consist of a non driveable 5 foot top section with an assumed 1.5 to 1 slope with a 5 cu. Ft./LF. Soil for the berm assumes 1/2 available from onsite excavation and 1/2 brought in from offsite.

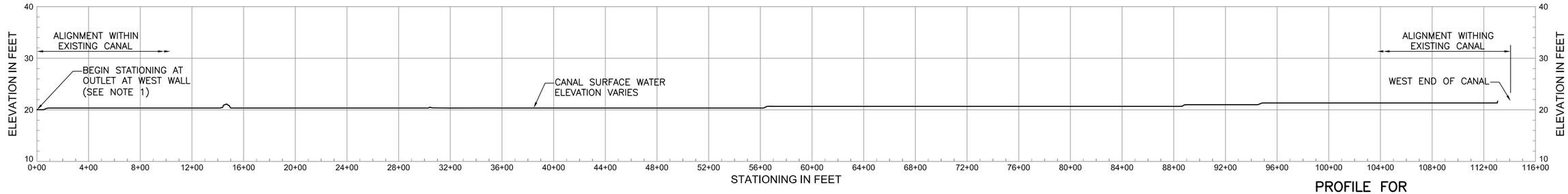
Alternative 1C involves abandonment of the District's diversion from the San Joaquin River as a continued water supply source. The District would rely on both groundwater pumping and the DMC to supply their customers with the current contractual requirements for water.

Abandonment of the District's diversion would eliminate a very reliable water supply and would require reliance on the DMC and four groundwater wells for the full contract amount for delivery. The District's connection to the DMC consists of three concrete pipes that are capable of delivery of 140 cfs to the District's lateral 6. This is the maximum capacity that can be achieved only under optimum condition with the DMC operating full and the District's lateral 6 near empty. The DMC supply is subject to reduction based on availability, the District can in any give year have their allocation reduced to zero due to the current provisions of Tier 1 contracts and the M&I Shortage policy. The District's four groundwater wells can supply a maximum of 20 cfs, this combined with the DMC supplies when available will leave the District with over a 140 cfs shortage.

The limited availability of a reliable source of water to meet the District's contractual requirements has eliminated this alternative from consideration.

Site 2 Alternatives 2C, 2D, 2E, and 2F - New Vertical Flat Plate Screen Intake Facility at San Joaquin River Mile (RM) 83.6

Alternatives 2C through 2F also provide for a new intake facility with a capacity of 347 cfs; however, the new facility will instead include a vertical flat plate screen type intake facility as previously described located along the west bank of the San Joaquin River at RM 83.6. This alternative would require sixteen 12-foot long vertical flat plate screens along the front face of a concrete sump structure, new parallel discharge pipelines, and new access.

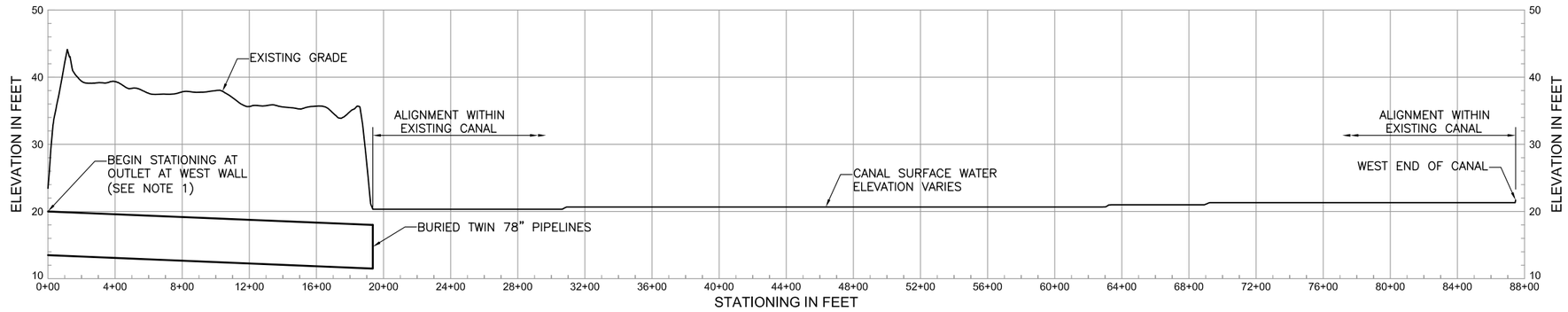


PROFILE FOR ALTERNATIVES 1A AND 1B

(ROUTING OF PIPELINES WITHIN THE CANAL FOR ALTERNATIVE 1A NOT SHOWN)

SCALE: 1" = 400' H
1" = 10' V

A
–

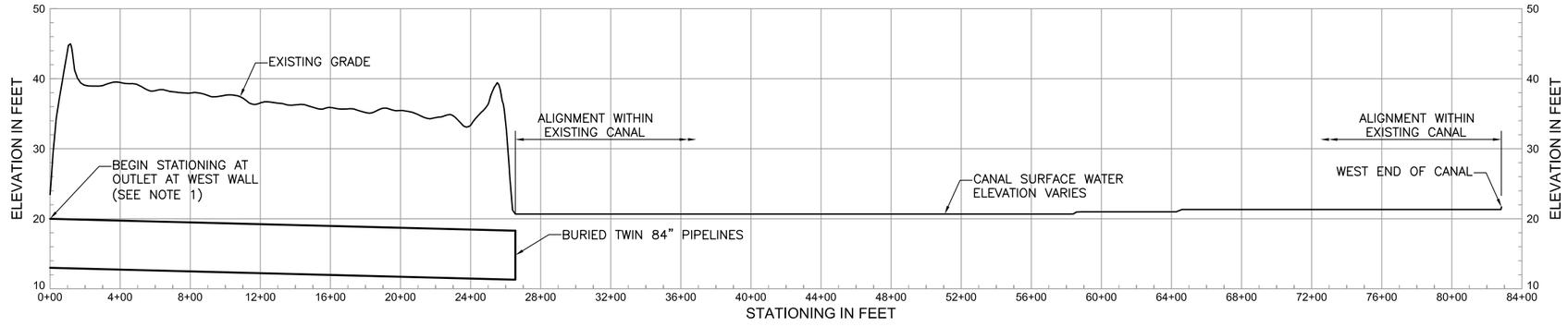


PROFILE FOR ALTERNATIVES 2C AND 2D

(CONTINUATION OF PIPELINES WITHIN THE CANAL FOR ALTERNATIVE 2D NOT SHOWN)

SCALE: 1" = 400' H
1" = 10' V

B
–

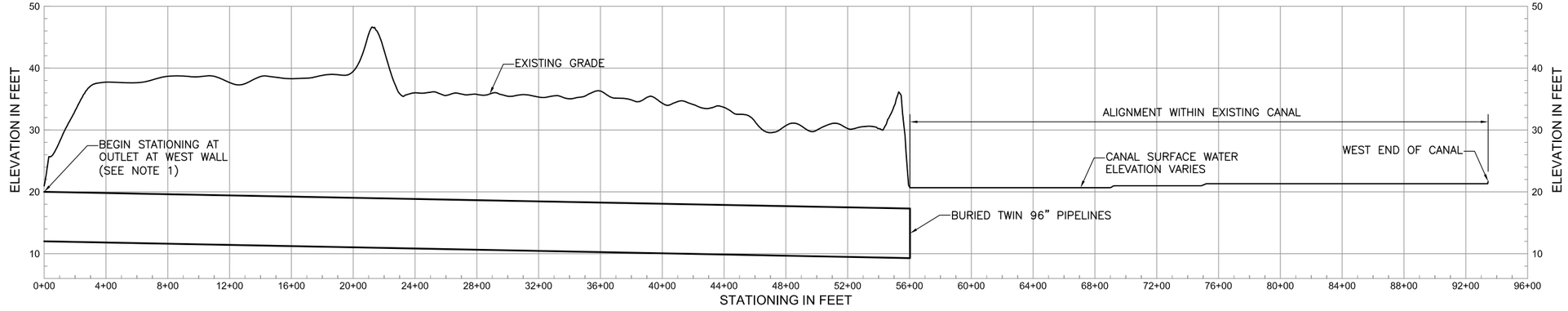


PROFILE FOR ALTERNATIVES 2E AND 2F

(CONTINUATION OF PIPELINES WITHIN THE CANAL FOR ALTERNATIVE 2F NOT SHOWN)

SCALE: 1" = 400' H
1" = 10' V

C
–



PROFILE FOR ALTERNATIVES 3G AND 3H

(CONTINUATION OF PIPELINES WITHIN THE CANAL FOR ALTERNATIVE 3H NOT SHOWN)

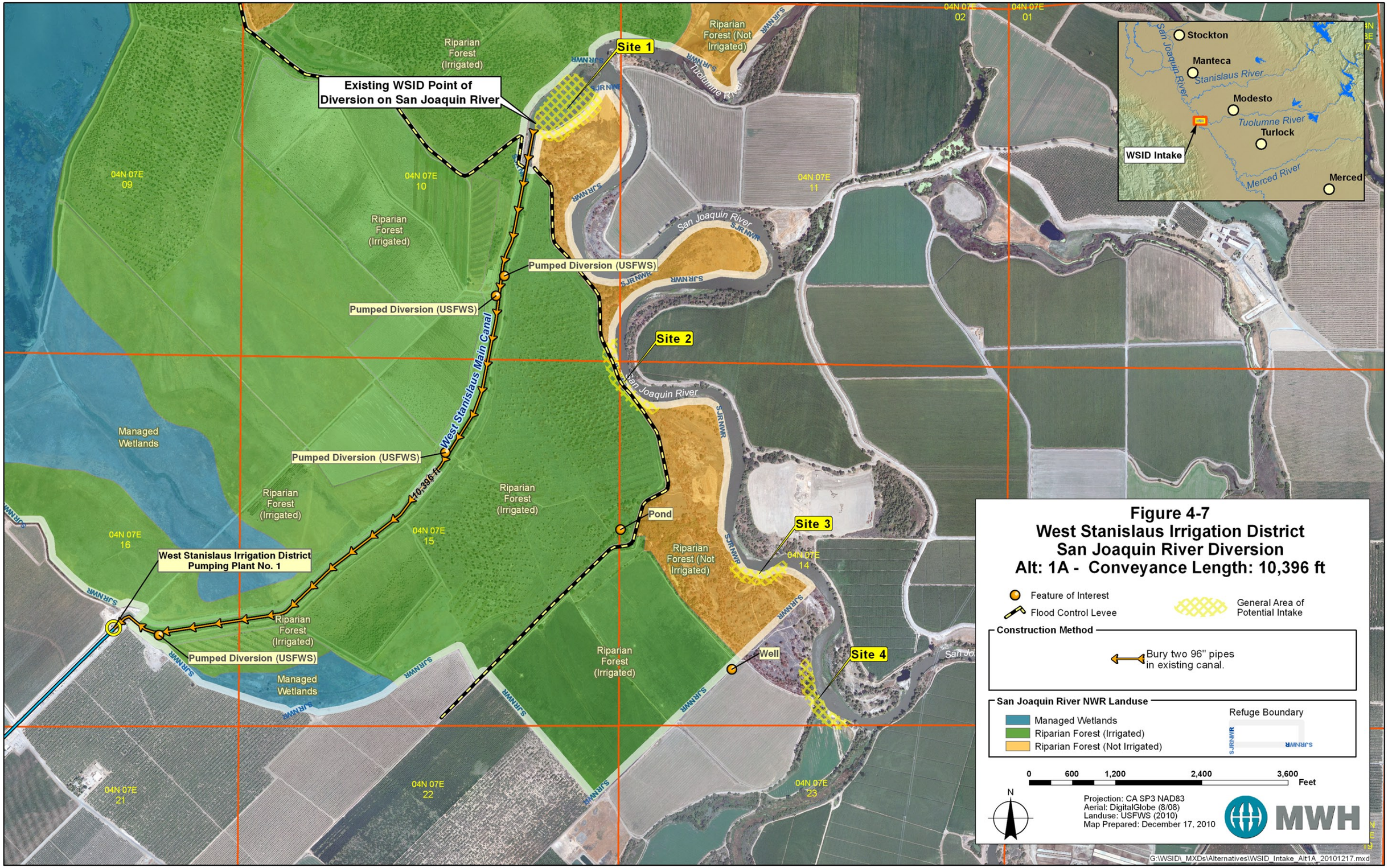
SCALE: 1" = 400' H
1" = 10' V

D
–

GENERAL NOTE:

