Low Head Pump Salinity Control Study

Prepared
to meet requirements of the
State of California State Water Resources Control Board
Water Rights Order WR 2010-0002, Condition A.7

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Acronyms and Abbreviations

BOs	Biological Opinions
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game
CES	Cost Estimating Section
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CV	Central Valley
CVP	Central Valley Project
DOE	Division of Engineering
DSM2	Delta Simulation Model 2
DWR	California Department of Water Resources
EC	Electrical Conductivity
EFH	essential fish habitat
ESA	federal Endangered Species Act
FRWA	Freeport Regional Water Authority
IEPPWT	Interagency Ecological Program Project Work Team
IS/MND	Initial Study/Mitigated Negative Declaration
µS/cm	microsiemens per centimeter
mmhos/cm	millimhos per centimeter
NC	No change
NMFS	National Marine Fisheries Service
NWP	Nation Wide Program
OCAP	2009 Operations Criteria and Plan
OMR	Old and Middle River
SDWA	South Delta Water Agency
SMWC	Sutter Mutual Water Company
SWP	State Water Project
SWRCB	State Water Resources Control Board
TBP	Temporary Barriers Project
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

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Executive Summary

The Department of Water Resources (DWR) has completed a study of the feasibility of installing low head pumps in conjunction with temporary barriers in the south Delta. The purpose of the low head pumps would be to improve water quality (salinity) through improved water circulation and would operate in tandem with the temporary barriers which are installed annually by DWR to maintain water elevations to meet the needs of local agricultural diverters. The study has been done to meet water right permit responsibilities for the operation of the State Water Project (SWP) and the Central Valley Project (CVP). These responsibilities are identified in Condition A.7 of the State of California State Water Resources Control Board (the Board) Water Rights Order WR 2010-0002 (Order) and are shared with the United States Bureau of Reclamation (Reclamation).

Under Condition A.7, DWR and Reclamation are responsible for evaluating the feasibility of installing low lift (low head) pumps at one or more of the temporary barriers and the feasibility of increasing flows in the San Joaquin River to ensure compliance with the interior southern Delta salinity objectives. These objectives are 0.7 millimhos per centimeter (mmhos/cm) electrical conductivity (EC) from April 1 through August 31 and 1.0 mmhos/cm EC from September 1 through March 31 at the following three locations in the interior southern Delta: (1) Station C6-San Joaquin River at Brandt Bridge, (2) Station C8-Old River near Middle River, and (3) Station P12-Old River at Tracy Road Bridge.

The objective of this report is to inform the Board of the evaluation and findings regarding low head pumping. This report does not inform the Board on the feasibility of increasing flows in the San Joaquin River as required in the Order. A report regarding increasing flows is being provided under separate cover by Reclamation.

The study was performed following the general tasks described in an approved revised study plan submitted on August 3, 2010 (DWR/Reclamation 2010) and approved by the Board on September 21, 2010. The study analysis approach comprised multiple steps of review, planning, technical evaluation, and documentation. These steps included reviewing of related regulatory requirements and guidance and technical documentation; discussions with DWR and Reclamation technical experts; preparing of an internal study plan and identifying initial conceptual low head pumping scenarios; Delta Simulation Model 2 (DSM2) modeling and evaluating of the initial conceptual scenarios; meeting with the South Delta Water Agency (SDWA) to discuss the initial conceptual scenarios and consideration of SDWA suggestions; iterative modeling analysis of variations of the initial conceptual scenarios; identifying of a suite of scenarios which together present a comparative look at the potential range of water quality benefits of low head pumping; and developing conceptual level engineering layouts, planning level costs, and environmental impacts.

The study findings include results of DSM2 modeling, conceptual engineering layouts, the practicality of constructing permanent or temporary pump facilities estimated planning level costs, and an assessment of regulatory requirements and permitting. Additional findings include an assessment of potential mitigation needed to address construction and operation impacts on downstream water levels and diverters.

Hydrodynamic and Water Quality Modeling

DSM2 modeling results of low head pumping used in conjunction with the temporary rock barriers in the south Delta indicate the potential for improved water quality at the two interior south Delta compliance locations C8-Old River near Middle River and P12-Old River at Tracy Road Bridge. The potential for improved water quality at C6-San Joaquin River at Brandt Bridge is not indicated although modeling results shows some minor reductions. Modeling is based on the period of July through October for water years 2007 through 2009 which were dry to critically dry years. The July through October period coincides with the historical barrier installation period when all barriers would be in-place. During this dry and critically dry historical period exceedences occur at C6-San Joaquin River at Brandt Bridge about 23% of the study period, about 22% of the study period at C8-Old River near Middle River about, and about 49% of the study period at P12-Old River at Tracy Road Bridge.

General observations regarding pumping at only one barrier indicate that pumping at either the Middle River or Old River barrier sites would be the most effective at improving water quality measured at the compliance station closest to that barrier. The effects on the compliance stations further from either barrier are much less. Elimination of 100% of the historical exceedences at C8-Old River near Middle River appears possible at a pumped flow of 500 cubic feet per second (cfs) or greater when pumping at the Middle River barrier only. However, this same pumping eliminates only about 2% of historical exceedences at P12-Old River at Tracy Road Bridge and only 9% when the pumping rate is increased to 1000 cfs. Elimination of 40-60% of the historical exceedences at P12-Old River at Tracy Road Bridge appears possible when pumping 500 to 1000 cfs, respectively at the Old River barrier only. However, this same pumping eliminates only 4% of the exceedences at C8-Old River near Middle River at a pumping rate of 500 cfs and eliminates only 22% of the exceedences when the rate is increased to 1000 cfs.

Pumping at the Grant Line Canal barrier site only is less effective at improving water quality at both compliance stations with the exception of pumping 1000 cfs at C8-Old River near Middle River. Pumping at 1000 cfs at Grant Line Canal Barrier eliminates approximately 26% of the exceedences at C8-Old River near Middle River. Elimination of exceedences at C6-San Joaquin River at Brandt Bridge is less than 4% for all pumping locations and rates.

General observations regarding concurrent and equal pumping at two barriers indicate that pumping at more than one barrier site is less effective at reducing exceedences for the same total pumped flow. Pumping at the two locations of Middle River and Old River eliminates approximately 10% and 20% of the exceedences at C8-Old River near Middle River and at P12-Old River at Tracy Road Bridge, respectively, by pumping at a combined flow of 500 cfs. When the combined pumping rate is increased to 1000 cfs, most exceedences at C8-Old River near Middle River are eliminated but only about 40% of the exceedences are eliminated at P12-Old River at Tracy Road Bridge. Concurrent and equal pumping at either Middle River and Grant Line Canal or Old River and Grant Line Canal provides less overall reduction in exceedences. Elimination of exceedences at C6-San Joaquin River at Brandt Bridge is less than 4% for all pumping locations and rates.

The success with which low head pumping could eliminate or reduce the historical exceedences is affected by a number of factors. In particular, the success is influenced by the sources of water which would be drawn into the south Delta. These sources include the Sacramento River, the San Joaquin River, and San Francisco Bay water. For the July through October period of 2007-2009 analyzed in this report, the majority of the water at C8-Old River near Middle River and at P12-Old River at Tracy Road Bridge came from the San Joaquin River. Simulated low head pumping at Middle River changed the major water source at C8-Old River near Middle River to the lower-salinity Sacramento River water, but only slightly increased the amount of Sacramento River water at P12-Old River at Tracy Road Bridge. Conversely, pumping at Old River changed the major water source at P12-Old River at Tracy Road Bridge to the lower-salinity Sacramento River water, but only slightly increased the amount of Sacramento River water at C8-Old River near Middle River. For all of the alternatives, increasing the pumping rate from 500 to 1000 cfs increased the fraction of lower salinity Sacramento River water at the compliance sites. This increase in pumping also introduces a larger fraction of higher salinity water from San Francisco Bay.

For all scenarios, redirected impacts regarding water levels and water quality at diversion points of interest and on flow regarding Net Delta Outflow appear to be minor based on daily average flow data and 30-day running average water quality data. The results of modeling analysis indicate that redirected impacts resulting from low head pumping, while dependent on pumped flow volume, range from no change (NC) to slight for average conditions. These impacts include reductions in Net Delta Outflow, water levels, and changes in water quality. Approximate reductions in Net Delta Outflow range from NC to 3% for all scenarios. Locations of most interest regarding water level impacts are agricultural diversions downstream of the barrier sites and various water supply export locations. Based on average daily flow data, the average decrease in water levels downstream of the temporary barriers varied from NC to 0.09 feet at pumping rates up to 1000 cfs. The corresponding maximum water level decrease varied from 0.16 to 0.36 feet. Similarly, the average decrease in water levels at the water supply export locations varied from NC to 0.05 feet. The corresponding maximum water level decrease varied from 0.11 to 0.22 feet. Because the modeled results are based on average daily flow data, intermittent periods with larger decreases in water levels would be expected to occur. These would especially be expected to occur during low-low tide events.

Changes in water quality at the agricultural diversions downstream of the barriers would vary under the low head pumping scenarios. In general, these changes would be beneficial with decreased salinity similar to that indicated for the interior south Delta compliance locations. The analysis of water quality changes at the various water export locations of interest indicate that salinity changes would be less than 1% at all export sites, with the exception of Victoria Canal which showed a maximum change as an increase in salinity ranging from 2.3 to 4.3% for 500 to 1000 cfs, respectively. Because the modeled results are based on a 30-day running average EC data intermittent periods with larger changes in concentrations would be expected to occur.

Engineering Details and Practicality

The evaluation of conceptual engineering layouts and practicality included an assessment of pump facility concepts for single-pumping site alternatives at all of the three barrier locations and two-pumping site alternatives with concurrent pumping at the Middle River and Old River barriers and at Middle River and Grant Line Canal barriers. The evaluation indicates that all three barrier sites could accommodate either permanent or temporary pumping facilities. The facilities would be constructed on the water-side of existing levees with an intake structure and pumping system downstream of a barrier and a discharge structure located upstream. Conveyance piping for both permanent and temporary facilities would be installed from the pump facility to the upstream discharge structure. The piping would be installed below ground for the permanent facilities and above ground for the temporary facilities for the most part.

Although some dredging may be required for installation of the permanent intake and discharge facilities at all barrier locations, significant dredging would be required at the Middle River barrier for both permanent and temporary facilities. The Middle River dredging would be required because the existing river channel is shallow.

Two permanent pumping facility concepts were evaluated including a flat screen intake structure and a cylindrical screen intake. Pumping facility concepts were based on prior DWR experience and existing facilities constructed by other public or private entities. The flat screen intake is typical of major pumping facilities in the Delta where as the cylindrical screen is typical of lower-flow systems. The flat screen intakes would be permanently installed in the water column. The cylindrical screens would be installed on the levee on inclined tracks or rails for automated lowering into or raising from the water column. The permanent pumping facilities would remain in-place year round. In addition, a single temporary pump facility concept was evaluated which would include cylindrical screen intakes similar to the permanent concept but would be manually installed and utilize rented or leased skid-mounted diesel engine driven pumps. The temporary cylindrical screens, skid-mounted pumps and conveyance piping would be installed and removed annually when the temporary barriers are constructed and removed. Some on-levee bank minor piping connections associated with the temporary facility intake and discharge are proposed to remain in-place year round to facilitate installation.

Estimated Costs

The range of estimated costs to construct and operate either permanent or temporary pumping facilities as single-or two-pumping site alternatives are summarized below. The costs are conceptual level planning costs with an accuracy of -25% to 50% and include initial capital (Table ES.1), and annual and capitalized costs (Table ES.2). The initial capital costs include construction, real estate, design, environmental compliance and permitting, construction management, and a 25% contingency for materials and installation. Annual costs include operation and general maintenance of the facilities. Overall capitalized costs were developed as an indicator of the relative cost of the permanent and temporary alternatives. The capitalized cost is the initial capital cost plus the annual cost adjusted to represent the time value of future expenditures.

	Single Pumping Sites		
Total Pumping Capacity (cfs)	250	500	1000
Pump facility Configuration			
Temporary	$5.5-20.7	$9.8-40.9	$19.6-80.9
Permanent Cylindrical Screen	$20.2-60.8	$40.9-112.9	$81.7-234.3
Permanent Flat Screen	$120-161.4	$214.5-286.6	$391.7-551
	Two Pumping Sites		
Total Pumping Capacity (cfs)	250	500	1000
Pump facility Configuration			
Temporary	$14.9	$28.4	$55.5
Permanent Cylindrical Screen	$49.5	$87.6	$168.1
Permanent Flat Screen	$186.9	$301.0	$540.7

[1] All values in million

Table ES.1 Range of Estimated Alternative Initial Capital Costs

	Single-Pumping Sites					
Total Pumping Capacity (cfs)	250		500		1000	
Pump facility Configuration						
Temporary	$10-22.6	$147.6-343.9	$15.6-45.1	$232.8-685.8	$32.4-89.9	$482.9-1365
Permanent Cylindrical Screen	$0.7-1.4	$30-80.4	$1.4-2.6	$60.5-149.6	$2.7-5.3	$121-310.1
Permanent Flat Screen	$3.4-4.5	$179-210	$6.1-8.5	$325-376.1	$11.8-16.3	$602-719.7
	Two-Pumping Sites					
Total Pumping Capacity (cfs)	250		500		1000	
Pump facility Configuration						
Temporary	$17.8	$269	$33.5	$507.3	$62.7	$951.9
Permanent Cylindrical Screen	$1.3	$68.0	$2.3	$120.8	$4.5	$232.8
Permanent Flat Screen	$4.7	$254.3	$8.0	$414.6	$14.7	$750.3

[1] All values in million

[2] Annual Cost | Capitalized Cost

Table ES.2 Range of Estimated Alternative Annual and Capitalized Costs

In summary, the estimated costs vary depending on the pumping capacity, the technical approach and the barrier installation site. The flat and cylindrical screen costs are based on designs incorporating screening criteria specified by NMFS for juvenile salmon and CDFG recommendations regarding USFWS criteria for delta smelt. This conservative approach is taken to reduce any potential negative impact to these species. Less restrictive screening criteria would result in lower costs and may be applicable given the proposed operation period for low head pumping. The temporary alternatives provide the least initial capital costs but overall capitalized costs can exceed the capitalized cost for some permanent alternatives as a result of substantial annual operation and maintenance costs. The permanent flat screen alternatives have the highest initial capital costs due to the material and installation costs for the flat screen technology. The costs also vary by barrier installation site as a result of site-specific conditions. In particular, the Middle River barrier site requires substantial dredging to provide sufficient submergence for the pump facility intake screens.

The alternative providing the greatest reduction in exceedences for concurrent or two-pumping site alternatives is 1000 cfs combined pumping at Middle River and Old River barriers as described under Hydrodynamic and Water Quality Modeling. The least capitalized cost to implement this alternative is $232.8 million, which utilizes permanent cylindrical screens, has an initial capital cost of $168.1 million and annual costs of $4.5 million. The comparable costs utilizing temporary skid mounted pump systems with manually-placed cylindrical intake screens are $55.5 million with an annual cost of $62.7 million. Although the initial capital cost of $55.5 million for a temporary system is lower the annual costs are substantial and the associated capitalized cost is larger by a factor of almost four ($951.9 to $232.8 million).

Environmental Compliance and Permitting

Environmental compliance and permitting for the construction and operation of either permanent or temporary low head pumping facilities are considered to be a modification of the currently implemented temporary barriers project. Minor modifications to existing permits and mitigation obligations are anticipated. Potential impacts to environmental factors are expected to range from "less than significant" to requiring general mitigation actions or environmental commitments. Overall, the permanent systems would require that DWR provide mitigation for the footprint of the new pumping systems in addition to the mitigation already in place for the temporary barriers project. For the temporary pumping systems, no additional mitigation is expected but the installation and removal of these systems each year could result in air quality effects for which additional mitigation is required.

Environmental documentation and permit requirements for the permanent systems are expected to include preparation of a supplemental Initial Study/Mitigated Negative Declaration under CEQA, USACE Clean Water Act Section 404 and Rivers and Harbors Section 10 permitting, including Endangered Species Act consultation with USFWS and NMFS, and Essential Fish Habitat (EFH) consultation under the federal Magnusson-Stevens Act. At the State level, coordination with the CDFG will be required to obtain a 1601 Streambed Alteration Agreement as well as an Incidental Take Permit. Additionally, a Section 401 certification or waiver will be needed from the Board for approval of in-water work. At the local level, coordination with the San Joaquin Valley Air Pollution Control District will be needed to obtain a necessary construction emission reduction credit lease. These documentation and permitting actions would require approximately 18 months to complete.

Due to the temporary nature of the temporary pumping systems environmental documentation and permit requirements are expected to be less than that required for a permanent system. State level coordination will be required with the CDFG to obtain an Incidental Take Permit and local level coordination will be required with the San Joaquin Valley Air Pollution Control District to obtain a construction emission reduction credit lease. These documentation and permitting actions would require approximately 12 months to complete.

The actual permits that would be required and the time to acquire them would depend on the actual estimated effects of the final proposal and coordination with resource and regulatory agencies. This also assumes that there would be no need to re-consult on the CVP/SWP Long Term Operations Biological Opinions as there are no expected increased effects on federally-listed species resulting from the proposed annual July through October operation. As described above, the permit requirements are based on the assumption that construction of these facilities would be included as an amended project description for the temporary barriers, similar to previous modifications (i.e., Middle River barrier raise). As such, permit documents would be abbreviated and would indicate that of the pumping facilities would be a modified component of the overall TBP. Should this be unacceptable to the regulatory agencies, the estimated timelines to obtain these permits would likely increase.

Conclusions

Low head pumping used in conjunction with the temporary barriers has the potential to improve water quality at the compliance stations in the south Delta. DSM2 modeling results indicate the potential to reduce historic exceedences of the of salinity objectives at compliance stations C8-Old River near Middle

River and at P12-Old River at Tracy Road Bridge. There is no potential indicated for reducing historic exceedences at station C6-San Joaquin River at Brandt Bridge. A 100% reduction in exceedences (27 days less) appears possible at C8-Old River near Middle River when pumping at a total flow of 500 cfs at the Middle River barrier and about 96% when pumping a total of 1000 cfs equally split between the Middle River and Old River barriers. Under the latter condition, about a 40% reduction in exceedences (also 27 days less) appears possible at P12-Old River at Tracy Road Bridge. Analysis of total pumping rates as high as 1500 cfs indicate only slight improvements in reductions would be achieved.

The least estimated capitalized cost to achieve the 96% reduction in exceedences at C8-Old River near Middle River and about a 40% reduction in exceedences at P12-Old River at Tracy Road Bridge is $232.8 million with an initial capital cost of $168.1 million and an annual cost of $4.5 million. This cost is for pumping a total of 1000 cfs with 500 cfs pumping facilities at both Middle and Old River barriers utilizing permanent pumps and retractable cylindrical screen intakes. The comparable costs utilizing temporary skid mounted pump systems with manually-placed cylindrical intake screens are $951.9 million in capitalized costs with an initial capital cost of $55.5 million and an annual cost of $62.7 million.

Redirected impacts on water levels and water quality at diversion points of interest and on the Net Delta Outflow appear to be minor based upon daily average flow data and 30-day running average water quality data. Because the modeled results are based on average daily flow data, intermittent periods with larger decreases in stage would be expected to occur.

With respect to environmental compliance and permitting for the construction and operation of either permanent or temporary low head pumping facilities, the system would be considered a modification of the currently implemented temporary barriers project. Minor modifications to existing permits and mitigation obligations are anticipated. Overall, the permanent systems would require that DWR provide mitigation for the footprint of the new pumping systems in addition to the mitigation already in place for the temporary barriers project. For the temporary pumping systems, no additional mitigation for species is expected but the installation and removal of these systems each year could result in air quality effects for which additional mitigation is required. Estimated time to complete environmental compliance and permitting is approximately 18 months. The design of the pumping facilities could be prepared during this environmental compliance and permitting phase. Following this phase an estimated 24-36 months will be required to complete construction.

The actual permits that would be required and the time to acquire them would depend on the actual estimated effects of the final proposal and coordination with resource and regulatory agencies. Because there are no expected increased effects on federally-listed species resulting from the proposed pump operation, the permitting approach assumes that there would be no need to re-consult on the CVP/SWP Long Term Operations Biological Opinions.

I. Introduction

Controlling salinity in the Sacramento-San Joaquin Delta Basin is important so as to protect beneficial water uses. These beneficial uses include both non-consumptive fish and wildlife uses and consumptive agricultural, municipal, and industrial uses. The State Water Resources Control Board (Board) has established water quality objectives for "reasonable" protection of these beneficial uses. These objectives as well as responsibilities of water rights holders are defined in various Board documents and court proceedings. As water right holders, for the operation of the State Water Project (SWP) and the Central Valley Project (CVP), the Department of Water Resources (DWR) and the United States Bureau of Reclamation (Reclamation) respectively have been assigned a responsibility in accordance with Condition A.7 of the State of California State Water Resources Control Board Water Rights Order WR 2010-0002 (Order). Under Condition A.7, DWR and Reclamation are responsible for evaluating the feasibility of installing low-lift (head) pumps at one or more of the temporary barriers and the feasibility of increasing flows in the San Joaquin River to ensure compliance with the interior southern Delta salinity objectives. Water rights for the SWP and CVP are conditioned on implementation of 0.7 millimhos per centimeter (mmhos/cm) electrical conductivity (EC) from April 1 through August 31 each year and 1.0 mmhos/cm EC from September 1 through March 31 each year at the following three locations in the interior southern Delta: (1) Station C6-San Joaquin River at Brandt Bridge, (2) Station C8-Old River near Middle River, and (3) Station P12-Old River at Tracy Road Bridge. [Figure I.1]. These objectives are referred to in the Order as the interior southern Delta salinity objectives.

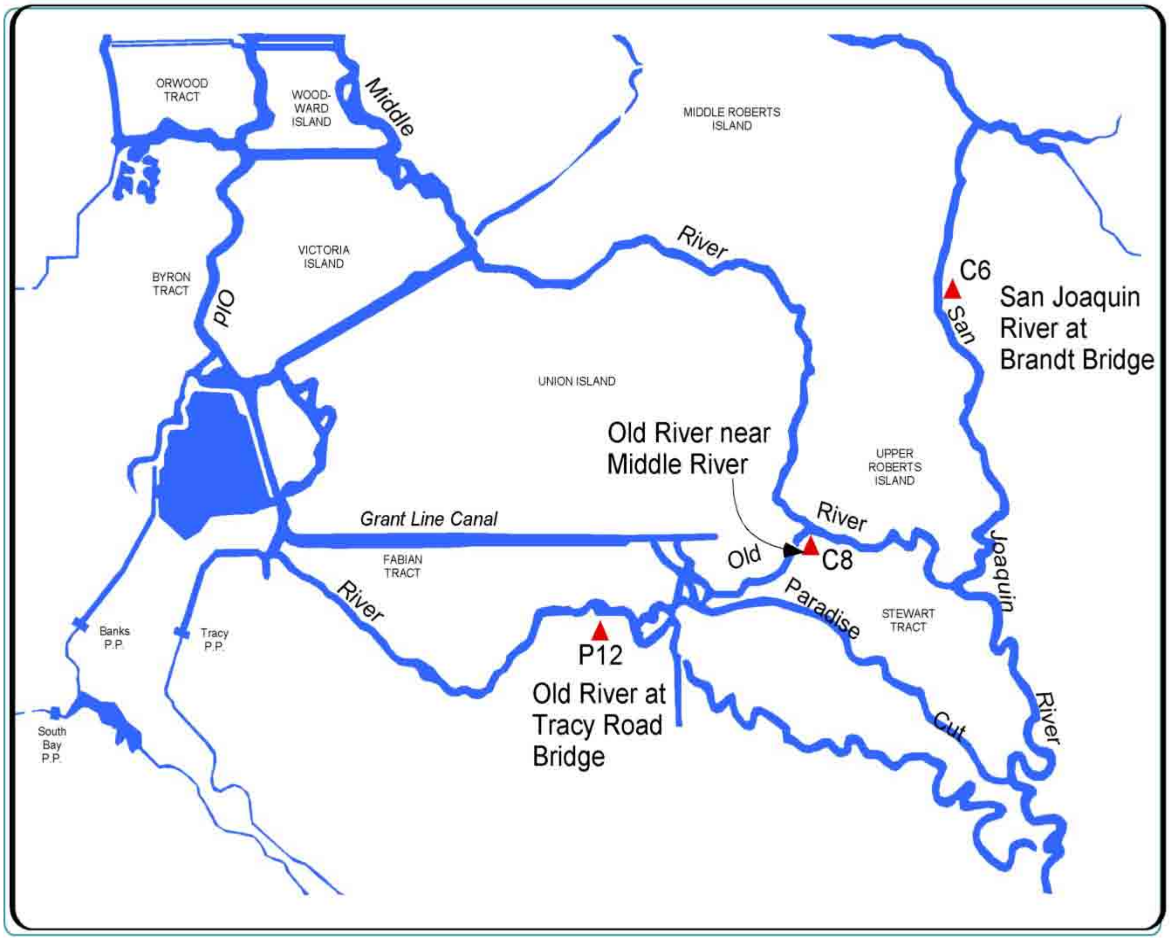


Figure I.1: Interior Southern Delta Compliance Locations

A. Purpose and Objective

The purpose of this report is to satisfy requirements regarding the feasibility evaluation of low head pumping under Condition A.7 of the Order. The objective of this report is to inform the Board of the evaluation and findings. These findings include results of hydrodynamic and water quality modeling, conceptual engineering details, an assessment of regulatory requirements and permitting, estimated planning-level costs, and the practicality of constructing permanent or temporary pump facilities. Additional findings include an assessment of potential mitigation needed to address construction and operation impacts on downstream water levels and diverters. This report does not inform the Board on the feasibility of increasing flows in the San Joaquin River as required in the order. A report regarding increasing flows is being provided by Reclamation.

B. Report Organization

The report includes the following sections and appendices.

Background

Alternative Analysis
- Analysis Approach
- Alternatives Development
- Hydrodynamic and Water Quality Analysis
- Permitting and Environmental Analysis
- Engineering and Cost Analysis

Conclusions

Appendices
- Hydrodynamic and Water Quality Analysis
- Engineering and Cost Analysis
- Environmental Compliance and Permitting Analysis

References

II. Background

The Board issued Cease and Desist Order WR 2010-0002 against DWR and Reclamation on January 5, 2010. In this order, the SWRCB ordered DWR and Reclamation to take corrective actions to correct threatened violations of permits and license. The permits and license require DWR and USBR to meet the salinity objective for beneficial water use by southern Delta agriculture at specified southern Delta compliance locations (see Section I. Introduction). In response to the Order, DWR and Reclamation submitted a Feasibility Study to Meet Water Rights Order WR2010-0002 Condition A.7 on March 8, 2010. The feasibility study plan detailed how DWR and Reclamation would evaluate the low head pumps at one or more temporary barrier sites (See Figure II.1) and the feasibility of increasing flows in the San Joaquin River to ensure compliance with the interior southern Delta salinity compliance objective. The plan also included a revised and updated Compliance Plan for Station C6.

The Board provided comment on the study plans to DWR and Reclamation on June 21, 2010. Specifically, the Board requested timelines and for additional specifications for investigating the practicality of installing low head pumps and a phased approach to the evaluation of San Joaquin

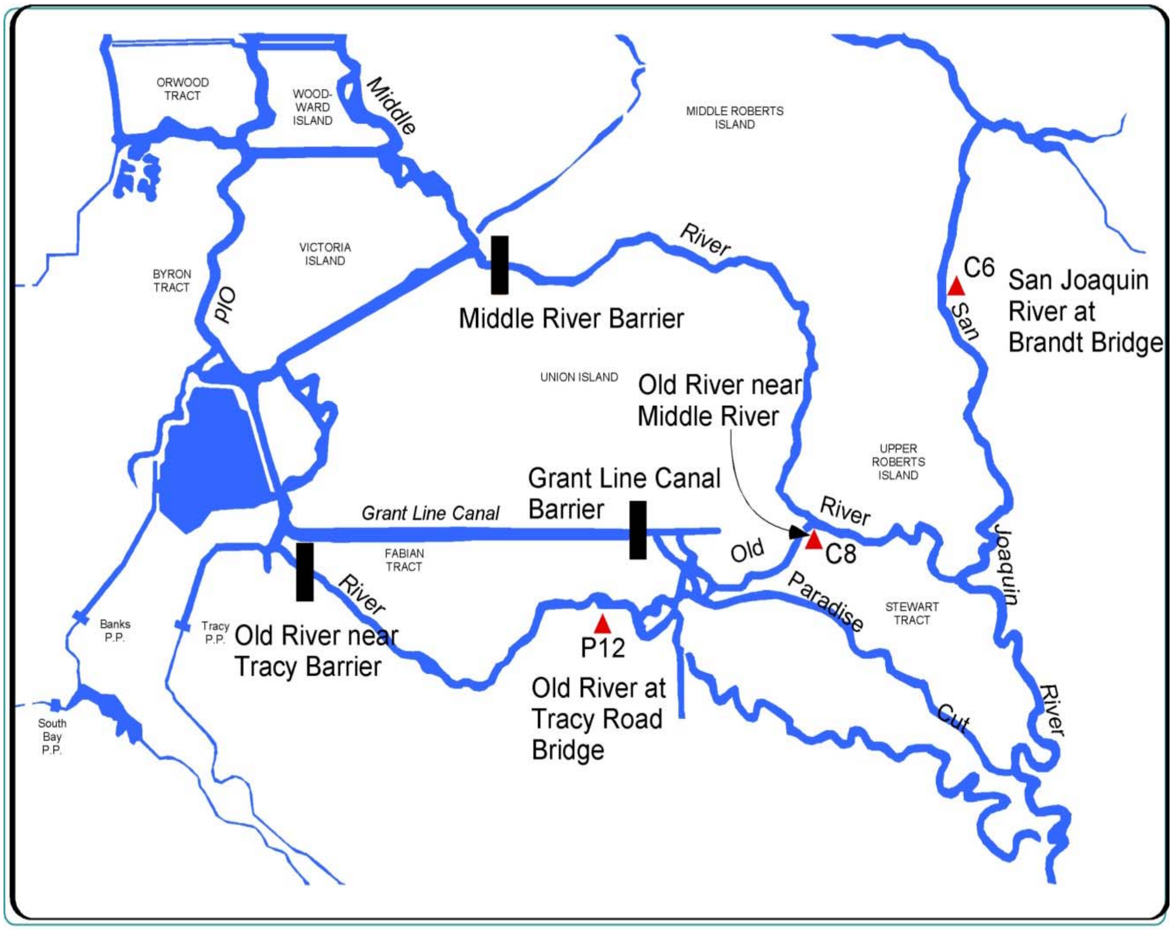


Figure II.1: Temporary Barrier Sites

River flows. A revised study plan was submitted to the Board on August 3, 2010 and approved by the Board on September 21, 2010.

Regarding the evaluation of low head pumps, the September 21, 2010 approval letter states the Board's understanding of the proposed scope and tasks for the study. The letter states that "DWR now proposes to perform a more extensive modeling analysis in coordination with the South Delta Water Agency, and investigate the costs and practicality of constructing permanent pumping facilities or installing an array of temporary pumps." Further, the letter stated "We note that the proposed modeling analysis of low-lift pumps will evaluate both the extent to which the pumps could control salinity and whether the pumps could result in compliance with the salinity objective." Furthermore, as detailed in the study plan "Review of regulatory requirements and permitting will be done. An assessment of mitigation needed to address construction/installation impacts of the pumps on downstream water levels and diverters will be conducted." And "Within 180 days from the date of this letter which constitutes the Deputy Director's conditional approval of the Plan, DWR and Reclamation shall submit a report to the Executive Director that describes the study and its results”.

III. Analysis

The analysis of potential low head pumping was performed following the general tasks as described in the September 21, 2010 Board letter. Expanded task work developed from these general tasks included a review of relevant regulatory requirements and guidance; review of historical flow and water quality (salinity) data records for the Sacramento-San Joaquin River Basin; review of historical temporary barriers operations records; extensive hydrodynamic and water quality simulation modeling using Delta Simulation Modeling (DSM2); development of conceptual engineering details and costs; and an assessment of potential permitting and mitigation requirements. The approach to the analysis, alternatives development, modeling, conceptual engineering details and costs, and potential permitting and mitigation requirements are presented below.

A. Analysis Approach

The analysis approach comprised multiple steps of review, planning, technical evaluation, and documentation. These steps included the review of related regulatory requirements and guidance and technical documentation; discussions with technical DWR and Reclamation experts; preparation of an internal study plan and identification of initial conceptual low head pumping scenarios; DSM2 modeling and evaluation of the initial conceptual scenarios; meeting with the South Delta Water Agency (SDWA) to discuss the initial conceptual scenarios and consideration of SDWA suggestions; iterative modeling analysis of variations of the initial conceptual scenarios; identification of a suite of scenarios which together present a comparative look at the potential range of water quality benefits of low head pumping; development of conceptual level engineering details, planning level costs, and environmental impacts.

1. Regulatory Requirements and Guidance and Technical Documentation

Regulatory requirements and guidance documents were reviewed to ensure identification of appropriate study criteria. These documents included the Board letter from Victoria A. Whitney to Katherine Kelly and Richard Woodley approving the study plan (SWRCB 2010), SWRCB Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995), SWRCB Water Rights Decision 1641 (SWRCB 2000), SWRCB Water Rights Decision 1485 (SWRCB 1978), prior SWRCB hearing testimony (Hildebrand 2009), and the interim remedial court order regarding Delta flows (Wanger 2007). Technical water quality and water level data were reviewed to ensure the use and consideration of applicable information. These data included previous analyses of low head pumping, historic salinity levels, quarterly compliance reports, Board testimony regarding low head pump concepts, and temporary barrier operation data. These data were used to develop a study plan for guiding the analysis.

The SWRCB letter (2010) provided approval of the revised Feasibility Study Plan to Meet Water Rights Order 2010-002, Requirement 7, submitted by DWR and Reclamation. As described in Section II. Background, the letter stated the Board's understanding of the proposed scope and tasks for the study. This scope and these general tasks were used as a basis for execution of the project study.

The SWRCB Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995), SWRCB Water Rights Decision 1641 (SWRCB 2000) and Decision 1485 (SWRCB 1978) were referenced regarding relevant Delta water flow, level and quality criteria. These criteria are of importance to address potential impacts of low head pumping on south and central Delta agricultural diverters, the operations of other Delta users, and general water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh.

Prior SWRCB hearing testimony from the June 25, 2009 Hearing Considering Changes to water rights order WR2006-0006 was reviewed. This testimony, provided by Mr. Alex Hildebrand, representing the SDWA, included an Attachment 1, Oral SDWA Testimony by Alex Hildebrand for presentation at the 1/16/07 Workshop of SWRCB re South Delta Salinity, and Attachment 2, 11/1/2008 Measures Which Can Meet All Regulatory Requirements in South Delta Channels By Alex Hildebrand, Engineer for South Delta Water Agency. This testimony is of importance as it identifies the general conceptual approach and expected benefit of low head pumps.

The interim court order regarding protection of Delta smelt as issued by Federal Judge Oliver Wanger in December 2007 presents flow restrictions regarding Old and Middle rivers. These restrictions are of importance to address potential impacts of low head pumping on Old and Middle river flows and were evaluated in the hydrodynamic modeling.

A previous study analysis of low head pumping titled <u>DSM2 Studies to Investigate the Use of Auxiliary Flow Pumps Across South Delta Flow Structures</u> was conducted by DWR in 2002. This study was performed to evaluate the potential benefit of using auxiliary flow pumps across all three agricultural barriers to improve dissolved oxygen in the San Joaquin River at Brandt Bridge. The study included salinity simulations to address potential impacts of pumping on stagnant water conditions as well as an assessment of potential effects on Net Delta Outflow. The study findings of interest were: without auxiliary pumping the main source of salinity in the south Delta is the San Joaquin River; auxiliary pumping transports the better quality water coming from the north to the south Delta; without auxiliary pumping, poor water circulation patterns are created which lead to stagnant conditions; maintaining a high flow rate in the main stem of the San Joaquin River prevents any direct salinity intrusion into the San Joaquin River; and since the Net Delta Outflow is unaffected by the auxiliary pumping, the salinity intrusion patterns are not altered elsewhere, explaining why the changes in the water quality for the rest of the Delta are minimal.

2. Historical Flow and Water Quality (salinity) Data Records

Historical flow and salinity data based on the 1991 – 2010 California Data Exchange Center (CDEC) records as well as monthly DWR operation reports were evaluated for the study. These data and reports were evaluated to identify data study periods in which compliance with the D-1641interior south Delta salinity objectives were not met. Priority consideration was given to more recent periods which would be representative of current operation strategies for the temporary barriers. These strategies include a one-foot elevation increase of the Middle River Barrier overflow weir and tidal/non-tidal barrier culvert operations at all three temporary barriers.

The data study period selected for analysis was 2007-2009. The water year types during this period were dry to critically-dry (2008) which reflect a typical low flow conditions in the south Delta. Historical of the salinity objectives during this period are shown in Figure III.1. This figure presents salinity (EC) plots for the three interior south Delta compliance locations C6-San Joaquin River at Brandt Bridge, C8-Middle River near Old River, and P12-Old River at Tracy Road Bridge, and C10-San Joaquin River near Vernalis. Data plots are shown for the time period of January 2005 through June 2010 with periods of shown in yellow (cross hatch).

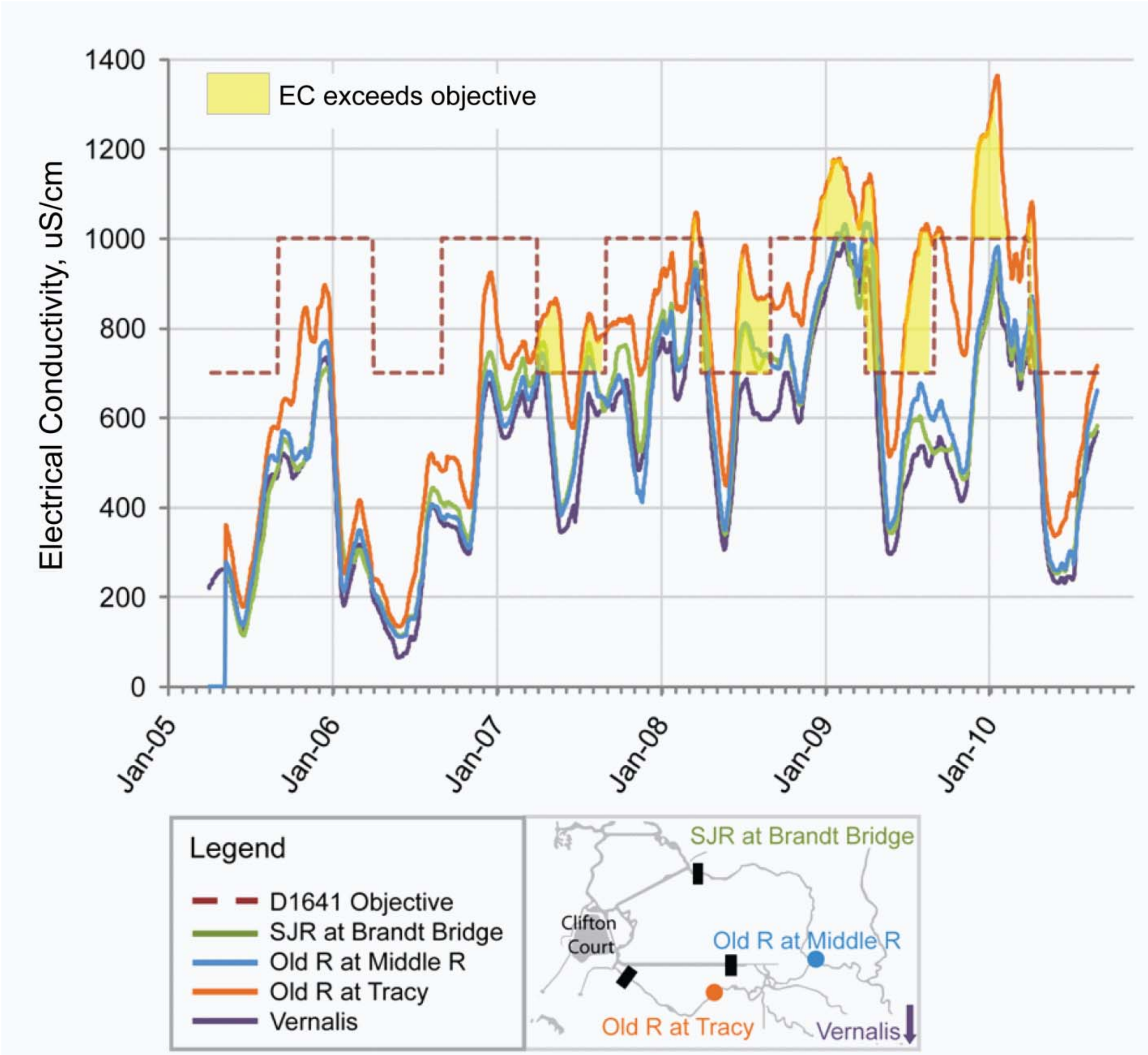


Figure III.1 Historical D1641 Water Quality Objective
(Shaded yellow areas indicate periods when the salinity objective was exceeded. Data provided by California Dept. of Water Resources Operations and Maintenance office)

3. DSM2 Modeling

A set of general study characteristics were developed from which DSM2 modeling scenarios could be evaluated. An initial set of conceptual pumping scenarios for pumping at one or more temporary barriers were identified as a starting point for analysis. The conceptual scenarios were used to perform modeling to provide a general indication of concept approach, feasibility, flow ranges and water quality benefits. Iterative modeling analysis of variations of the initial conceptual scenarios was performed. The iterative modeling was performed to identify a suite of scenarios which together would present a comparative look at the potential range of water quality benefits of low head pumping.

4. Development of Conceptual Level Engineering Details and Planning Level Cost Estimates

Based on the suite of modeled pumping scenarios conceptual level engineering details and costs were developed. Detail development included: an evaluation of potential permanent and temporary pumping systems; review of general barrier site specific requirements and constraints; preparation of conceptual configurations for the various permanent and temporary pump systems; analysis of system hydraulic sizing to meet modeled flow requirements as well as permitting requirements; preparation of conceptual "foot print" drawings to show space and location requirements; and calculation of a range of capital construction and annual operation and maintenance planning level costs.

5. Evaluation of Environmental Impacts and Permit Requirements

A summary level evaluation of environmental impacts and permit requirements for construction and operation of permanent and temporary pumping systems was completed. The evaluation was based on current federal and State regulations and requirements. Impacts were evaluated relative to physical, biological, social and economic factors that might be affected. Potential impacts and possible mitigation commitments or obligations as well as expected regulatory compliance permits and approvals were identified.

B. Alternatives Development

Low head pumping alternatives were developed for the study by DWR and through consultation with the South Delta Water Agency. Prior low head pump evaluation analyses were reviewed (DWR 2002) as well as testimony from the June 25, 2009 SWRCB Hearing Considering Changes to WR2006-0006 (SWRCB 2009). An initial set of alternatives or scenarios were developed to examine the simulated reduction in salinity levels at the two interior Delta compliance locations. The initial set of scenarios included (1) a single pump station at the Grant Line Canal barrier and (2) a pump station at the Middle River barrier and a pump station at the Old River barrier. The premise for selection of these initial alternatives was that either alternative could generate circulation patterns in the south Delta to more uniformly mix existing salinity and introduce Sacramento River water with lower salinity concentrations.

Based on initial DSM2 modeling results a number of alternative pumping concepts were developed. These concepts included variations of single- and two-pumping location alternatives, symmetric (uniform) and asymmetric (non-uniform) pumping for two-pumping location alternatives, and increased and decreased elevation of temporary barrier weir heights. These variations were evaluated to examine if:

- Pumping at a single barrier location could consistently meet the salinity objective at both C8-Middle River near Old River and P12-Old River at Tracy Road Bridge;
- Pumping at two barrier locations simultaneously, whether with uniform or non-uniform pumping, could consistently meet the salinity objective at both C8-Old River near Middle River and P12-Old River at Tracy Road Bridge;
- Raising or lowering barrier heights when combined with either single- or two-barrier location pumping approaches would significantly improve maximum achievable salinity reductions.

These alternative concepts were used to evaluate a variety of modeling scenarios as presented in the following section.

C. Hydrodynamic and Water Quality Analysis

The analysis of the hydrodynamic and water quality impacts included the review of historic salinity levels in the south Delta (1992 to present), selection of water years to evaluate where salinity levels exceeded the Delta salinity objectives, and the use of simulation modeling to evaluate the potential benefits of various low head pumping scenarios. The analysis approach, modeling scenarios, modeling assumptions, and results are presented below.

1. Approach

Potential effectiveness of low head pumping on water quality objective compliance in the South Delta was examined using the Delta Simulation Model 2 (DSM2) (DSM2, 2011). This model represents flow, water levels, and water quality in the Delta for both historical and hypothetical conditions, such as use of the low head pumps. DSM2 has been calibrated or “tuned” to represent observed Delta flows, water levels, and salinity (IEP PWT, 2000). The model has a long history of applications for planning and management purposes in the Delta (DSM2, 2011). Enhancements to the model are documented in annual reports to the State Water Resources Control Board (DMS, 2011). The model was used to estimate possible effects of low head pumping scenarios to reduce historical exceedences of South Delta salinity objectives (see Section I Introduction).

Although Delta models, including DSM2, are tuned to best represent available salinity observations, representing Delta salinity in a model is challenging since there is a lack of field observations for some key salinity sources including agricultural return flows from Delta islands, groundwater seepage and other unmonitored source flows. Thus Delta salinity models, including DSM2, tend to under predict salinity in the South Delta. The degree to which the models under predict salinity varies by location. For example the modeled salinity estimates at Middle River at Old River are closer to field observations than those at Old River at Tracy (see Appendix A). DSM2 uses the best available estimate of Delta Island Consumptive Use to represent agricultural withdrawals and return flows (DWR, 1995), however these estimates are based on limited field observations. There are also additional sources of salinity that aren't accounted for in any Delta model due to the lack of available field data. To compensate for the under-prediction of modeled Delta salinity, this study combined field observations of total salinity concentrations with modeled changes in salinity due to low head pumping to provide estimated impacts to salinity standard compliance (see Appendix A).

2. Modeled Scenarios

Scenarios examined for this study included three main considerations

- Location of pumping
- Amount of pumping
- Temporary agricultural barrier operations

For this study, 58 low head pumping scenarios were investigated that reflected a range of pumping configurations and temporary agricultural barrier operations (Table III.1). For all scenarios, the low head pumps were located at temporary agricultural barriers and pumping was in the eastward direction. Three single pumping locations were considered: Middle River, Grant Line Canal and Old River. Three multiple site pumping configurations were also examined: Middle River and Old River, Middle River and Grant Line Canal, and Grant Line Canal and Old River. Pumping rates examined ranged from 50 cfs to 150 cfs. The bulk of the scenarios used pumping rates of 125 cfs, 250 cfs, 500 cfs, or 1000 cfs. For the scenarios with two pumping sites, pumping rates were typically distributed evenly between the two sites (e.g., for a total pumping rate of 500 cfs, 250 cfs would be pumped at each site). A few scenarios were run with the pumping rates distributed unevenly between the two sites, but the resulting impact on water quality objective compliance was nearly identical to an even distribution of the same total pumping rate. A range of agricultural barrier operations were also examined. Some scenarios used the historical barrier operations. Other scenarios examined changing the weir heights on the barriers to try to enhance circulation. This was done by raising the weir height on the barrier or barriers with low head pumping and lowering the weir heights on the barrier or barriers without low head pumping. For example for the case with Middle River and Old River pumping, the weir heights were raised on the Middle River and Old River barriers, and weir heights were lowered on the Grant Line Canal barrier. Since the temporary barrier operations have been evolving over the past few years to try to enhance circulation such as raising the Middle River barrier weir height (Addendum to Mitigated Negative Declaration for the South Delta Temporary Barriers Project, DWR, March 2010), some scenarios examined using barrier operating rules based on 2010 historical operations.

The study period selected was 2007-2009, three recent years when the D1641 salinity objectives were exceeded (Figure III.1). Water years 2007 and 2009 were classified as dry and 2008 was classified as critically dry using the Sacramento 40-30-30 index (CDEC, 2011). For evaluation of the effectiveness of the low head pumping to reduce exceedences of the salinity objectives, the analysis focused on the July-October period since this is the time period when all three temporary agricultural barriers are installed, and thus this would be the period when low head pumping could be utilized to try to enhance circulation and reduce salinity objective exceedences.

Table III.1: Characteristics Examined by 58 Low Head Pumping Study Scenarios

Study Characteristic	Range Evaluated
Study period	2007-2009
Objective compliance evaluation period	July-October (period when all 3 agricultural barriers are installed)
Pumping locations	Single pumping sites: Middle River Grant Line Canal Old River Two pumping sites: Middle River and Old River Middle River and Grant Line Canal Grant Line Canal and Old River
Pumping rates	50 cfs to 1500 cfs
Pumping distribution for scenarios with 2 pumping sites	Same pumping rate at both pumping sites (symmetrical) Different pumping rates at the 2 pumping sites (asymmetrical)
Temporary agricultural barrier operations	Historical Historical with changed weir heights to enhance circulation 2010 based operations applied to 2007-2009

Although nearly 60 total scenarios were examined in this study, this report focuses on four select alternative scenarios that were found to have the most effect on reducing exceedences of the D1641 salinity objectives (Table III.2). These four scenarios focus on the three single-pumping site alternatives

(Middle River, Grant Line Canal, and Old River) and one two-pumping site alternative (Middle River and Old River) (Figure III.2). The report focuses on results for total pumping rates of 250, 500 cfs and 1000 cfs. For the two-pumping site alternatives, the total pumping was split evenly between the two sites. The selected alternatives used the historical temporary barrier operations.

Table III.2: Characteristics of Select Low Head Pumping Study Alternatives

Study Characteristic	Range Evaluated
Study period	2007-2009
Objective compliance evaluation period	July-October (period when all 3 agricultural barriers are installed)
Pumping locations	Single pumping site: Middle River Grant Line Canal Old River Two pumping sites: Middle River and Old River
Total Pumping rates	250 cfs, 500 cfs, and 1000 cfs
Pumping distribution for scenarios with 2 pumping sites	Same pumping rate at both pumping sites (symmetrical)
Temporary agricultural barrier operations	Historical

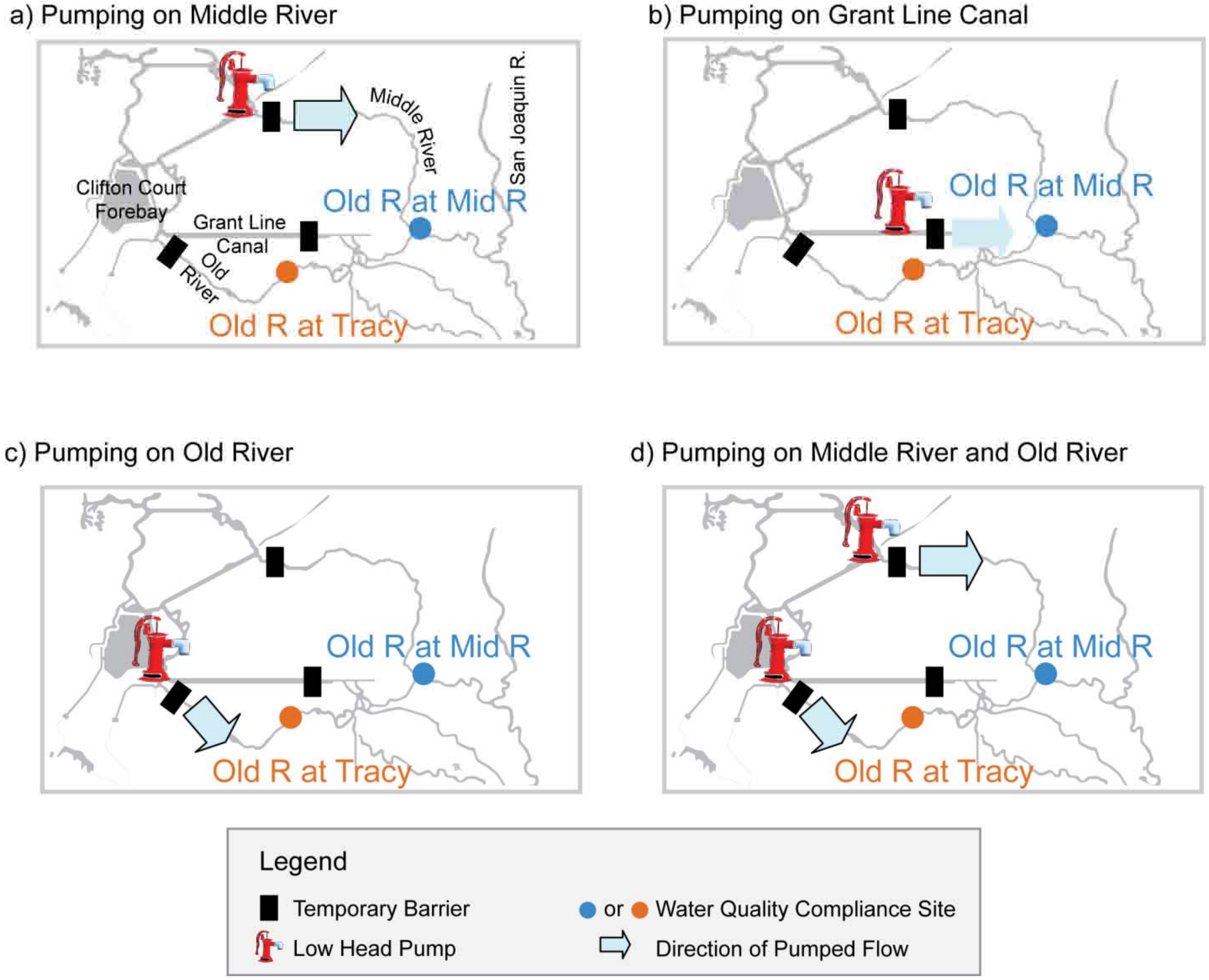


Figure III.2: Select low head pumping scenarios

3. Modeling Assumptions

Assumptions made in the select modeling scenarios include

- Historical Delta inflows, exports and tidal conditions for 2007-2009
- Use of historical temporary agricultural barrier operations
- Low head pumps are used at designated temporary barrier locations
- Low head pumps operate 24 hours a day when the temporary barriers are installed
- If there are two pumping sites, that total pumping rate is divided evenly between the two sites
- Leakage through the rock barriers is not considered (leakage could reduce the efficiency of the low head pumping)

4. Water Quality and Flow Impact Analysis

Salinity Objective

For this study, of the D1641 objectives was examined for three of the compliance sites: C8-Old River near Middle River, P12-Old River at Tracy Road Bridge and the C6-San Joaquin River at Brandt Bridge. Effects of low head pumping on salinity at a fourth compliance site, C10-San Joaquin River near Vernalis, could not be assessed because Vernalis salinity is a specified boundary value in DSM2. Thus the model used historical salinity at Vernalis for all simulations.

Salinity objective for the select low head pumping alternatives was compared to historical conditions for the July-October (123 days) evaluation period for 2007-2009 (Figure III.3 and Figure III.4). During this dry and critically dry historical period, occurred at C6-San Joaquin River at Brandt Bridge about 23% (28 out of 123 days) of the study period, at C8-Old River near Middle River about 22% (27 out of 123 days) of the study period, while at P12-Old River at Tracy Road Bridge, occurred about 55% (67 out of 123 days) of the study period.

Results for 500 cfs pumping scenarios are summarized in Table III.3, and results for the 1000 cfs scenarios are given in Table III.4. A results summary table for 250 cfs scenarios was not prepared because other than for potential reductions in at P8-Old River near Middle River reductions were much less than for higher pumping rates as shown on Figure III.4. Although each alternative provided some reduction in the amount of time that the salinity objectives were exceeded, no single alternative was the most effective at reducing salinity objective concurrently at all of the compliance sites. The most effective alternative for reducing salinity objective at C8-Old River near Middle River was pumping on Middle River. Similarly the most effective alternative for reducing salinity objective at P12-Old River at Tracy Road Bridge was pumping at Old River. None of the alternatives had a significant impact on salinity objective at the C6-San Joaquin River at Brandt Bridge site. Therefore, the results in this report focus primarily on the C8-Old River near Middle River and P12-Old River at Tracy Road Bridge compliance sites.

Pumping rates of 250 cfs or higher were typically required to reduce the amount of time that the salinity objectives were exceeded in July-October for conditions from 2007-2009. Full compliance with the salinity objectives at C8-Old River near Middle River was achieved for the pumping at Middle River alternative for pumping rates of 500 cfs or higher. As shown in Table III.4, pumping at Middle River eliminates only 2% of the exceedences at P12-Old River at Tracy Road Bridge at 500 cfs and 9% of the

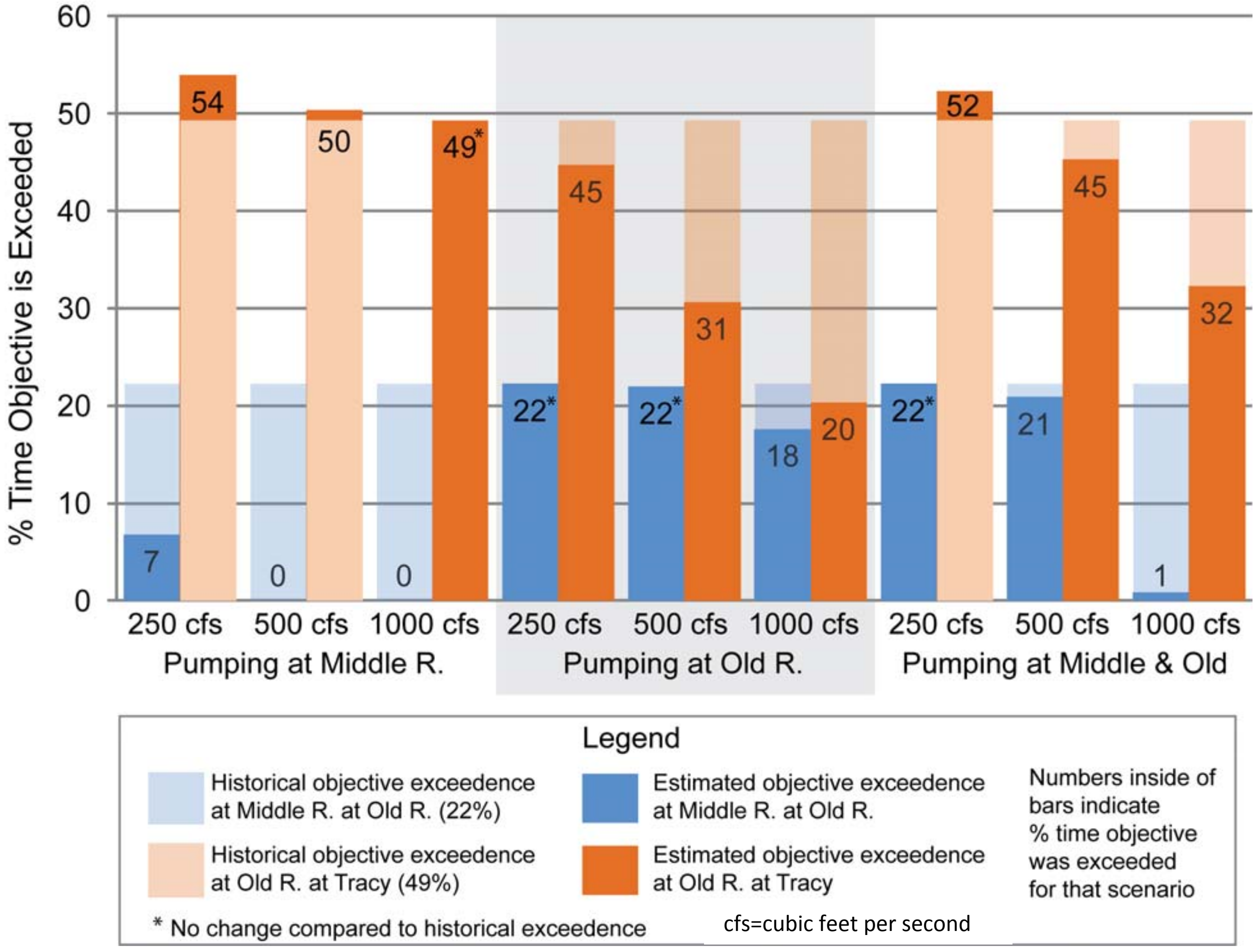


Figure III.3: Water Quality Objective for Pumping Alternatives vs. Historical Values (The same information is presented in a different format in Figure III.4)

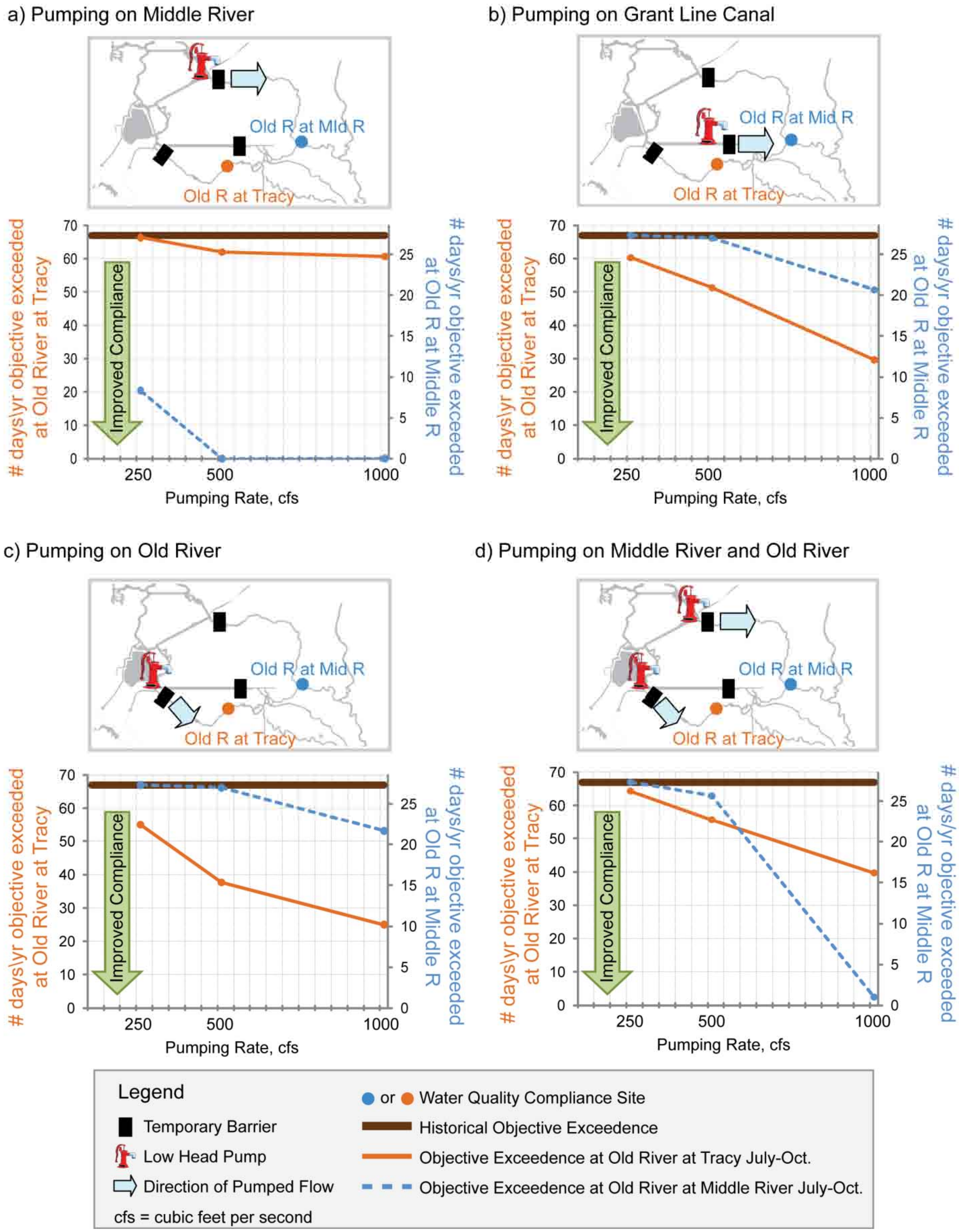


Figure III.4: Estimated Change in Water Quality Objective for July-Oct. Annual average impacts from a three year modeling study based on 2007-2009

Table III.3: Estimated Annual Change in of Salinity Objectives for 500 cfs* Low Head Pumping Scenarios for a Three Year Study Period based on 2007-2009

	Location	*Historical Annual Average*		Pumping at Middle River		Pumping at Grant Line Canal		Pumping at Old River		Pumping at Middle R. & Old R.	
		Jul-Aug	***Sep-Oct***	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct
	D1641 Objective	***700 µS/cm***	***1000 µS/cm***	700 µS/cm	1000 µS/cm	700 µS/cm	1000 µS/cm	700 µS/cm	1000 µS/cm	700 µS/cm	1000 µS/cm
Compliance Sites	Old River near Middle River	***27 days***	***HC***	↓27 days (100%)	HC	↓1 day (3.7%)	HC	↓1 day (3.7%)	HC	↓2 days (7.4%)	HC
		Combined % Change		(100%)		(3.7%)		(3.7%)		(7.4%)	
	Old River at Tracy Road Bridge	***61 days***	***6 days***	NC	↓1 days (16.7%)	↓9 days (14.8%)	↓6 days (100%)	↓23 days (37.7%)	↓6 days (100%)	↓10 days (16.4%)	↓2 days (33.3%)
		Combined % Change		(1.5%)		(22.4%)		(43.3%)		(17.9%)	
	San Joaquin R. at Brandt Bridge	***28 days***	***HC***	↓1 day (3.6%)	HC	↓1 day (3.6%)	HC	↓1 day (3.6%)	HC	↓1 day (3.6%)	HC
		Combined % Change		(3.6%)		(3.6%)		(3.6%)		(3.6%)	

*For the Middle & Old River scenario, there is 250cfs pumping at each site. All others have 500cfs pumping at that site.
↓ reduced thus improving compliance, NC= No Change, HC= 100% compliance historically, µS/cm = microsiemens/centimeter, Combined % change = sum of changes in exceedences for Jul – Aug and Sep – Oct as a %.