1. EACH ALIGNMENT BEGINS AT THE WEST END OF THE PROPOSED INTAKE FACILITY OUTLET.

SCALE:	WARNING			
AS SHOWN	0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.	MWH	WEST STANISLAUS IRRIGATION DISTRICT	SAN JOAQUIN RIVER DIVERSION PROFILES FOR ALTERNATIVES	FIGURE 4–6


Existing WSID Point of Diversion on San Joaquin River
Site 1
Site 2
Site 3
Site 4
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
West Stanislaus Main Canal
10,396 ft
West Stanislaus Irrigation District Pumping Plant No. 1
Pond
Well
WSID Intake
Stockton
Manteca
Modesto
Turlock
Merced
San Joaquin River
Stanislaus River
Tuolumne River
Merced River
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Managed Wetlands
04N 07E 09
04N 07E 10
04N 07E 11
04N 07E 02
04N 07E 01
04N 07E 16
04N 07E 15
04N 07E 14
04N 07E 21
04N 07E 22
04N 07E 23
S.JRNWR
Figure 4-7
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 1A - Conveyance Length: 10,396 ft
Feature of Interest
Flood Control Levee
General Area of Potential Intake
Construction Method
Bury two 96" pipes in existing canal.
San Joaquin River NWR Landuse
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Refuge Boundary
0 600 1,200 2,400 3,600 Feet
N
Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 17, 2010
MWH
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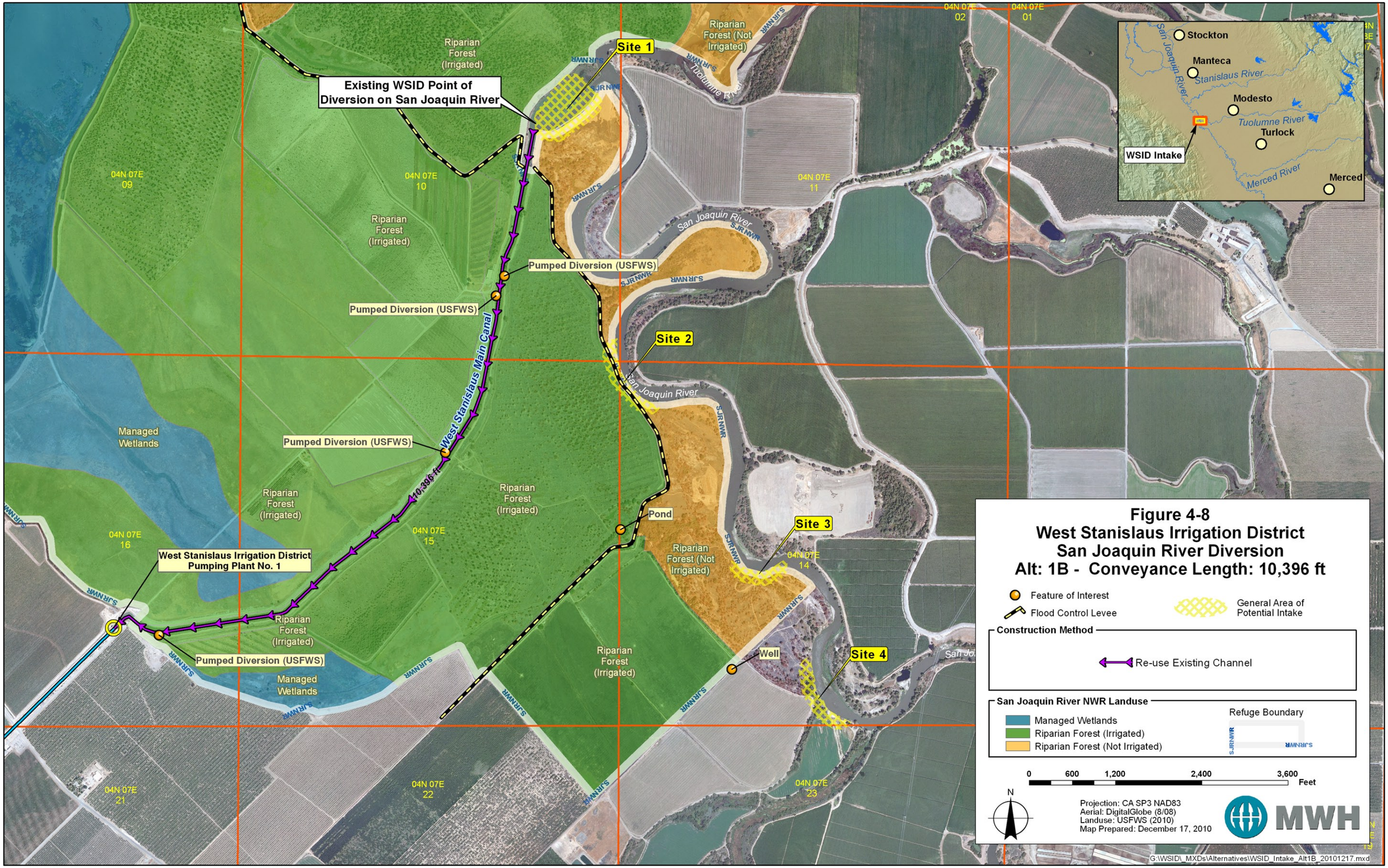
Existing WSID Point of Diversion on San Joaquin River
Site 1
Site 2
Site 3
Site 4
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
West Stanislaus Main Canal
10,396 ft
West Stanislaus Irrigation District Pumping Plant No. 1
Pond
Well
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Managed Wetlands
San Joaquin River
Tuolumne River
S.JRNWR
04N 07E 09
04N 07E 10
04N 07E 11
04N 07E 02
04N 07E 01
04N 07E 16
04N 07E 15
04N 07E 14
04N 07E 21
04N 07E 22
04N 07E 23
Stockton
Manteca
Modesto
Turlock
Merced
Stanislaus River
Tuolumne River
Merced River
San Joaquin River
WSID Intake
Figure 4-8
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 1B - Conveyance Length: 10,396 ft
Feature of Interest
Flood Control Levee
General Area of Potential Intake
Construction Method
Re-use Existing Channel
San Joaquin River NWR Landuse
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Refuge Boundary
0 600 1,200 2,400 3,600 Feet
N
Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 17, 2010
MWH
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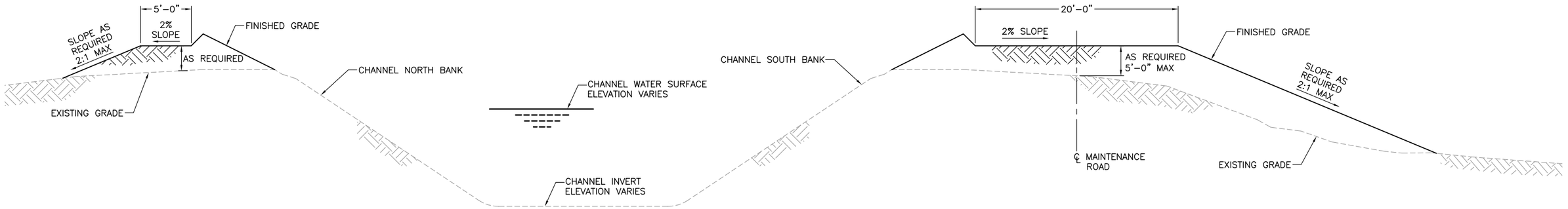
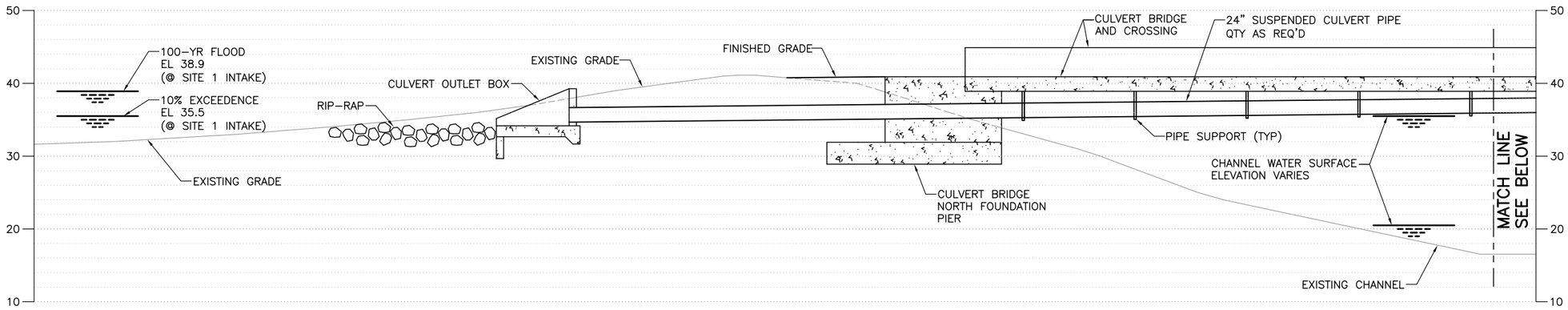


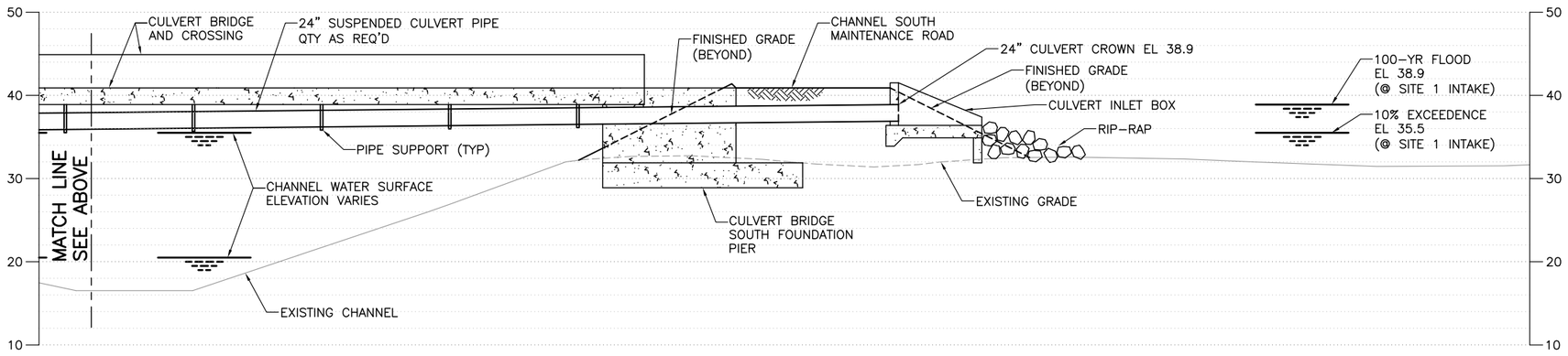
CHANNEL TYPICAL SECTION ROAD AND BERM IMPROVEMENTS

SCALE: NONE



CHANNEL SECTION AT LOW POINT CULVERT BRIDGE CROSSING

SCALE: 1" = 10' H
1" = 10' V



CHANNEL SECTION AT LOW POINT CULVERT BRIDGE CROSSING (CONT)

SCALE: 1" = 10' H
1" = 10' V

SCALE:	WARNING			
AS SHOWN	0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.	MWH	WEST STANISLAUS IRRIGATION DISTRICT	SAN JOAQUIN RIVER DIVERSION CHANNEL BANK ACCESS ROAD AND CROSSING IMPROVEMENTS	FIGURE 4-9

An automated mechanical brush screen cleaning system and pressurized sediment suspension system would be included along the face for cleaning of the screens and removal of any accumulation of sediment around the screens.

Alternatives 2C and 2E would convey water via two new 78" or larger diameter parallel pipes routed below grade from the Intake Facility to discharge midway along the existing Channel. Both of these alternatives would utilize a lower section of the existing Channel for conveyance to the District Lift Station No. 1. The amount of below grade pipeline for Alternatives 2C and 2E are 2,000 and 2,800 feet respectively (refer to **Figures 4-10 and 4-12**).

Alternatives 2D and 2F are similar to Alternatives 2C and 2E, except the new 78" or larger diameter parallel pipes would be constructed along the alignment of the existing Channel to the existing District's Lift Station No. 1 (refer to **Figures 4-11 and 4-13**). The parallel pipes along the Channel alignment would be installed and buried within the existing Channel prism. For these alternatives, turnouts would be required to allow USFWS to obtain the water service required for their existing pumping facilities; however, modifications to each of the USFWS facilities will likely be required.

Site 3 Alternatives 3G and 3H - New Vertical Flat Plate Screen Intake Facility at San Joaquin River Mile (RM) 84.3

Alternatives 3G and 3H provide for the same type of intake facility and cleaning system as for the alternatives for Site 2 above, located along the west bank of the San Joaquin River at RM 84.3.

Alternative 3G would convey water via two new 96" or larger diameter parallel pipes routed below grade from the new Intake Facility and discharge approximately two-thirds of the way down the existing Channel. Conveyance would then continue in the lower third of the Channel to the existing District's Lift Station No. 1 (refer to **Figure 4-14**). This portion of the Channel would require improvements with the addition of concrete lining or possibly improved prism.

Alternative 3H is similar to Alternatives 3G, except the new 96" or larger diameter parallel pipes would continue along the alignment of the existing Channel all the way to the District's Lift Station No. 1 (refer to **Figure 4-15**). The parallel pipes along the Channel alignment would be installed and buried within the existing Channel. For this alternative turnouts would be required to allow USFWS to obtain the water service required for their existing pumping facilities; however, modifications to each of the USFWS facilities will likely be required.

Site 4 Alternatives - New Vertical Flat Screen Type Intake Facility at San Joaquin River Mile (RM) 84.9

Alternatives for Site 4 would provide for the same type of intake facility and cleaning system as for the alternatives for Site 2 and 3 above, located along the west bank of the San Joaquin River at RM 84.9. However, due to the substantial increase in pipeline alignment length required to convey water from an intake facility at this location, and the probable larger costs associated with substantially longer pipelines and increased headloss as a result, no further analysis has been made for alternatives relating to this site.

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Existing WSID Point of Diversion on San Joaquin River

Site 1

Site 2

Site 3

Site 4

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

West Stanislaus Irrigation District Pumping Plant No. 1

West Stanislaus Main Canal

1,927 ft

6,926 ft

Pond

Well

WSID Intake

Stockton

Manteca

Modesto

Turlock

Merced

San Joaquin River

Stanislaus River

Tuolumne River

Merced River

Riparian Forest (Irrigated)

Riparian Forest (Not Irrigated)

Managed Wetlands

04N 07E 09

04N 07E 10

04N 07E 11

04N 07E 02

04N 07E 01

04N 07E 16

04N 07E 15

04N 07E 14

04N 07E 21

04N 07E 22

04N 07E 23

S.JRNWR

Figure 4-10
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 2C - Conveyance Length: 8,853 ft

Feature of Interest

Flood Control Levee

General Area of Potential Intake

Construction Method

Bury two 78" pipes in new trench.

Re-use Existing Channel

San Joaquin River NWR Landuse

Managed Wetlands

Riparian Forest (Irrigated)

Riparian Forest (Not Irrigated)

Refuge Boundary

0 600 1,200 2,400 3,600 Feet

N

Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 30, 2010

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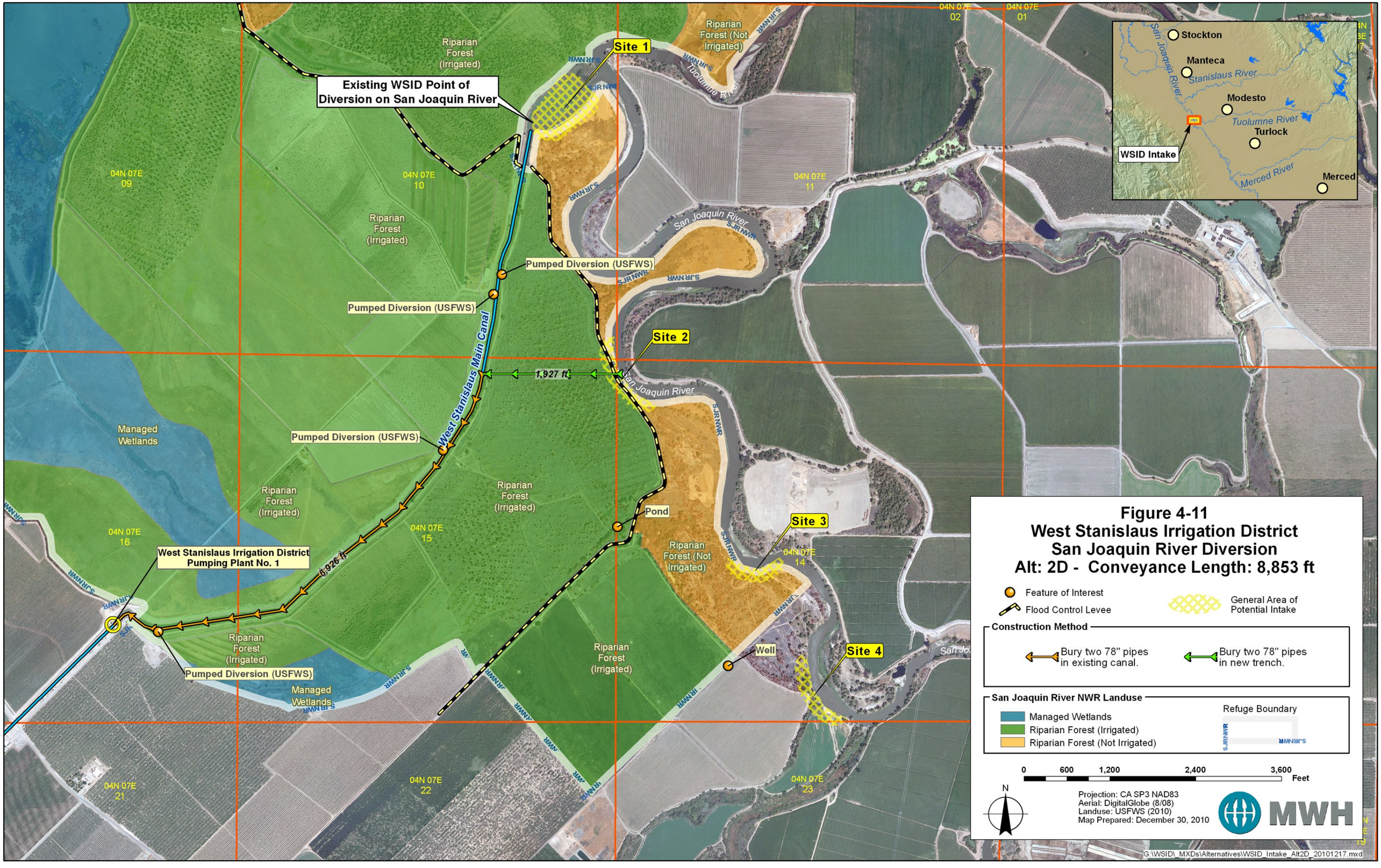
Site 1
Existing WSID Point of Diversion on San Joaquin River
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Site 2
1,927 ft
West Stanislaus Main Canal
San Joaquin River
Managed Wetlands
Pumped Diversion (USFWS)
Riparian Forest (Irrigated)
Riparian Forest (Irrigated)
Pond
Site 3
Riparian Forest (Not Irrigated)
West Stanislaus Irrigation District Pumping Plant No. 1
6,926 ft
Riparian Forest (Irrigated)
Pumped Diversion (USFWS)
Managed Wetlands
Riparian Forest (Irrigated)
Well
Site 4
04N 07E 09
04N 07E 10
04N 07E 11
04N 07E 02
04N 07E 01
04N 07E 16
04N 07E 15
04N 07E 14
04N 07E 21
04N 07E 22
04N 07E 23
S.JRNWR
Tuolumne River
San Joaquin River
Stockton
Manteca
Stanislaus River
Modesto
Tuolumne River
Turlock
WSID Intake
Merced River
Merced
Figure 4-11
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 2D - Conveyance Length: 8,853 ft
Feature of Interest
Flood Control Levee
General Area of Potential Intake
Construction Method
Bury two 78" pipes in existing canal.
Bury two 78" pipes in new trench.
San Joaquin River NWR Landuse
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Refuge Boundary
0 600 1,200 2,400 3,600 Feet
N
Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 30, 2010
MWH
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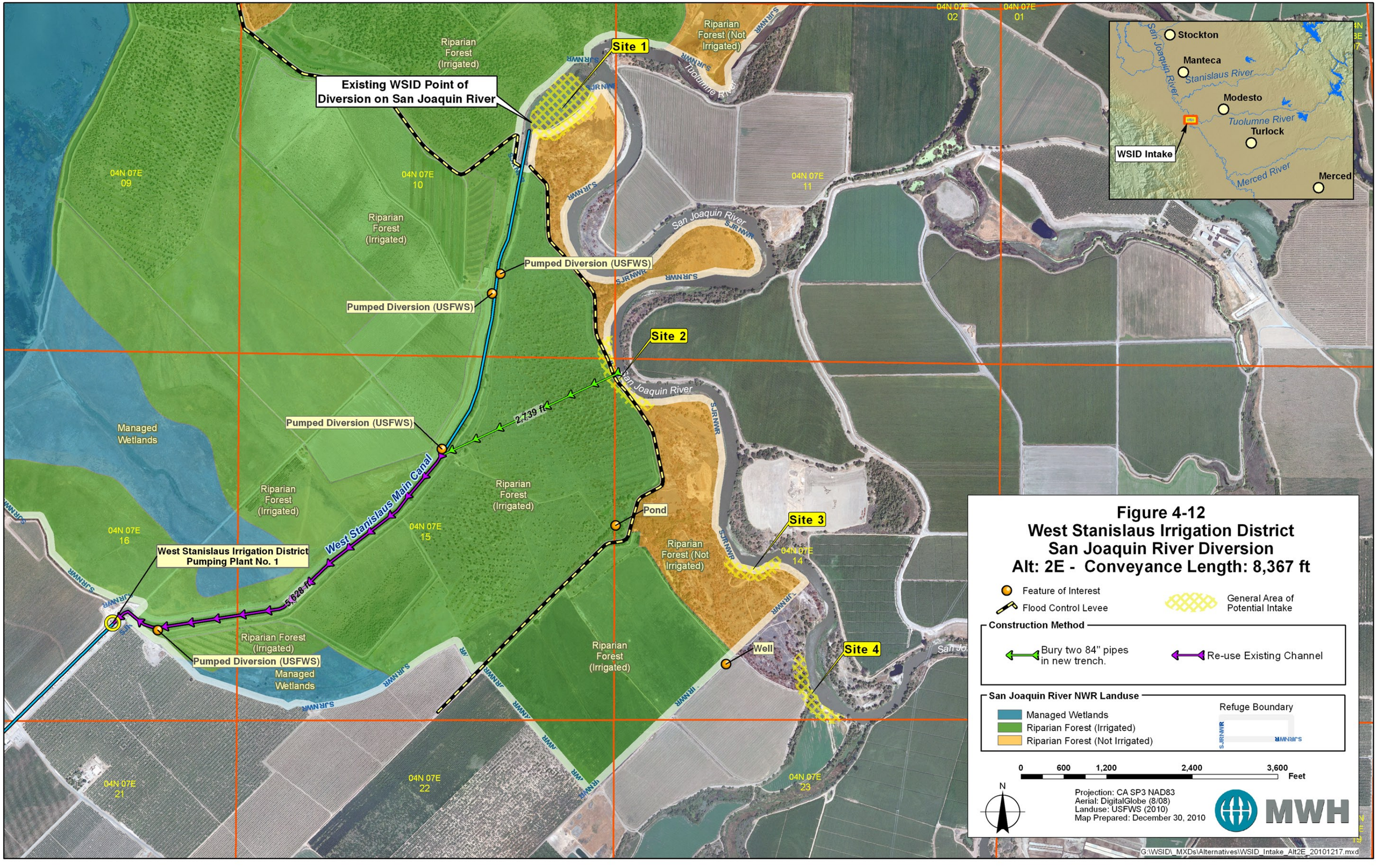
Existing WSID Point of Diversion on San Joaquin River
Site 1
Site 2
Site 3
Site 4
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
2,739 ft
5,628 ft
West Stanislaus Main Canal
West Stanislaus Irrigation District Pumping Plant No. 1
Pond
Well
WSID Intake
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Managed Wetlands
San Joaquin River
Tuolumne River
Stanislaus River
Merced River
Stockton
Manteca
Modesto
Turlock
Merced
04N 07E 09
04N 07E 10
04N 07E 11
04N 07E 02
04N 07E 01
04N 07E 16
04N 07E 15
04N 07E 14
04N 07E 21
04N 07E 22
04N 07E 23
SJRNWR
Figure 4-12
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 2E - Conveyance Length: 8,367 ft
Feature of Interest
Flood Control Levee
General Area of Potential Intake
Construction Method
Bury two 84" pipes in new trench.
Re-use Existing Channel
San Joaquin River NWR Landuse
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Refuge Boundary
0 600 1,200 2,400 3,600 Feet
N
Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 30, 2010
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Existing WSID Point of Diversion on San Joaquin River

Site 1

Site 2

Site 3

Site 4

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

Pumped Diversion (USFWS)

2,739 ft

5,628 ft

West Stanislaus Main Canal

West Stanislaus Irrigation District Pumping Plant No. 1

Pond

Well

WSID Intake

Stockton

Manteca

Modesto

Turlock

Merced

San Joaquin River

Stanislaus River

Tuolumne River

Merced River

Riparian Forest (Irrigated)

Riparian Forest (Not Irrigated)

Managed Wetlands

04N 07E 09

04N 07E 10

04N 07E 11

04N 07E 02

04N 07E 01

04N 07E 16

04N 07E 15

04N 07E 14

04N 07E 21

04N 07E 22

04N 07E 23

SJRNWR

Figure 4-13
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 2F - Conveyance Length: 8,367 ft

Feature of Interest

Flood Control Levee

General Area of Potential Intake

Construction Method

Bury two 84" pipes in existing canal.