Table III.4: Estimated Annual Change in with Salinity Objectives for 1000 cfs* Low Head Pumping Scenarios for a Three Year Study Period based on 2007-2009

	Location	*Historical Annual Average*		Pumping at Middle River		Pumping at Grant Line Canal		Pumping at Old River		Pumping at Middle R. & Old R.	
		Jul-Aug	***Sep-Oct***	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct
	D1641 Objective	***700 µS/cm***	***1000 µS/cm***	700 µS/cm	1000 µS/cm	700 µS/cm	1000 µS/cm	700 µS/cm	1000 µS/cm	700 µS/cm	1000 µS/cm
Compliance Sites	Old River near Middle River	***27 days***	***HC***	↓27 days (100%)	HC	↓7 days (25.9%)	HC	↓6 days (22.2%)	HC	↓26 days (96.3%)	HC
		Combined % Change		(100%)		(25.9%)		(22.2%)		(96.3%)	
	Old River at Tracy Road Bridge	***61 days***	***6 days***	NC	↓6 days (100%)	↓31 days (50.8%)	↓6 days (100%)	↓36 days (59.0%)	↓6 days (100%)	↓21 days (34.4%)	↓6 days (100%)
		Combined % Change		(9.0%)		(55.2%)		(62.7%)		(40.3%)	
	San Joaquin R. at Brandt Bridge	***28days***	***HC***	↓1 day (3.6%)	HC	↓1 day (3.6%)	HC	↓1 days (3.6%)	HC	↓1 day (3.6%)	HC
		Combined % Change		(3.6%)		(3.6%)		(3.6%)		(3.6%)	

*For the Middle & Old River scenario, there is 500cfs pumping at each site. All others have 1000cfs pumping at that site.
↓ reduced thus improving compliance, NC= No Change, HC = 100% compliance historically, µS/cm=microsiemens/centimeter, Combined % change = sum of changes in for Jul – Aug and Sep – Oct as a %.

exceedences when increased to 1000 cfs. None of the alternatives resulted in full compliance with the salinity objective at P12-Old River at Tracy Road Bridge.

The largest reduction in objective exceedences at P12-Old River at Tracy Road Bridge was obtained by the 1000 cfs pumping scenario at Old River (about 60%). When pumping 500 cfs at Old River, the exceedence is reduced by only about 40 % at P12-Old River at Tracy Road Bridge. Pumping at Old River only eliminates 4% of the exceedences at C8-Old River near Middle River at a pumping rate of 500 cfs and eliminates only 22% percent of exceedences when the rate is increased to 1000 cfs. Combined pumping of 500 cfs at both the Middle River and Old River sites resulted in a reduction in salinity objective exceedence of 10 - 20% at C8-Old River near Middle River and P12-Old River at Tracy Road Bridge, respectively. When the pumping rate is increased to 1000 cfs of combined pumping (500 cfs at each site) the salinity objective exceedence at C8-Old River near Middle River is almost completely eliminated and P12-Old River at Tracy Road Bridge is reduced by 40%.

Pumping at Grant Line Canal reduced salinity exceedence at P12-Old River at Tracy Road Bridge by 22% at 500 cfs, but only reduced exceedences at C8-Old River near Middle River by about 4% at this same pumping rate. When the pumping at Grant Line Canal was increased to 1000 cfs, exceedences at C8-Old River near Middle River were reduced by about 25% and about 55% at P12-Old River at Tracy Road Bridge. Neither the pumping at Grant Line Canal or the combined pumping at Middle River and Old River alternatives were as effective at reducing salinity objective exceedence at a single compliance site as the alternative with pumping on the river with the compliance site; in other words pumping on Middle River provides the most benefit for reducing salinity at C8-Old River near Middle River and pumping on Old River provides the most benefit for reducing salinity at P12-Old River at Tracy Road Bridge. Elimination of exceedences at C6-San Joaquin River at Brandt Bridge was less than 4% for all pumping locations and rates.

Salinity at D1641 Objective Compliance Sites and Water Supply Exports

Changes in salinity were examined at the salinity objective compliance sites and at several major water supply export locations for the 2007-2009 study period. Results for the 500 cfs pumping alternative scenarios are shown in Table III.5, and results for the 1000 cfs pumping alternatives are in Table III.6. A result summary table for 250 cfs alternative scenarios was not prepared but would be less than for the 500 cfs pumping rate.

Table III.5: Estimated Change in Average Salinity (Electrical Conductivity, µS/cm) for 500 cfs* Low Head Pumping Scenarios for a Three Year Study Period Based on 2007-2009

	Location	Pumping at Middle River		Pumping at Grant Line Canal		Pumping at Old River		Pumping at Middle R. & Old R.	
		Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct
Compliance Sites	Middle River at Old River	-237 (-39.3%)	-158 (-27.1%)	0 (0.0%)	-11 (-1.8%)	3 (0.4%)	-7 (-1.3%)	-25 (-4.1%)	-12 (-2.1%)
	Old River at Tracy Bridge	-13 (-2.2%)	-15 (-2.5%)	-124 (-20.6%)	-61 (-10.3%)	-121 (-20.0%)	-28 (-4.8%)	-41 (-6.7%)	7 (1.2%)
	San Joaquin R. at Brandt Bridge	1 (0.2%)	0 (0.0%)	1 (0.2%)	0 (0.0%)	1 (0.2%)	0 (0.0%)	1 (0.2%)	0 (0.0%)
Export Sites	State Water Project (Banks PP)	1 (0.2%)	2 (0.4%)	2 (0.6%)	4 (0.7%)	2 (0.6%)	3 (0.6%)	2 (0.4%)	2 (0.4%)
	Central Valley Project (Jones PP)	3 (0.7%)	2 (0.4%)	1 (0.2%)	1 (0.2%)	1 (0.2%)	1 (0.1%)	0 (0%)	2 (0.3%)
	Contra Costa Pumping Plant #1	0 (0.0%)	0 (-0.1%)	-1 (-0.2%)	-3 (-0.4%)	-1 (-0.2%)	-2 (-0.3%)	0 (-0.1%)	-1 (-0.2%)
	Los Vaqueros	0 (0.1%)	1 (0.1%)	1 (0.3%)	1 (0.1%)	1 (0.2%)	1 (0.1%)	1 (0.2%)	1 (0.1%)
	Victoria Canal	1 (0.3%)	2 (0.4%)	6 (2.0%)	9 (2.3%)	5 (1.7%)	7 (1.9%)	3 (1.0%)	4 (1.1%)

*For the Middle & Old River scenario, there is 250 cfs pumping at each site. All others have 500 cfs pumping at that site. Red text indicates reductions in salinity. PP= Pumping Plant, µS/cm = microsiemens per centimeter, (#.#%) = percent change from historical 30-day running average of mean daily salinity.

Table III.6: Estimated Change in Average Salinity (Electrical Conductivity, µS/cm) for 1000 cfs* Low Head Pumping Scenarios for a Three Year Study Period Based on 2007-2009

	Location	Pumping at Middle River		Pumping at Grant Line Canal		Pumping at Old River		Pumping at Middle R. & Old R.	
		Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct
Compliance Sites	Middle River at Old River	-271 (-45.0%)	-176 (-30.2%)	-50 (-8.3%)	-39 (-6.7%)	-28 (-4.6%)	-26 (-4.5%)	-131 (-21.7%)	-83 (-14.3%)
	Old River at Tracy Bridge	-42 (-7.0%)	-38 (-6.3%)	-192 (-31.9%)	-87 (-14.6%)	-189 (-31.3%)	-84 (-14.1%)	-113 (-18.7%)	-23 (-3.8%)
	San Joaquin R. at Brandt Bridge	1 (0.2%)	0 (0.0%)	-1 (-0.2%)	-3 (-0.5%)	1 (0.2%)	-1 (-0.2%)	1 (0.2%)	0 (0.0%)
Export Sites	State Water Project (Banks PP)	4 (1.0%)	4 (0.9%)	2 (0.5%)	4 (0.7%)	5 (1.3%)	6 (1.3%)	5 (1.3%)	5 (1.1%)
	Central Valley Project (Jones PP)	4 (1.1%)	3 (0.5%)	4 (1.1%)	3 (0.5%)	1 (0.3%)	2 (0.4%)	3 (0.9%)	2 (0.3%)
	Contra Costa Pumping Plant #1	-1 (-0.2%)	-2 (-0.4%)	0 (0.0%)	-1 (-0.1%)	-2 (-0.4%)	-5 (-0.8%)	-1 (-0.3%)	-4 (-0.7%)
	Los Vaqueros	2 (0.4%)	1 (0.2%)	1 (0.3%)	2 (0.3%)	2 (0.6%)	1 (0.2%)	2 (0.5%)	1 (0.2%)
	Victoria Canal	7 (2.3%)	8 (2.1%)	2 (0.7%)	3 (0.9%)	12 (4.1%)	16 (4.3%)	10 (3.5%)	14 (3.6%)

For the Middle & Old River scenario, there is 500 cfs pumping at each site. All others have 1000 cfs pumping at that site. Red text indicates reductions in salinity. PP= Pumping Plant, µS/cm = microsiemens per centimeter, (#.#%) = percent change from historical 30-day running average of mean daily salinity

For the C8-Old River near Middle River site, the largest reduction in salinity was for the Middle River pumping alternative. Salinity in July and August was reduced by about 40% for 500 cfs of pumping and by about 45% for 1000 cfs of pumping. For September to October, salinity was reduced by about 30% for both 500 cfs and 1000 cfs of pumping. The combined pumping at Middle River and Old River 1000 cfs pumping scenario was the only other alternative that reduced salinity at C8-Old River near Middle River by more than ten percent.

For the P12-Old River at Tracy Road Bridge site, pumping at Old River had the largest effect on reducing of the salinity objectives. However both the Grant Line Canal and Old River pumping alternatives had similar impacts on total salinity. For both alternatives, salinity in July and August was reduced by about 20% for 500 cfs of pumping and by about 30% for 1000 cfs of pumping. For September to October, salinity was reduced by about 5-10% for 500 cfs and by 15% for 1000 cfs of pumping. The combined pumping at Middle River and Old River 1000 cfs pumping scenario was the only other alternative that reduced salinity at P12-Old River at Tracy Road Bridge by more than ten percent. For all alternatives, the salinity at the C6-San Joaquin River at Brandt Bridge was reduced by 0.5% or less.

Five water supply export locations were examined: the State Water Project's Banks Pumping Plant, the federal Central Valley Project's Jones Pumping Plant, and three intakes for Contra Costa Water District. For the 500 cfs pumping alternatives, salinity changes were less than 1% at all export sites, except for Victoria Canal which had a maximum increase in salinity of 2.3%. Similarly, for the 1000 cfs pumping alternatives, salinity changes were less than 1% at all export sites, except for Victoria Canal which had a maximum increase in salinity of 4.3%.

Sources of Water and Salinity

In addition to estimating the impacts of low head pumping to salinity, the modeling studies can be used to gain insights into changes in where the water and salinity at a given location originated. Although DSM2 has not been calibrated or "tuned" for source tracking, the modeled source estimates can be used to better understand the complex mixing processes in the Delta. The model estimates water and salinity from five sources: the Sacramento River, the San Joaquin River, San Francisco Bay, in-Delta agricultural return flows, and the eastside tributaries of the Cosumnes, Mokelumne and Calaveras Rivers. The

Sacramento River and eastside tributaries provide relatively fresh sources of water to the Delta. San Francisco Bay, the San Joaquin River and in-Delta agricultural return flows are more saline sources.

Sources of water and salinity at the salinity objective compliance sites are shown for historical conditions and 500 cfs (Figure III.5) and 1000 cfs (Figure III.6) pumping alternatives. For July-October of 2007-2009, the majority of the water at C8-Old River near Middle River and at P12-Old River at Tracy Road Bridge came from the San Joaquin River. Pumping at Middle River changed the major water source at C8-Old River near Middle River to the lower salinity Sacramento River water, but only slightly increased the amount of Sacramento River water at P12-Old River at Tracy Road Bridge. Conversely, pumping at Old River changed the major water source at P12-Old River at Tracy Road Bridge to the lower salinity Sacramento River water, but only slightly increased the amount of Sacramento River water at C8-Old River near Middle River. For all of the alternatives, increasing the pumping rate from 500 cfs to 1000 cfs increased the fraction of lower salinity Sacramento River water at the compliance sites.

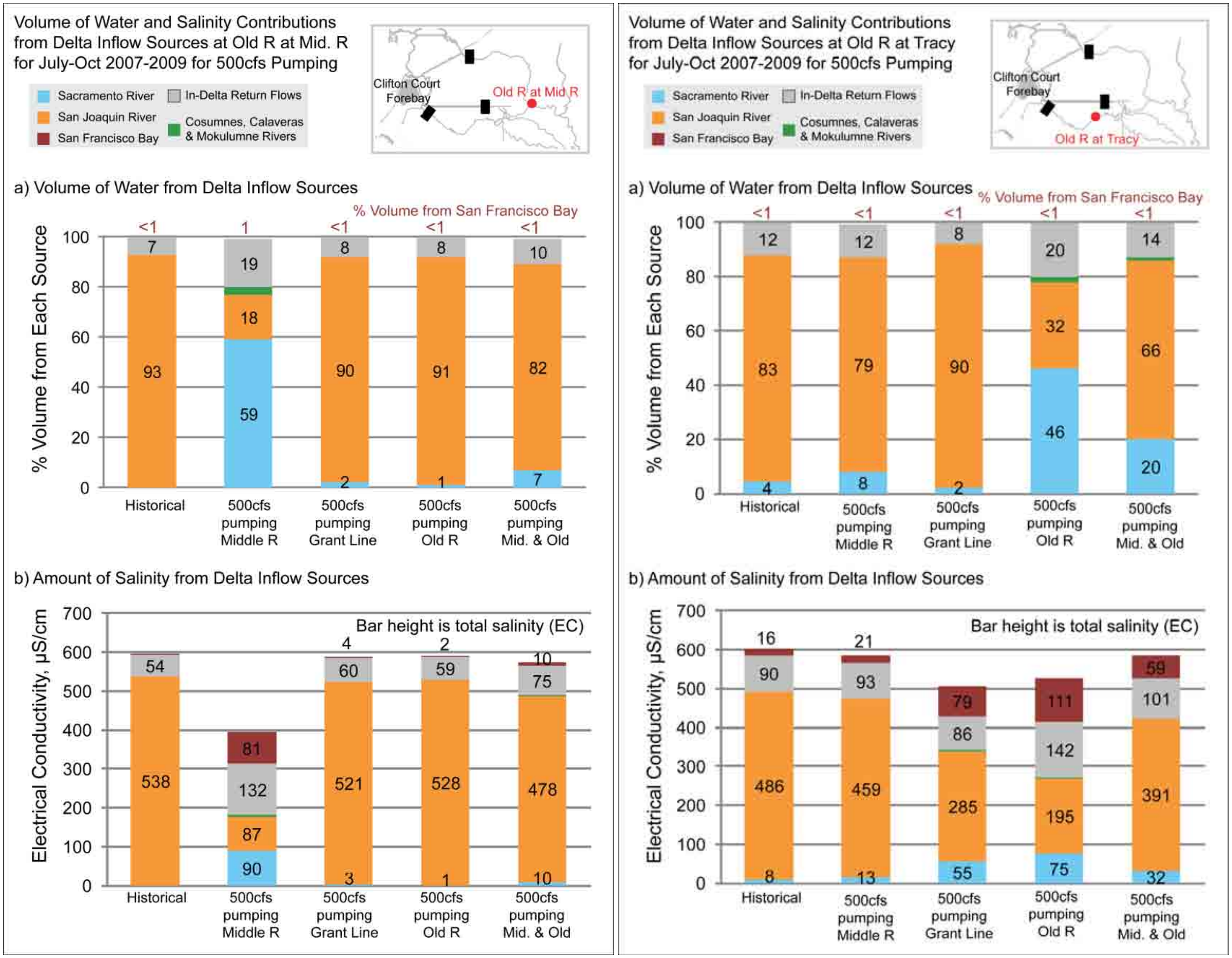


Figure III.5: Volume of Water and Amount of Salinity from Delta Inflow Sources for 500cfs Total Pumping for July-October of 2007-2009

Numbers inside bars indicate a) plots - % volume of water from a source, b) plots - µS/cm salinity from a source, cfs = cubic feet per second, µS/cm = microsiemens per centimeter

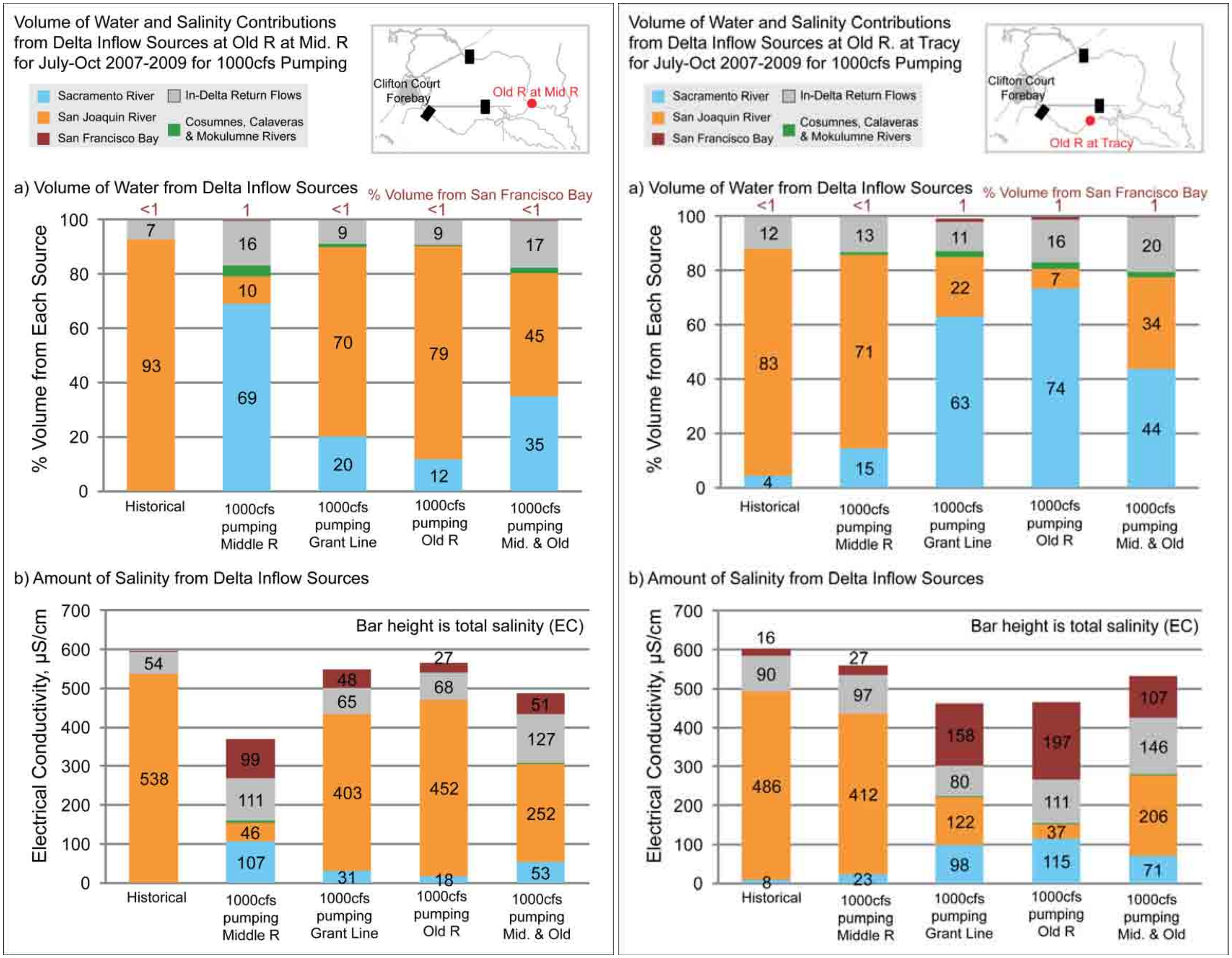


Figure III.6: Volume of Water and Amount of Salinity from Delta Inflow Sources for 1000cfs Total Pumping for July-October of 2007-2009

Numbers inside bars indicate a) plots - % volume of water from a source, b) plots - µS/cm salinity from a source, cfs = cubic feet per second, µS/cm = microsiemens per centimeter

In addition to increasing the amount of lower salinity Sacramento River water at the salinity objective compliance sites, the low head pumping also brings more saline in-Delta return flow to those sites. The simulations also show a slight increase in the amount of very saline water from San Francisco Bay.

Thus, the low head pumping increases the amount of water in the south Delta from all upstream sources, including lower salinity Sacramento River water and higher salinity in-Delta return flow water and Bay water. The net result is typically a reduction in salinity in the south Delta compared to historical conditions. Increasing the pumping rate from 500 cfs to 1000 cfs typically increases the amount of water in the south Delta from all of the upstream sources, and the results show that small increases in volume of water from higher salinity sources can have a large impact on the total amount of salinity. Thus some of the benefit of increasing the amount of fresher Sacramento River water at the compliance site is offset by increasing the amount of water from more saline sources as well.

Water Level Impacts

Water level impacts were examined for the low head pumping scenarios downstream of the temporary agricultural barriers (the intake side of the low head pumping) and at the water supply export locations (Table III.7 and Table III.8). Operating low head pumps lead to slight decreases in water levels near the pumping intakes on the downstream side of the temporary barriers. The maximum decrease in water level downstream of the temporary barriers was 0.16 feet for the 500 cfs pumping scenarios and 0.36 feet for the 1000 cfs scenarios. Similarly operating low head pumps lead to slight reductions in water levels at the water supply export locations. The maximum decrease in water level at the water supply exports locations was 0.11 feet for the 500 cfs pumping scenarios and 0.22 feet for the 1000 cfs scenarios.

Flow Impacts

Flow impacts resulting from low head pumping were examined for Old and Middle River flows and Delta outflow at Chipps Island (Table III.9 and Table III.10). Old and Middle River (OMR) flows were examined near Bacon Island, the location where OMR flows are considered for emigrating and yearling juvenile salmon and CV steelhead and Delta Smelt protection during winter months (NMFS 2009, USFWS 2008). Although the protection period for these species does not coincide with the July-October analysis period, OMR flows for 1000cfs pumping scenarios were examined as an indicator of flow impacts. Pumping at Middle River had the least impact on OMR flows with a maximum change of 3%. Pumping at Grant Line Canal had the largest impact on OMR flows with a maximum change of 11%. Average Net Delta Outflow at Chipps Island did not change with low head pumping, and maximum changes were 3% over a tidal cycle. Flow impacts are expected to be less for 500 cfs.

Table III.7: Estimated Reduction in Water Levels for 500 cfs* Low Head Pumping Scenarios for a Three Year Study Period based on 2007-2009

	Location	Pumping at Middle River		Pumping at Grant Line Canal		Pumping at Old River		Pumping at Middle R. & Old R.	
		Max (ft)[1]	Avg (ft)[2]	Max (ft)[1]	Avg (ft)[2]	Max (ft)[1]	Avg (ft)[2]	Max (ft)[1]	Avg (ft)[2]
Ag. Barriers	Middle River	-0.03	NC	-0.03	-0.01	**-0.04**	-0.01	**-0.04**	NC
Ag. Barriers	Grant Line Canal	-0.02	NC	**-0.16**	-0.04	-0.08	NC	-0.06	NC
Ag. Barriers	Old River at Tracy	-0.02	NC	-0.08	-0.01	**-0.16**	-0.05	-0.09	-0.02
Export s	State Water Project (Banks PP)	-0.01	NC	**-0.06**	-0.02	**-0.06**	-0.02	-0.04	-0.01
Export s	Central Valley Project (Jones PP)	-0.02	NC	-0.08	-0.02	**-0.11**	-0.03	-0.07	-0.01
Export s	Contra Costa Pumping Plant #1	NC	NC	**-0.01**	NC	**-0.01**	NC	**-0.01**	NC
Export s	Los Vaqueros	-0.01	NC	**-0.03**	-0.01	**-0.03**	-0.01	-0.02	NC
Export s	Victoria Canal	-0.03	NC	**-0.04**	-0.01	**-0.04**	-0.01	**-0.04**	NC

*For the Middle & Old River scenario, there is 250 cfs pumping at each site. All others have 500 cfs pumping at that site. **Red Text** indicates largest reduction in levels at a given location. PP= Pumping Plant, NC = No Change, cfs = cubic feet per second, ft = change in water levels from historic levels in feet

[1] Based on DSM2 15-minute data

[2] Based on tidally averaged DSM2 15-minute data

Table III.8: Estimated Reduction in Water Levels for 1000 cfs* Low Head Pumping Scenarios for a Three Year Study Period based on 2007-2009

Location		Pumping at Middle River		Pumping at Grant Line Canal		Pumping at Old River		Pumping at Middle R. & Old R.	
		Max (ft)[1]	Avg (ft)[2]	Max (ft)[1]	Avg (ft)[2]	Max (ft)[1]	Avg (ft)[2]	Max (ft)[1]	Avg (ft)[2]
Ag. Barriers	Middle River	-0.04	-0.01	-0.06	-0.01	**-0.07**	-0.01	-0.05	-0.01
	Grant Line Canal	-0.02	0.01	**-0.33**	-0.07	-0.13	NC	-0.08	NC
	Old River at Tracy	-0.03	NC	-0.14	-0.02	**-0.36**	-0.09	-0.17	-0.05
Export s	State Water Project (Banks PP)	-0.01	NC	**-0.10**	-0.05	**-0.10**	-0.04	-0.06	-0.02
	Central Valley Project (Jones PP)	-0.03	NC	-0.14	-0.03	**-0.22**	-0.05	-0.13	-0.03
	Contra Costa Pumping Plant #1	**-0.01**	NC	**-0.01**	NC	**-0.01**	NC	**-0.01**	NC
	Los Vaqueros	-0.02	NC	-0.05	-0.01	**-0.06**	-0.01	-0.04	-0.01
	Victoria Canal	-0.03	NC	-0.07	-0.02	**-0.08**	-0.01	-0.06	-0.01

*For the Middle & Old River scenario, there is 500 cfs pumping at each site. All others have 1000 cfs pumping at that site. **Red Text** indicates largest reduction in levels at a given location. PP= Pumping Plant, NC = No Change, cfs = cubic *feet per second, ft = change in water levels from historic levels in feet,*

[1] *Based on DSM2 15-minute data*

[2] *Based on tidally averaged DSM2 15-minute data*

Table III.9: Estimated Change in Flows (cfs) for 1000 cfs* Low Head Pumping Scenarios for July-October for a Three Year Study Period based on 2007-2009

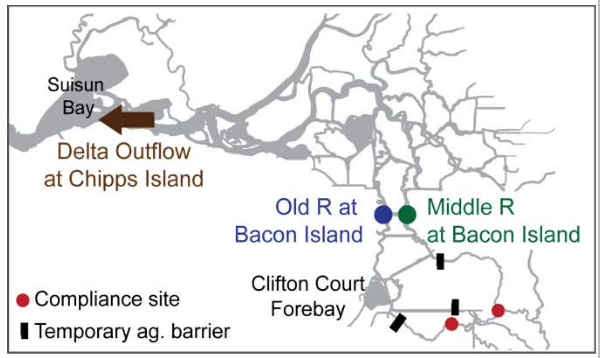
Location	Pumping at Middle River		Pumping at Grant Line Canal		Pumping at Old River		Pumping at Middle R. & Old R.	
	Max	Avg	Max	Avg	Max	Avg	Max	Avg
Old River at Bacon Is.	59 cfs ➔CCF (2%)	16 cfs ➔CCF (1%)	**347 cfs ➔CCF (11%)**	134 cfs ➔CCF (4%)	294 cfs ➔CCF (9%)	111 cfs ➔CCF (4%)	178 cfs ➔CCF (6%)	64 cfs ➔CCF (2%)
Middle River at Bacon Is.	127 cfs ➔CCF (3%)	46 cfs ➔CCF (1%)	**351 cfs ➔CCF (8%)**	154 cfs ➔CCF (4%)	298 cfs ➔CCF (7%)	129 cfs ➔CCF (3%)	234 cfs ➔CCF (6%)	88 cfs ➔CCF (2%)
Delta Outflow at Chipps Island	171 cfs ➔SF Bay (3%)	NC	**179 cfs ➔SF Bay (3%)**	NC	144 cfs ➔Delta (3%)	NC	41 cfs ➔Delta (1%)	NC

* For the Middle & Old River scenario, there is 500 cfs pumping at each site. All other scenarios have 1000cfs pumping at that site.

Flow and percent changes are relative to historical average flows

➔CCF= towards Clifton Court Forebay,
➔SF Bay = towards San Francisco Bay (ebb tide)
➔Delta = towards the Delta (flood tide)

Red Text indicates largest change in flow at a given location.
Cfs = cubic feet per second
NC = No Change



Impacts Summary

Selected conclusions drawn from the impacts assessment described in the preceding report sections are summarized in Table III.10.

Table III.10: Summary of Insights Gained from Modeling Studies on Low Head Pumping

Study Characteristic	Insight from model studies
Salinity objective	• None of the pumping scenarios examined provided full compliance of the salinity objective at all sites. • Full compliance at the Middle River at Old River site appears to be possible using low head pumping of at least 500cfs at the Middle River barrier. • Although some of the scenarios examined reduced the of the salinity objective at Old River at Tracy, none of the scenarios resulted in full compliance with that objective. • Low head pumping did not affect salinity objective at the San Joaquin at Brandt Bridge compliance site.
Pumping locations	• Using low head pumping at a temporary barrier reduces salinity objective at the compliance site on that river, e.g. a pump at Middle River barrier reduces at Middle River and pumping at the Old River barrier reduces at Old River and Old River at Tracy. • Pumping at both Middle River and Old River did not produce the same reduction in as pumping at a single barrier location.
Pumping rates	• Higher pumping rates lead to higher reductions in salinity standard. • Pumping of 500cfs or higher at Middle River barrier was required to get full compliance at C8-Old River near Middle River. This was the only alternative that provided full compliance at any of the compliance sites.
Operational changes to try to enhance effectiveness of low head pumping	None of the operational changes examined in the modeling studies had a significant impact on enhancing the reduction in salinity at the compliance sites compared to modeled historical barrier operations • Changing weir heights at the barriers to enhance circulation (higher at pump site and lower at other barriers) • 2010 based barrier operations • For scenarios with two pumping sites, splitting the total pumping unevenly between the two sites
Salinity at water supply intakes	• Salinity changes at the SWP and CVP intakes as well as Contra Costa's pumping plant #1 and Los Vaqueros intakes were less than 1% for all scenarios. • Salinity changes at Contra Costa's Victoria Canal alternate intake was less than 5% for all scenarios.
Old & Middle R. flows	• Average Middle and Old River flows changed by an average of less than 5%
Delta Outflow at Chipps Island	• Delta Outflow did not on average more change than 3%
Sources of water and salinity	Low head pumping circulates more upstream water into the South Delta. The upstream water is both fresher water from the Sacramento River and more saline water from In-Delta return flows and Bay water.

D. Engineering and Cost Analysis

An evaluation of the practicality and cost of constructing permanent or temporary low head pumping facilities at each barrier site was completed. The evaluation included a review of general site specific conditions, preparation of a set of conceptual pumping facility descriptions, development of planning level site layout plans, analysis of general hydraulic and environmental agency requirements for equipment sizing, and determination of estimated costs. Pumping facility concepts were based on prior DWR experience and existing facilities constructed by other public or private entities. These concepts included from permanent pump facilities with intakes with flat or cylindrical screens and temporary facilities with intakes with cylindrical screens that utilize rented or leased skid-mounted pump systems.

An internal informational report (DOE Conceptual Engineering Support Document) prepared by DWR Division of Engineering is included in Appendix B. The report presents engineering and cost details for a wide range of alternative pumping configurations. These configurations were based on modeling analyses described in Section III.C. Hydraulic and Water Quality Analysis. The configurations include pumping capacities from 50 to 1000 cfs. The intake designs for the Old River and Grant Line barrier sites with a pumping capacity of 250 cfs were used as a basis of design from which cost information was extrapolated for other pumping-level alternatives. More detailed costs were developed for the four most effective or select alternatives as described in Section III.C. These alternatives include single-pumping sites at the Middle River barrier, at the Grant Line barrier, or the Old River barrier and the two-pumping sites alternatives with concurrent pumping at both the Middle River barrier and Old River barrier.

1. Pumping Facility Concepts

A range of different pumping configurations exist in the Delta. Most intake pumps in the Delta are quite small considering that they act as agricultural diversions. According to the DWR's Delta Atlas, about 1800 agricultural diversions exist in the Delta. During the peak summer months, diversions from these facilities collectively exceed 4000 cfs. In addition to agricultural diversions there are several municipal diversions with pumping capacities of several hundred cfs. Three different intake configurations were considered for this evaluation. These three configurations with designs based on current NMFS criteria for juvenile salmon and CDFG recommendations regarding USFWS criteria for delta smelt include permanent flat screen intakes, permanent cylindrical screen intakes, and temporary cylindrical screen intakes.

Permanent Flat Screen Intakes

The permanent flat screen intake configuration would be an on-bank intake that is located within and parallel to the bank and would produce little relative projection into the river width. The intake would be a reinforced concrete structure that would be built partially within the levee embankment. The front wall, on the water-side of the structure, would house a bank of fish screens and would be relatively smooth. The back wall would be a retaining wall supporting the levee road. The top deck of the intake would be set at or above the 100-year flood elevation. The floor of the intake would be set at approximately the same elevation as the adjacent river bed. This permanent configuration would be constructed once and left in place for the life of the facility, and would remain in place whether the temporary barrier is in place or not.

Water would enter the intake through the fish screens into a space that is divided into pump bays by interior concrete walls. A pump, floor mounted on the top deck of the intake, would be centered over each pump bay with a pump column that extends vertically down into the pump bay. The water would be pumped up the column and into a dedicated intake pipeline that is trenched under the adjacent levee road.

The fish screens would be stainless steel assemblies constructed of stainless steel wedge wire with screen opening slots 1.75mm wide. Flow control baffles and a fish screen cleaning system may be required for maintenance and for assurance that the design approach velocity is being met.

A permanent on-bank flat screen intake would be similar to Contra Costa Water District's 250 cfs intake on Victoria Canal or the Freeport Regional Water Authority's (FRWA) 285 cfs intake on the Sacramento River. (See Figure III.7).

Figure III.7: Example of an On-Bank Intake – FRWA Intake on the Sacramento River

Permanent Cylindrical Screen Intakes

The permanent cylindrical screen intake configuration would be comprised of a bank of cylindrical submerged self-cleaning fish screens, placed side by side, that are mounted on retrieval tracks that follow the waterside slope of the levee. A control/support platform would be constructed adjacent to the levee road from which the screens can be controlled and serviced. The platform would be a steel framed structure covered with grating which would be set at or above the 100-year flood elevation. The platform and frames supporting the retrieval track and the inlet pipe would be supported on piles. Water would enter the cylindrical fish screens; flow through manifolds and up inlet pipes. The fish screens would be stainless steel drum assemblies constructed of stainless steel wedge wire with screen opening slots 1.75mm wide. Cylindrical fish screens are proprietary and depending on the manufacturer come equipped with internal flow baffles and a screen cleaning system. When in use the screens would be lowered onto the docking manifolds within the water channel. When the screens are not in use they can be docked at the top of the retrieval track above the support platform. For this study, it was assumed that one pump and a dedicated inlet pipe would be provided for each cylindrical screen unit. The water would be pumped up the inlet pipes which will be trenched under the adjacent levee road. This permanent configuration would be constructed once and left in place for the life of the facility. The screens would remain in place whether the temporary barrier is in place or not.

A permanent cylindrical screen intake would be similar to Sutter Mutual Water Company's 175 cfs State Ranch Pumping Plant near Knights Landing (See Figure III.8).

Figure III.8: Example of Cylindrical Screen Intake – SMWC State Ranch PP Temporary Cylindrical Screen Intakes

Temporary Cylindrical Screen Intakes

The temporary cylindrical screen intake configuration would be similar to the permanent cylindrical screen intake configurations. The main difference between the two configurations is that the temporary configuration would have some elements constructed once and left in place with the remaining elements installed and removed seasonally, at the same time that the temporary barrier is installed and removed.

The permanent elements of this configuration would be the portion of the inlet pipes that are located on the waterside of the levee. The permanent inlet pipe would run along the slope of the levee, from the in-water location of the cylindrical screen to the waterside levee hinge (waterside edge of the levee road). This portion of the inlet pipes, along with the docking manifolds and the inlet pipe steel support frames and piles, would be constructed once and left in place for the life of the facility.

Seasonally, as the temporary barrier is installed and removed, the remaining elements of this configuration will be installed and removed. The cylindrical screens will be installed over the manifolds at the ends of the permanent inlet pipes. The remaining portion of the inlet pipes would be brought in and attached to the permanent inlet pipes at the side of the levee road. The temporary inlet pipes will run over the top of the levee, down the landside slope of the levee, and connect to portable pump and generator systems. Depending on the pumping capacity and location of the scenario, one pump may be provided for each cylindrical screen unit or one pump may be provided for several screen units. The temporary inlet pipes, the cylindrical screens and their control system, the pumps, and the generators would be brought on site and installed on a seasonal basis.

The fish screens would be the same stainless steel drum assemblies that are used for the permanent cylindrical screen intakes (see Figure III.8). It is recommended that self-cleaning screen units, that have an internal and external brushed cleaning system, be provided in order to keep the units clean and maintain the design approach velocity. The seasonally installed control panels will be needed to program the running of the screens. For this temporary option the screens would always be placed over the docking manifold when they are installed, there is not a retrieval track or control platform for withdrawal of the screens. Divers would be required to install and remove the screens as needed.

A water side portion of the temporary cylindrical screen intake would be similar to the permanent cylindrical screen intake shown in Figure III.8. The pumps for a temporary facility will be similar to the pumps shown in Figure III.9.

Figure III.9: Example of Temporary Pump and Generator Units

2. General Assumptions

Assumptions regarding the conceptual design approach and the cost estimation basis are shown in Table III.11.

Design Criteria	Description/Value
All Facilities	
Operation period	July-October (period when all 3 agricultural barriers are installed); 24 hour per day
Pumping rates	250 cfs, 500 cfs, and 1000 cfs
Permanent Facilities	
Useful life	50 years-Flat screen facility; 20 years-Cylindrical screen facility
Installation	Facility components remain in-place year round
Operation	Automated for unmanned supervision
Maintenance	Periodic weekly inspection and service
Temporary Facilities	
Useful life	Leased or rental; 10 years for cylindrical screen
Installation	Facility components installed concurrent with rock barrier installation and removed[1] with rock barrier removal
Operation	Automated for unmanned supervision
Maintenance	Regular fueling of diesel motor drivers; periodic weekly inspection and service
Cost Criteria	**Description/Value**
Estimate Type	Planning level estimate with -25 to 50% accuracy
[1] Intake screens for temporary pumping alternatives which incorporate cylindrical fish screens meeting fish service requirements remain in-place year round but are retracted during non-barrier periods.	

Table III.11 General Design and cost Estimations Assumptions

3. Analysis of Practicality

The practicality of installing and operating permanent and temporary pump facilities was evaluated for each barrier site. The evaluation included constructability based on the site specific conditions of spatial limitations, permanent and temporary pump system constraints, hydrodynamic limitations due to canal or river cross-section and water level characteristics, placement constraints for intake and discharge piping and structures, availability of power or fuel supply and other infrastructure and estimated cost. Additionally, aquatic and non-aquatic environmental constraints were evaluated by ICF International (Appendix C). Limitations or constraints regarding the practicality of facility installation and operation are shown in Table III.12.

Limitation or Constraint	Barrier Site		
	Middle River	Grant Line	Old River
Spatial	None identified	South Tracy Blvd. bridge may inhibit placement of intake	None identified
Pump Systems	Temporary systems of 500 cfs to 1000 cfs capacity, although possible, may require a complex arrangement of between10 to 40 skid mounted motor driven pumps and diesel fuel supply systems		
Hydrodynamic	River depth insufficient for necessary intake submergence without dredging. A long intake is required and future sedimentation may occur.	None identified	Installation requires placement of intake on river curve which may result in future sedimentation issues.
Placement	None identified	Discharge pipeline installation requires construction under Tracy Boulevard road subgrade	Installation requires placement of intake on river curve which may result in future sedimentation issues.
Infrastructure	Installation of high-voltage power supply required for permanent intakes	Installation of high-voltage power supply required for permanent intakes	Installation of high-voltage power supply required for permanent intakes
Environmental[1]			
Aquatic	Intake screen and discharge structure criteria subject to federal permit approvals		
Non-Aquatic	None identified	Potential Swainson's Hawk habitat in placement area of discharge piping and structure	None identified
[1] Determination of environmental constraints require confirmation through expected biological assessment surveys			

Table III.12 Practicality Limitations or Constraints

Based on the conceptual planning level evaluation the installation of either permanent or temporary pumping facilities appear to be practical subject to the limitations and constraints identified in Table III.12. Dredging needed to improve channel hydrodynamics on Middle River would be subject to more extensive Federal and State permit approvals.

4. Cost Analysis

A conceptual planning level cost analysis was performed and cost estimates developed for the range of modeled pumping scenarios. The analysis included pumping capacities ranging from 50 to 1000 cfs (see Appendix B. Engineering and Cost Analysis). However, as shown on Figures III.3 and III.4 in Section III.D. Hydrodynamic and Water Quality Analysis, simulated reduction in exceedences at the interior south Delta compliance locations were significantly less at pumping capacities below 250 cfs. Therefore, for the purpose of this analysis a flow capacity of 250 cfs was selected for detailed cost estimating as a basis-of-design from which to extrapolate cost information for other alternatives. Quantity estimates and configuration information was provided to the Cost Estimating Section (CES) of DOE, which in turn developed detailed cost information. The general cost criteria and description are presented below in Table III.13.

Cost Criteria	Description/Value
Construction Cost Subtotal	Cost of Materials and Installation
Mobilization and Demobilization	5% of Construction Cost Subtotal
Contingency	25% of Construction Cost Subtotal
Land Right-of-Way Acquisition[1]	15% of Construction Cost Subtotal
Capital Outlay Construction Total	Sum of Construction Cost Subtotal, Mobilization and Demobilization, Contingency, and Land Right-of-Way Acquisition
Project Support including Environmental Planning, Design, Permits, and Construction Management[2]	35% of Capital Outlay Construction Total
Project Grand Total	Sum of Capital Outlay Construction Total and Project Support Cost
Initial Capital Cost	Equal to Project Grand Total cost for initial installation
Annual Cost	Equal to recurring costs (yearly installation costs, if applicable (temporary facility cost equals Project Grand Total), power costs, maintenance costs)
Amortized Annual Cost	Annual Cost divided by effective annual interest rate (i)
Effective Annual Interest Rate (i)	Effective rate of interest if funds were borrowed
Capitalized Cost	Sum of Initial Cost and Amortized Annual Cost

[1] Land Right-of-Way acquisition costs for temporary easements were assumed to be 10% of the Construction Cost Subtotal

[2] Project Support for temporary facilities were assumed to be 20% of Capital Outlay Construction Total for yearly permit acquisition, design, and construction management

Table III.13 General Cost Criteria

Estimated initial capital costs for the various alternative scenarios for the four select or most effective alternatives are presented in tables III.14 and III.15. These alternatives include single-pumping sites at the

Middle River barrier, the Grant Line barrier, or the Old River barrier and two-pumping sites with concurrent pumping at both the Middle River and Old River barriers.

	Pumping Site								
	Middle River			Grant Line			Old River		
Pumping Capacity (cfs)	250	500	1000	250	500	1000	250	500	1000
Pump facility Configuration									
Temporary	$20.7	$40.9	$80.9	$5.5	$9.8	$19.6	$7.7	$14.6	$29.1
Permanent Cylindrical Screen	$60.8	$112.9	$234.3	$20.2	$40.9	$81.7	$26.8	$55.2	$110.1
Permanent Flat Screen	$161.4	$286.6	$551	$120	$214.5	$391.7	$139.6	$254.1	$469.2
[1] All values in million									

Table III.14 Estimated Single-Pumping Site Alternative Initial Capital Costs

	Pumping Site		
	Middle River and Old River		
Pumping Capacity (cfs)	250	500	1000
Pump facility Configuration			
Temporary	$14.9	$28.4	$55.5
Permanent Cylindrical Screen	$49.5	$87.6	$168.1
Permanent Flat Screen	$186.9	$301	$540.7
[1] All values in million			

Table III.15 Estimated Two-Pumping Site Alternative Initial Capital Costs

Estimated annual and capitalized total cost for the various alternative scenarios for the four select or most effective alternatives are presented in Table III.16 and III.17. These annual costs include typical operation and maintenance costs of electrical power or fuel, regular lubrication and equipment adjustment, and minor repairs. The annual cost is presented in the first column for each flow category (250, 500, and 1000) and the capitalized cost in the shaded second column. The capitalized cost, which allows the direct comparison of the overall cost of alternatives, includes the sum of the Initial Capital cost (see tables III.14 and III.15) and the value of the Annual Cost divided by and an effective interest rate of 7%.

	Pumping Location																	
	Middle River						Grant Line Canal						Old River					
Pumping Capacity (cfs)	250		500		1000		250		500		1000		250		500		1000	
Temporary Cylindrical Screen	$22.6	$343.9	$45.1	$685.8	$89.9	$1365	$10.0	$147.6	$15.6	$232.8	$32.4	$482.9	$10.9	$163.3	$17.6	$266.1	$36.4	$549.5
Permanent Cylindrical Screen	$1.4	$80.4	$2.6	$149.6	$5.3	$310.1	$0.7	$30.0	$1.4	$60.5	$2.7	$121.0	$1.0	$40.4	$2.0	$83.2	$3.9	$166.1
Permanent Flat Screen	$3.4	$210.4	$6.1	$374.2	$11.8	$719.7	$4.1	$179.0	$7.7	$325	$14.7	$602.0	$4.5	$204.2	$8.5	$376.1	$16.3	$702.0
[1] All values in million																		
[2] Annual Cost | Capitalized Cost																		

Table III.16 Estimated Single-Pumping Site Alternative Annual and Capitalized Costs

	Pumping Location Middle River and Old River					
Pumping Capacity (cfs)	250		500		1000	
Temporary Cylindrical Screen	$17.8	$269.0	$33.5	$507.3	$62.7	$951.9
Permanent Cylindrical Screen	$1.3	$68.0	$2.3	$120.8	$4.5	$232.8
Permanent Flat Screen	$4.7	$254.3	$8.0	$414.6	$14.7	$750.3
[1] All values in $ million [2] Annual Cost | Capitalized Cost						

Table III.17 Estimated Two-Pumping Site Alternative Annual and Capitalized Costs

E. Environmental Compliance and Permitting Analysis

An assessment of environmental impacts due to construction and installation of permanent and temporary pumping systems was completed. The assessment was based on current regulations and requirements of Title 14. Chapter 3, of the California Code of Regulations and Division 13, of the California Public Resource Code. Impacts were evaluated relative to physical, biological, social and economic factors that might be affected. Potential impacts and possible mitigation commitments or obligations as well as expected regulatory compliance permits and approvals were identified.

Assumptions

The assessment of impacts of permanent and temporary pump facilities was based on the following general assumptions related to various construction and operation criteria.

<u>Permanent Pump Facilities</u>

The general assumptions for permanent pump facilities were:

Construction

- Installation of the pump facilities would occur during and outside the existing temporary barrier construction period and require up to a year or more to complete.
- Construction of pump facility intake and discharge would require the temporary installation of a cofferdam and dewatering within the cofferdam

- Installation of high voltage power lines would be required to bring electric power to the barrier sites

- Construction staging areas larger than that required for temporary barriers alone

Operations

- Pumping operations would occur 24 hours per day from July 1 through October 31 (or over the period the temporary barrier is installed)

- Pump facility maintenance would require regular periodic site inspection and the performance of necessary maintenance

Temporary Pump Facilities

The general assumptions for temporary pump facilities were:

Construction

- Installation of the pump facilities would occur in the spring and would require up to 90 - 120 days the first year. After the first installation, future annual installation would likely require less time because some minor infrastructure remain in place after the pumps are removed;

- To the extent possible, staging areas used for construction of the barriers would also be used for installing the temporary pumps at these locations; and

- Most of the temporary pumping facilities would be confined to the crown and waterside of the levee with the exception of water conveyance pipelines.

Operations

- Pumping operations would occur 24 hours per day from July 1 through October 31 (or over the period the temporary barrier is installed)

- Pump facility maintenance would require regular fueling of engine driven pumps and the performance of necessary maintenance

Potential Impacts and Possible Mitigation Commitments or Obligations

Construction and operation of either permanent or temporary low head pumping facilities or systems are considered to be a modification of the currently implemented Temporary Barriers Program (TBP). Environmental considerations of this modification are expected to require minor modifications to existing permits and mitigation obligations.

Overall, the permanent systems would require that DWR provide mitigation for the footprint of the new pumping systems in addition to the mitigation already in place for the TBP. This could be accomplished at a mitigation bank, such as was done at Kimball Island for the TBP. The temporary pumping systems would not require additional mitigation for species, but the installation and removal of these systems each year could result in air quality effects that could require mitigation above and beyond what is currently required for the TBP. A summary of the potential impacts and possible mitigation obligations based on generally applied physical, biological, social, and economic factors is presented below. A more complete summary is presented in Appendix C. Environmental Compliance and Permitting Analysis.

Permanent Pumping Facilities

Potential impacts of constructing and operating permanent pumping facilities are expected to be consistent with similar actions in the Delta. Impact to environmental factors is expected to range from "less than significant" to requiring general mitigation actions or environmental commitments. These actions or commitments include:

- Standard mitigating design features;
- Standard mitigating construction practices;
- Standard environmental pre- and post- construction surveys of sensitive biological resources; and
- Implementation of appropriate monitoring, avoidance, minimization and exclusion actions for sensitive biological resources.

Unique impacts of permanent pumping facilities include a larger physical footprint, high voltage power supply infrastructure, and more intrusive in-water construction of the water intake and discharge structures. A common impact for both permanent and temporary facilities would include river dredging for pumping facilities installed at the Middle River barrier site. As noted in Section D. Engineering and Cost Analysis, the existing channel at this site has insufficient depth and capacity to maintain minimum intake structure submergence. The Grant Line Canal and Old River barrier sites are not expected to require similar dredging.

Temporary Pumping Facilities

Potential impacts of constructing and operating temporary pumping facilities are expected to be generally consistent with those for permanent facilities. General mitigation actions or environmental commitments would be the same as those listed above.

Unique impacts of temporary pumping facilities include fuel supply infrastructure, fuel transportation, annual installation and removal of equipment, a larger physical footprint, high voltage power supply infrastructure, and more intrusive in-water construction of the water intake and discharge structures. A common impact for both permanent and temporary facilities would include river dredging for pumping facilities installed at the Middle River barrier site (see Section D. Engineering and Cost Analysis).

Permitting

As described under *Potential Impacts and Possible Mitigation Commitments or Obligations* the construction and operation of permanent or temporary low head pumping facilities are considered to be a modification of the currently implemented TBP. Minor modifications to existing permits and mitigation obligations are expected to be required. A summary of expected permits and approvals including associated timelines is presented below.

Permanent Pumping Facilities

Table III.18 provides an overview of the environmental permits that may be required for the construction and operation of the permanent pumping facilities. The actual permits that would be required and the time to acquire them would depend on the actual estimated effects of the final proposed project and coordination with resource and regulatory agencies. This also assumes that there would be no need to re-consult on the CVP/SWP Long Term Operations BOs (OCAP) primarily because there are no expected increased effects on federally-listed species resulting from the proposed annual July through October system operation. However, the NMFS and FWS may require that re-consultation is necessary to address the minor changes in the project description of the BOs that would occur as a result of modifying the TBP. As described above, the permit requirements are based on the assumption that construction of these facilities would be included as an amended project description for the temporary barriers, similar to previous modifications (i.e., Middle River barrier raise). As such, permit documents would be abbreviated and would indicate that implementation of the pumping facilities would be a modified component of the overall TBP. Should this be unacceptable to the regulatory agencies, the estimated timelines to obtain these permits would likely increase.

Table III.18 Permit and Approval Requirements for Permanent Pumping Facilities

Authority/Agency	Permit/Approval	Timeline	Trigger
U.S. Army Corps of Engineers	Clean Water Act Section; 404/ Rivers and Harbors Act, Section 10	NWP: up to 3 months IP: up to 8 months[1]	Work within waters of the United States; Construction of any structure in or over any navigable water of the United States, or any other work affecting the course, location, condition, or physical capacity of these waters.
California Department of Water Resources	CEQA	Addendum: 1 month Supplemental IS/MND: 4 months	Potential impacts to the physical environment
U.S. Fish and Wildlife Service	ESA Take Permit (Section 7 consultation)	9 months[2]	Potential effects on delta smelt or its designated critical habitat
National Marine Fisheries Service	ESA Take Permit (Section 7 consultation) Magnusson-Stevens Act, EFH Consultation	12 months[2]	Potential take of steelhead, winter-run and spring-run Chinook salmon, green sturgeon or effects to designated critical habitat
California Department of Fish and Game	Incidental Take Permit	9 months[2]	Potential take of delta smelt, longfin smelt, spring-run Chinook salmon, or Swainson's hawk
California Department of Fish and Game	Streambed Alteration Agreement	6 months	Construction activity within waterside hinges of the levee
Central Valley Regional Water Quality Control Board	Section 401 Certification or Waiver	Up to 12 months[3]	Work within waters of the United States
San Joaquin Valley Air Pollution Control District	Emission Reduction Credit Lease	Up to 5 months	Particulate and exhaust emission impacts beyond established thresholds

ESA = federal Endangered Species Act.

CESA = California Endangered Species Act.

EFH = Essential Fish Habitat.

[1] If an individual permit is required, NEPA documentation may also be required.

[2] This timeline assumes that no re-consultation on OCAP is necessary.

[3] This timeline assumes the RWQCB does not issue a permit until NMFS and FWS issue BOs

Temporary Pumping Facilities

Table III.19 provides an overview of the environmental permits that may be required for the construction and operation of the temporary pumping facilities. The actual permits that would be required and the time to acquire them would depend on the actual estimated effects of the final proposed project and coordination with resource and regulatory agencies

Based on preliminary discussions with the U.S. Army Corps of Engineers and California Department of Fish and Game, it is assumed that the placement and operation of temporary pump systems would not require permits for federal Clean Water Act, California Fish and Game Code Section 1602, or other in-water effects regulated by these agencies. Based on this input and assuming that there would be no need to re-consult on OCAP, it is assumed that consultation under the federal Endangered Species Act would also not be required primarily because there are no expected increased effects on federally-listed species during the proposed annual July through October operation period. As such, the only potential effects are related primarily to noise and pollutant emissions that would occur when the pump systems are placed and operated.

Table III.19 Permit and Approval Requirements for Temporary Pumping Facilities

Authority/Agency	Permit/Approval	Trigger
California Department of Fish and Game	Incidental Take Permit	Potential effects on Swainson’s hawk
San Joaquin Valley Air Pollution Control District	Emission Reduction Credit Lease	Particulate and exhaust emission impacts beyond established thresholds

IV. Conclusions

DSM2 modeling results of low head pumping used in conjunction with the temporary rock barriers in the south Delta indicate the potential for improved water quality at the two D1641 interior south Delta compliance locations C8-Old River near Middle River and P12-Old River at Tracy Road Bridge. The potential for improved water quality at C6-San Joaquin River at Brandt Bridge was not indicated although modeling results showed some minor reduction in exceedences. General observations indicate that pumping at either the Middle River or Old River barrier sites would be the most effective at improving water quality measured at the compliance station closest to that barrier. Pumping only at the Grant Barrier site is less effective at improving water quality at both compliance stations. General observations regarding concurrent pumping at two barriers indicate that pumping at more than one barrier site is less effective at reducing exceedences for the same total pumped flow. For all scenarios redirected impacts regarding water levels and water quality at diversion points of interest and on flow regarding Net Delta Outflow appear to be minor based on daily average flow data and 30-day running average water quality data.

The results show that low head pumping, when pumping at only one barrier site, could be effective at:

- Eliminating all of the historical exceedences at C8-Old River near Middle River, but only about 2% of the at P12-Old River at Tracy Bridge by pumping at the Middle River barrier at a flow of 500 cfs ;

- Eliminating approximately 43% of the historical exceedences at P12-Old River at Tracy Road Bridge but only about 4% of the exceedences at C8-Old River near Middle River by pumping at the Old River barrier at a flow of 500 cfs

- Eliminating approximately 63% of the historical at P12-Old River at Tracy Road Bridge but only about 22% of the exceedences at C8-Old River near Middle River by pumping at the Old River Barrier at a flow of 1000 cfs;

- Eliminating approximately 4% of the historical exceedences at C8-Old River near Middle River and 22% of the historical exceedences at P12-Old River at Tracy Road Bridge by pumping at the Grant Line barrier at a flow of 500 cfs; and

- Eliminating approximately 26% of the historical exceedences at C8-Old River near Middle River and 55% of the exceedences at P12-Old River at Tracy Road Bridge by pumping at the Grant Line barrier at a flow of 1000 cfs or greater.

- Eliminating less than 4% of the historic at C6-San Joaquin River at Brandt Bridge for all scenarios and flows

The results show that low head pumping, when pumping concurrently and equally at the Middle River and Old River barrier sites, could be effective at:

- Eliminating approximately 7% of the historical exceedences at C8-Old River near Middle River and 18% of the historical exceedences at P12-Old River at Tracy Road Bridge by pumping at a combined flow of 500 cfs; and

- Eliminating approximately 96% of the historical exceedences at C8-Old River near Middle River and about 40% of the historical exceedences at P12-Old River at Tracy Road Bridge by pumping at a combined flow of 1000 cfs or greater.

- Eliminating less than 4% of the historic exceedences at C6-San Joaquin River at Brandt Bridge for all scenarios and flows

The success with which low head pumping could eliminate or reduce the historical exceedences is affected by a number of factors. In particular, the success is influenced by the sources of water which would be drawn into the south Delta. These sources include the Sacramento River, the San Joaquin River, and San Francisco Bay water. For the July through October period of 2007-2009 analyzed in this report, the majority of the water at C8-Old River near Middle River and at P12-Old River at Tracy Road Bridge came from the San Joaquin River. Simulated low head pumping at Middle River changed the major water source at C8-Old River near Middle River to the lower-salinity Sacramento River water, but only slightly increased the amount of Sacramento River water at P12-Old River at Tracy Road Bridge. Conversely, pumping at Old River changed the major water source at Old River at Tracy to the lower-salinity Sacramento River water, but only slightly increased the amount of Sacramento River water at C8-Old River near Middle River. For all of the alternatives, increasing the pumping rate from 500 to 1000 cfs increased the fraction of lower-salinity Sacramento River water at the compliance sites. This increase in pumping also introduces a larger fraction of higher-salinity water from San Francisco Bay.

The results of modeling analysis of redirected impacts resulting from low head pumping, while dependent on pumped flow volume, range from no change (NC) to slight for average conditions. These impacts include reductions in water levels and changes in water quality. Locations of most interest regarding these impacts are agricultural diversions downstream of the barrier sites and various water supply export locations. Based on average daily flow data the average decrease in water levels downstream of the temporary barriers varied from NC to 0.09 feet at pumping rates up to 1000 cfs. The corresponding maximum water level decrease varied from 0.16 to 0.36 feet. Similarly, the average decrease in water levels at the water supply export locations varied from NC to 0.05 feet. The corresponding maximum water level decrease varied from 0.11 to 0.22 feet. Because the modeled results are based on average daily flow data intermittent periods with larger decreases in water levels would be expected to occur.

Changes in water quality at the agricultural diversions downstream of the barriers would vary under the low head pumping scenarios. In general, these changes would be beneficial with decreased salinity similar to that indicated for the interior south Delta compliance locations. The analysis of water quality changes at the water support export locations of interest indicate that salinity changes would be less than 1% at all export sites, with the exception of Victoria Canal which showed a maximum change as an increase in salinity ranging from 2.3 to 4.3% for 500 to 1000 cfs, respectively. Because the modeled results are based on a 30-day running average EC data intermittent periods with larger changes in concentrations would be expected to occur.

The range of estimated costs includes installation of typical pump station features and infrastructure for either screen approach. The flat screen intake is typically used for higher flow water supply intakes and includes automated screen cleaning systems. The cylindrical screen intakes are significantly less costly and provide the advantage of being retractable from a canal or river for cleaning using a brush cleaning system. The less costly cylindrical screen approach was used for the temporary cylindrical screen alternatives but screens would be manually installed and removed each year.

The range of estimated costs to construct and operate either permanent or temporary pumping facilities as single- or two-pumping site alternatives is summarized below. The costs are conceptual level planning costs with an accuracy of -25% to 50% and include initial capital (Table IV.1), and annual and capitalized costs (Table IV.2). The initial capital costs include construction, real estate, design, environmental compliance and permitting, construction management, and a 25% contingency for materials and installation. Annual costs include operation and general maintenance of the facilities. Overall capitalized costs were developed as an indicator of the relative cost of the permanent and temporary alternatives. The capitalized cost is the initial capital cost plus the annual cost adjusted to represent the time value of future expenditures.

	Single Pumping Sites		
Total Pumping Capacity (cfs)	250	500	1000
Pump facility Configuration			
Temporary	$5.5-20.7	$9.8-40.9	$19.6-80.9
Permanent Cylindrical Screen	$20.2-60.8	$40.9-112.9	$81.7-234.3
Permanent Flat Screen	$120-161.4	$214.5-286.6	$391.7-551
	Two Pumping Sites		
Total Pumping Capacity (cfs)	250	500	1000
Pump facility Configuration			
Temporary	$14.9	$28.4	$55.5
Permanent Cylindrical Screen	$49.5	$87.6	$168.1
Permanent Flat Screen	$186.9	$301.0	$540.7
[1] All values in million			

Table IV.1 Range of Estimated Alternative Initial Capital Costs

	Single-Pumping Sites					
Total Pumping Capacity (cfs)	250		500		1000	
Pump facility Configuration						
Temporary	$10-22.6	$147.6-343.9	$15.6-45.1	$232.8-685.8	$32.4-89.9	$482.9-1365
Permanent Cylindrical Screen	$0.7-1.4	$30-80.4	$1.4-2.6	$60.5-149.6	$2.7-5.3	$121-310.1
Permanent Flat Screen	$3.4-4.5	$179-210	$6.1-8.5	$325-376.1	$11.8-16.3	$602-719.7
	Two-Pumping Sites					
Total Pumping Capacity (cfs)	250		500		1000	
Pump facility Configuration						
Temporary	$17.8	$269	$33.5	$507.3	$62.7	$951.9
Permanent Cylindrical Screen	$1.3	$68.0	$2.3	$120.8	$4.5	$232.8
Permanent Flat Screen	$4.7	$254.3	$8.0	$414.6	$14.7	$750.3
[1] All values in million [2] Annual Cost | Capitalized Cost						

Table IV.2 Range of Estimated Alternative Annual and Capitalized Costs

In summary, the estimated costs vary depending on the pumping capacity, the technical approach and the barrier installation site. The flat and cylindrical screen costs are based on designs incorporating screening criteria specified by NMFS for juvenile salmon and CDFG recommendations regarding USFWS criteria for delta smelt. This conservative approach is taken to reduce any potential negative impact to these species. Less restrictive screening criteria would result in lower costs and may be applicable given the proposed operation period for low head pumping. The temporary alternatives provide the least initial capital costs but overall capitalized costs can exceed the capitalized cost for some permanent alternatives as a result of substantial annual operation and maintenance costs. The permanent flat screen alternatives have the highest initial capital costs due to the material and installation costs for the flat screen technology. The costs also vary by barrier installation site as a result of site-specific conditions. In particular, the Middle River barrier site requires substantial dredging to provide sufficient submergence for the pump facility intake screens.

The alternative providing the greatest reduction in exceedences for concurrent or two-pumping site alternatives is 1000 cfs pumping equally split between Middle River and Old River barriers as described under Hydrodynamic and Water Quality Modeling. The least capitalized cost to implement this alternative is $232.8 million, which utilizes permanent cylindrical screens, has an initial capital cost of $168.1 million and annual costs of $4.5 million. The comparable costs utilizing temporary skid mounted pump systems with manually-placed cylindrical intake screens are $55.5 million with an annual cost of $62.7 million. Although the initial capital cost of $55.5 million for a temporary system is lower than the comparable cost of the permanent system, the annual costs are substantial and the associated capitalized cost is larger by a factor of almost four ($951.9 to $232.8 million).

Environmental compliance and permitting for the construction and operation of either permanent or temporary low head pumping facilities are considered to be a modification of the currently implemented temporary barriers project. Minor modifications to existing permits and mitigation obligations are anticipated. Potential impacts to environmental factors are expected to range from “less than significant” to requiring general mitigation actions or environmental commitments. Overall, the permanent systems would require that DWR provide mitigation for the footprint of the new pumping systems in addition to the mitigation already in place for the temporary barriers project. For the temporary pumping systems, no additional mitigation for species is expected but the installation and removal of these systems each year could result in air quality effects for which additional mitigation is required.

Environmental documentation and permit requirements for the permanent systems are expected to include preparation of a supplemental Initial Study/Mitigated Negative Declaration under CEQA, USACE Clean Water Act Section 404 and Rivers and Harbors Section 10 permitting, including Endangered Species Act consultation with USFWS and NMFS, as well as consultation on EFH per the Magnusson-Stevens Act. At the State level coordination with the CDFG will be required to obtain a 1601 Streambed Alteration Agreement as well as an Incidental Take Permit. Additionally, a Section 401 certification or waiver will be needed from the SWRCB for approval of in-water work. At the local level, coordination with the San Joaquin Valley Air Pollution Control District will be needed to obtain a construction emission reduction credit lease. These documentation and permitting actions are expected to require approximately 18-months to complete.

Due to the temporary nature of the temporary pumping systems, environmental documentation and permit requirements are expected to be limited. State level coordination will be required with the CDFG to obtain an Incidental Take Permit and local level coordination required with the San Joaquin Valley Air Pollution Control District to obtain a construction emission reduction credit lease. These documentation and permitting actions would require approximately 12 months to complete.

The actual permits that would be required and the time to acquire them would depend on the actual estimated effects of the final proposal and coordination with resource and regulatory agencies. This also assumes that there would be no need to re-consult on the CVP/SWP Long Term Operations Biological Opinions primarily because there are no expected increased effects on federally-listed species resulting from the proposed annual July through October system operation. As described above, the permit requirements are based on the assumption that construction of these facilities would be included as an amended project description for the temporary barriers, similar to previous modifications (i.e., Middle River barrier raise). As such, permit documents would be abbreviated and would indicate that implementation of the pumping facilities would be a modified component of the overall TBP. Should this be unacceptable to the regulatory agencies, the estimated timelines to obtain these permits would increase.

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Appendix A

Hydrodynamic and Water Quality Analysis

This appendix contains supplementary information on the hydrodynamic and water quality modeling that was conducted to explore effectiveness of low head pumping to reduce exceedences of the D1641 salinity objectives.