Bury two 84" pipes in new trench.

San Joaquin River NWR Landuse

Managed Wetlands

Riparian Forest (Irrigated)

Riparian Forest (Not Irrigated)

Refuge Boundary

SJRNWR

0 600 1,200 2,400 3,600 Feet

N

Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 30, 2010

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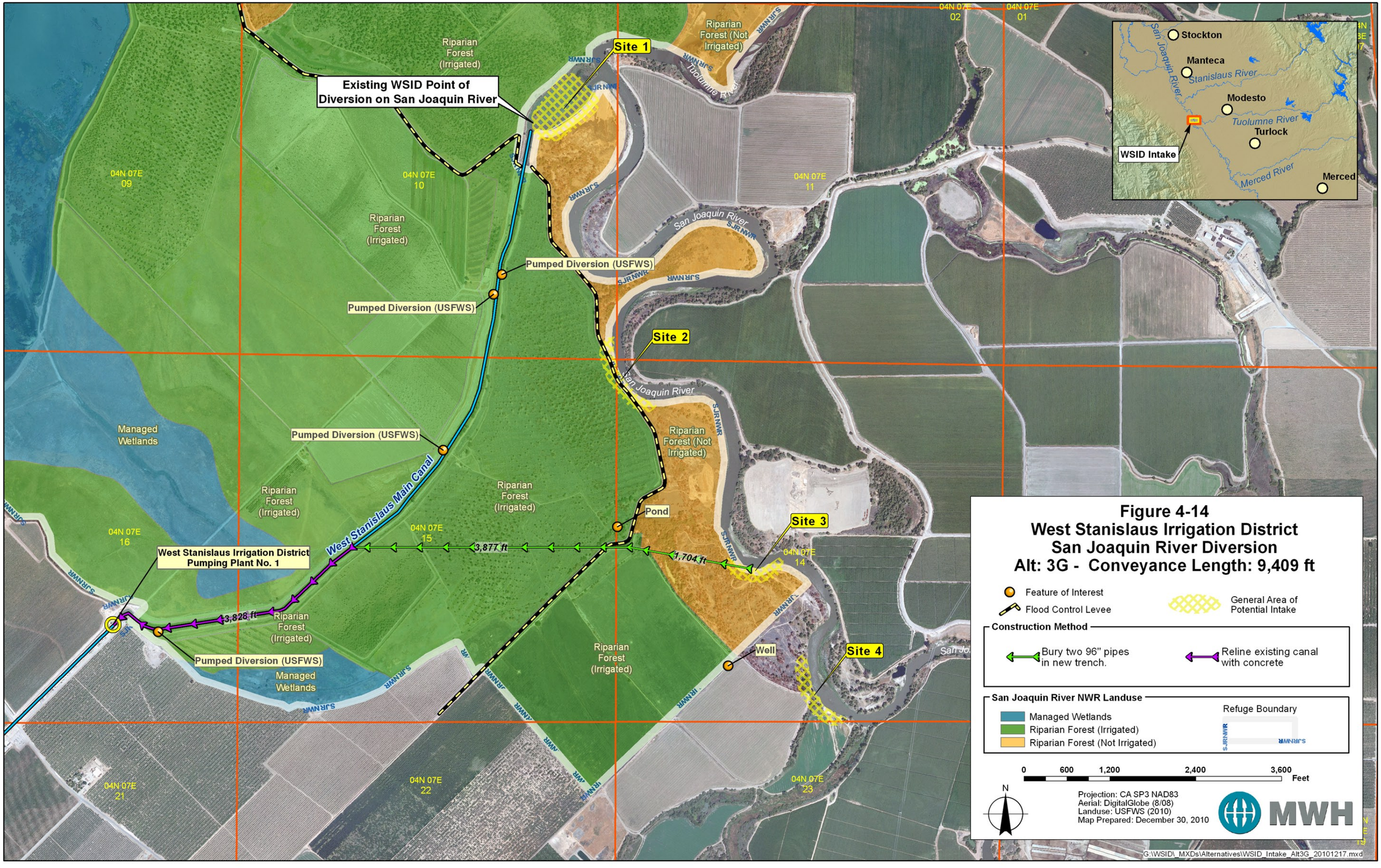
Site 1
Existing WSID Point of Diversion on San Joaquin River
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Site 2
San Joaquin River
Managed Wetlands
Pumped Diversion (USFWS)
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
West Stanislaus Main Canal
Pond
Site 3
3,877 ft
1,704 ft
West Stanislaus Irrigation District Pumping Plant No. 1
3,828 ft
Riparian Forest (Irrigated)
Pumped Diversion (USFWS)
Managed Wetlands
Riparian Forest (Irrigated)
Well
Site 4
04N 07E 09
04N 07E 10
04N 07E 11
04N 07E 02
04N 07E 01
04N 07E 16
04N 07E 15
04N 07E 14
04N 07E 21
04N 07E 22
04N 07E 23
Stockton
Manteca
Stanislaus River
San Joaquin River
Modesto
Tuolumne River
Turlock
WSID Intake
Merced River
Merced
Figure 4-14
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 3G - Conveyance Length: 9,409 ft
Feature of Interest
Flood Control Levee
General Area of Potential Intake
Construction Method
Bury two 96" pipes in new trench.
Reline existing canal with concrete
San Joaquin River NWR Landuse
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Refuge Boundary
0 600 1,200 2,400 3,600 Feet
N
Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 30, 2010
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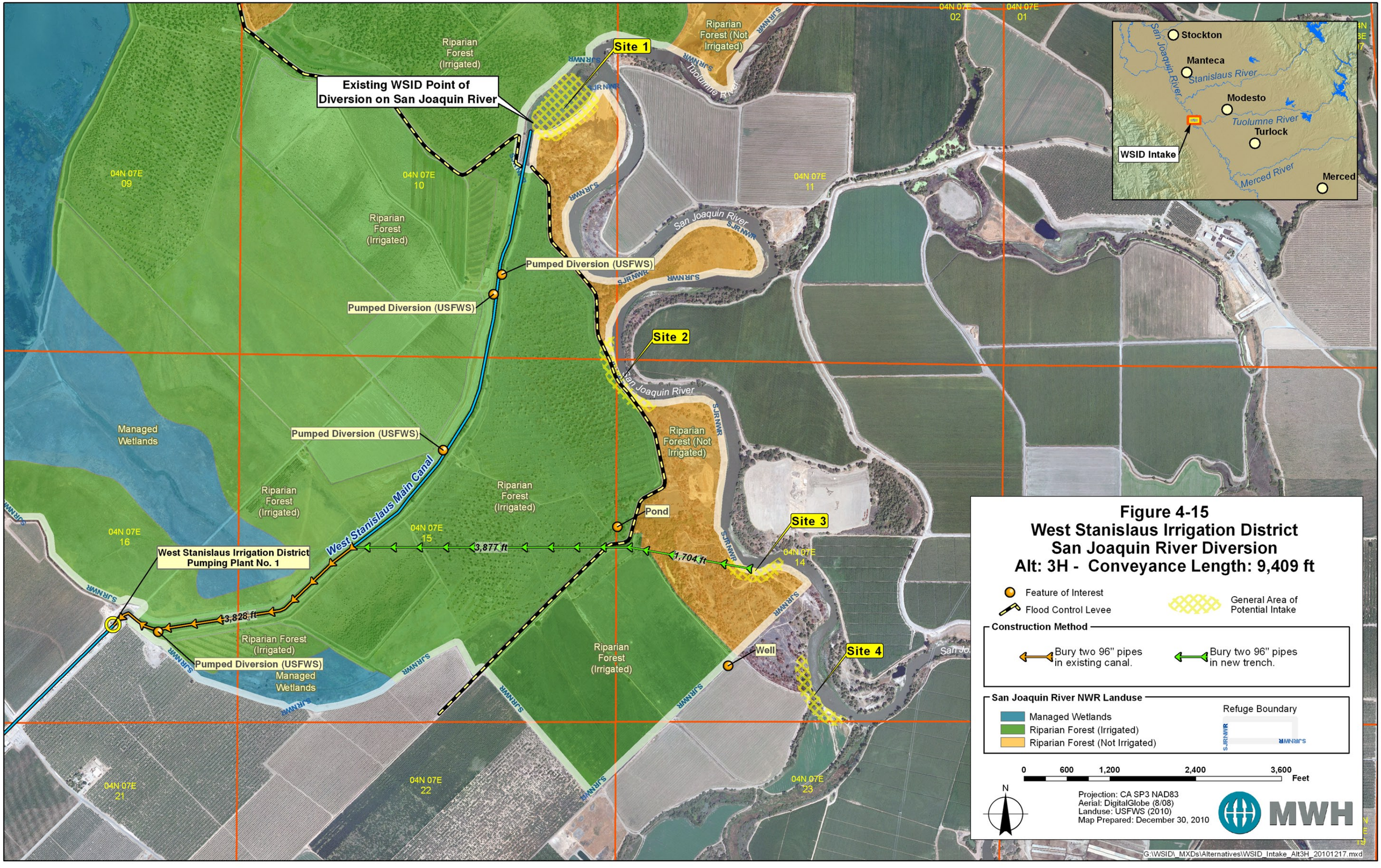
Site 1
Existing WSID Point of Diversion on San Joaquin River
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
04N 07E 09
04N 07E 10
04N 07E 11
04N 07E 02
04N 07E 01
Pumped Diversion (USFWS)
Pumped Diversion (USFWS)
Site 2
San Joaquin River
Tuolumne River
SJRNWR
Managed Wetlands
Pumped Diversion (USFWS)
West Stanislaus Main Canal
Pond
Site 3
04N 07E 16
04N 07E 15
04N 07E 14
3,877 ft
1,704 ft
West Stanislaus Irrigation District Pumping Plant No. 1
3,828 ft
Pumped Diversion (USFWS)
Well
Site 4
04N 07E 21
04N 07E 22
04N 07E 23
Stockton
Manteca
Stanislaus River
Modesto
Tuolumne River
Turlock
WSID Intake
Merced River
Merced
Figure 4-15
West Stanislaus Irrigation District
San Joaquin River Diversion
Alt: 3H - Conveyance Length: 9,409 ft
Feature of Interest
Flood Control Levee
General Area of Potential Intake
Construction Method
Bury two 96" pipes in existing canal.
Bury two 96" pipes in new trench.
San Joaquin River NWR Landuse
Managed Wetlands
Riparian Forest (Irrigated)
Riparian Forest (Not Irrigated)
Refuge Boundary
0 600 1,200 2,400 3,600 Feet
N
Projection: CA SP3 NAD83
Aerial: DigitalGlobe (8/08)
Landuse: USFWS (2010)
Map Prepared: December 30, 2010
MWH
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SECTION 5 – PROJECT COSTS

INTRODUCTION

This section presents planning level cost estimates for each of the three final alternatives. The three final alternatives represent the lowest scoring alternatives for each of the sites evaluated (refer to Section 6). The estimated project costs are for the current year (2010) and have not been inflated to the time of estimated construction (2012). Operation and maintenance costs have been estimated. Lifetime project costs have also been estimated, and are based on a net interest (discount) rate of 3 percent (inflation rate of 3 percent, interest rate of 5 percent), and a fish screen life expectancy of 50 years.