I Scenarios

For this study, nearly 60 low head pumping scenarios were investigated that reflected a range of pumping configurations and temporary agricultural barrier operations (Table A.1). For all scenarios, the low head pumps were located at temporary agricultural barriers and pumping was in the eastward direction. Three single pumping locations were considered: Middle River, Grant Line Canal and Old River. A scenario was defined by the following criteria:

- Pumping location at temporary agricultural barriers
  - Single site
    - Middle River
    - Grant Line Canal
    - Old River
  - Two sites
    - Middle River and Old River
    - Middle River and Grant Line Canal
    - Grant Line Canal and Old River
- Pumping amount
  - 50 cfs to 1,500 cfs
- Temporary agricultural barrier operations
  - Historical
  - Historical with changes in weir elevations
  - Based on 2010 temporary barrier operations

Note that not every possible combination of pumping and barrier operations was explored. Results were analyzed as they were obtained, and the study focused on exploring alternatives that indicated a reduction in exceedences of salinity objectives.

For the purposes of this report, four select alternatives were selected that illustrate the alternatives that had the most impact on reducing salinity objective exceedences for the July-October 2007-2009 study period (highlighted in gray in Table A.1). The select scenarios included:

Table A.1: Modeled Low Head Pumping Scenarios

Gray shading indicates select scenarios in report write-up.

Scenario #	Total Pumped Flow	@ Middle	@ GLC	@ Old R	Barrier Operations	Change Middle River Barrier Elev	Change GLC Barrier Elev	Change Old R Tracy Barrier Elev
Historical	0				Historical			
1	250	125		125	Historical			
2	500	250		250	Historical			
3	1000	500		500	Historical			
4	1500	750		750	Historical			
5	250		250		Historical			
6a	500		500		Historical			
6b	500		500		2010 based operations			
7	1000		1000		Historical			
8	1500		1500		Historical			
9	250	125		125	Historical with weir changes	+1		
10	500	250		250	Historical with weir changes	+1		
11	1000	500		500	Historical with weir changes	+1		
12	1500	750		750	Historical with weir changes	+1		
13	250		250		Historical with weir changes	+1		
14a	500		500		Historical with weir changes	+1		
14b	500		500		2010 based w/weir changes	+1		
15	1000		1000		Historical with weir changes	+1		
16	250	125	125		Historical			
17	500	250	250		Historical			
18	1000	500	500		Historical			
19	250	125	125		Historical with weir changes	+1	+1.5	-1
20a	500	250	250		Historical with weir changes	+1	+1.5	-1
20b	500	250	250		2010 based w/weir changes	+1	+1.5	-1

Table A.1: Modeled Low Head Pumping Scenarios (continued)

Gray shading indicates select scenarios in report write-up.

Scenario #	Total Pumped Flow	@ Middle	@ GLC	@ Old R	Barrier Operations	Change Middle River Barrier Elev	Change GLC Barrier Elev	Change Old R Tracy Barrier Elev
21a	1000	500	500		Historical with weir changes	+1	+1.5	-1
21b	1000	500	500		2010 based w/weir changes	+1	+1.5	-1
22	0 (historical)				Historical with weir changes	+1	+1	-1
23	0 (historical)				Historical with weir changes	+1.5	+1.5	-1
24	0 (historical)				Historical with weir changes	+1.5	+1.5	-0.5
25	100	50		50	Historical			
26	100		100		Historical			
27	100	50		50	Historical with weir changes	+1		
28	100		100		Historical with weir changes	+1		
29	100	50	50		Historical			
30	125	62.5	62.5		Historical with weir changes	+1	+1	-1
31	100	50	50		Historical with weir changes	+1	+1.5	-1
32a	250	250			Historical with weir changes	+1	+1.5	-1
32b	250	250			2010 based w/weir changes	+1	+1.5	-1
33	250		250		Historical with weir changes	+1	+1.5	-1
34	375	250	125		Historical with weir changes	+1	+1.5	-1
35	300	250	50		Historical with weir changes	+1	+1.5	-1
36	375	125	250		Historical with weir changes	+1	+1.5	-1
37	500	250	250		Historical with weir changes	+1	+1.5	-0.5
38	250	250			Historical with weir changes	+1	+1.5	
39	500	250	250		Historical with weir changes	+1	+1.5	
40	500	500			Historical with weir changes	+1	+1.5	-1
41	500		500		Historical with weir changes	-1	+1.5	-1
42	500			500	Historical with weir changes	-1	+1.5	+1
43	500		250	250	Historical with weir changes	-1	+1.5	+1

Table A.1: Modeled Low Head Pumping Scenarios (continued)

Gray shading indicates select scenarios in report write-up.

Scenario #	Total Pumped Flow	@ Middle	@ GLC	@ Old R	Barrier Operations	Change Middle River Barrier Elev	Change GLC Barrier Elev	Change Old R Tracy Barrier Elev
44	1000		500	500	Historical with weir changes	-1	+1.5	+1
45	1000	500		500	Historical with weir changes	+2	-1	+1
46	250			250	Historical with weir changes	-1	+1.5	+1
47	1000			1000	Historical with weir changes	-1	+1.5	+1
48	250	250			Historical with weir changes	-1	+1.5	-1
49	1000			1000	Historical			
50	500			500	Historical			
51	250			250	Historical			
52	1000	1000			Historical			
53	500	500			Historical			
54	250	250			Historical			

- Pumping location at temporary agricultural barriers
    - Middle River
    - Grant Line Canal
    - Old River
    - Middle River and Old River
- Pumping amount of 250 cfs to 1,000 cfs
- Historical temporary agricultural barrier operations

II. DSM2 Estimation of Historical Salinity

The Delta Simulation Model 2 (DSM2) can be used to estimate historical salinity in the Sacramento-San Joaquin Delta. Since this study focused on possible changes to compliance with salinity objectives, it is important to compare how the modeled salinity compares to historical observations (Figure A.1). Although Delta models, including DSM2, are tuned to best represent available salinity observations, salinity at certain locations in the South Delta tends to be under-predicted. For the compliance sites, the modeled salinity estimates at Middle River at Old River are closer to field observations than those at Old River at Tracy.

The modeled salinity can be attributed to five sources: the Sacramento River, the San Joaquin River, San Francisco Bay, in-Delta agricultural return flows, and the eastside tributaries of the Cosumnes, Mokelumne and Calaveras Rivers (Figure A.1). The Sacramento River and eastside tributaries provide relatively fresh sources of water to the Delta. San Francisco Bay, the San Joaquin River and in-Delta agricultural return flows are more saline sources. The difference between the field observations and the modeled salinity can be considered as unrepresented sources of salinity in the model. This is due in part to lack of field observations for some key salinity sources including agricultural return flows from Delta islands, groundwater seepage and other unmonitored source flows.

DSM2 uses the best available estimate of Delta Island Consumptive Use (DICU) to represent agricultural withdrawals and return flows (DWR, 1995), however these estimates are based on limited field observations. There are also additional sources of salinity that aren't accounted for in any Delta model due to the lack of available field data. To compensate for the under prediction of modeled Delta salinity, this study combined field observations of total salinity concentrations with modeled changes in salinity due to low head pumping to provide estimated impacts to salinity standard compliance.

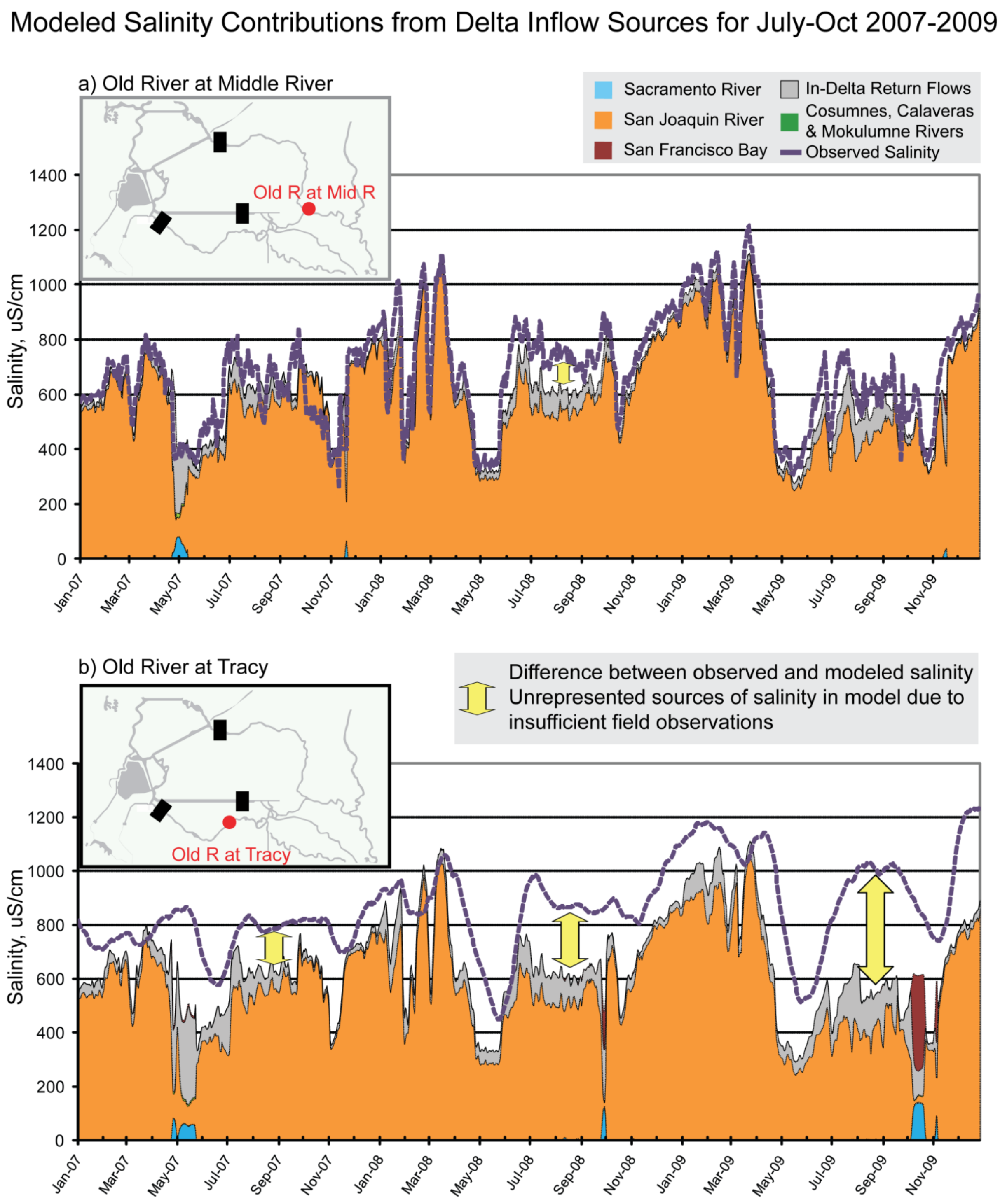

Figure A.1 Modeled Salinity Contributions from Delta Inflow Sources for July-Oct 2007-2009

III. Estimating Impacts of Low Head Pumping on Salinity Objective Compliance

Since the modeled salinity at Old River at Tracy is typically lower than the observed values, the DSM2 historical simulation does not reproduce the historical salinity objective exceedence (Figure A.2 part a). Thus modeled results for the low head pumping scenarios could not directly be used to estimate impacts on salinity objective exceedence. Therefore, modeled and observed salinity values were used together to estimate potential impacts of low head pumping on salinity objective compliance. First the estimated change in salinity was estimated by subtracting the modeled salinity from the low head pumping scenario from the modeled salinity for the simulated historical conditions (Figure A.2 part b). The estimated impact on salinity objective compliance was then estimated by subtracting the modeled salinity difference from the observed salinity data at that compliance site (Figure A.2 part c). This method implicitly assumes that the unrepresented salinity sources in the model do not have a major impact on salinity objective compliance.

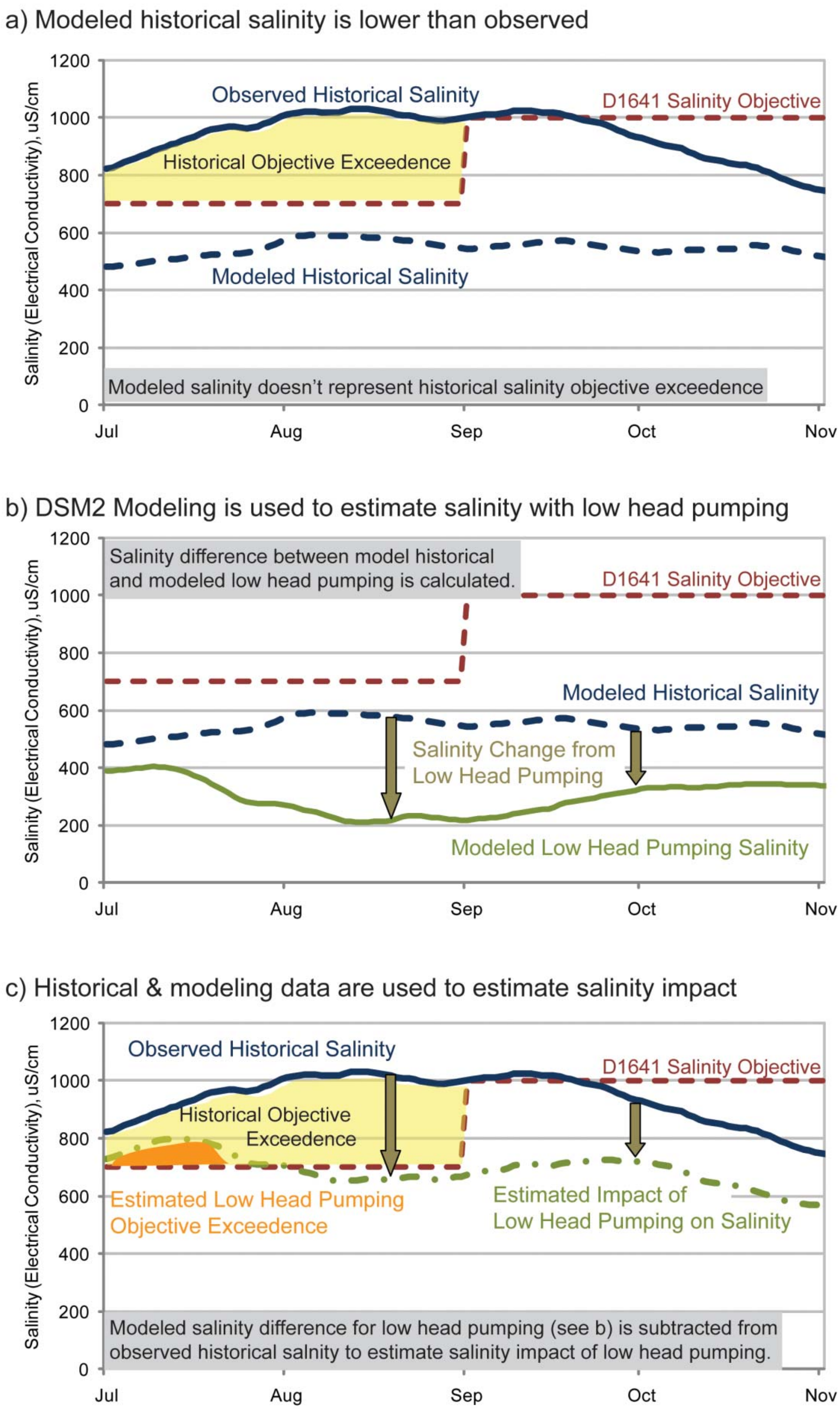

Figure A.2: Method for Estimating Impact of Low Head Pumping on Salinity Objective Exceedence

APPENDIX B

Engineering and Cost Analysis

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State of California
California Natural Resources Agency
Department of Water Resources
Division of Engineering

SOUTH DELTA LOW HEAD PUMP SALINITY CONTROL STUDY

DOE CONCEPTUAL ENGINEERING SUPPORT DOCUMENT

Study Report
April, 2011

Prepared by:
The Delta Engineering Branch

INTRODUCTION

The Delta Engineering Branch (DEB) of the Division of Engineering (DOE) was asked to assist the Bay-Delta Office (BDO) with their Low Head Pump Salinity Control Study. The study's main goal is to investigate whether the installation and use of low-head pumps to transport water over the South Delta temporary agricultural barriers will improve water circulation and lower salinity levels within the waterways of Grant Line Canal, Middle River, and Old River.

OBJECTIVE & SCOPE

In addition to investigating the effect that low-head pumps have on the water quality within the southern Delta, the study will be investigating the practicality and cost of constructing either permanent or temporary pumping facilities. To assist the BDO in determining the overall feasibility of constructing pumping facilities, the DEB provided technical support and documentation for the sizing and layout of all the pumping scenario alternatives. This information was used to determine conceptual cost estimates for each of the pumping scenario alternatives.

As outlined in Appendix A, a total of fifty-eight pumping scenarios were chosen for in-depth hydraulic modeling analysis by the Delta Modeling Support Branch of the BDO. The BDO selected thirty-four of these scenarios for layout and cost development by the General Engineering Section of the DEB. These thirty-four alternatives are a combination of different pumping sites, pumping capacities, and raising or lowering of the temporary barrier elevations. The pumping sites could be located adjacent to the temporary barriers at Grant Line Canal, Middle River, or Old River; the pumping capacities ranged between 50 cfs and 1,000 cfs at an individual site; and the temporary barrier designs could be modified to be raised or lowered by 1 ft. Additionally, the thirty-four alternatives could be accomplished by using permanent pumping facilities or temporary pumping facilities.

For the DEB's purpose of sizing and laying out the pumping alternatives, there were fifteen layouts at the Grant Line Canal site, fifteen layouts at the Middle River site, and fifteen layouts at the Old River site, for a total of forty-five facility layouts. The forty-five layouts include three different intake configurations; fifteen of the layouts are for permanent flat screen intakes, fifteen are for permanent cylindrical screen intakes, and fifteen are for temporary cylindrical screen intakes. The layout for each specific site, specific pumping capacity, and intake configuration are the same whether they are used individually or in conjunction with another pumping site and whether they are used with or without the raising/lowering of the barrier elevations. Table 1 lists the forty-five DEB intake layouts and notes the location, the pumping capacity, and the intake configuration (permanent flat screen, permanent cylindrical screen, or temporary cylindrical screen) of each layout. Table 2 lists the thirty-four BDO hydraulic modeling scenarios and for its permanent and temporary options lists the corresponding DEB layout(s) that it is comprised of.

Of the forty-five DEB layouts, the BDO has chosen DEB intake layouts 3, 8, 13, 18, 23, and 28 for more detailed development by the DEB. These six layouts, each with a 250 cfs pumping capacity, are to be used as basis-of-design examples for more detailed intake development. The six layouts include a permanent flat screen intake, a permanent cylindrical screen intake, and a temporary cylindrical screen intake at both Grant Line Canal and Middle River. These basis-of-design layouts are highlighted in Table 1.

For each facility layout, an individual cost estimate was determined. These individual estimates were combined with other individual facility estimates and/or with costs associated with the raising/lowering of the barrier elevations as needed to determine a total cost for each of the thirty-four BDO scenarios using permanent flat screen intakes, permanent cylindrical screen intakes, or temporary cylindrical screen intakes.

Table 1: DEB Intake Facility Layout Numbers & Descriptions

DEB Intake Layout Number			Intake Location	Pumping Capacity (cfs)
Permanent Flat Screen Intake	Permanent Cylindrical Screen Intake	Temporary Cylindrical Screen Intake		
1	6	11	GLC	50
2	7	12	GLC	125
3	8	13	GLC	250
4	9	14	GLC	500
5	10	15	GLC	1000
16	21	26	MR	50
17	22	27	MR	125
18	23	28	MR	250
19	24	29	MR	500
20	25	30	MR	1000
31	36	41	OR	50
32	37	42	OR	125
33	38	43	OR	250
34	39	44	OR	500
35	40	45	OR	1000

GLC=Grant Line Canal; MR=Middle River; OR=Old River

Table 2: BDO Pumping Scenarios & Corresponding DEB Layouts

BDO Hydraulic Modeling Scenario	BDO Pumping Scenario Number	Total Pumping Capacity (cfs)	Corresponding DEB Layout(s)		
			Permanent Flat Screen Intake	Permanent Cylindrical Screen Intake	Temporary Cylindrical Screen Intake
M&O	1	100	16, 31	21, 36	26, 41
	2	250	17, 32	22, 37	27, 42
	3	500	18, 33	23, 38	28, 43
	4	1000	19, 34	24, 39	29, 44
GLC	5	50	1	6	11
	6	250	3	8	13
	7	500	4	9	14
	8	1000	5	10	15
M&G	9	100	1, 16	6, 21	11, 26
	10	250	2, 17	7, 22	12, 27
	11	500	3, 18	8, 23	13, 28
	12	1000	4, 19	9, 24	14, 29
M&O+1MR	13	100	16, 31	21, 36	26, 41
	14	250	17, 32	22, 37	27, 42
	15	500	18, 33	23, 38	28, 43
	16	1000	19, 34	24, 39	29, 44
GLC+1MR	17	125	2	7	12
	18	250	3	8	13
	19	500	4	9	14
	20	1000	5	10	15
M&G+1MG-1Old	21	100	1, 16	6, 21	11, 26
	22	250	2, 17	7, 22	12, 27
	23	500	3, 18	8, 23	13, 28
	24	1000	4, 19	9, 24	14, 29
M	25	50	16	21	26
	26	125	17	22	27
	27	250	18	23	28
	28	500	19	24	29
	29	1000	20	25	30
O	30	50	31	36	41
	31	125	32	37	42
	32	250	33	38	43
	33	500	34	39	44
	34	1000	35	40	45

G=GLC=Grant Line Canal; M=MR=Middle River; O=Old=Old River
+1MR=Raising the temporary barrier at Middle River by 1 ft
+1MG-1Old=Raising the temporary barriers at Middle River and Grant Line Canal by 1 ft and lowering the temporary barrier at Old River by 1 ft

SUMMARY OF DEB DELIVERABLES

Site plans, intake footprints, typical intake cross-sections, layouts for the basis-of-design intakes, and cost estimates were provided by the DEB for support of this study.

A site plan is provided for each of the potential pumping sites; one each for Grant Line Canal, Middle River, and Old River. Each site plan shows the temporary barrier, the location of the intake, the location of the discharge site, and the location of the conveyance line between the intake and discharge sites. Site plans are included in the Appendix – Sheets 1, 15, and 29.

Intake footprints have been provided for each of the forty-five DEB layouts. As noted earlier, fifteen layouts have been provided for the alternatives at the Grant Line Canal site, fifteen layouts have been provided for the alternatives at the Middle River site, and fifteen layouts have been provided for the alternatives at the Old River site. For each site five layouts are for permanent flat screen intakes, five layouts are for permanent cylindrical screen intakes, and five layouts are for temporary cylindrical screen intakes. The footprints for the permanent cylindrical screen and temporary cylindrical screen layouts are the same at a given site and given pumping capacity. Each intake footprint shows the footprint plan dimensions of the intake, its transition to the bank, its offset from the waterside levee hinge, and its position relative to the adjacent temporary barrier. Footprints are included in the Appendix – Sheets 2-6, 8-12, 16-20, 22-26, 30-34, and 36-40.

Typical intake cross-sections have been provided through each of the potential pumping sites; three each for Grant Line Canal, Middle River, and Old River. For each site there is one cross-section for a permanent flat screen intake, one cross-section for a permanent cylindrical screen intake, and one cross-section for a temporary cylindrical screen intake. Each cross-section shows the grade of the river channel, the adjacent banks, the design water elevations, and how the intake is configured relative to the site topography and bathymetry. The cross-sections depict the main elements of the intakes. For the permanent flat screen intake the intake walls, flat fish screen panels, support foundation, pumps, and conveyance lines are shown. For the permanent cylindrical screen intakes the cylindrical fish screens, retrieval tracks, support platforms, supporting piles, pumps, and buried conveyance lines are shown. For temporary cylindrical screen intakes the cylindrical fish screens, supporting piles, permanent inlet pipes, temporary pumps, and temporary above grade conveyance lines are shown. Cross-sections are included in the Appendix – Sheets 7, 13, 14, 21, 27, 28, 35, 41, and 42.

For the basis-of-design alternatives, layouts have been provided showing a plan view of each basis-of-design intake facility. The six basis-of-design alternatives each have a capacity of 250 cfs. The basis-of-design layouts depict a permanent flat screen intake, a permanent cylindrical screen intake, and a temporary cylindrical screen intake at both Grant Line Canal and Middle River. These layouts show the arrangement of the main structural components, the fish screens, and the dimensions used in the design of the intakes. Basis-of-design intake layouts are included in the Appendix – Sheets 43 to 48.

Finally, cost estimates for each of the thirty-four BDO scenarios have been provided for each configuration. For the basis-of-design layouts, construction quantities were provided to the DOE Cost Estimating office for project cost determination. Estimates for cost for all the other alternatives were extrapolated from and based on the cost estimates for the basis-of-design layouts. The cost estimates provide the capital outlay costs for construction and include a 25% contingency for this level of design. Also included in the total project cost estimates are approximate costs for land and right-of-way acquisition, environmental report (EIR/EIS) preparation, permit acquisition, and design and construction support.

DESIGN DATA

Topography and Bathymetry

Topographic and bathymetric data for each of the three pumping sites was taken from previous DWR projects and studies. For all sites the data is in California State Plane Zone 3, NAD83, NAVD88, survey feet. The data for Grant Line Canal was taken from LiDAR and bathymetric data taken for the Temporary Barriers Project (TBP). The data for Middle River was taken from survey data taken for the proposed Permanent Barriers Project, South Delta Improvements Program (SDIP). The data for Old River was taken from LiDAR data taken for the TBP. This data was used to create a topographic map at each of the pumping sites. Cross-sections in the vicinity of the proposed intakes were created from the topographic maps. Table 3 is a summary of river bottom elevations taken at certain distances from the approximate location of the levee's waterside hinge point.

Table 3: Site Bathymetry Elevations

Waterway	Bathymetry Elevations[1,2,3,4,5,6]								
	Distance into the Water Channel from the Approximate Levee Waterside Hinge Point & Corresponding River Bottom Elevation								
	30 ft	35 ft	40 ft	45 ft	50 ft	55 ft	60 ft	65 ft	70 ft
Grant Line Canal	5	2	0	-2	-4	-7	-8	-10	-11
Middle River	2	1	0 / -4	-1 / -4	-1 / -4	-2 / -4	-2 / -4	-2 / -4	-2 / -4
Old River	-1	-2	-3	-4	-5	-6.5	-8	-8	-7.5

1. Bathymetry for GLC was taken from LiDAR & topographic data taken for the TBP
2. Bathymetry for MR was taken from survey data taken for the SDIP
3. Bathymetry for OR was taken from LiDAR data collected when the temporary barrier was in place
4. For GLC the distances and depths are measured for locations on the northern side of the waterway
5. For MR the distances and depths are measured for locations on the southern side of the waterway. Highlighted elevations are river channel elevations achieved by dredging of the river bottom.
6. For OR the distances and depths are measured for locations on the northern side of the waterway

Stage Data

Due to seasonal and tidal influences, the water surface elevation (WSEL) in the vicinity of the proposed intakes can vary dramatically. To have the option to keep the intakes in operation for the majority of the time, the intakes must be designed to operate during periods of typical low WSEL levels. The mean high high water (MHHW) elevations and the mean low low water (MLLW) elevations were taken from the SDIP for Grant Line Canal and Middle River, and from the TBP for Old River. These elevations are shown in Table 4. BDO hydraulic feasibility-level analyses of the proposed pumping activities have determined that the pumping activities may cause a drop in WSEL downstream of the barriers. Based on these analyses, a stage drop of 0.3 ft is assumed to occur downstream of the barrier at all three of the pumping sites.

For this study, an elevation of MLLW minus the stage drop is used as the design water surface elevation for the intake design. This is intended to ensure that, except in extreme cases, the option of withdrawing water from the river channels is possible. Table 4 lists the design water elevations for each site.

The 100-year flood elevations for the river channels and the banks north and south of the river channels were obtained from FEMA Flood Insurance Rate Maps. These are the base flood elevations (BFE) and are summarized in Table 4.

Table 4: Water Surface Elevations

Waterway	Water Surface Elevations[1,2,3,4,5,6,7]						
	MHHW Elevation	MLLW Elevation	Stage Drop Downstream of Barrier	Design Water Surface Elevation	Waterway BFE	Northland BFE	Southland BFE
Grant Line Canal	6	2	0.3	1.7	11	14	14
Middle River	5.54	2.23	0.3	1.93	10	9	14
Old River	5.4	1.4	0.3	1.1	11	14	10

1. MHHW/MLLW for GLC taken from drawings for the SDIP at GLC (June 2007) Sheets C1-8, C1-10 & S2-3
2. MHHW/MLLW for MR taken from drawings for the SDIP at MR (June 2007) Sheet C1-3
3. MHHW/MLLW for OR taken from drawings for the TBP at OR (November 2009) Sheet C4-2
4. Assumed stage drop downstream of barriers due to pumping activities based on the DSM2 modeling scenario runs (for feasibility-level analysis only)
5. Design Water Surface Elevation = MLLW - Stage Drop
6. "Northland" refers to the land north of the waterway and "Southland" refers to the land south of the waterway
7. BFEs taken from FEMA Flood Insurance Rate Maps

DESIGN CRITERIA

Fish Screen Criteria

As required by State and Federal agencies, fish screens are to be placed at all water withdrawal facilities in the Delta to prevent the take of listed fish species and to allow the migratory passage of listed fish without delay or injury. Additionally, the intake structure is required to be designed to mitigate undesirable hydraulic effects and predator opportunities.

The intake fish screens, for the two permanent and one temporary intake designs, were sized to meet criteria for the listed delta smelt species with a uniform approach velocity across the face of the screen of 0.2 ft/sec or less. The approach velocity and other pertinent criteria were taken from California Department of Fish and Game (Exhibit A, Department of Fish and Game Fish Screening Criteria, June 19, 2000) and National Marine Fisheries Service (Juvenile Fish Screen Criteria, February 16, 1995; Juvenile Fish Screen Criteria for Pump Intakes, May 9, 1996; Fish Screening Criteria for Anadromous Salmonids, January 1997; Anadromous Salmonid Passage Facility Design, February 2008) guidelines. The guidelines and criteria outlined by the CDFG and NFMS are general in nature and waivers may be requested for higher sweeping velocities and increased exposure time. Waivers may be required due to the tidal nature of the channel's flow and due to the length of the intakes.

Pumped Intake Structure

The American National Standards Institute (ANSI) and the Hydraulic Institute (HI) has determined a set of guidelines for laying out and sizing pumped intakes. These guidelines are outlined in ANSI/HI Standards Section 9.8, "Pump Intake Design", 1998. These are guidelines intended to provide a functional pump system that does not cause vortices or other pumping problems. The permanent flat screen intake layouts for the basis-of-design layouts were developed using this standard.

Modifications to Water Channel Banks

The conveyance line between the intake and the discharge sites will be crossing through or over and running parallel to the levee adjacent to the bank of the water channels. The California Code of Regulations (CCR) outlines requirements for activities that will modify or affect an existing levee. For this study, CCR, Title 23, Division 1, Chapter 1, Article 8, Sections 120 (Levees) and 123 (Pipelines, Conduits, and Utility Lines) will be referenced for conveyance line requirements and modifications to the levee road. Additionally, certain Reclamation Districts require that the bottom of a pipeline crossing a levee be set at the base flood elevation (100-year flood elevation), and for this study it is assumed that this requirement will need to be met.

INTAKE TECHNOLOGIES & CONFIGURATIONS

Two intake technologies using three different intake configurations were investigated for this study. The two intake technologies used were flat screen and cylindrical screen intakes. The three configurations used were permanent flat screen intakes, permanent cylindrical screen intakes, and temporary cylindrical screen intakes. All three configurations are on-bank facilities that are accessible directly from the adjacent levee.

Permanent Flat Screen Intakes
The permanent flat screen intake designs will be on-bank intakes that are located within and parallel to the bank and produce little relative projection into the river width. The intake will be a reinforced concrete structure that will be built partially within the levee embankment. Transition walls will be constructed from the waterside face of the intake to the bank. These transition walls will be configured to provide smooth water flow and to minimize habitat for fish predator species. As a rule of thumb, transitions should provide a minimum 3:1 ratio of the length along the river to the distance into the river. The front wall, on the water-side of the structure, will house a bank of fish screens and will be relatively smooth. The back wall will be a retaining wall supporting the levee road. The top deck of the intake will be set at or above the 100-year flood elevation. The floor of the intake will be set at approximately the same elevation as the adjacent river bed. This permanent configuration will be constructed once and left in place for the life of the facility, and will remain in place whether the temporary barrier is in place or not.

Water will enter the intake through the fish screens into a space that is divided into pump bays by interior concrete walls. A pump, floor mounted on the top deck of the intake, will be centered over each pump bay with a pump column that extends vertically down into the pump bay. The water will be pumped up the column and into a dedicated intake pipeline that is trenched under the adjacent levee road. Access from the top deck to the floor will be provided by access stairwells at the ends of the intake. Metal beam guardrails will be provided around the waterside perimeter of the intake structure

The fish screens will be stainless steel assemblies constructed of stainless steel wedge wire with screen opening slots 1.75mm wide. Flow control baffles and a fish screen cleaning system may be required for maintenance and for assurance that the design approach velocity is being met.

Additional components that may be installed are gantry cranes for removal of the screens for maintenance, a log boom for protection of the screens and structure, and a sediment control system on the floor of the intake.

A permanent on-bank intake would be similar to Contra Costa Water District's intake on Victoria Canal (250 cfs capacity) or Freeport Regional Water Authority's (FRWA) intake on the Sacramento River (285 cfs capacity). See Figure 1 for the Freeport intake.

Figure 1: Example of an On-Bank Intake – FRWA Intake on the Sacramento River

Permanent Cylindrical Screen Intakes

The permanent cylindrical screen intake designs will be comprised of a bank of cylindrical submerged self-cleaning fish screens, placed side by side, that are mounted on retrieval tracks that follow the waterside slope of the levee. A control/support platform will be constructed adjacent to the levee road from which the screens can be controlled and serviced. The platform will be a steel framed structure covered with grating which will be set at or above the 100-year flood elevation. The platform will be supported on piles. Security fencing will be provided around the perimeter of the platform. The retrieval tracks for the screens will be mounted to the inlet pipes that follow the slope of the waterside levee. The inlet pipes and the retrieval tracks will be supported by steel frames supported on piles. The tracks will run from the support platform to docking manifolds located far enough into the water that sufficient water cover is provided all around the cylindrical screens. Water will enter the cylindrical fish screens, go through the manifolds and up the inlet pipes. For this study, it is assumed that one pump and a dedicated inlet pipe will be provided for each cylindrical screen unit. The pumps will be slant mounted at the top of the inlet pipes, above the level of the support platform. The pumps may require bracing to the support platform. The water will be pumped up the inlet pipes which will be trenched under the adjacent levee road. This permanent configuration will be constructed once and left in place for the life of the facility, and will remain in place whether the temporary barrier is in place or not.

The fish screens will be stainless steel drum assemblies constructed of stainless steel wedge wire with screen opening slots 1.75mm wide. See Figure 2 for a cylindrical screen and its typical components. Cylindrical fish screens are proprietary and depending on the manufacturer come equipped with internal flow baffles and a screen cleaning system. It is suggested that an active self-cleaning type of screen, with an internal and external brushed cleaning system, be provided in order to maintain the design approach velocity. Control panels, mounted on the support platform, will be needed to program the running of the screens. When in use the screens would be lowered onto the docking manifolds within the water channel. When the screens are not in use they can be docked at the top of the retrieval track above the support platform.

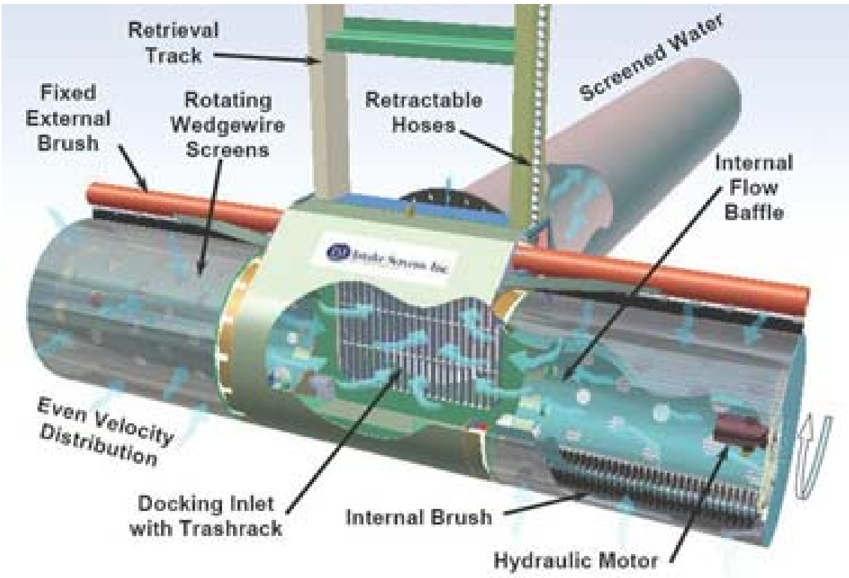

Figure 2: Schematic of a Cylindrical Screen

An additional component that may be installed is a log boom for protection of the screens and structure.

A permanent cylindrical screen intake would be similar to Sutter Mutual Water Company's State Ranch Pumping Plant near Knights Landing (175 cfs capacity). See Figure 3.

Figure 3: Example of Cylindrical Screen Intake – SMWC State Ranch PP

Temporary Cylindrical Screen Intakes

The temporary cylindrical screen intake designs will be similar to the permanent cylindrical screen intake designs. The main difference between the two configurations is that all elements of the permanent configuration will be constructed once and left in place for the life of the facility, while the temporary configuration will have some elements that are constructed once and left in place with the remaining elements installed and removed seasonally, at the same time that the temporary barrier is installed and removed.

The permanent elements of this configuration will be the portion of the inlet pipes that are located on the waterside of the levee. The permanent inlet pipe will run along the slope of the levee, from the in-water location of the cylindrical screen to the waterside levee hinge (waterside edge of the levee road). This portion of the inlet pipes, along with the docking manifolds, and the inlet pipe steel support frames and piles, will be constructed once and left in place for the life of the facility. Security fencing will be provided around the perimeter of the permanent facilities.

Seasonally, as the temporary barrier is installed and removed, the remaining elements of this configuration will be installed and removed. The cylindrical screens will be installed over the manifolds located at the ends of the permanent inlet pipes. The remaining portion of the inlet pipes will be brought in and attached to the permanent inlet pipes at the side of the levee road. The temporary inlet pipes will run over the top of the levee, down the landside slope of the levee, and connect to portable pump and generator systems. Depending on the location of the scenario, one pump may be provided for each cylindrical screen unit or one pump may be provided for several screen units. The temporary inlet pipes, the cylindrical screens and their control system, the pumps, and the generators will be brought on site and installed on a seasonal basis.

The fish screens will be the same stainless steel drum assemblies that are used for the permanent cylindrical screen intakes (see Figure 2). It is still recommended that active self-cleaning screen units, with an internal and external brushed cleaning system, be provided in order to maintain the design approach velocity. The seasonally installed control panels will be needed to program the running of the screens. For this temporary option the screens will always be in place over the docking manifold when they are installed, there is not a retrieval track or control platform for withdrawal of the screens. Divers will be required to install and remove the screens as needed.

An additional component that may be installed is a log boom for protection of the screens and structure.

The water side portion of the temporary cylindrical screen intake would be similar to the permanent cylindrical screen intake shown in Figure 3. The pumps for a temporary facility will be similar to the pumps shown in Figure 4.

Figure 4: Example of Temporary Pump and Generator Units

CONVEYANCE PIPELINE

The conveyance line consists of the inlet pipes, transport pipes, and outlet pipes. For this study, for the permanent intake designs, unless noted otherwise, it is assumed that for all alternatives the inlet and outlet pipes will be 3 ft diameter steel pipes, and the transport pipes are 4 ft diameter reinforced concrete pipes. For the temporary intake designs it is assumed that the inlet, outlet, and transport pipes are 3 ft diameter steel pipes. The quantity of the pipes used for each alternative will depend on the design's pumping capacity and the number of pumps used. The inlet pipes will be used to withdraw the water from the water channel, they will connect to the transport pipes which will convey the water to the outlet pipes, which will in turn discharge the water upstream of the temporary barrier.

Permanent Flat Screen Intakes

The inlet pipes will withdraw water from the channel via vertical pump columns and will convey the water up and over the levees. Where the pipes pass through the top of the levee, they will be placed perpendicular to the levee line, will have the pipe inlet set at the 100-year flood elevation, and will have a minimum of 2 ft of cover over the top of them, as mandated by the CCR. It is assumed that the portion of pipe that crosses under the levee road will be enclosed in a steel pipe casing sleeve for protection. At the Middle River pumping sites it was necessary to raise the top of the levee in the vicinity of the intake to accommodate the CCR requirements. Each inlet pipe will be provided with a butterfly valve to provide a positive closure device in case of a flood occurrence.

Once the inlet pipes are trenched over the top of the levee, the pipes will be trenched down the landside slope of the levee with a minimum cover of 1 ft. At a minimum distance of 10 ft beyond the landside levee toe, the inlet pipes will connect to the concrete transport line that will run parallel to the levee toe. At the discharge site the transport line will branch into several steel outlet pipes configured similarly to the inlet pipes. The outlet pipes will be trenched back up and over the levee to the discharge facility.

Permanent Cylindrical Screen Intakes
The conveyance line for the permanent cylindrical screen intakes will be similar to the conveyance line for the permanent flat screen intakes. The only difference between the conveyance systems is that the inlet pipes withdraw water from the channel via a sloped pipe, rather than a vertical pump column. The remainder of the conveyance line system will be the same as described for the permanent flat screen intakes.

Temporary Cylindrical Screen Intakes
The inlet pipes will withdraw water from the channel via the permanently installed sloped inlet pipe which will convey the water to the top of the levees, where it will enter the temporary portion of the inlet pipe. The temporary pipe will be laid over the top of the levee and will be placed perpendicular to the levee line. For protection of the pipe a steel pipe casing sleeve will enclose the portion of pipe that crosses over the levee road. Traffic along the levee road may be required to be detoured while the temporary pumping facilities are in place. Alternatively, if analysis of the levee determines that infill on top of the levee is acceptable, traffic along the levee road may be accommodated if considerations, such as ramps, gravel infill, and steel road plate, are installed. Each permanent inlet pipe will be provided with a butterfly valve to provide a positive closure device in case of a flood occurrence.

Once the temporary inlet pipes pass over the top of the levee, the pipes will run down the surface of the landside slope of the levee. At a minimum distance of 10 ft beyond the landside levee toe, the inlet pipes will connect to the portable pump and generator system. The steel transport lines will exit from this system and will run overland, parallel to the levee toe. At the discharge site the transport lines will connect to the outlet pipes that are configured similarly to the inlet pipes. The outlet pipes will be run up the surface of the landside levee and over the levee road to the discharge facility.

DISCHARGE FACILITY

The discharge facility is the facility that returns the pumped water to the water channel upstream of the temporary barrier. Discharge facility designs need to account for several environmental and operational concerns. First, the discharge facility needs to ensure that the discharged water exits at a velocity that is comparable to the river's velocity so that fish are not drawn to the discharge site and so that the discharged water does not scour the river bed near the outlet. And second, when the facility is not in use, it must ensure that delta smelt and migrating fish species do not go off river and enter the discharge/conveyance facilities.

Permanent Flat Screen Intakes
For the permanent flat screen configurations, the discharge facility has been assumed to be similar in design to a permanent flat screen intake. It will be a reinforced concrete structure that will be built partially within the levee embankment, with the water-side wall housing a bank of fish screens. The main difference between the intake and the

discharge facility is that the discharge facility will not require pumps; the water will be discharged using the pumps located on the intake. The steel outlet pipes will run from the transport pipe and empty into the concrete discharge facility. The fish screens will ensure that fish cannot enter the facilities and the screen openings will be sized to limit the velocity of the discharged water.

Permanent Cylindrical Screen Intakes

For the permanent cylindrical screen configurations, the discharge facility has been assumed to be a bank of parallel steel outlet pipes that discharge directly into the water channel. The outlet pipes will run from the transport pipe, up and over the levee, and will terminate on the waterside face of the levee into imported rip-rap. A screen will be placed at the end of the outlet pipe so that fish cannot enter the facilities. The outlet pipe's diameter will be sized to maintain an exit velocity that is acceptable to the environmental agencies and the rip-rap will be in place to help limit the potential for scouring of the river bed near the outlet.

Temporary Cylindrical Screen Intakes

For the temporary cylindrical screen configurations, the discharge facility has been assumed to be a bank of parallel steel outlet pipes that discharge directly into the water channel. The outlet pipes will run from the transport pipe, up and across the top of the levee, and will terminate on the waterside face of the levee into imported rip-rap. A screen will be placed at the end of the outlet pipe so that fish cannot enter the facilities. The outlet pipe's diameter will be sized to maintain an exit velocity that is acceptable to the environmental agencies and the rip-rap will be in place to help limit the potential for scouring of the river bed near the outlet. The portion of the outlet pipes that are on the water side slope of the levee will be constructed once and installed permanently for the life of the facility.

INFRASTRUCTURE

All pumping sites and all pumping scenarios will require access, power, fire protection, and communication infrastructure. All sites are accessible from the adjacent levee roads. Depending on expected traffic use and final facility layout, the levee roads may require widening, paving, minor realignment, or may be required to be detoured. At the Grant Line Canal site, the crossing of the conveyance line at South Tracy Boulevard will need to be addressed for the 500 cfs and 1,000 cfs intakes that are located on the west side of South Tracy Boulevard. For these intake scenarios, the crossing of the conveyance line at the road can be achieved by pipe jacking the line under the road or by bridging the existing road over the conveyance line. Power will be required at all sites for the running of the pumps, operation of the fish screen cleaning systems, raising/lowering of the cylindrical screens, and for other miscellaneous items such as site lighting. Depending on the required pumping rate, the proximity and capacity of existing power sources, and the intake configuration used a power line, a substation, or a generator may be required to be installed at the permanently or temporarily at the intake sites. Fire protection may be required for the intakes. Protection can be provided via the adjacent water channel with pumps, waterlines, and tanks designed and installed to meet the requirements of the California Fire Code, or portable fire extinguishers may be provided if determined to be acceptable. Communication lines may be required in the form of phone or internet lines, and antennas or dishes in order to allow direct or remote operation of the facility. For the temporary configuration it may be adequate to use cell phones or other portable communication systems. Communication systems and control systems for the pumps and screens may be housed in an operations building. The size of the operations building will be dependent on the primary operation mode and the pumping capacity, and intake configuration. The pumps for the permanent facilities can be housed within the operations building or can be manufactured for exterior conditions.

These infrastructure components have not been analyzed for this study and specific requirements and associated costs for these provisions have not been included or accounted for.

PUMPING SITE FACILITY LAYOUTS

Each of the pumping sites at Grant Line Canal, Middle River, and Old River, for all of the pumping scenarios, have been laid out in the same manner. The intakes are situated downstream (based on the governing flow direction) of the temporary barrier at a location determined by bathymetry, design water depths, and existing infrastructure. The discharge sites are assumed to be 1,000 ft upstream of the temporary barrier. The location of the intake and discharge sites will need further investigation if the study of low-head pumps is advanced, in order to ensure that the pumped water is routed to its intended locations and does not get routed back over the barriers. The intake and the discharge sites are connected by water conveyance lines. Staging areas will be required for each scenario, while it is in construction and while it is in use. Staging areas have not been located, but will need to have ready access to the intake and discharge sites. Right-of-way or temporary easements will need to account for the staging area requirements.

Permanent Flat Screen Intake Pumping Sites

The permanent flat screen intake sites consist of a permanent reinforced concrete on-bank intake, the buried steel and concrete conveyance lines, and a permanent discharge facility that is similar to the intake. The permanent intake is located downstream of the temporary barrier. The intake will house the fish screens, the fish screen cleaning system, the pumps, the vertical pump columns, and the mechanical and electrical controls for the pumps and screens. The conveyance line will run from the intake to the discharge site using trenched steel and concrete pipes. The discharge site will be a permanent discharge facility consisting of a reinforced concrete structure with fish screens. The levee access road will provide personnel access to and between the intake and discharge facilities.

Permanent Cylindrical Screen Intake Pumping Sites

The permanent cylindrical screen intake sites consist of a permanent bank of cylindrical fish screen intakes, the buried steel and concrete conveyance lines, and a permanent discharge facility consisting of a bank of screened outlet pipes. The permanent intake is located downstream of the temporary barrier. The intake is made up of the cylindrical fish screen units with incorporated cleaning system, the retrieval track, inlet pipes, support frames and piles, the support platforms, the pumps, and the mechanical and electrical controls for the pumps and screens. The conveyance line will run from the support platform to the discharge site using trenched steel and concrete pipes. The discharge site will be a permanent discharge facility consisting of a bank of screened steel outlet pipes. The levee access road will provide personnel access to and between the intake and discharge facilities.

Temporary Cylindrical Screen Intake Pumping Sites

The temporary cylindrical screen intake sites consist of a combination of permanent and temporary elements. The inlet and outlet pipes on the waterside slope of the levee will be installed permanently while the fish screens, pumps, and conveyance lines will be installed seasonally and temporarily while the temporary barrier is in place. The intake is located downstream of the temporary barrier. The intake is made up of the permanent inlet pipes placed on the waterside slope of the levee, along with the permanent support frames, support piles, and manifolds. To complete the intake, the cylindrical fish screen units with incorporated cleaning system, the temporary inlet pipes, and the mechanical and electrical controls for the screens will be installed when the intake is in use. The temporary intake pipes will be installed above grade over the levee to the temporary pump and generator units. The conveyance lines will run from the pump/generator units to the permanent outlet pipes. The conveyance lines will use above ground steel pipes. The discharge site will be a bank of permanently installed screened steel outlet pipes. The levee access road will be detoured or will have provisions made to allow traffic over the temporarily installed inlet and outlet pipes. The detoured or modified levee road will provide personnel access to and between the intake and discharge facilities.

SIZING OF FACILITIES

Permanent Flat Screen Intakes

The footprints for the fifteen permanent flat screen intake facility scenarios were all sized using the same guidelines and procedures. The procedure is outlined below.

Required and Design Fish Screen Areas: The fish screen criteria prescribed by the CDFG and NMFS state that the minimum wetted screen area shall be computed by dividing the required pumping rate by the allowed approach velocity (for delta smelt this is 0.2 ft/sec). To allow for potential debris accumulation and biological growth on the face of the screen and to compensate for the reduction in screen area due to structural screen supports, a 10% increase in the wetted screen surface area was applied to obtain the minimum design screen area. The design screen areas are the same for a given pumping rate, regardless of whether it is for a permanent or temporary intake and regardless of intake location. Table 5 summarizes the design screen areas.

Table 5: Fish Screen Area Requirements

Pumping Rate at a Single Pump Location (cfs)	Min. Req'd Screen Area at Ea. Pump Location (ft^2)	Design Req'd Screen Area at Ea. Pump Location (ft^2)	Corresponding DEB Layouts
50	250	275	1, 6, 11, 16, 21, 26, 31, 36, 41
125	625	688	2, 7, 12, 17, 22, 27, 32, 37, 42
250	1250	1375	3, 8, 13, 18, 23, 28, 33, 38, 43
500	2500	2750	4, 9, 14, 19, 24, 29, 34, 39, 44
1000	5000	5500	5, 10, 15, 20, 25, 30, 35, 40, 45

Design Water Depths, Sill Heights and Screen Heights: The design water depth is the depth of water at the face of the intake and is the difference between the design water surface elevation and the design river bottom elevation at the intake face. Using the water surface elevations given in Table 4 and the cross-sections at each site a face of screen location was chosen. The face screen location was determined by selecting a location that had sufficient water depth without disturbing the existing bathymetry or encroaching too far out into the water channel. Due to the bathymetry at the Middle River site, it was determined that dredging of the river channel would be needed to obtain sufficient depth to minimize the length of the intake. Dredging at Middle River will remove approximately a 2 to 4 ft thickness of material off of the river bottom. The design water depths for each water channel are summarized in Table 6.

A sill, a distance between the river bottom and the base of the screen, was provided to limit the amount of sediment that can enter the intake. Most of the time the sediment bed load is concentrated at the river bottom but during turbulent flows or with secondary currents the sediment can be lifted up and off of the river bottom. To exclude these bed loads from entering the intake a sill was provided. For an on-bank intake a minimum standard sill height is set at 20% of the design water depth. The remaining height, between the top of the water and the top of the sill, is the maximum screen height. The minimum sill height, maximum screen height, and the design screen height for each water channel are summarized in Table 6.

Table 6: Design Depths, Sill Heights & Screen Heights

Water Channel	Dist. from Levee Hinge Point (ft)	Design River Bottom Elev. at Face of Screen	Design Water Surface Elev.	Design Water Depth (ft)	Req'd Sill Height (ft)	Max. Screen Height (ft)	Design Screen Height (ft)
Grant Line Canal	65	-10	1.7	11.7	2.34	9.36	9.25
Middle River	55	-4	1.93	5.93	1.19	4.74	4.5
Old River	60	-8	1.1	9.1	1.92	7.28	7.25

The Middle River channel is assumed to be dredged and re-graded to obtain a "Design River Bottom Elev. at Face of Screen" of -4.

Design Fish Screen Lengths, Intake Lengths, and Intake Widths: The required length of screen is the required screen area divided by the design screen height. The intake length is based on the required screen length and the structural support of the structure. The intake structure is comprised of the screens and the support piers between the screens. For this study, access areas to the pump wells were provided at the ends of the intake structure, with one access area for intakes requiring screen lengths of 200 ft or less and two access areas for intakes requiring screen lengths longer than 200 ft. All intake walls were assumed to be 2 ft thick. The maximum length for an individual screen was assumed to be 15 ft, and 2 ft wide wall piers were placed between adjacent screens. Using these parameters the length of the intake was determined for all fifteen of the DEB permanent flat screen intake layouts. Transition lengths at each end of the structure are not included in the design lengths. See Table 7 for a summary of intake design lengths. Highlighted layouts are the basis-of-design layouts.

Table 7: Permanent Flat Screen Intake Lengths

DEB Site Layout	Intake Location	Pumping Capacity (cfs)	Req'd Screen Length (ft)	Individual Screen Length (ft)	Number of Flat Panel Screens	Design Intake Structure Length (ft)
1	GLC	50	30	15	2	46
2	GLC	125	74	15	5	97
3	GLC	250	149	15	10	182
4	GLC	500	297	15	20	362
5	GLC	1000	595	15	40	702
11	MR	50	61	12.25	5	84
12	MR	125	153	14	11	188
13	MR	250	306	14.75	21	374
14	MR	500	611	15	41	719
15	MR	1000	1,222	15	82	1,416
21	OR	50	38	12.75	3	57
22	OR	125	95	13.75	7	123
23	OR	250	190	14.75	13	230
24	OR	500	379	14.75	26	458
25	OR	1000	759	15	51	889

The width of the intakes was determined using the HI Standards, in order to provide the minimum clearances around the pump column and the minimum dimensions for each pump bay. Using the minimum design water depth for each of the three sites and the minimum required pump column submergence, it was determined that a 3 ft diameter pump column would be the largest allowed. This diameter pump column was used for determining the width of the intake. Additionally, for the basis-of-design layouts a 3 ft diameter pump column was used to lay out the pump wells. The width for all of the permanent intakes is 40 ft from front to back face.

Permanent & Temporary Cylindrical Screen Intakes

The footprints for the fifteen permanent cylindrical screen and the fifteen temporary cylindrical screen intake facility scenarios were all sized using the same guidelines and procedures. The procedure is outlined below.

Required & Design Fish Screen Areas: The required and design fish screen areas are the same for the cylindrical screen intakes as they are for the flat screen intakes. See Table 5.

Design Water Depths, Screen Clearances and Screen Diameters: The design water elevations and design water depths are the same for the cylindrical screen intakes as they are for the flat screen intakes and are summarized in Table 8. Similar to providing a sill for the flat screen intakes, minimum clearances must be maintained between the cylindrical screen and the channel bottom and the cylindrical screen and the free surface of the water. Per NMFS, a cylindrical screen must have a minimum of one screen radius between the riverbed and the bottom of the screen and one screen radius between the top of the screen and the top of the design water elevation. Thus, the maximum screen diameter is half of the design water depth. The design screen diameters were determined based on proprietary screen sizes stocked by a screen manufacturer. The maximum screen diameter and the design screen diameter for each water channel are summarized in Table 8.

Table 8: Design Depths & Screen Diameters

Water Channel	Distance from Levee Hinge Point (ft)	Design River Bottom Elev. at Face of Screen	Design Water Surface Elev.	Design Water Depth (ft)	Max. Screen Diameter (ft)	Design Screen Diameter (ft)
Grant Line Canal	65	-10	1.7	11.7	5.85	5
Middle River	55	-4	1.93	5.93	2.97	2.5
Old River	60	-8	1.1	9.1	4.55	4

The Middle River channel is assumed to be dredged and re-graded to obtain a "Design River Bottom Elev. at Face of Screen" of -4.

Design Intake Lengths: The overall intake footprint length for the cylindrical screen intakes is measured from the outside of the first cylindrical screen placed in a series to the outside of the last cylindrical screen in the series. The overall lengths were determined using the design pumping rates and the design screen diameter. Using proprietary screen dimensions, allowable flow rates (at 0.2 ft/sec approach velocity), and suggested screen clearances for screens placed in a series, the length from screen end to screen end was determined. Using these parameters the length of the intake was determined for all fifteen of the DEB permanent cylindrical screen intake layouts and all fifteen of the DEB temporary cylindrical screen intake layouts. See Table 9 for a summary of intake design lengths. Highlighted layouts are the basis-of-design layouts.

Table 9: Permanent &Temporary Cylindrical Screen Intake Lengths

DEB Site Layouts	Intake Location	Pumping Capacity (cfs)	Number of Cylindrical Screens Req'd	Design Intake Structure Length (ft)
6, 11	GLC	50	2	44
7, 12	GLC	125	3	66
8, 13	GLC	250	6	134
9, 14	GLC	500	11	248
10, 15	GLC	1000	22	497
21, 26	MR	50	6	69
22, 27	MR	125	14	163
23, 28	MR	250	27	314
24, 29	MR	500	54	629
25, 39	MR	1000	107	1,248
36, 41	OR	50	2	37
37, 42	OR	125	5	93
38, 43	OR	250	9	167
39, 44	OR	500	17	317
40, 45	OR	1000	34	634

Conveyance Pipelines

To determine the diameter of the conveyance pipes an upper bound was put on the velocity of the water in the pipes. The upper bound was set at 10 ft/sec to minimize the potential for abrasion of the pipe. The hydraulic continuity equation, shown below, was used to determine the required flow area and the corresponding diameter of the conveyance lines.

Hydraulic Continuity Equation:

$$A_{PIPE} = Q_{PIPE} / V_{PIPE}$$

Q_{PIPE} = Flow rate in pipe
V_{PIPE} = Velocity of the flow

Discharge Facility

For this study the discharge facility was assumed to be similar to its corresponding permanent or temporary intake structure.

For the permanent flat screen intake scenarios, the discharge facility is a reinforced concrete structure with the same design as the intake structure. The discharge facility will be exactly the same as the intake, except that pumps and pump columns will not be provided. The structure and screen sizes and configuration are assumed to be the same.

For the permanent and temporary cylindrical screen intake scenarios, the discharge facility is a bank of steel outlet pipes. For the purposes of this study it is assumed that the size and number of outlet pipes will be the same as the size and number of inlet pipes used at the intake. The outlet pipes are assumed to be screened. A final design would need to be based on allowed exit velocities approved by environmental agencies.

Intake Pumps

The main assumption used in the design of the permanent intake pumps, for both the flat screen and the cylindrical screen configuration, is that one pump will be provided for each pump bay in a flat screen intake scenario and one pump will be provided for each cylindrical fish screen unit in a cylindrical screen intake scenario. The main assumption used in the design of the temporary intake pumps is that a single 60 cfs portable pump unit would be provided to run the maximum number of cylindrical screen units. Using these assumptions a required pumping rate for a pump was determined.

For the basis-of-design scenarios the required total dynamic head (TDH) was also determined. The TDH accounted for the friction losses in the pipes, the minor losses through pipe bends/valves/transitions, and the static head due to the change in water surface elevation from the intake to the discharge sites. Using a pump efficiency of 75% and a motor efficiency of 85%, estimates of pump power and motor power were determined based on the TDH. See Table 10.

Table 10: Pump & Motor Requirements for Basis-of-Design Layouts

DEB Site Layout	Intake Location & Type	Number of Pumps	TDH per Pump (ft)	Pump Power per Pump (kW)	Motor Power per Pump (kW)	Total Motor Power for All Pumps (kW)
3	GLC Permanent Flat Screen	10	10	22	25	2,310
8	GLC Permanent Cylindrical Unit	6	15	53	62	372
13	GLC Temporary Cylindrical Unit	6	51	180	211	1,266
18	GLC Permanent Flat Screen	11	9	17	20	220
23	GLC Permanent Cylindrical Unit	27	8	6	7	189
28	GLC Temporary Cylindrical Unit	9	27	64	75	675

To convert kW to hp multiply kW by 1.34

COST ESTIMATE

Basis-of-Design Layouts

For the basis-of-design layouts, the DEB determined material quantities for the major construction activities for the site work, intake foundation, intake structure, conveyance line, and miscellaneous work. These quantities and conceptual designs were provided to the DOE Cost Estimating office (CEo), which in turn provided a cost estimate for all of the quantities listed.

For the permanent flat screen and permanent cylindrical screen intakes, the DEB used the cost estimate from the CEo to determine the Construction Cost Subtotal (CCS). A cost for Mobilization/Demobilization (M/D) was determined as 5% of the CCS. A contingency of 25% of the CCS and M/D was used to account for the conceptual study phase design. Land/Right-of-Way (ROW) acquisition costs were assumed to be 15% of the CCS, and the sum of the CCS, M/D, contingency, and ROW costs is the Capital Outlay Construction Total (COCT). Additionally, project support costs (which include costs for EIR/EIS preparation, permit acquisition, and design and construction management support) of 35% of the COCT was added to obtain an Initial Layout Total Cost. See Table 11 for the basis-of-design layout costs.

For the temporary cylindrical screen intakes, the cost estimate from the CEo provided a cost estimate for the permanently installed elements and a cost estimate for the yearly installed and removed elements. The DEB used the two cost estimates from the CES to determine the Construction Cost Subtotal (CCS) for the one-time installation and for the recurring yearly installation. For the one-time installation, a M/D cost was determined as 5% of the CCS; a contingency of 25% of the CCS and M/D was used to account for the conceptual study phase design; ROW acquisition costs were assumed to be 15% of the CCS; the sum of the CCS, M/D, contingency, and ROW costs is the COCT; project support costs (which include costs for EIR/EIS preparation, permit acquisition, and design and construction management support) of 35% of the COCT was added to obtain a one-time installation Initial Layout Total Cost. For the recurring yearly installation, a M/D cost was determined as 5% of the CCS; a contingency of 25% of the CCS and M/D was used to account for the conceptual study phase design; ROW acquisition costs for temporary easements were assumed to be 10% of the CCS; the sum of the CCS, M/D, contingency, and ROW costs is the COCT; project support costs (which include costs for yearly permit acquisition and design and construction management support) of 20% of the COCT was added to obtain a recurring yearly installation Yearly Layout Total Cost. See Table 11 for the basis-of-design Initial Layout Total Costs.

Table 11: Basis-of-Design Layout Cost Estimates

	COMPONENT	COST (Millions)
DEB Layout 3 Grant Line Canal Permanent Flat Screen 250 cfs Intake	Construction Cost Subtotal (CCS)	$60.8
	Mobilization/Demobilization Cost (M/D)	$3.0
	Contingency – 25%	$16.0
	Land & Right-of-Way Acquisition Cost (ROW)	$9.1
	Capital Outlay Construction Total (COCT)	$88.9
	Project Support Cost	$31.1
	Initial Layout Total Cost	$ 120.0

Table 11: Basis-of-Design Layout Cost Estimates (Continued)

DEB Layout 8 Grant Line Canal Permanent Cylindrical Screen 250 cfs Intake	COMPONENT	COST (Millions)
	Construction Cost Subtotal (CCS)	$10.3
	Mobilization/Demobilization Cost (M/D)	$0.5
	Contingency – 25%	$2.7
	Land & Right-of-Way Acquisition Cost (ROW)	$1.5
	Capital Outlay Construction Total (COCT)	$15.0
	Project Support Cost	$5.2
	Initial Layout Total Cost	$20.2

DEB Layout 13 Grant Line Canal Temporary Cylindrical Screen 250 cfs Intake	COMPONENT	COST (Millions)
	Construction Cost Subtotal (CCS)	$2.8
	Mobilization/Demobilization Cost (M/D)	$0.1
	Contingency – 25%	$0.7
	Land & Right-of-Way Acquisition Cost (ROW)	$0.4
	Capital Outlay Construction Total (COCT)	$4.1
	Project Support Cost	$1.4
	Initial Layout Total Cost	$5.5

DEB Layout 18 Middle River Permanent Flat Screen 250 cfs Intake	COMPONENT	COST (Millions)
	Construction Cost Subtotal (CCS)	$81.7
	Mobilization/Demobilization Cost (M/D)	$4.1
	Contingency – 25%	$21.5
	Land & Right-of-Way Acquisition Cost (ROW)	$12.3
	Capital Outlay Construction Total (COCT)	$119.6
	Project Support Cost	$41.8
	Initial Layout Total Cost	$ 161.4

DEB Layout 23 Middle River Permanent Cylindrical Screen 250 cfs Intake	COMPONENT	COST (Millions)
	Construction Cost Subtotal (CCS)	$30.8
	Mobilization/Demobilization Cost (M/D)	$1.5
	Contingency – 25%	$8.1
	Land & Right-of-Way Acquisition Cost (ROW)	$4.6
	Capital Outlay Construction Total (COCT)	$45.0
	Project Support Cost	$15.8
	Initial Layout Total Cost	$ 60.8

DEB Layout 28 Middle River Temporary Cylindrical Screen 250 cfs Intake	COMPONENT	COST (Millions)
	Construction Cost Subtotal (CCS)	$10.5
	Mobilization/Demobilization Cost (M/D)	$0.5
	Contingency – 25%	$2.7
	Land & Right-of-Way Acquisition Cost (ROW)	$1.6
	Capital Outlay Construction Total (COCT)	$15.3
	Project Support Cost	$5.4
	Initial Layout Total Cost	$20.7

All Other DEB Layouts

Using the initial layout total costs for the basis-of-design layouts, the DEB extrapolated initial layout total costs for the remaining DEB layouts, using ratios of pumping capacities and construction quantities. See Table 12 for the initial cost estimates for all of the DEB layouts.

BDO Scenarios
Cost estimates for the BDO scenarios were determined using the estimated initial layout costs for the DEB layouts. As needed, costs were added together and costs were added or subtracted for the raising or lowering of the temporary barrier. See Table 13 for the initial cost estimates for the BDO scenarios.