In considering the cost estimates, it is important to realize that changes during final design as well as changes in scope and the cost of materials, labor, and equipment will result in comparable changes in the cost estimates presented in this report.

COST ESTIMATES

Planning level construction cost estimates for Alternatives 1B, 2C and 3G are summarized in **Table 5-1**. Alternative 4 was not carried further into a full evaluation because of location and the potential that this site would be unprotected against less than 100 year flood. At the planning level of project development a Class 4 level opinion of probable cost was prepared for each alternative.

Class 4 construction cost estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. Typically, engineering is 10% to 40% completed. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Virtually all Class 4 estimates use stochastic estimating methods such as cost curves, capacity factors, and other parametric and modeling techniques. Expected accuracy ranges are from -15% to - 30% on the low side and +20% to 50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. Preparation of the Class 4 construction cost estimate follows the procedures and protocol of AACE International Recommended Practices and Standards estimating methodology.

Detailed construction cost estimates for the three alternatives are presented in Appendix E. The estimates include expenditures for direct construction costs, indirect construction costs, design and management costs. Direct construction costs include the materials, labor, and services necessary to build the proposed project based on the alternatives as described in the previous section. Indirect construction costs account for the contractor's mobilization/demobilization, insurance/bonds, and overhead and profit. Design, legal, administrative and management costs encompass a variety of items including project administration/management, planning/predesign, design, environmental documentation, permits/legal fees, construction management, and startup/testing and monitoring. These costs have been estimated at 25% of the estimated construction cost for each alternative.

O&M costs include daily, monthly, and annual labor and materials costs as well as power costs. The cost of O&M for a new facility is based on an assumed number of hours required and on a labor rate of $69.00 per hour. It was also assumed that the existing District Main Lift Station No. 1 would remain in operation continuously for the irrigation season 8-month period from March through October.

O&M assumptions included 74 hours per month for periodic, monthly and annual maintenance on equipment for each alternative. Note that Alternative 1B includes a higher cost for O&M due to pumping to return fish to the river, all other alternatives will have sedimentation pumps and a screen cleaning system that will require annual power costs.

Table 5-1
Planning Level Cost Estimates for the Final Alternatives

	Alternative 1B V- Screen Intake	**Alternative 2C Intake**	**Alternative 3G Intake**
Mobilization	$1,390,000	$1,580,000	$2,180,000
Access Road/Civil Work	$2,249,300	$1,823,200	$1,570,700
River Diversion Fish Screen Intake	$15,183,200	$14,823,600	$15,029,400
Conveyance Facilities	$0	$3,120,000	$10,713,600
Subtotal	**$18,822,500**	**$21,346,800**	**$29,493,000**
Contingency (10%)	$1,740,000	$1,980,000	$2,730,000
Total Direct Construction Cost	$20,560,000	$23,330,000	$32,220,000
Construction Oversight (10%)	$2,056,000	$2,333,000	$3,222,000
Eng/Admin/Legal (10%)[(1)]	$1,644,800	$1,866,400	$2,577,600
Permitting/Planning/ Procurement (5%)[(2)]	$616,800	$699,900	$966,600
Estimated Project Cost	**$24,880,000**	**$28,200,000**	**$39,000,000**
O&M (Estimated Annual Cost)	$80,772	$63,772	$63,772
O&M (Present Worth)	$2,699,129	$2,131,046	$2,131,046

Notes:
(1) Includes preliminary and final design.
(2) Assumes CEQA/NEPA with FONSI/NEG DEC.

SECTION 6 – EVALUATION AND RECOMMENDATIONS

INTRODUCTION

Evaluation of the alternatives has shown in some cases that the relationship of one site to another makes differentiation of the impacts difficult related to the criteria. This is especially the case when reviewing the environmental considerations for this project. There are however distinctions between alternative sites as compiled in the remainder of this section that provides a clear recommendation of a preferred alternative.

As stated in Section 4, Alternative 4 was dropped from further evaluation. Variations of the three alternatives carried forward have been evaluated based on the following criteria:

- Resource Protection/Potential Environmental Impacts
- Geomorphology/Sediment/Scour & Bank Stabilization
- Maintaining Water Supply
- Operation and Maintenance
- Estimated Cost

Resource protection and potential environmental impacts includes evaluation of adverse effects of the facility construction and operation on the environment. The type of fish screen, location and necessary construction of the intake and conveyance is evaluated for impacts to the environment. This criterion evaluates how well the alternatives meet the requirements for fish protection in the river in relation to terrain of a over-riverbank facility with periodic flooding. This layout would dictate the type of habitat to be maintained on the SJRNWR.

Geomorphology/Sediment/Scour & Bank Stabilization influence a suitable intake location in relation to long term riverbank stability and operational issues with sediment loading and river scour in the streambed.

Water supply considers the effect that each alternative has on the San Joaquin River flow and the diversion capability.

Operation and maintenance considers the ease of maintaining and the cost of operating the facility. Operational considerations include the complexity of operation and maintenance, and the relative amount of operating time and required maintenance.

The estimated construction cost criterion includes estimated costs including engineering, legal, administration, and construction management.

The relative advantages and disadvantages among the alternatives with respect to each criterion are discussed below.

EVALUATION

Resource Protection/Environmental Impact

The eight alternatives evaluated are located at three different sites with two differing types of fish screen technologies. Alternatives at Site 1 utilize opposing vertical flat plate wedge wire screens which span the width of a channel and directs flow into a progressively narrowing configuration the length of which is comprised of screen material as side walls. Alternatives at Site 2 and Site 3 utilize flat plate vertical wedge-wire screens that are oriented parallel to river flow constructed along the bank of the river. Alternatives at a given site vary in terms of specific conveyance methods that include buried pipe and open channel combinations as described in Chapter 4.

Fisheries

As a result of their close proximity and similarity of aquatic habitat conditions, adverse effects for intake construction would be comparable for all alternative intake sites. It is expected that impacts to fishery resources and aquatic habitat due to the construction and operation will be reduced to a level that is less than significant for each of the project alternatives through implementation of Best Management Practices (BMPs) to avoid adverse impacts to fish and aquatic habitat. In terms of direct comparison between alternatives presented, the environmental impact from a fisheries standpoint will be less at Site 1.

Terrestrial Wildlife

The purpose of review of the Terrestrial Wildlife is to identify the biological resources that exist in the study area and discuss how their occurrence may affect alternative selection for future consideration. Evaluation of the impact of construction of an intake facility at the various sites utilized a level of constraint as described below:

High Constraint – The project implementation could result in direct impacts to sensitive species or habitats and directly impact a moderate to high amount of habitat relative to the other project alternatives.

Moderate-high Constraint – The project implementation could result in direct impacts to sensitive species or habitats and directly impact a small amount of habitat relative to the other project alternatives.

Moderate Constraint – The project implementation could directly impact common wildlife, result in temporary indirect impacts to protected species such as nesting raptors, and directly impact a moderate to high amount of habitat relative to the other project alternatives.

Moderate-low Constraint – The project implementation could directly impact common wildlife, result in temporary indirect impacts to protected species such as nesting raptors, and directly impact small amount of habitat relative to the other project alternatives.

Low Constraint – The project implementation would not directly or indirectly impact biological resources.

The ranking of alternatives based on the Terrestrial Wildlife is below:

Alternative 1A, 2D, 2E, 2F, 3G, and 3H – these alternatives are expected to have constraint levels ranging from moderate-high to high on habitat and species.

Alternative 1B – Alternative 1B is expected to have a constraint level of moderate low on habitat and species.

Alternative 2C – Alternative 2C is expected to have a constraint level of moderate on habitat and species.

Cultural Resources

The following is a summary of the findings and an evaluation of alternatives related to archival research into the existence of cultural resources in the study area.

Alternative Site 1 – There are two archaeological sites (CA-STA-395 and CA-STA-34) located within close proximity of this site west of the river. Indications are that this general area was occupied by Native American in prehistoric and historic times. While this project site is in closest proximity to these archaeological sites, it may be best suited because it will result in the least amount of ground disturbance since it is reusing existing disturbed areas such as the channel for conveyance. The 50 foot deep channel is likely far below any archaeological deposit that may have once existed.

Alternative Sites 2 & 3 – One archaeological resource was recorded adjacent to the southernmost pipeline alignment for this alternative. This resource is a concrete pad possibly linked to 20th century agricultural practices related to buildings/structures no longer standing but depicted in 1952 topographic mapping. This resource will require formal evaluation as a part of the CEQA and/or Section 106 process. In addition, since this alternative has a below grade pipeline that is currently covered with heavy vegetation, the alignment will need to be cleared and surveyed as a part of the CEQA and/or Section 106 process. If archaeological resources are identified during the survey, then a formal evaluation and impacts analysis will be conducted including a subsurface investigation.

Geomorphology/Sediment/Scour & Bank Stabilization

Geomorphology, sediment, scour & bank stabilization are important to the long term operational stability of the fish screened intake. As was stated previously the proximity of some of the sites offers little in the way of differentiation, but river meandering, river cross section and river velocity is different enough to be used in the final evaluation and recommendations.

Site 1

This is the present diversion site. The river channel appears stable at this site, but it is an inferior location for reasons of sediment withdrawal and sediment deposition within the intake channel. **Figure 6-1** shows the benefit of locating an intake on the outside bend of an alluvial river channel. The secondary currents move the coarser sediment (the bedload) away from the bank and towards the opposite bank.

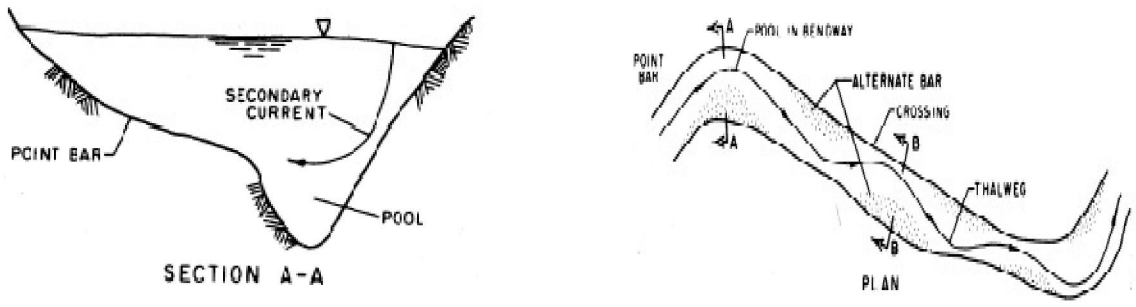

Figure 6-1
Alluvial River Channel Outside Bend Conditions

Site 1 does not have this attribute and therefore will always take a disproportionate amount of coarser sediment.

Site 2

This site appears the most stable of the alternatives. The bank shows no movement from 1994 to 2008 and there is no indication of migration of the river bend. There is some rock (most likely cobbles) in the levee embankment. There is some erosion upstream and downstream of the riprap section. The site meets the criteria of preferred hydraulic conditions to minimize sediment intake.

Site 3

The bank at this site is actively eroding. The map comparison indicates that the bend is migrating at a substantial rate. Although the intake conditions would be acceptable at the lower end of the curve, a large amount of riprap would be required to stabilize the bend.

Site 4

This site actively eroding and is migrating. Again, a great deal of bank stabilization would be required to make this an acceptable location.

Sediment

Taber Consultants (2004) completed size distribution analyses of 5 samples from two borings at the Patterson Irrigation District project site. The Patterson Irrigation District site is located approximately 10 miles northwest of the District's existing diversion and is considered representative for the District's diversion site. The samples from one boring were at approximate elevations 30, 25, 10, and –15 feet. Streambed elevation at this site is approximately 26 feet.

Size distributions of the bed material are shown on in **Figure 6-2**; the USGS data (four random samples) and the Mussetter data for this reach. It can be concluded that the D50 of the streambed material at the site is about 0.4 mm. A more definitive analysis will have to await the results of geotechnical investigations at depth at the chosen site. It can be concluded that the diversions at all sites will carry a substantial sand load from the channel bed material.