Comparing Cost Estimates
In order to compare the costs between the two different permanent intakes and the temporary intake, an engineering economics analysis was done to estimate the present worth of each of the options using the capitalized cost method (life cycle cost), using the equation below.

$$\text{Capitalized Cost} = \text{Initial Cost} + \frac{\text{Annual Costs}}{i}$$

Initial Cost = One time installed Project Grand Total Cost
Annual Costs = Recurring costs (yearly installation costs, power costs, maintenance costs)
i = effective annual interest rate

Assuming an effective annual interest rate of 7%, yearly maintenance costs of 4% of the CCS, and power costs of $0.17 per kWh (for the permanent intake scenarios) and $5.00 per gallon of diesel fuel (for the temporary intake scenario, assuming 470 gallons per day for each pump unit) a present worth value was determined for each BDO scenario. See Table 14.

Table 12: DEB Layout Cost Estimates

DEB Site Layout	Intake Location-Type-Size	Construction Cost Subtotal	Capital Outlay Construction Cost	Support Cost	Initial Layout Total Cost
1	GLC-PF-50	$26.3	$38.5	$13.5	$52.0
2	GLC-PF-125	$39.9	$58.4	$20.4	$78.8
3	GLC-PF-250	$60.8	$88.9	$31.1	$120.0
4	GLC-PF-500	$108.6	$158.9	$55.6	$214.5
5	GLC-PF-1000	$198.4	$290.1	$101.5	$391.7
6	GLC-PC-50	$3.7	$5.4	$1.9	$7.3
7	GLC-PC-125	$6.1	$8.9	$3.1	$12.1
8	GLC-PC-250	$10.3	$15.0	$5.2	$20.2
9	GLC-PC-500	$20.7	$30.3	$10.6	$40.9
10	GLC-PC-1000	$41.4	$60.5	$21.2	$81.7
11	GLC-TC-50	$0.9	$1.3	$0.5	$1.8
12	GLC-TC-125	$1.4	$2.0	$0.7	$2.7
13	GLC-TC-250	$2.8	$4.1	$1.4	$5.5
14	GLC-TC-500	$5.0	$7.3	$2.5	$9.8
15	GLC-TC-1000	$9.9	$14.5	$5.1	$19.6
16	MR-PF-50	$29.5	$43.1	$15.1	$58.2
17	MR-PF-125	$49.1	$71.8	$25.1	$96.9
18	MR-PF-250	$81.7	$119.5	$41.8	$161.4
19	MR-PF-500	$145.2	$212.3	$74.3	$286.6
20	MR-PF-1000	$279.1	$408.1	$142.8	$551.0
21	MR-PC-50	$7.1	$10.4	$3.7	$14.1
22	MR-PC-125	$16.1	$23.6	$8.3	$31.9
23	MR-PC-250	$30.8	$45.0	$15.8	$60.8
24	MR-PC-500	$57.2	$83.6	$29.3	$112.9
25	MR-PC-1000	$118.7	$173.6	$60.7	$234.3
26	MR-TC-50	$2.3	$3.4	$1.2	$4.6
27	MR-TC-125	$5.4	$7.9	$2.8	$10.6
28	MR-TC-250	$10.5	$15.3	$5.4	$20.7
29	MR-TC-500	$20.7	$30.3	$10.6	$40.9
30	MR-TC-1000	$41.0	$60.0	$21.0	$80.9
31	OR-PF-50	$28.7	$42.0	$14.7	$56.6
32	OR-PF-125	$45.6	$66.7	$23.3	$90.0
33	OR-PF-250	$70.7	$103.4	$36.2	$139.6
34	OR-PF-500	$128.7	$188.2	$65.9	$254.1
35	OR-PF-1000	$237.7	$347.6	$121.6	$469.2
36	OR-PC-50	$3.9	$5.7	$2.0	$7.7
37	OR-PC-125	$8.9	$13.0	$4.6	$17.6
38	OR-PC-250	$13.6	$19.9	$7.0	$26.8
39	OR-PC-500	$27.9	$40.9	$14.3	$55.2
40	OR-PC-1000	$55.8	$81.6	$28.6	$110.1
41	OR-TC-50	$0.9	$1.3	$0.5	$1.8
42	OR-TC-125	$2.2	$3.2	$1.1	$4.3
43	OR-TC-250	$3.9	$5.7	$2.0	$7.7
44	OR-TC-500	$7.4	$10.8	$3.8	$14.6
45	OR-TC-1000	$14.7	$21.5	$7.5	$29.1

Intake Type: PF=Permanent Flat Screen; PC=Permanent Cylindrical Screen; TC=Temporary Cylindrical Screen

Table 13: BDO Scenario Cost Estimates

BDO Hydraulic Modeling Scenario	BDO Pumping Scenario Number & Capacity (cfs)	Configuration								
		Permanent Flat Screen			Permanent Cylindrical Screen			Temporary Cylindrical Screen		
		Cost of Layouts	Cost to Raise/ Lower Barriers	Initial Scenario Total Cost	Cost of Layouts	Cost to Raise/ Lower Barriers	Initial Scenario Total Cost	Cost of Layouts	Cost to Raise/ Lower Barriers	Initial Scenario Total Cost
M&O	1 - 100	$114.8	$0	$114.8	$21.8	$0	$21.8	$6.4	$0	$6.4
	2 - 250	$186.9	$0	$186.9	$49.5	$0	$49.5	$14.9	$0	$14.9
	3 - 500	$301.0	$0	$301.0	$87.6	$0	$87.6	$28.4	$0	$28.4
	4 - 1000	$540.7	$0	$540.7	$168.1	$0	$168.1	$55.5	$0	$55.5
GLC	5 - 50	$52.0	$0	$52.0	$7.3	$0	$7.3	$1.8	$0	$1.8
	6 - 250	$120.0	$0	$120.0	$20.2	$0	$20.2	$5.5	$0	$5.5
	7 - 500	$214.5	$0	$214.5	$40.9	$0	$40.9	$9.8	$0	$9.8
	8 - 1000	$391.7	$0	$391.7	$81.7	$0	$81.7	$19.6	$0	$19.6
M&G	9 - 100	$110.2	$0	$110.2	$21.4	$0	$21.4	$6.4	$0	$6.4
	10 - 250	$175.7	$0	$175.7	$44.0	$0	$44.0	$13.3	$0	$13.3
	11 - 500	$281.4	$0	$281.4	$81.0	$0	$81.0	$26.2	$0	$26.2
	12 - 1000	$501.1	$0	$501.1	$153.8	$0	$153.8	$50.7	$0	$50.7
M&O +1MR	13 - 100	$114.8	$0.02	$114.8	$21.8	$0.02	$21.8	$6.4	$0.02	$6.4
	14 - 250	$186.9	$0.02	$186.9	$49.5	$0.02	$49.5	$14.9	$0.02	$14.9
	15 - 500	$301.0	$0.02	$301.0	$87.6	$0.02	$87.6	$28.4	$0.02	$28.4
	16 - 1000	$540.7	$0.02	$540.7	$168.1	$0.02	$168.1	$55.5	$0.02	$55.5
GLC +1MR	17 - 125	$78.8	$0.02	$78.8	$12.1	$0.02	$12.1	$2.7	$0.02	$2.7
	18 - 250	$120.0	$0.02	$120.0	$20.2	$0.02	$20.2	$5.5	$0.02	$5.5
	19 - 500	$214.5	$0.02	$214.5	$40.9	$0.02	$40.9	$9.8	$0.02	$9.8
	20 - 1000	$391.7	$0.02	$391.7	$81.7	$0.02	$81.7	$19.6	$0.02	$19.6
M&G +1MG-1Old	21 - 100	$110.2	$0.05	$110.3	$21.4	$0.05	$21.5	$6.4	$0.05	$6.5
	22 - 250	$175.7	$0.05	$175.8	$44.0	$0.05	$44.1	$13.3	$0.05	$13.4
	23 - 500	$281.4	$0.05	$281.5	$81.0	$0.05	$81.1	$26.2	$0.05	$26.3
	24 - 1000	$501.1	$0.05	$501.2	$153.8	$0.05	$153.9	$50.7	$0.05	$50.8
M	25 - 50	$58.2	$0	$58.2	$14.1	$0	$14.1	$4.6	$0	$4.6
	26 - 125	$96.9	$0	$96.9	$31.9	$0	$31.9	$10.6	$0	$10.6
	27 - 250	$161.4	$0	$161.4	$60.8	$0	$60.8	$20.7	$0	$20.7
	28 - 500	$286.6	$0	$286.6	$112.9	$0	$112.9	$40.9	$0	$40.9
	29 - 1000	$551.0	$0	$551.0	$234.3	$0	$234.3	$80.9	$0	$80.9
O	30 - 50	$56.6	$0	$56.6	$7.7	$0	$7.7	$1.8	$0	$1.8
	31 - 125	$90.0	$0	$90.0	$17.6	$0	$17.6	$4.3	$0	$4.3
	32 - 250	$139.6	$0	$139.6	$26.8	$0	$26.8	$7.7	$0	$7.7
	33 - 500	$254.1	$0	$254.1	$55.2	$0	$55.2	$14.6	$0	$14.6
	34 - 1000	$469.2	$0	$469.2	$110.1	$0	$110.1	$29.1	$0	$29.1

Table 14: BDO Scenario Capitalized Costs for Comparison of Intake Configurations

BDO Hydraulic Modeling Scenario	BDO Pumping Scenario Number & Capacity (cfs)	Configuration								
		Permanent Flat Screen			Permanent Cylindrical Screen			Temporary Cylindrical Screen		
		Initial Cost	Annual Costs	Capitalized Cost	Initial Cost	Annual Costs	Capitalized Cost	Initial Cost	Annual Costs	Capitalized Cost
M&O	1 - 100	$114.8	$2.7	$153.4	$21.8	$0.5	$29.3	$6.4	$8.3	$125.3
	2 - 250	$186.9	$4.7	$254.3	$49.5	$1.3	$68.0	$14.9	$17.8	$269.0
	3 - 500	$301.0	$8.0	$414.6	$87.6	$2.3	$120.8	$28.4	$33.5	$507.3
	4 - 1000	$540.7	$14.7	$750.3	$168.1	$4.5	$232.8	$55.5	$62.7	$951.9
GLC	5 - 50	$52.0	$1.4	$71.9	$7.3	$0.2	$10.2	$1.8	$3.3	$48.7
	6 - 250	$120.0	$4.1	$179.0	$20.2	$0.7	$30.0	$5.5	$10.0	$147.6
	7 - 500	$214.5	$7.7	$325.0	$40.9	$1.4	$60.5	$9.8	$15.6	$232.8
	8 - 1000	$391.7	$14.7	$602.0	$81.7	$2.7	$121.0	$19.6	$32.4	$482.9
M&G	9 - 100	$110.2	$2.6	$147.4	$21.4	$0.5	$28.7	$6.4	$8.3	$125.3
	10 - 250	$175.7	$4.5	$239.8	$44.0	$1.1	$59.6	$13.3	$17.1	$257.0
	11 - 500	$281.4	$7.6	$389.4	$81.0	$2.1	$110.4	$26.2	$32.6	$491.6
	12 - 1000	$501.1	$13.9	$699.2	$153.8	$3.9	$210.1	$50.7	$60.7	$918.5
M&O +1MR	13 - 100	$114.8	$2.7	$153.4	$21.8	$0.5	$29.3	$6.4	$8.3	$125.3
	14 - 250	$186.9	$4.7	$254.3	$49.5	$1.3	$68.0	$14.9	$17.8	$269.0
	15 - 500	$301.0	$8.0	$414.6	$87.6	$2.3	$120.8	$28.4	$33.5	$507.3
	16 - 1000	$540.7	$14.7	$750.3	$168.1	$4.5	$232.8	$55.5	$62.7	$951.9
GLC +1MR	17 - 125	$78.8	$2.4	$113.7	$12.1	$0.4	$17.6	$2.7	$4.9	$73.1
	18 - 250	$120.0	$4.1	$179.0	$20.2	$0.7	$30.0	$5.5	$10.0	$147.7
	19 - 500	$214.5	$7.7	$325.0	$40.9	$1.4	$60.6	$9.8	$15.6	$232.8
	20 - 1000	$391.7	$14.7	$602.0	$81.7	$2.7	$121.0	$19.6	$32.4	$482.9
M&G +1MG-1Old	21 - 100	$110.3	$2.6	$147.4	$21.5	$0.5	$28.8	$6.5	$8.3	$125.3
	22 - 250	$175.8	$4.5	$239.9	$44.1	$1.1	$59.7	$13.4	$17.1	$257.0
	23 - 500	$281.5	$7.6	$389.4	$81.1	$2.1	$110.4	$26.3	$32.6	$491.6
	24 - 1000	$501.2	$13.9	$699.3	$153.9	$3.9	$210.1	$50.8	$60.7	$918.6
M	25 - 50	$58.2	$1.2	$75.5	$14.1	$0.3	$18.6	$4.6	$5.0	$76.6
	26 - 125	$96.9	$2.0	$126.1	$31.9	$0.7	$42.1	$10.6	$12.1	$183.9
	27 - 250	$161.4	$3.4	$210.4	$60.8	$1.4	$80.4	$20.7	$22.6	$343.9
	28 - 500	$286.6	$6.1	$374.2	$112.9	$2.6	$149.6	$40.9	$45.1	$685.8
	29 - 1000	$551.0	$11.8	$719.7	$234.3	$5.3	$310.1	$80.9	$89.9	$1,364.7
O	30 - 50	$56.6	$1.5	$77.8	$7.7	$0.2	$10.7	$1.8	$3.3	$48.7
	31 - 125	$90.0	$2.7	$128.2	$17.6	$0.6	$25.9	$4.3	$5.7	$85.1
	32 - 250	$139.6	$4.5	$204.2	$26.8	$1.0	$40.4	$7.7	$10.9	$163.3
	33 - 500	$254.1	$8.5	$376.1	$55.2	$2.0	$83.2	$14.6	$17.6	$266.1
	34 - 1000	$469.2	$16.3	$702.0	$110.1	$3.9	$166.1	$29.1	$36.4	$549.5

Cost Estimate Considerations

For this study the cost estimates are based on conceptual level schematic designs. There are many factors that can affect the designs that will in turn affect the cost estimates. These factors include, but are not limited to, the inclusion of a log-boom protection system, a sediment control system, exclusion of the gantry crane, the extents and requirements for levee road improvements, levee reinforcement, power supply infrastructure, fire protection system, and communication lines. Design assumptions for the intake and discharge facilities need to be approved by the environmental agencies and their decisions may affect the structural design. Additionally, hydraulic modeling and analysis of the water channels with the intake and discharge facilities in place has not been done. These would need to be done for a final design in order to study and determine levee integrity, levee seepage, and effects on levee freeboard. The hydraulic modeling and analysis may indicate that the facility placement needs to be modified or that cut-off walls are required, which may increase the project cost.

The contingency of 25% is used to try to cover these uncertainties in the design, but unanticipated project requirements may increase the cost of the project substantially.

PROJECT TIMELINE CONSIDERATIONS

Many factors affect a project's preparation, design and engineering, and construction timeline. The size of a project, the preparation of environmental documents, the procurement of environmental permits, the design phases, the procurement of materials, and any environmental in-water or on-land construction windows will affect a project's timeline. All of these factors will affect the timeline of an intake and discharge facility located in the south Delta. The preparation of environmental documents, acquisition of environmental permits, restriction of work windows, and the procurement of pumps may have the most impact on determination of the project's timeline.

The 285 cfs capacity Freeport Regional Water Authority (FRWA) intake, located on the Sacramento River, had a final approximate timeline of eight years, from project inception to the completion of the intake. It took approximately three years to complete the environmental review, two years to design and engineer the intake, and three years to construct the intake.

The intakes for the South Delta Low Head Pump Salinity Control Study have pumping capacities that range between 50 cfs and 1,000 cfs, with some scenarios constructing intakes and two different locations. Using the timeline of the FRWA intake as comparison, the South Delta pump project may take between six and ten years to be realized, from project inception to completion.

PUMPING SCENARIO CONSIDERATIONS

Intake Pumping Capacity

As the pumping capacity increases, so does the size of the required facilities. The intake size increases, the conveyance line increases, and the discharge facility size increases. Due to the fish screen area requirements, at a given site, there is an approximately 1:1 linear ratio between the pumping capacity and the intake length. Depending on the environmental parameters for the discharge site, there is also potential for the discharge length to increase at a 1:1 ratio as the pumping capacity increases. The time to construct the facilities and the cost of the facilities also increases. As the facilities increase in length more of the levee and the river are impacted and correspondingly the environmental and engineering permits may be more difficult to acquire.

Intake Configuration

The permanent flat panel screen intake is a configuration that is robust and can be designed to withstand flood, impact, and seismic loads. It can be readily maintained and will have a long life. This configuration will maintain the integrity of the levee, even with the installation of pipes through the freeboard of the levee, as the back wall of a cofferdam installed for construction will remain in place and act as a cut-off wall. The timeline for the permanent flat panel screen intake will be longer, for both design and construction, and the cost will be higher than for the other two intake configurations. This type of system would be designed to meet all the environmental criteria, the water code, and the building code.

The permanent cylindrical screen intake is a configuration that is less robust than the flat panel screen intake. It may be designed for flood, impact, and seismic loads, but the degree of damage these forces may cause would be higher than for the reinforced concrete structure. Damaged portions may need to be removed and replaced if the damage affects the performance of the intake. Additionally, placement of the pipes through the freeboard of the levee and installation of the support piles within the levee may decrease the levee integrity or may not be permitted by the levee's governing agencies. Costly cut-off walls may be required to allow for trenching of the inlet pipes and for installation of the supporting piles. This may be a concern, particularly at the Middle River site where fill is proposed over the top of the pipe to meet criteria in the CCR, where levee stabilization is an issue due to seepage through the levee or differential settlement of the levee. This type of system would be designed to meet all the environmental criteria, the water code, and the building code, although there may be more ambiguity in the design and any modifications to the levee will require diligence so that the levee integrity is not compromised.

The temporary cylindrical screen intake is a configuration that is even less robust than the permanent cylindrical screen intake. Like, the permanent cylindrical screen intake, it is susceptible to damage. Efforts would need to be coordinated every year for installation and removal of the temporary elements. The temporarily installed elements (screens, pipes, pumps) may be purchased by DWR and the contract each year would be for installation/removal or the temporarily installed elements may have a contract each year for procurement and installation/removal. With either scenario, each year divers would be required to install and remove the screens, permits and temporary easements would need to be obtained, and pumps, generators and pipes would need to be set-up. With this intake configuration, the levee road may need to be detoured. The permanent elements would be designed to meet all the environmental criteria, the water code, and the building code. There may be more ambiguity in the installation of the temporary conveyance lines.

Intake Location

Each site provides its own challenges. The Grant Line Canal site has very little room between the temporary barrier and the South Tracy Boulevard Bridge. Depending on the size of the intake and the required distance between the intake and the barrier, the intake may need to be located on the west side of the bridge, which would result in issues in having to pass the conveyance line under South Tracy Boulevard. The Middle River site is very shallow, and correspondingly the intake is longer than all the other sites. Additionally, the Middle River site is located on a sharp narrow ninety degree bend in the river that may cause sedimentation issues. The Old River site provides a fairly straight stretch of river, but for the larger capacity intakes the structure may end up being located on an inside bank of a river curve which may cause sedimentation issues.

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DEB SITE LAYOUT PLANS AND DETAILS

1" = 80' 80 0 80 160 240 320 SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

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DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
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DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT AND TEMPORARY INTAKE
GRANT LINE CANAL PUMP SITE
SITE PLAN
DEB LAYOUTS 1 TO 15

SPEC. No.
DRAWING No.
REV. | SHEET No. 1

1" = 50' — 50 0 50 100 150 200 SCALE OF FEET

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SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
GRANT LINE CANAL PUMP SITE
50 CFS CAPACITY
DEB LAYOUT 1

SPEC. No. / DRAWING No. / REV. / SHEET No. 2

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SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
GRANT LINE CANAL PUMP SITE
125 CFS CAPACITY
DEB LAYOUT 2

DESIGNED	CHECKED	APPROVAL RECOMMENDED:	DATE:
DRAWN	REVIEWED	APPROVAL RECOMMENDED:	DATE:
SUBMITTED:		APPROVED:	DATE:

REV.	DATE	DESCRIPTION	SUB.	APP'D

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SPEC. No.
DRAWING No.
REV. SHEET No. 3

1" = 50'
50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

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SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
GRANT LINE CANAL PUMP SITE
250 CFS CAPACITY
DEB LAYOUT 3

SPEC. No.
DRAWING No.
REV. | SHEET No. 4

1" = 50' 50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: | DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: | DATE:
SUBMITTED: | APPROVED: | DATE:

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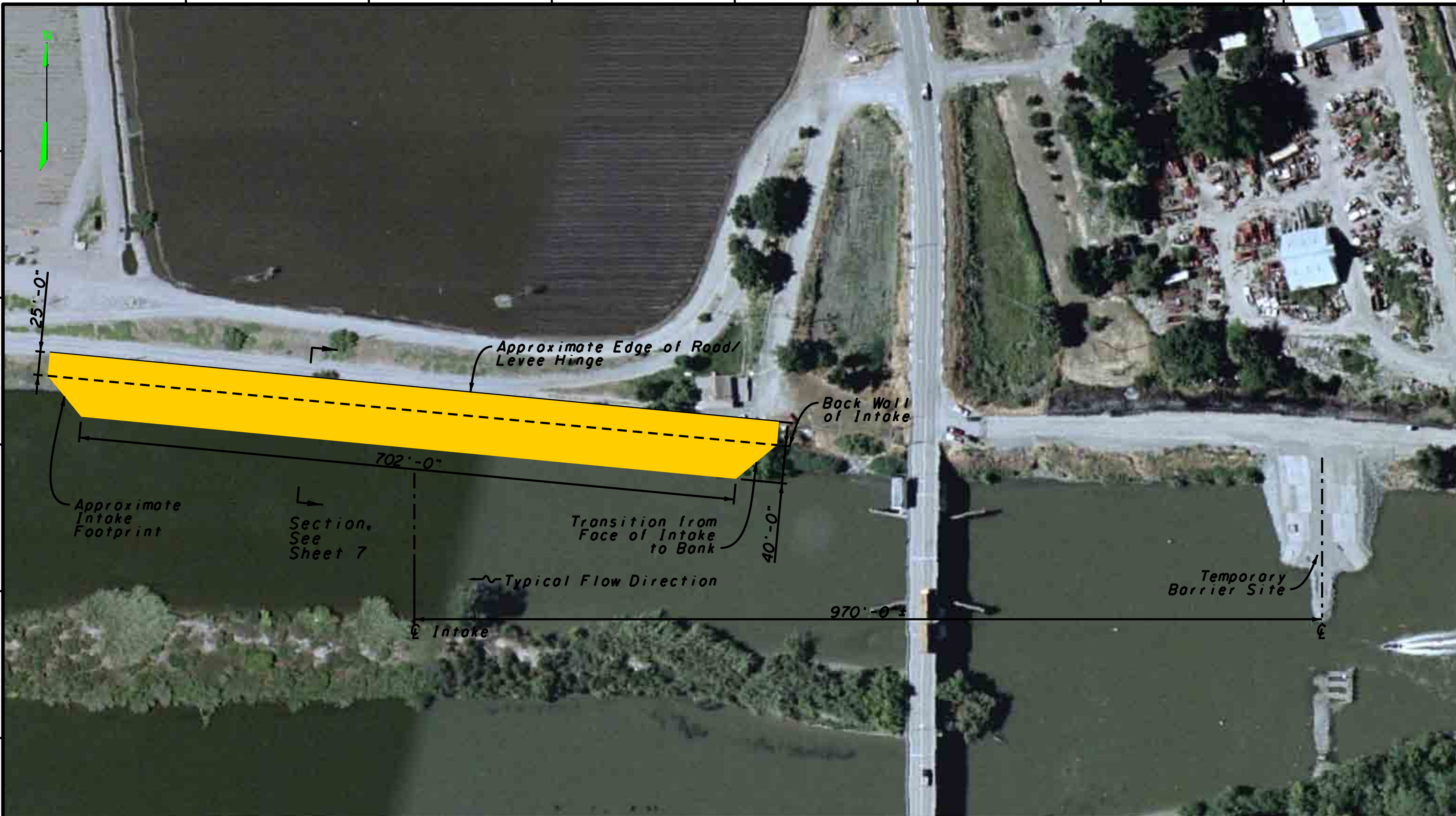
SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
GRANT LINE CANAL PUMP SITE
500 CFS CAPACITY
DEB LAYOUT 4

SPEC. No.
DRAWING No.
REV. | SHEET No. 5



1" = 50' SCALE OF FEET (50, 0, 50, 100, 150, 200)

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

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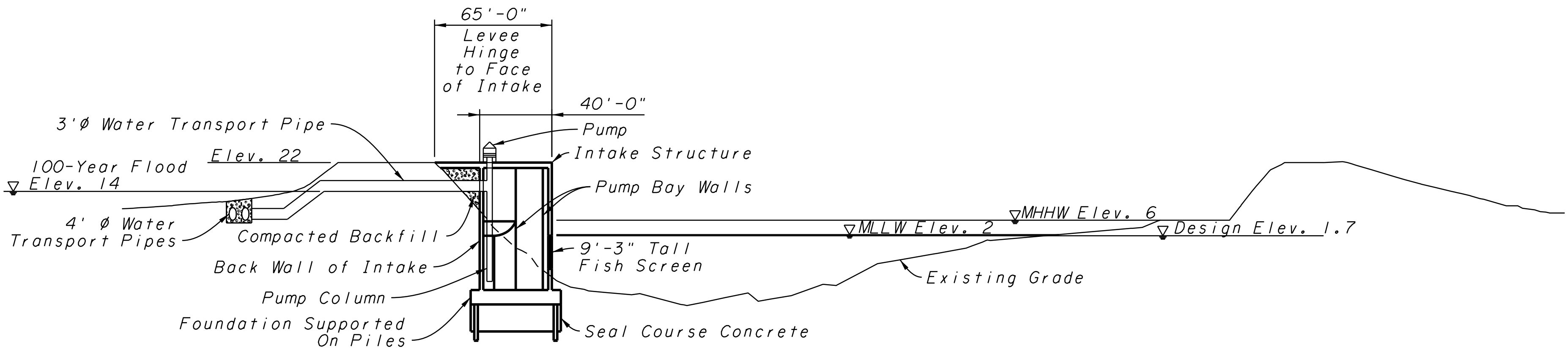
SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
GRANT LINE CANAL PUMP SITE
1000 CFS CAPACITY
DEB LAYOUT 5

SPEC. No.
DRAWING No.
REV. SHEET No. 6



SECTION

Scale: 1" = 30'

Sta. 3+00

Note: This section is shown with a 2:1 vertical exaggeration.

1" = 30' 30 0 30 60 90 120 SCALE OF FEET

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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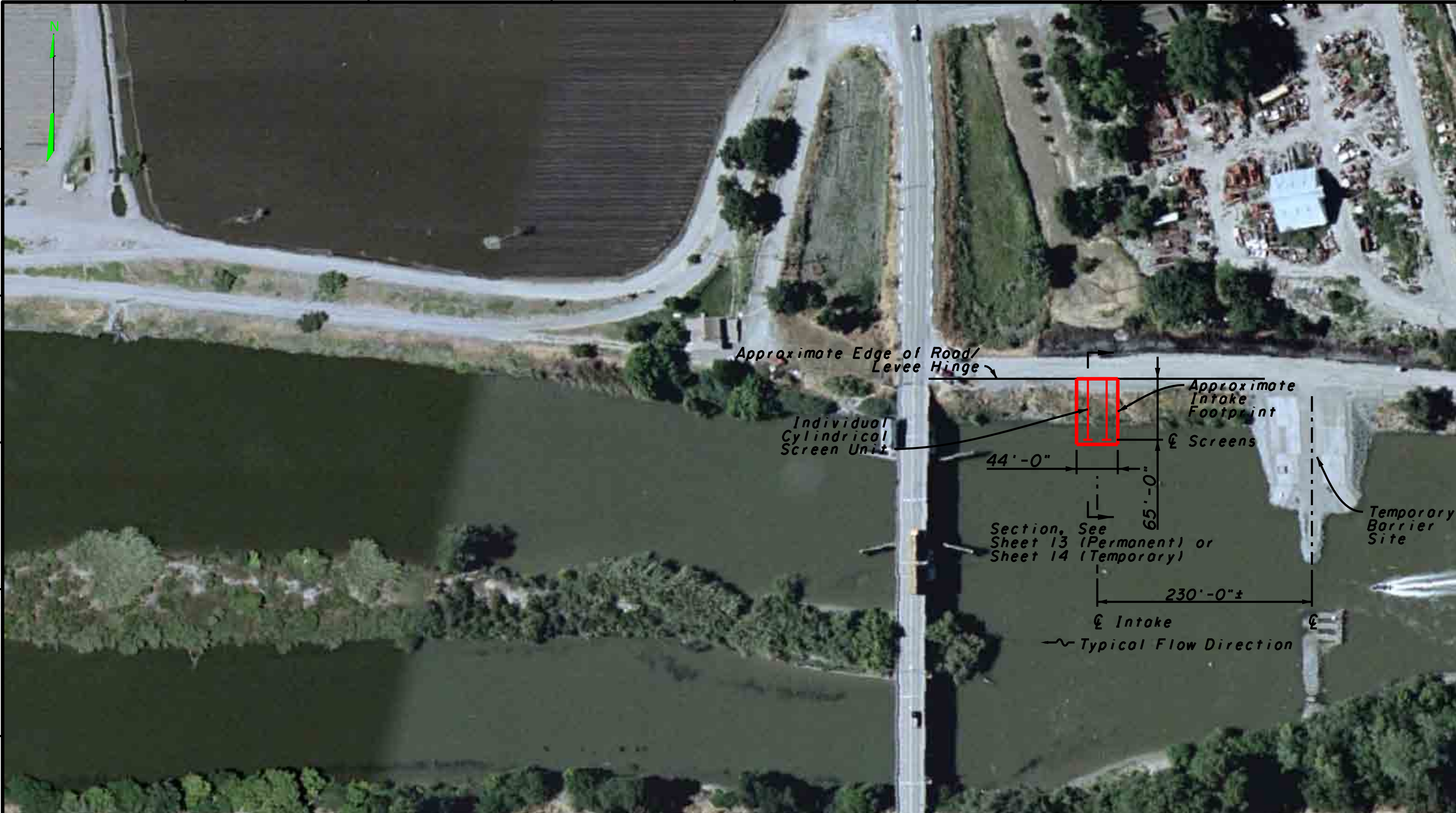
SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
GRANT LINE CANAL PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 1 TO 5

SPEC. No.
DRAWING No.
REV. SHEET No. 7



1" = 50'

SCALE OF FEET: 50, 0, 50, 100, 150, 200

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: | DATE:

DRAWN | REVIEWED | APPROVAL RECOMMENDED: | DATE:

SUBMITTED: | APPROVED: | DATE:

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SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
GRANT LINE CANAL PUMP SITE
50 CFS CAPACITY
DEB LAYOUT 6 & 11

SPEC. No.
DRAWING No.
REV. | SHEET No. 8

1" = 50' 50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
GRANT LINE CANAL PUMP SITE
125 CFS CAPACITY
DEB LAYOUT 7 & 12

SPEC. No.
DRAWING No.
REV. SHEET No. 9

1" = 50'

SCALE OF FEET: 50 0 50 100 150 200

THINK SAFETY – ACT SAFELY

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
GRANT LINE CANAL PUMP SITE
250 CFS CAPACITY
DEB LAYOUT 8 & 13

DESIGNED	CHECKED	APPROVAL RECOMMENDED:	DATE:
DRAWN	REVIEWED	APPROVAL RECOMMENDED:	DATE:
SUBMITTED:		APPROVED:	DATE:

REV.	DATE	DESCRIPTION	SUB.	APP'D

REG. STAMP

SPEC. No.
DRAWING No.
REV. | SHEET No. 10

1" = 50'
50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:
APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

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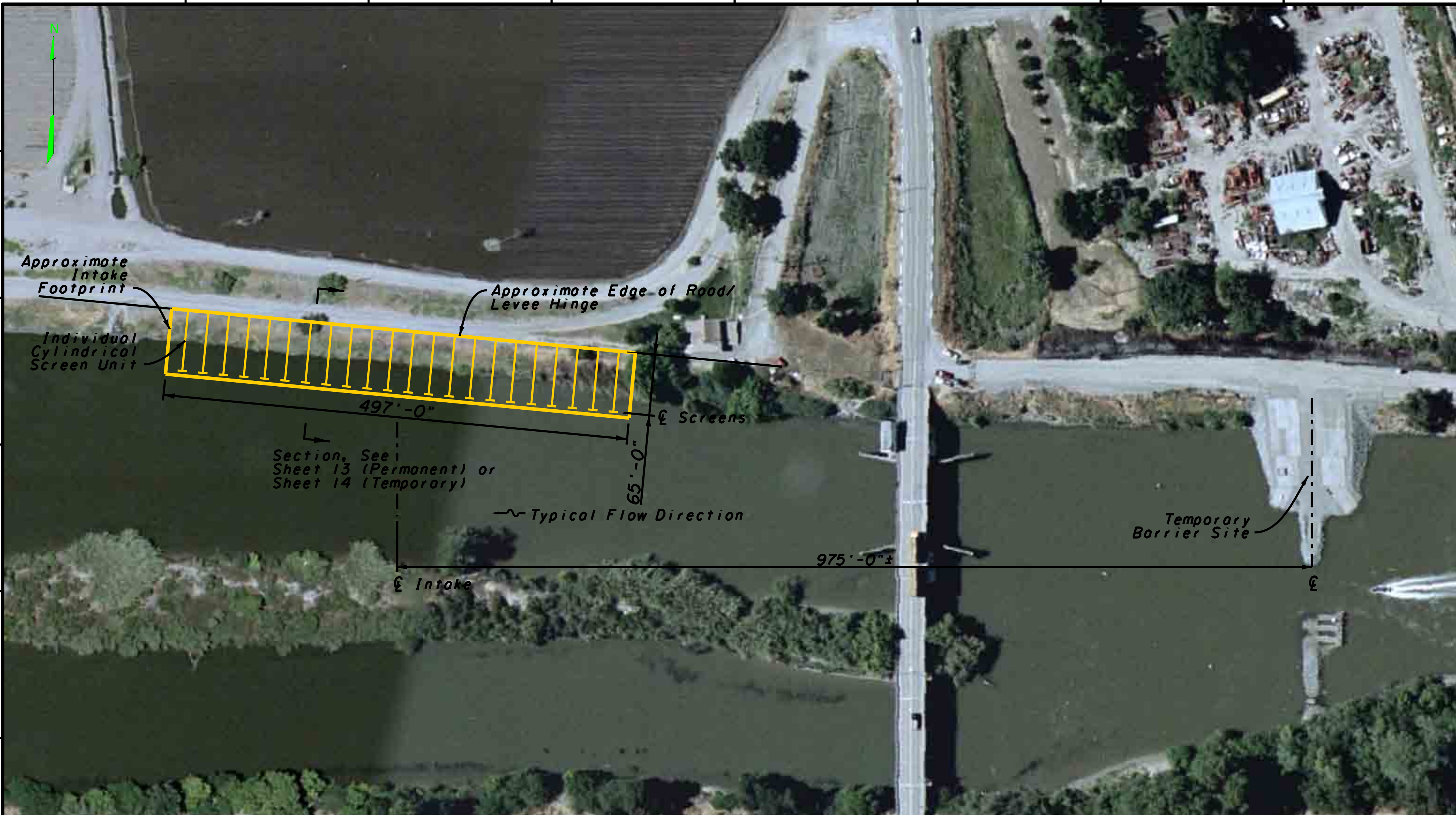
REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
GRANT LINE CANAL PUMP SITE
500 CFS CAPACITY
DEB LAYOUT 9 & 14

SPEC. No.
DRAWING No.
REV.
SHEET No. 11



1" = 50' 50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

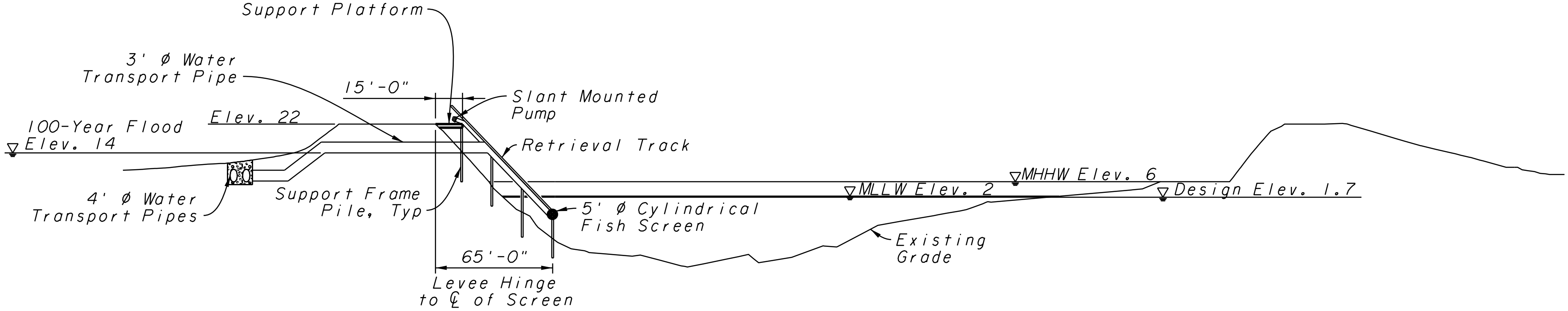
DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
GRANT LINE CANAL PUMP SITE
1000 CFS CAPACITY
DEB LAYOUT 10 & 15

SPEC. No.
DRAWING No.
REV. SHEET No. 12



SECTION

Scale: 1" = 30'

Sta. 3+00

Note: This section is shown with a 2:1 vertical exaggeration.