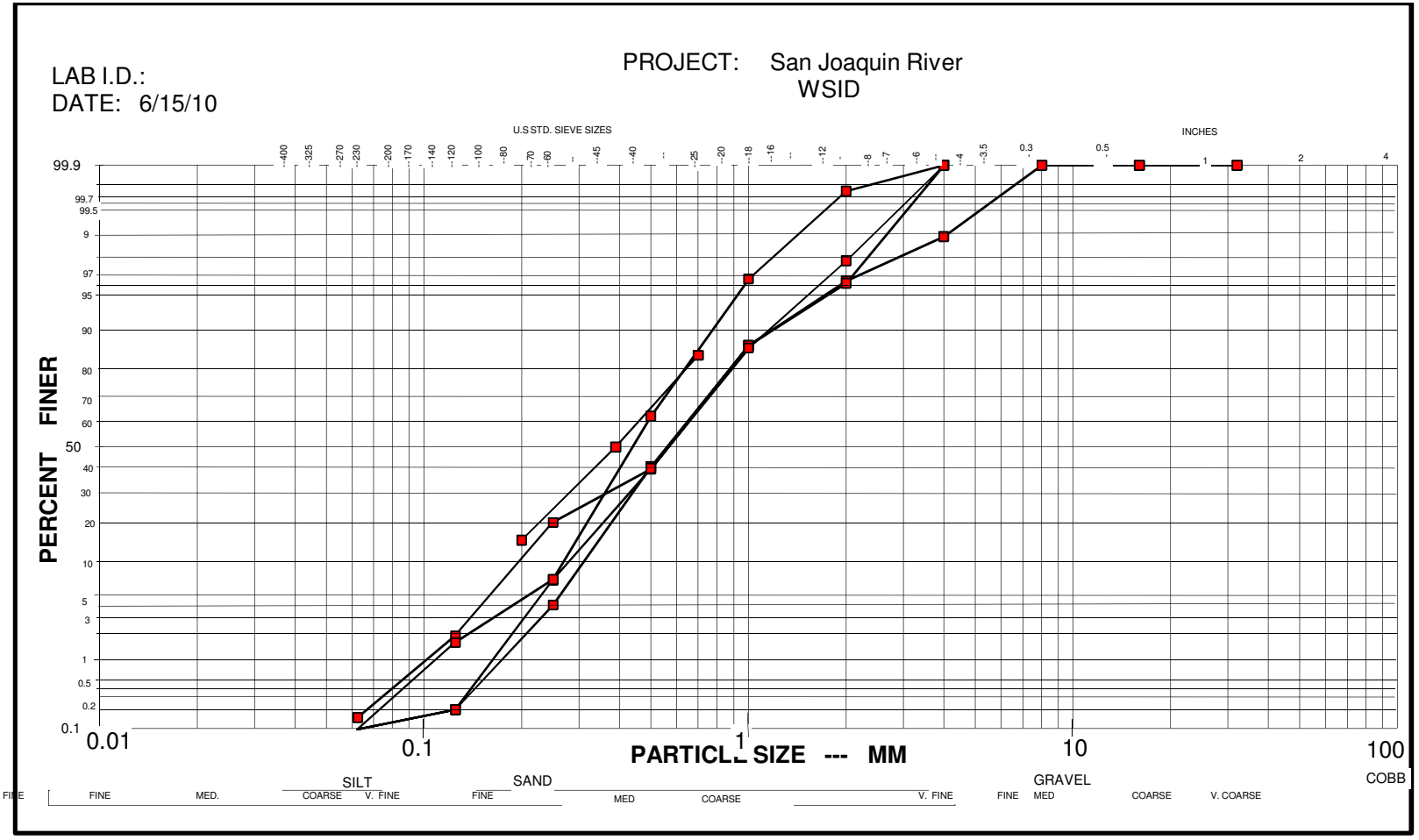

Figure 6-2
Bed Material Size Distribution

Scour Analysis

Most estimates of potential scour are made with the use of empirically developed formulae based on observed scour in laboratories and field installations (USBR, 1984).

Blench (1969) proposed a series of equations that may be used to predict scour in natural streambeds and at structures built on the stream. For scour at bankline structures in reaches with mild channel approach angles, the equation is:

ds = 0.6 q2/3 / Fbo1/3
in which:

ds = Depth of scour below streambed in feet
q = Discharge per unit width, ft3/s/ft
Fbo = A "bed factor" related to the D50 of the streambed material

Lacey (1930) developed the following relationship for bankline structures in reaches with moderate bends:

ds = 0.5 (Q/f) 1/3
in which:

ds = Depth of scour below streambed , feet
Q = Design flood discharge, ft3/s f =
1.76 (D50)0.5, a "silt factor"

The Blench equation is more applicable to this site because the levee and the existing structure have altered the natural hydraulic relationships between main channel and overbank flow.

The final depth of scour prediction will have to await the results of a hydraulic model of the river reach at the selected site for the design flood and the results of size gradations of the foundation material at depth. We can, however, draw some comparative conclusions based upon the analysis at the diversion site and the relative channel differences between the alternate sites in this project.

The predicted depth of scour at the diversion site for the passage of the 100-year flood was 20 feet. This number was slightly greater than what would be expected from the bed material samples due to the discovery of finer material at depth.

Protection

The California Division of Highways (1979) developed a procedure for estimating the size of riprap required for protecting riverbanks and shorelines. This procedure is described in a publication entitled, Bank and Shore Protection in Highway Practice. It is a nomograph procedure, which utilizes the following parameters:

- Specific gravity of the riprap
- Bankline side slope
- Main channel velocity
- Degree of impingement

At the PID diversion site the required rock size was a D50 of 12 inches and a blanket thickness of 24 inches as shown in **Figure 6-3**. A comparable level of protection is anticipated at each of the sites. Again the final sizing of the riprap will have to await the hydraulic studies at the selected site and the designer's selection of the bankline slope.

Intake location

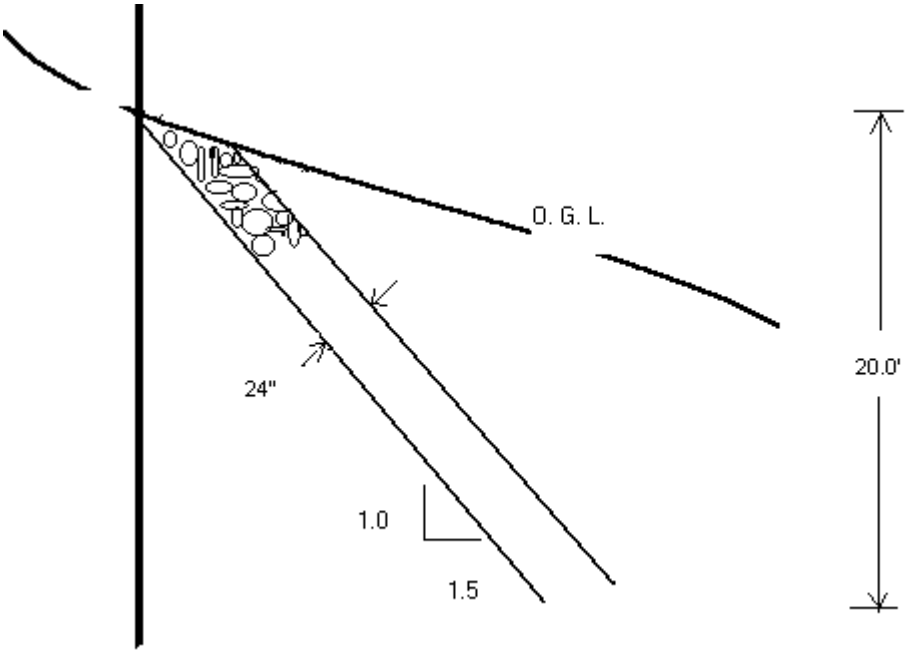

Figure 6-3
Bank Protection Recommendation

Water Supply

The District has the capacity to divert 262 cfs of water for irrigation from the San Joaquin River between Mendota Pool and Vernalis in accordance with their License Number 3957 (Permit 2758, Application 1987). The District also is under a 1939 agreement to divert 45 cfs of irrigation water at its diversion point on the San Joaquin River for irrigation of riparian land adjacent to the district, known as the White Lake Mutual Water Company. In addition, USFWS has a 40 cfs riparian habitat water right that is fulfilled through their pumps within the same channel that conveys the District flows.

The District's Point of Diversion is described as north twenty nine degrees fifty minutes east (N29d50E), nineteen thousand two hundred ninety (19,290) feet from W 1/2 corner of Section 28, T4S, R7E, Mount Diablo Base and Meridian (MDB&M), being within the SE 1/ NE 1/ of Section 10, T4S, R7E MDB&M. This Point of Diversion is tied to this water right, a change in the location of this diversion would require submitting a petition to the State Water Resources Control Board. This type of application would require a lengthy review process of past and current pumping and has the potential to change certain provisions of the Districts' water right. This type of process would be necessary for all alternatives with the exception of Alternatives

1A and 1B. The District has stated that they would not be interested in changing their current point of diversion specifically related to a change in their water right in addition to their customer base being very familiar with the current water quality and look to the District for consistency in supply and quality.

The alternatives under evaluation will be susceptible to low streamflow conditions in the San Joaquin River. The ability for the Intake Fish Screen to convey the District's allocation of 262 cfs, USFWS Riparian Water Right of 40 cfs and White Lake's contract amount of 45 cfs can only be met if there are sufficient flows in the San Joaquin River. This is independent of the location and the type of fish screen constructed. Location of the intake will not overcome those special cases of drought or natural catastrophe that impact normal operation.

As was discussed previously, in past years there have been conditions where the District has been unable to take diversion flows due to hydraulic impediment. At times the amount of sediment has been significant to partially obstruct the mouth of the shared channel and the District has diverted less than required for their customer deliveries and been forced to supplement with more expensive water supplies.

The vertical flat plate V-screens in Alternative 1 would be located in the shared channel and would be less of an encroachment into the San Joaquin River. This type of screen in theory has a limited exposure.

Encroachment of the fish screened intake into the river cross section may have some slight impact on flood flows. Alternatives at Sites 2 & 3 consist of a vertical flat plate screen intake structure that is constructed into the bank of the river. In order for this style of fish screen to operate correctly it must rely on a minimum water surface elevation and depth of water to divert by gravity. This type of screen construction is parallel to the flow of the river so it does not obstruct river flow and takes flow by a sidestream diversion.

Likely all of the alternatives would be impacted by flood flows. From the Philip Williams & Associates San Joaquin River National Wildlife Refuge Phase 2 Habitat Implications of Levee Breaching Alternatives Study dated April 1, 2004, it appears that this District and USFWS shared channel would be a main source for conveyance of flood flows. This would create a condition where Alternatives at Site 1 would construct a fish screen in the conveyance channel and this could damage fish screens when flood flows occur in the channel. Alternatives at sites 2 & 3 are parallel to flow and would also be impacted by flood levels but not to the degree of Alternatives at site 1.

Alternatives at sites 2 & 3 would experience river velocities assisting with creation of sweeping velocities but would have to be mitigated in design to avoid riverbank scour. Prior to selection of an alternative, river modeling should be performed to verify impacts of the structure on river elevation at flood stage.

Operation & Maintenance

Different types of fish screens have been evaluated for the project including a V-type screen and vertical wedgewire screen. Alternatives at site 1 utilize the V-type while Alternatives at sites 2 &

3 utilize the vertical flate plate screens. The flat plate fish screens would be significantly easier to remove and inspect than the fish screens in Alternative 1.

The configuration of the facility carefully considers location of equipment related to intended use, access to equipment, safety, routing of conduit and location of power source. Protection of fish screens and mechanical equipment are key concerns in maintenance of the proposed facility. Having equipment on the bank of the river, such as Alternatives at sites 2 & 3, is preferred due to the powerful forces that can be generated in the river. However, design layout that prevents access of the public to equipment inherently makes it less susceptible to vandalism.

All of the alternatives would use a brush cleaning system on the face of the screens periodically to keep debris from clogging the screen openings. Alternatives at sites 1 would require a dual brush cleaning system since this option has two sets of screens on each side of the triangular configuration that makes up the Vee-type screen. Alternatives at sites 2 & 3 would rely on a single brush cleaning system for the screen that is the most favorable cleaning system because it is one directional and simple to operate.

All alternatives would require sediment control systems to maintain a clear opening from river bed sediment. The frequency of use would have to be determined after further study of the project site conditions.

Estimated Costs

The cost for Alternative 1B includes a Vee-type screen configuration with vertical screens and intake gate structure and a fish return pump system. This alternative would be constructed in the District's and USFWS shared channel with temporary cofferdam and a pile supported concrete superstructure. Alternative 1B also includes conveyance to the District's Main Lift Station No. 1 in the existing shared channel. The opinion of probable construction costs for this alternative is $20,560,000 and overall program cost is $24,880,000.

Alternative 2C is a flat vertical wedgewire screen intake parallel to river flow with temporary cofferdam and a pile supported concrete superstructure with a log boom for facility protection. This alternative includes 2,000 feet of dual 78-inch diameter gravity pipelines and 7,000 feet of improvements (clearing and regrading) to the existing shared District and USFWS channel conveying water to the existing District Main Lift Station No. 1. The opinion of probable construction costs for this alternative (rounded) is $23,330,000 and overall program cost is $28,200,000.

Alternative 3G is a flat vertical wedgewire screen intake parallel to river flow with temporary cofferdam and a pile supported concrete superstructure with a log boom for facility protection. This alternative includes 5,500 feet of dual 96-inch diameter gravity pipelines and 3,900 feet of improvements to the existing shared District and USFWS channel conveying water to the existing District Main Lift Station No. 1. The opinion of probable construction costs for this alternative is $32,220,000 and overall program cost is $39,000,000. This increase in cost is because of the additional conveyance channel being placed in pipe reducing the open conveyance channel.

Refer to Appendix E for the Class 4 (AACE) cost estimates.

SUMMARY

Evaluation of the criteria described for each of the alternatives was completed and inserted into an evaluation summary matrix (refer **Table 6-1**). This matrix describes each of the alternatives and how each of the criteria was evaluated specific to the location of the intake, the type of screen and the conveyance option. Similarly, **Table 6-2** summarizes the evaluation, ranking, weight and scoring of the alternatives in comparison to the other alternatives with low overall scores reflective of a favorable evaluation. This table reflects weighting factors as input from the District and those that were evaluated based on the studies completed regarding feasibility. **Table 6-2** shows that Alternative 1B scores the lowest and based on the weight and ranking is the preferred alternative.

RECOMMENDATION

Any of the alternative locations and types of fish screen described in this study will meet the design criteria for the proposed project. Of the alternatives evaluated, the least expensive to construct based on the Class 4 cost estimate per AACE guidelines is Alternative 1B. This alternative however is not as well suited in terms geomorphology since it is in an inferior location from a sediment movement and sediment deposition standpoint. This in turn may require that the District implement a maintenance program to prevent impact from sediment accumulation. Additional concern regarding this site is the probability of flood flows conveyed in the shared channel behind the fish screen and the likelihood that fish would become trapped by the fish screen that is suppose to protect them. The area would have to be leveed to prevent flood waters from entering the channel to protect against fish entrapment. This site does have the benefit of Tuolumne River water raising the water surface elevation when the San Joaquin has lower flows, this benefit would also apply to Alternative 2C but to a slightly lesser degree.

The Alternative 1B site will require substantial civil site work and sheet pile retaining wall construction which increase the cost and complexity. Lastly, this alternative also includes a fish return pumping facility which requires handling of fish and adds an annual pumping cost and maintenance to the O&M for the District and is the highest cost on a present worth analysis.

Alternative 1B does have three distinct advantages over the other locations and conveyance options presented. The first advantage is the location of the fish screen which would remain at the current point of diversion for the District. Selection of this location would not involve a potentially lengthy and laborious process of submitting for a change in the point of diversion. Secondly, this location has provided the District's customer base with a consistent level of water quality for which they have become very familiar. Lastly, the extension of power lines, access road and conveyance would be located within the District's existing easement.

Environmentally, the locations of the evaluated sites are relative close to one another and share similarity of aquatic habitat conditions. The research for this project shows that Alternative 1B would have the least impact by only a small margin.

Table 6-1
West Stanislaus Irrigation District
Alternative Comparison Matrix

Alt	Description	Available Power	Access	USFWS Provisions	Pro	Con
1A	Alternative 1A construction of a fish screen at the location of the existing diversion channel to WSID Main Lift Station No. 1. The fish screen is a Vee-screen type with a fish return line delivering fish downstream of the confluence of the Toulumne River. This alternative includes conveyance through two 96-inch diameter pipelines located in the existing channel to be direct buried with infill of the channel. Approximately 10,400 feet of dual pipeline would be required for this alternative.	Above ground power lines would be installed within the District Right of Way to provide District negotiated power. A total of 10,400 feet of power lines required for power to operate the fish screen, brush cleaning system and ancillary components.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 10,500 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This pressure pipe alternative would allow for a direct tap with pressure reduction from the mainline pipe without the need for pumping.	No change in point of diversion. Solution for channel entrapment. No change in water quality. Very little impact to current USFWS pumping and below ground facilities. Stable site.	Sandy soils and difficult construction. Sediment issue at intake. Handling fish with return pumping. Sediment in buried pipe. Expensive option.
1B	Alternative 1B construction of a fish screen at the location of the existing diversion channel to WSID Main Lift Station No. 1. The fish screen type is a V-Screen type with a fish return line delivering fish downstream of the confluence of the Toulumne River. This alternative includes conveyance in the existing channel, channel improvements include dredging and subgrade stabilization. Additional improvements involve construction of three bridges across the channel for vehicle access and support for culvert piping to convey flood waters.	Above ground power lines would be installed within the District Right of Way to provide District negotiated power. A total of 10,400 feet of power lines required for power to operate the fish screen, brush cleaning system and ancillary components.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 10,500 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This open channel alternative would allow for resumption of existing operation for USF&WLS for irrigation to existing trees and habitat.	No change in point of diversion. Solution for channel entrapment. Least expensive option. No change in water quality. Stable site.	Sandy soils and difficult construction. Sediment issue. Handling fish with return pumping.
2C	Alternative 2C construction of a fish screen at Site 2 upstream of the existing WSID Diversion. The fish screen type is vertical flat plat screen parallel to flow along the banks of the San Joaquin River. This alternative includes conveyance through two 78-inch diameter pipelines extending westerly from the pump station to the existing channel. Approximately 1,950 feet of dual pipeline constructed in a new trench would intersect at the existing channel. At the channel, the inpipe pressure system will transition to 6,950 feet of gravity conveyance in a newly concrete lined channel (existing) to the existing WSID Lift Station No. 1.	Above ground power lines installed both within the District Right of Way and below ground to provide District negotiated power. A total of 8,900 feet of power lines to operate the fish screen, brush cleaning system and ancillary components. Approximately 6,950 feet above grade in the District's Right of Way and 1,950 in buried conduit across USFWS lands.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 9,000 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This pressure pipe and open channel alternative would require extension of small diameter piping for two locations (and pressure reduction) with two locations retaining normal pumped operation.	Stable site with bank improvements. Consistent sweeping velocities. Would allow for USFWS wildlife enhancement by partial burying of existing channel.	Change in point of diversion. Potential change in water quality. Cost of alternative. Requires right of way acquistion or an easement. Trenching through existing USFWS Infrastructure. Longer distance for power service. Longer distance for access roadway. Added piping for USFWS pumps. Sediment in buried pipe.
2D	Alternative 2D construction of a fish screen at Site 2 upstream of the existing WSID Diversion. The fish screen type is vertical flat plat screen parallel to flow along the banks of the San Joaquin River. This alternative includes conveyance through two 78-inch diameter pipelines extending westerly from the pump station to the existing channel. Approximately 1,950 feet of dual pipeline constructed in a new trench would then intersect the existing channel with dual pipe continuing an additional 6,950 feet using the existing channel as a trench.	Above ground power lines installed both within the District Right of Way and below ground to provide District negotiated power. A total of 8,900 feet of power lines to operate the fish screen, brush cleaning system and ancillary components. Approximately 6,950 feet above grade in the District's Right of Way and 1,950 in buried conduit across USFWS lands.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 9,000 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This pressure pipe alternative would allow for a direct tap for two locations where pumping occurs and would require extension of small diameter piping for the remaining two locations all with pressure reduction from the mainline pipe without the need for pumping.	Stable site with bank improvements. Consistent sweeping velocties. Would allow for USFWS wildlife enhancement by full burial of existing channel.	Change in point of diversion. Potential change in water quality. Cost of alternative. Requires right of way acquistion or an easement. Trenching through existing USFWS Infrastructure. Longer distance for power service. Longer distance for access roadway. Added piping for USFWS pumps. Sediment in long buried pipe.

Table 6-1
West Stanislaus Irrigation District
Alternative Comparison Matrix

Alt	Description	Available Power	Access	USFWS Provisions	Pro	Con
2E	Alternative 2E consists of construction of a fish screen at Site 2 upstream of the existing WSID Diversion. The fish screen type is vertical flat plat screen parallel to flow along the banks of the San Joaquin River. This alternative includes conveyance through two 66-inch diameter pipelines extending westerly from the pump station to the existing channel. Approximately 2,750 feet of dual pipeline constructed in a new trench would intersect at the existing channel. At the channel, the inpipe pressure system will transition to 5,650 feet of gravity conveyance in a newly concrete lined channel (existing) to the existing WSID Lift No. 1.	Above ground power lines installed both within the District Right of Way and below ground to provide District negotiated power. A total of 8,400 feet of power lines required for power to operate the fish screen, brush cleaning system and ancillary components. Approximately 5,650 feet above grade in the District's Right of Way and 2,750 would be in buried conduit across USFWS lands.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 8,500 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This pressure pipe and open channel alternative would require extension of small diameter piping for two locations (and pressure reduction) with two locations retaining normal pumped operation.	Stable site with bank improvements. Consistent sweeping velocities. Would allow for USFWS wildlife enhancement by partial burying of existing channel.	Change in point of diversion. Change is water quality. Requires right of way acquistion or an easement. Trenching through existing USFWS Infrastructure. Longer distance for power service. Longer distance for access roadway. Added piping for USFWS pumps. Sediment in buried pipe.
2F	Alternative 2F construction of a fish screen at Site 2 upstream of the existing WSID Diversion. The fish screen type is vertical flat plat screen parallel to flow along the banks of the San Joaquin River. This alternative includes conveyance through two 66-inch diameter pipelines extending westerly from the pump station to the existing channel. Approximately 2,750 feet of dual pipeline constructed in a new trench would then intersect the existing channel with dual pipe continuing an additional 5,650 feet using the existing channel as a trench.	Above ground power lines installed both within the District Right of Way and below ground to provide District negotiated power. A total of 8,400 feet of power lines required for power to operate the fish screen, brush cleaning system and ancillary components. Approximately 5,650 feet above grade in the District's Right of Way and 2,750 in buried conduit across USFWS lands.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 8,500 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This pressure pipe alternative would allow for a direct tap for two locations where pumping occurs and would require extension of small diameter piping for the remaining two locations all with pressure reduction from the mainline pipe without the need for pumping.	Stable site with bank improvements. Consistent sweeping velocties. Would allow for USFWS wildlife enhancement by full burial of existing channel.	Change in point of diversion. Change is water quality. Requires right of way acquistion or an easement. Trenching through existing USFWS Infrastructure. Longer distance for power service. Longer distance for access roadway. Will need to add piping for USFWS pumps. Sediment in buried pipe.
3G	Alternative 3G construction of a fish screen at Site 3 upstream of the existing WSID Diversion. The fish screen type is vertical flat plat screen parallel to flow along the banks of the San Joaquin River. This alternative includes conveyance through two 66-inch diameter pipelines extending westerly from the pump station to the existing channel. Approximately 5,580 feet of dual pipeline constructed in a new trench would intersect at the existing channel. At the channel, the inpipe pressure system will transition to 3,850 feet of gravity conveyance in a newly concrete lined channel (existing) to the existing WSID Lift No. 1.	Above ground power lines installed both within the District Right of Way and below ground to provide District negotiated power. A total of 9,470 feet of power lines required for power to operate the fish screen, brush cleaning system and ancillary components. Approximately 3,830 feet above grade in the District's Right of Way and 5,590 feet in buried conduit across USFWS lands.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 9,570 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This pressure pipe and open channel alternative would require extension of small diameter piping for three locations (and pressure reduction) with one location retaining normal pumped operation.	Consistent sweeping velocties. Would allow for USFWS wildlife enhancement by full burial of existing channel.	Change in point of diversion. Change is water quality. Requires right of way acquistion or an easement. Trenching through existing USFWS Infrastructure. Longer distance for power service. Longer distance for access roadway. Will need to add piping for USFWS pumps. Sediment in buried pipe. Actively eroding bank.
3H	Alternative 3H construction of a fish screen at Site 3 upstream of the existing WSID Diversion. The fish screen type is vertical flat plat screen parallel to flow along the banks of the San Joaquin River. This alternative includes conveyance through two 66-inch diameter pipelines extending westerly from the pump station to the existing channel. Approximately 5,580 feet of dual pipeline constructed in a new trench would then intersect the existing channel with dual pipe continuing an additional 3,850 feet using the existing channel as a trench.	Above ground power lines installed both within the District Right of Way and below ground to provide District negotiated power. A total of 9,470 feet of power lines required for power to operate the fish screen, brush cleaning system and ancillary components. Approximately 3,830 feet above grade in the District's Right of Way and 5,590 in buried conduit across USFWS lands.	All weather access to the pump station location would require construction of an all weather road to the pump station consisting of 9,570 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	USF&WLS has four separate locations where they currently pump from the existing channel for riparian habitat. This pressure pipe alternative would allow for a direct tap for two locations where pumping occurs and would require extension of small diameter piping for the remaining two locations all with pressure reduction from the mainline pipe without the need for pumping.	Consistent sweeping velocties. Would allow for USFWS wildlife enhancement by full burial of existing channel.	Change in point of diversion. Change is water quality. Requires right of way acquistion or an easement. Trenching through existing USFWS Infrastructure. Longer distance for power service. Longer distance for access roadway. Will need to add piping for USFWS pumps. Sediment in buried pipe. Actively eroding bank.

Table 6-2
West Stanislaus Irrigation District
Alternative Evaluation and Ranking Matrix

Alt	Description	Available Power Weight = 2	Access Weight = 1.5	Geomorphology Weight = 2.5	Cultural Resources Weight = 3	Terrestrial Weight = 4	Fisheries Weight = 4	Water Right Weight = 4	Water Quality Weight = 5	Construction Costs Weight = 3	Overall
1A	Site 1 - V-Screen using fish bypass return pumps and with conveyance in buried 96-inch diameter pipes.	10,400 feet of above ground power lines within existing District Right of Way	10,500 feet of all weather access roadway constructed above 100 year flood	Stable location	No issues noted.	Moderate-High to High	Least impact.	At current point of diversion.	Same water quality since at same point of diversion.	$36,600,000	
Rank	n/a	2	4	2	2	2	2	1	2	4	
Score	n/a	4	6	6	6	8	8	4	10	12	64
1B	Site 1 - V-Screen using fish bypass return pumps and with conveyance within existing shared channel.	10,400 feet of above ground power lines within existing District Right of Way	10,500 feet of all weather access roadway constructed above 100 year flood elevation.	Stable location	No issues noted.	Moderate -Low	Least impact.	At current point of diversion.	Same water quality since at same point of diversion.	$20,560,000	
Rank	n/a	2	4	2	2	2	2	1	2	1	
Score	n/a	4	6	6	6	8	8	4	10	3	55
2C	Site 2 - Flat plate vertical screen parallel to flow, with 1,950 feet of buried twin 78-inch diameter pipes in a new trench and using the remaining 6,950 feet of existing channel for conveyance.	6,950 feet of above ground power lines within District Right of Way and 1,950 in buried conduit across USFWS lands.	9,000 feet of all weather access roadway constructed above 100 year flood elevation.	Most stable location	No issues noted.	Moderate-High to High	Moderate impact.	Requires a change in the point of diversion	Unknown water quality, no influence from Toulumne River.	$23,330,000	
Rank	n/a	3	2	1	1	1	3	3	3	1	
Score	n/a	6	3	3	3	4	12	12	15	3	61
2D	Site 2 - Flat plate vertical screen parallel to flow, with 1,950 feet of buried twin 78-inch diameter pipes in a new trench and using the remaining 6,950 feet for twin 78-inch pipes located in the existing channel as a trench for conveyance	6,950 feet of above ground power lines within District Right of Way and 1,950 in buried conduit across USFWS lands.	9,000 feet of all weather access roadway constructed above 100 year flood elevation.	Most stable location	No issues noted.	Moderate	Moderate impact.	Requires a change in the point of diversion	Unknown water quality, no influence from Toulumne River.	$33,240,000	
Rank	n/a	4	2	1	1	1	3	3	3	4	
Score	n/a	8	3	3	3	4	12	12	15	12	72
2E	Site 2 - Flat plate vertical screen parallel to flow, with 2,750 feet of buried twin 84-inch diameter pipes in a new trench and using the existing shared channel for the remaining 5,650 feet of conveyance.	5,650 feet of above ground power lines within the District Right of Way and 2,750 feet in buried conduit across USFWS lands.	8,500 feet of all weather access roadway constructed above 100 year flood elevation.	Most stable location	Pipeline construction thru prehistoric resources area.	Moderate-High to High	Moderate impact.	Requires a change in the point of diversion	Unknown water quality, no influence from Toulumne River.	$24,640,000	
Rank	n/a	4	1	1	4	2	3	3	3	1	
Score	n/a	8	1.5	3	12	8	12	12	15	3	74.5
2F	Site 2 - Flat plate vertical screen parallel to flow, with 2,750 feet of buried twin 84-inch diameter pipes in a new trench and using the remaining 5,650 feet for twin 84-inch pipes located in the existing channel as a trench for conveyance	5,650 feet above grade in the District's Right of Way and 2,750 feet in buried conduit across USFWS lands.	8,500 feet of all weather access roadway constructed above 100 year flood elevation.	Most stable location	Pipeline construction thru prehistoric resources area.	Moderate-High to High	Moderate impact.	Requires a change in the point of diversion	Unknown water quality, no influence from Toulumne River.	$32,430,000	
Rank	n/a	4	1	1	4	2	3	3	3	4	
Score	n/a	8	1.5	3	12	8	12	12	15	12	83.5
3G	Site 3 - Flat plate vertical screen parallel to flow, with 5,580 feet of buried twin 96-inch diameter pipes in a new trench and using the existing shared channel for the remaining 3,850 feet of conveyance	3,850 feet above grade in the District's Right of Way and 5,580 feet in buried conduit across USFWS lands.	9,570 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	Unstable location	Pipeline construction thru prehistoric resources area.	Moderate-High to High	Moderate impact.	Requires a change in the point of diversion	Unknown water quality, no influence from Toulumne River.	$32,220,000	
Rank	n/a	5	3	3	4	2	3	3	3	3	
Score	n/a	10	4.5	9	12	8	12	12	15	9	91.5
3H	Site 3 - Flat plate vertical screen parallel to flow, with 5,580 feet of buried twin 96-inch diameter pipes in a new trench and using the remaining 3,850 feet for twin 96-inch pipes located in the existing channel as a trench for conveyance	3,850 feet above grade in the District's Right of Way and 5,580 feet in buried conduit across USFWS lands.	9,570 feet of improvements to the existing channel dirt road and fire road along the south portion of the existing channel.	Unstable location	Pipeline construction thru prehistoric resources area.	Moderate-High to High	Moderate impact.	Requires a change in the point of diversion	Unknown water quality, no influence from Toulumne River.	$38,870,000	
Rank	n/a	5	3	3	4	2	3	3	3	5	
Score	n/a	10	4.5	9	12	8	12	12	15	15	97.5

Notes
(1) Rank 1=good, 5=bad.
(2) Weight refers to the level of importance, higher value factor reflects higher level of importance.
(3) Score = Rank x Weight

Alternative 2C has the second lowest capital cost and is located in a very stable location on the river bank. Slope stabilization improvements have been made previously to this site making it an attractive alternative for the intake. This alternative will also have one of the shortest lengths of pipeline with a 1,950 foot reach of dual 78-inch pipes to the existing shared channel to be used to convey flows to the District's Main Lift Station No. 1. This location would have above grade power poles extended within District easement along the channel and then buried conduit along the buried pipeline to the intake. As with all alternatives construction would include an all-weather access road constructed for access and maintenance.

The cost of Alternative 3G due to the large amount of piping has eliminated this from selection. Similar to Alternative 2C, this alternative would rely on large diameter buried conduit for conveyance of the water to a point where it would then enter into the existing open channel. In addition to the high cost of the pipeline, this length of buried piping would be a source of sediment deposition that would present maintenance issues both of which are very unfavorable to the project. Maintenance of this type of buried pipeline would present safety issues such as confined space entry and would expose workers to potentially dangerous conditions below ground with flooding danger of the pipeline.

Alternatives 1B and 2C both provide good solutions for the proposed project, but the potential drawbacks for Alternative 2C are greater. Although Alternative 1B will have to address sediment issues, is not as stable as Alternative 2C from a geomorphology perspective, and requires a fish bypass system, Alternative 1B has the important advantages of not requiring a change in the point of diversion for the District's water rights, providing superior water quality, and resulting in construction within an existing easement. The construction cost of this alternative is lower than Alternative 2C, however, the projected O&M costs somewhat higher.

Based upon the above reasoning and information presented elsewhere in this report, Alternative 1B is the recommended alternative. This alternative provides a durable intake structure with technology that has been proven effective at many other sites on both the San Joaquin and Sacramento Rivers at the most affordable cost.

The following items make Alternative 1B the most beneficial water delivery system for the District:

- Wedge-wire fish screens are a proven successful fish screen technology.
- Damaged screens can be replaced relatively quickly with little impact on diversion capabilities.
- Operation and maintenance required can be accomplished by District staff.
- The proposed facility will have a low impact on the river floodway.
- The facility intake will be easy to access via earth access ramp.
- Relatively lower estimated project cost.

ADDITIONAL DATA

To complete a detailed design of the selected alternative it is recommended that the following additional data be obtained:

- Additional survey data including bathymetric data at the proposed site and along the conveyance pipeline corridor and cross section through the shared channel to the District Main Lift Station No. 1.

- A hydraulic model for the river reach should be developed to verify the project's final design water surface elevations and to clarify the effects of the new structure on flood flows.

- Additional geotechnical data should be collected and specific recommendations developed including: allowable bearing pressure, pile design requirements, seepage analysis, and estimates of scour potential.

- Additional project refinements and cost reduction ideas should be evaluated and integrated as appropriate.

- Coordinate with the SJRNWR staff to improve the operations of the refuge as much as possible with the new diversion intake. This includes maintaining their water supply as needed.

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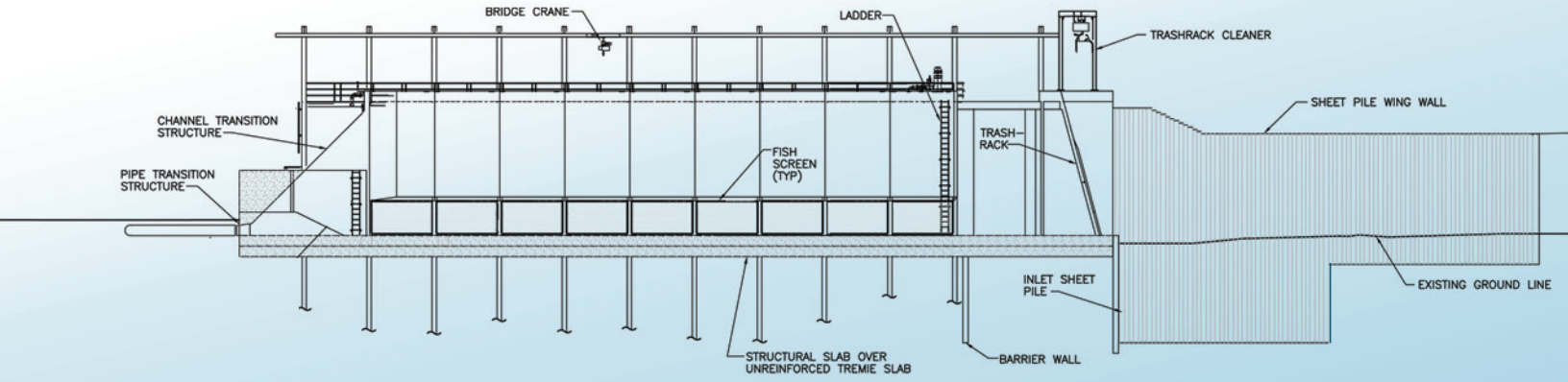

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