1" = 30' — 30 0 30 60 90 120 SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT CYLINDRICAL INTAKE
GRANT LINE CANAL PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 6 TO 10

SPEC. No.
DRAWING No.
REV. | SHEET No. 13

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$$$$$PRFNAME$$$$$$$$$
$$$DATE$$$$
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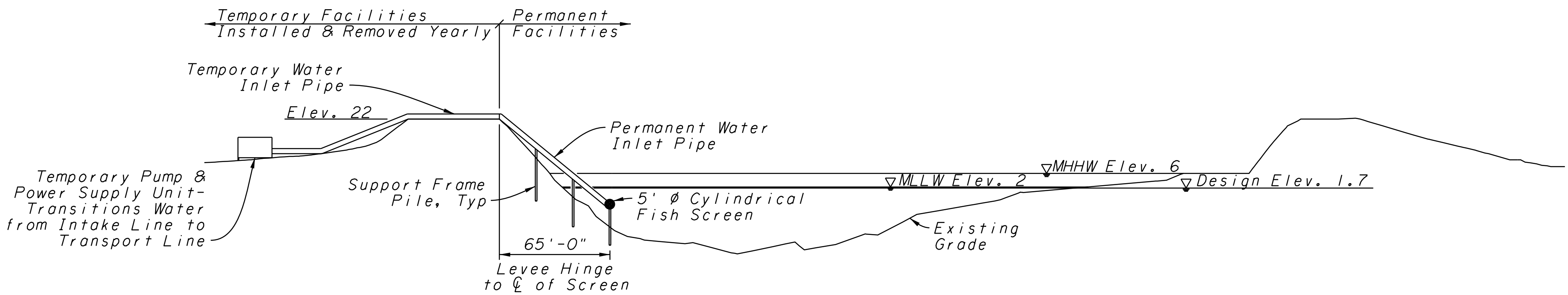
$$$$$DESIGNFILESPECIFICATION$$$$$$$$$$$$$$$$$



SECTION

Scale: 1" = 30'

Sta. 3+00

NOTES

1. This section is shown with a 2:1 vertical exaggeration.
2. 100-Year Flood Elevation is 14 ft (NAVD 88, CA State Plane Zone 3)

1" = 30' — SCALE OF FEET: 30, 0, 30, 60, 90, 120

THINK SAFETY - ACT SAFELY

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

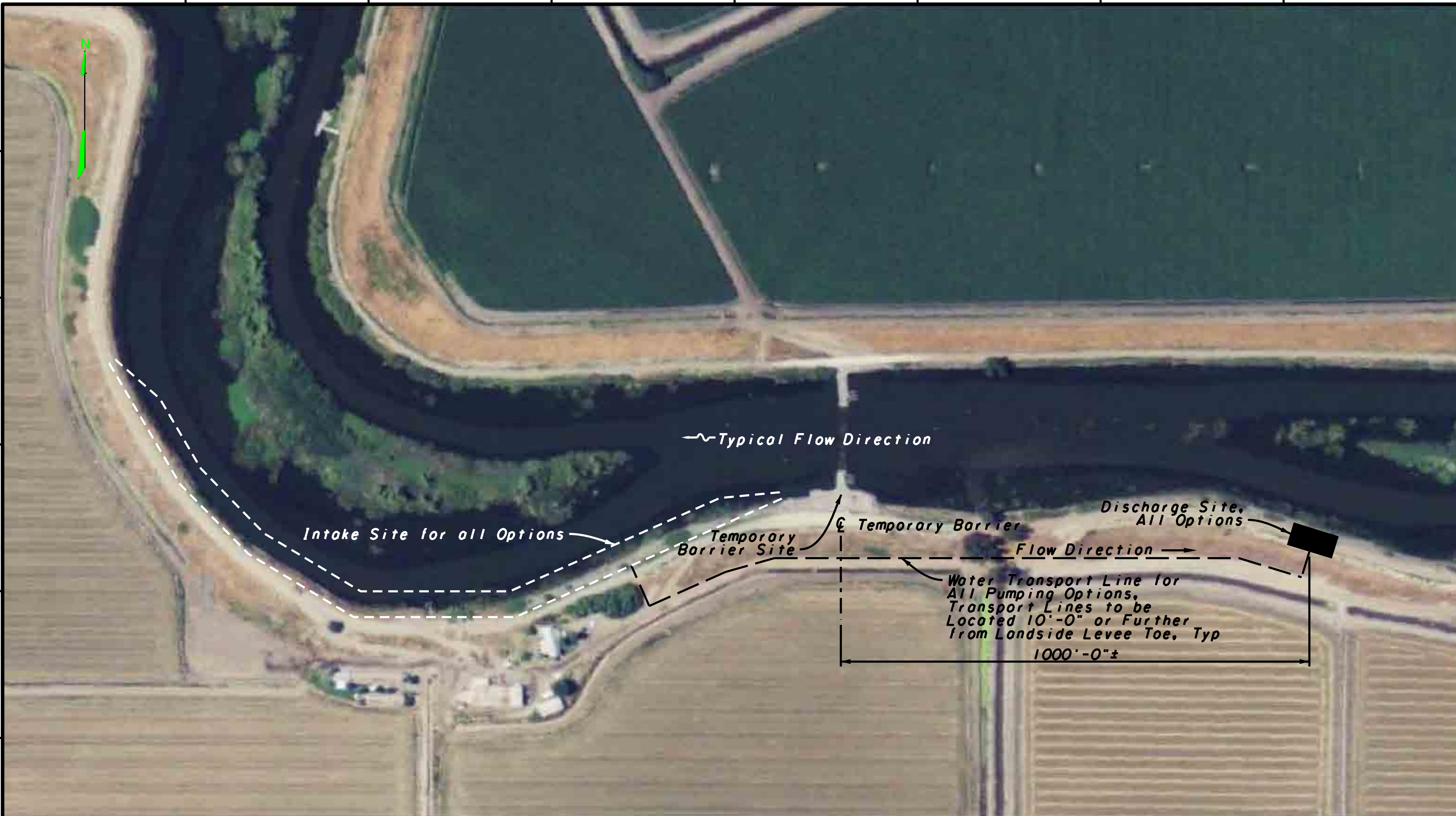
SOUTH DELTA LOW HEAD PUMP STUDY
TEMPORARY CYLINDRICAL INTAKE
GRANT LINE CANAL PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 11 TO 15

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED / APPROVAL RECOMMENDED: DATE: / APPROVAL RECOMMENDED: DATE: / APPROVED: DATE:

REG. STAMP

SPEC. No. / DRAWING No. / REV. / SHEET No. 14



1" = 100' 100 0 100 200 300 400
SCALE OF FEET

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:

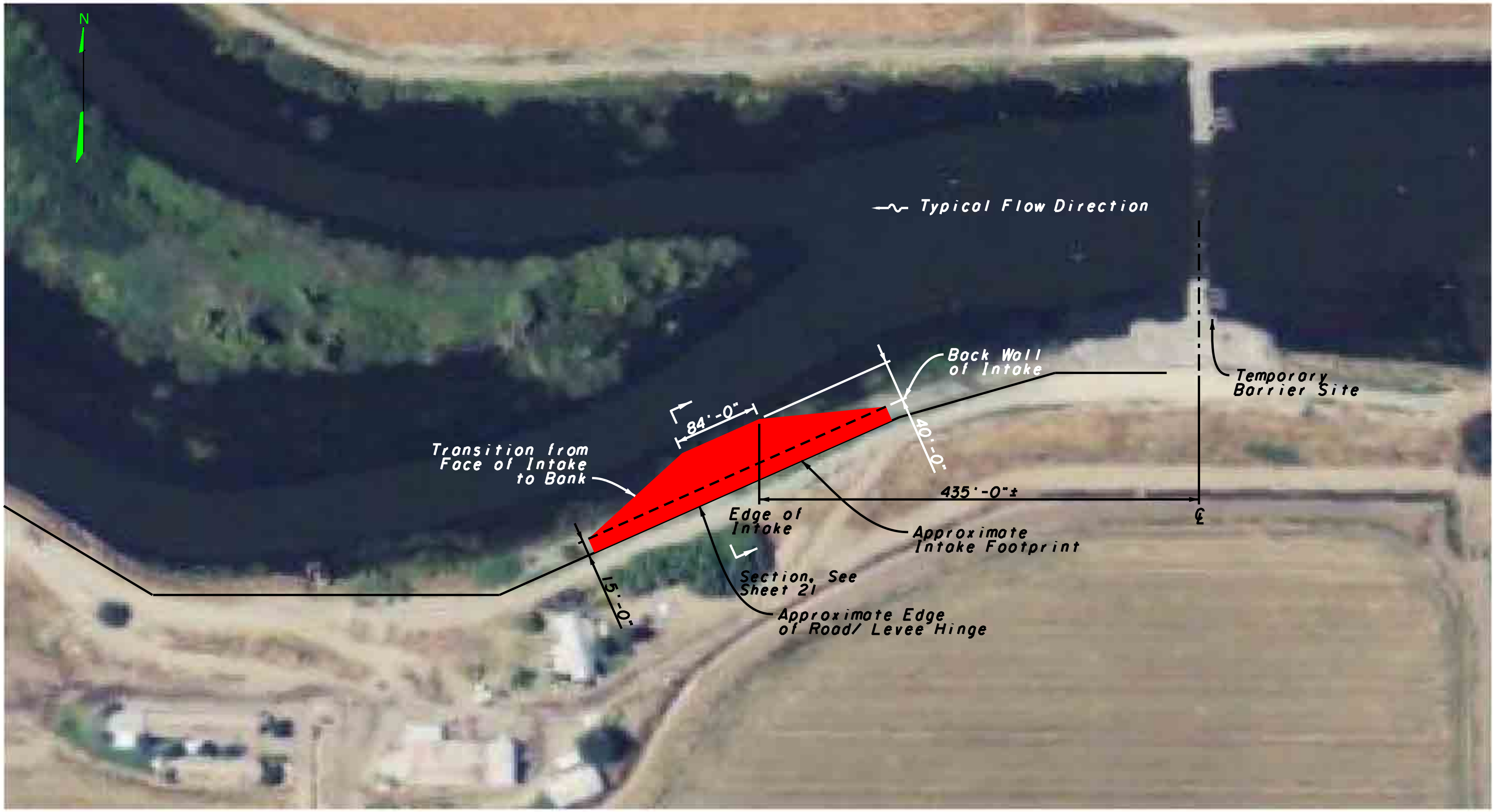
APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT AND TEMPORARY INTAKE
MIDDLE RIVER PUMP SITE
SITE PLAN
DEB LAYOUTS 16 TO 30

SPEC. No.
DRAWING No.
REV. SHEET No. 15



1" = 50'
50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

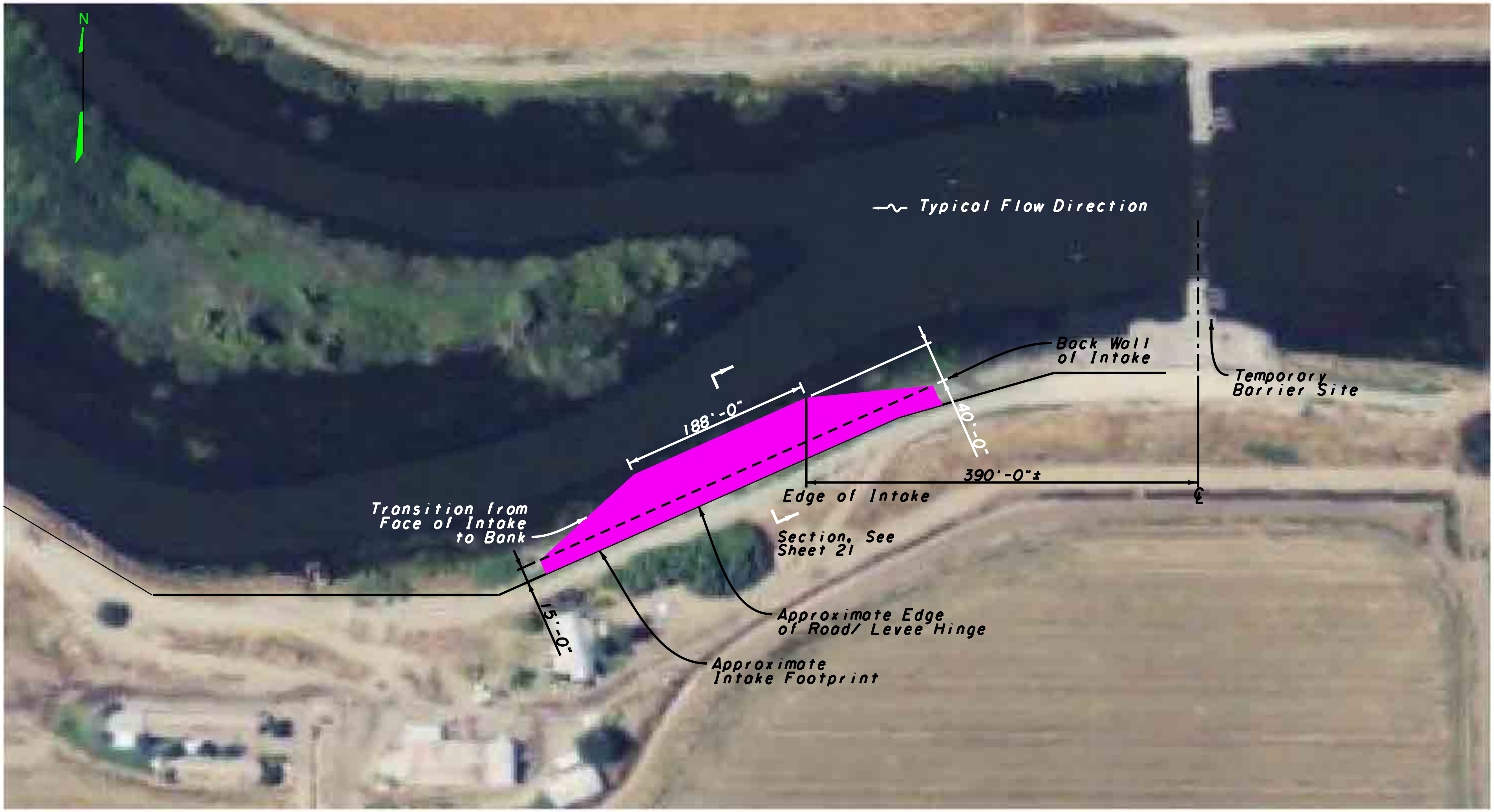
DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

REGISTERED PROFESSIONAL ENGINEER — STATE OF CALIFORNIA
REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
MIDDLE RIVER PUMP SITE
50 CFS CAPACITY
DEB LAYOUT 11

SPEC. No.
DRAWING No.
REV. | SHEET No. 16



1" = 50' — SCALE OF FEET: 50, 0, 50, 100, 150, 200

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:

APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

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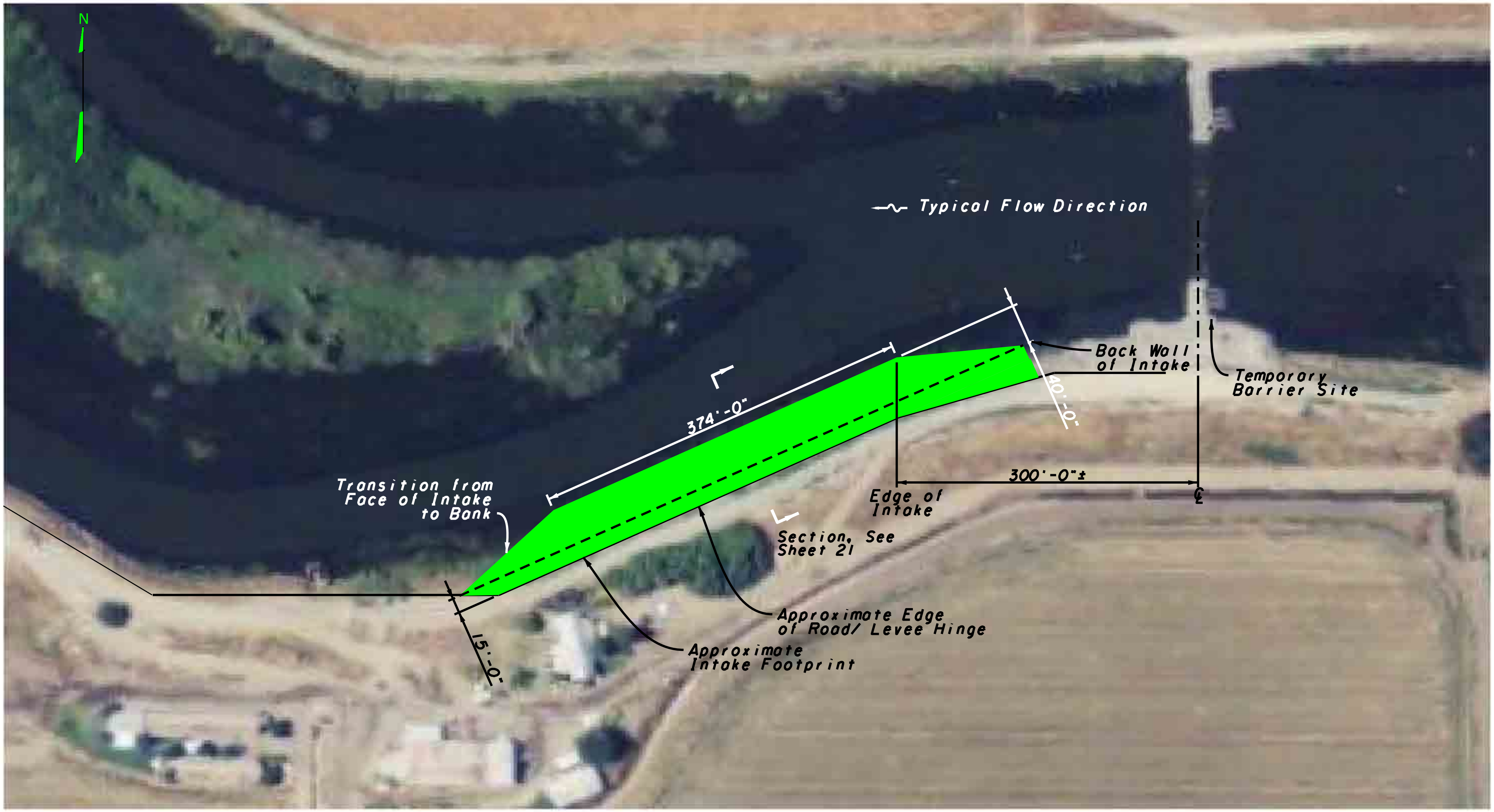
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
MIDDLE RIVER PUMP SITE
125 CFS CAPACITY
DEB LAYOUT 12

SPEC. No.
DRAWING No.
REV. SHEET No. 17



1" = 50'   50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / APPROVAL RECOMMENDED: DATE:
DRAWN / REVIEWED / APPROVAL RECOMMENDED: DATE:
SUBMITTED: / APPROVED: DATE:

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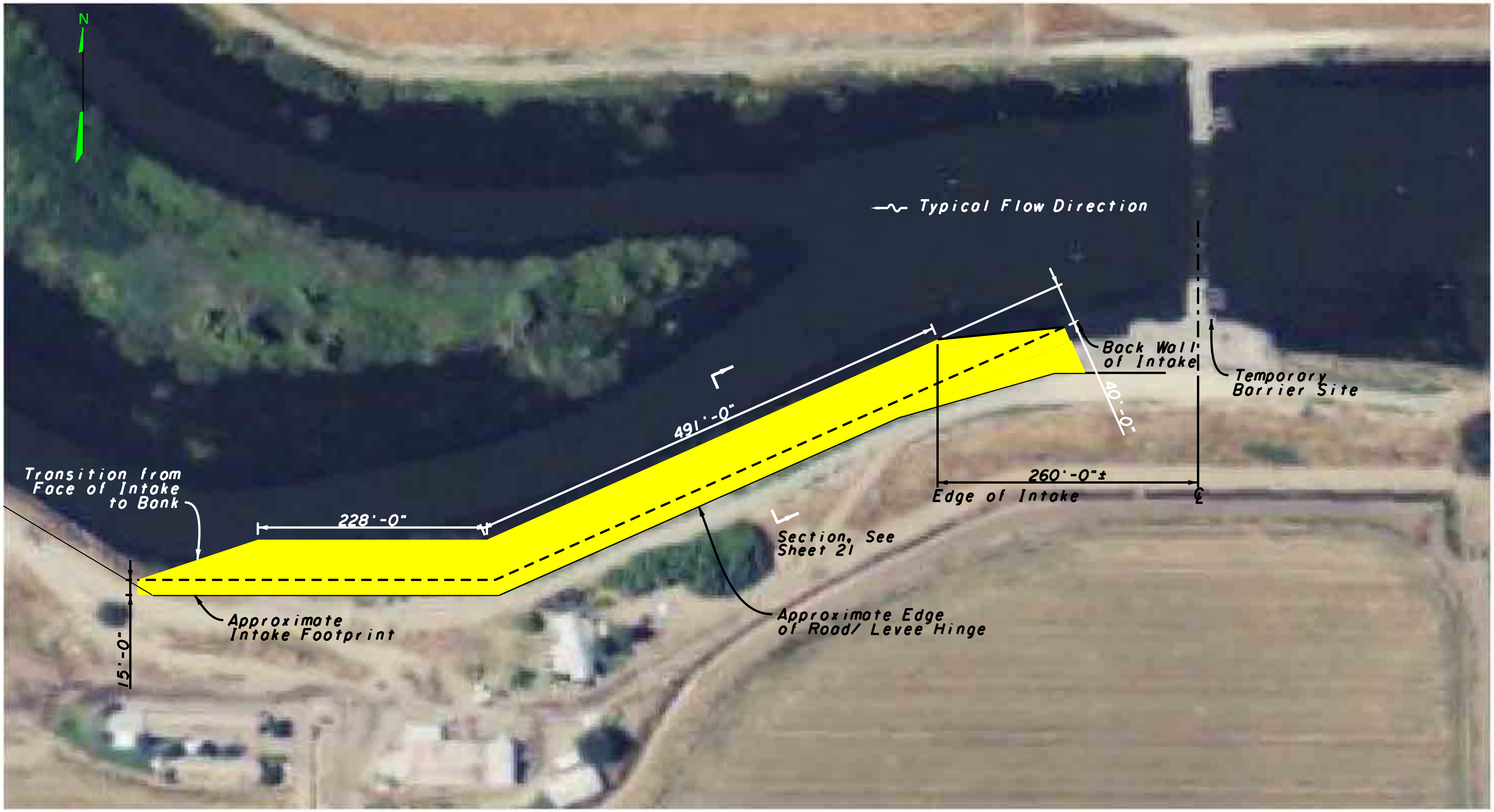
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
MIDDLE RIVER PUMP SITE
250 CFS CAPACITY
DEB LAYOUT 13

SPEC. No.
DRAWING No.
REV. SHEET No. 18

DATE
DESIGNFILESPECIFICATION



1" = 50' 50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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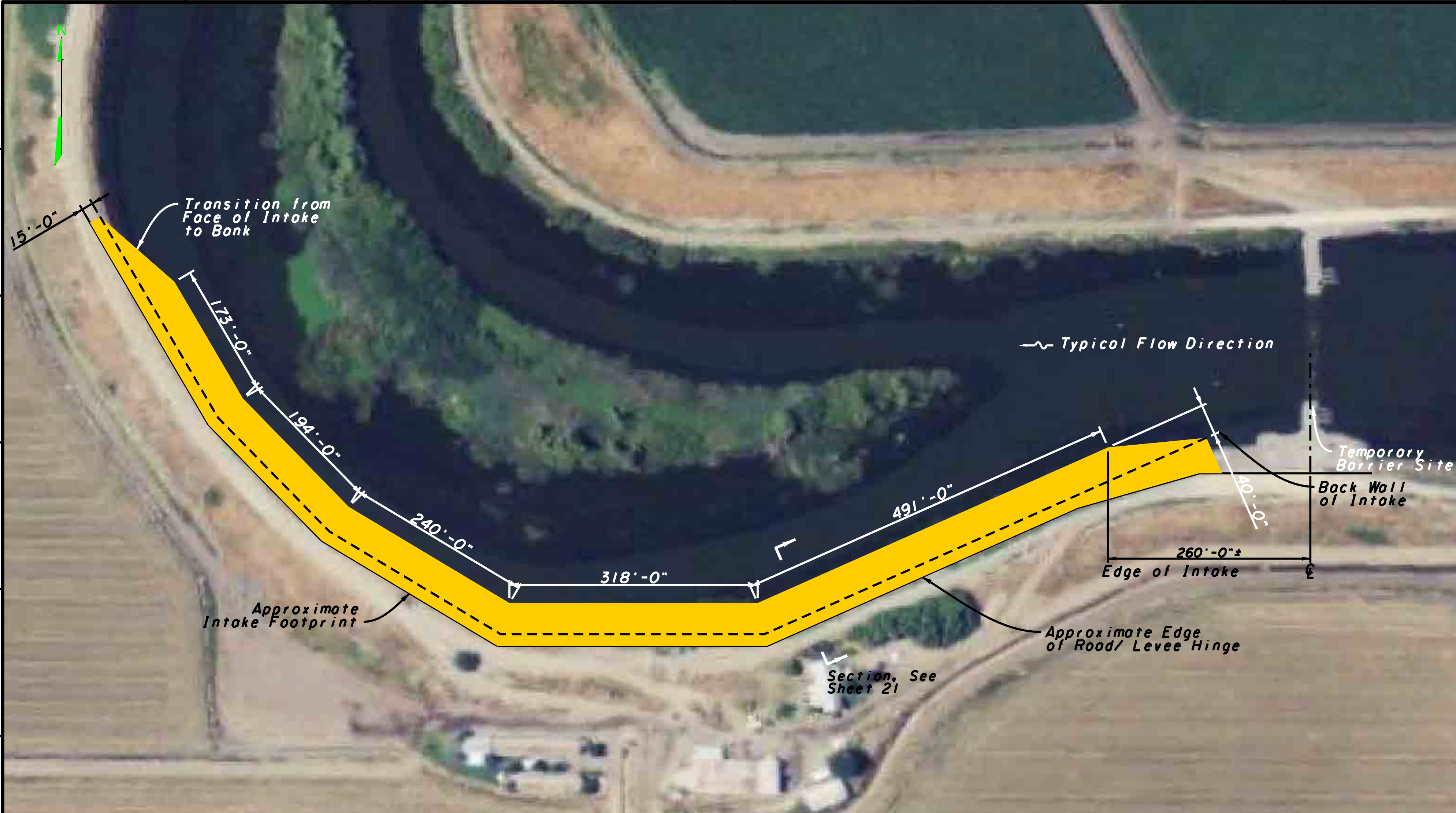
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
MIDDLE RIVER PUMP SITE
500 CFS CAPACITY
DEB LAYOUT 14

SPEC. No.
DRAWING No.
REV. | SHEET No. 19



1" = 60'

60 0 60 120 180 240

SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:

DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:

SUBMITTED: | APPROVED: DATE:

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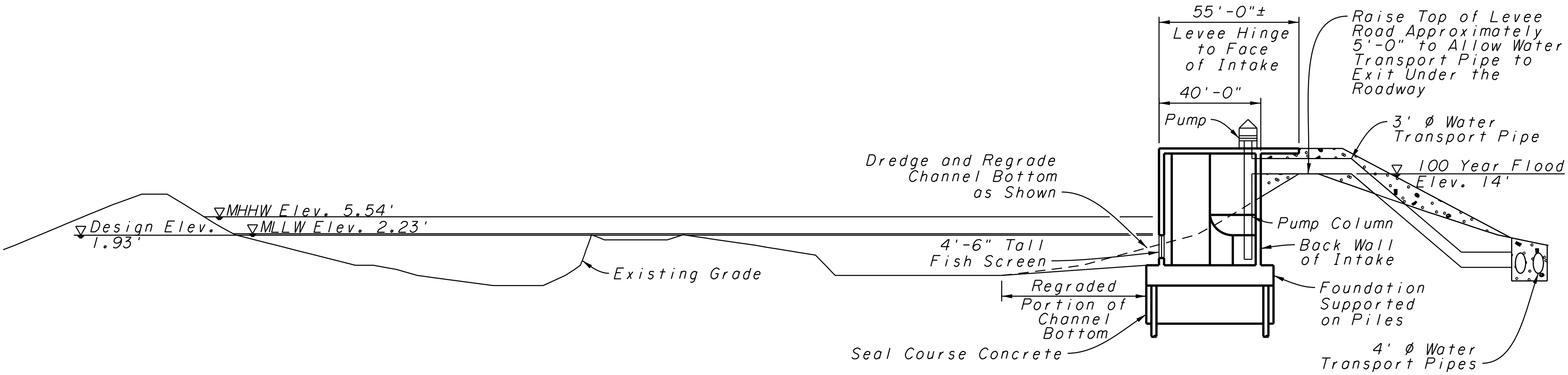
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
MIDDLE RIVER PUMP SITE
1000 CFS CAPACITY
DEB LAYOUT 15

SPEC. No.

DRAWING No.

REV. | SHEET No. 20



SECTION

Scale: 1" = 20'

NOTES

1. This section is shown with a 2:1 vertical exaggeration.
2. Maximum 2:1 slope of fill on land side of levee.

1" = 20' 20 0 20 40 60 80 SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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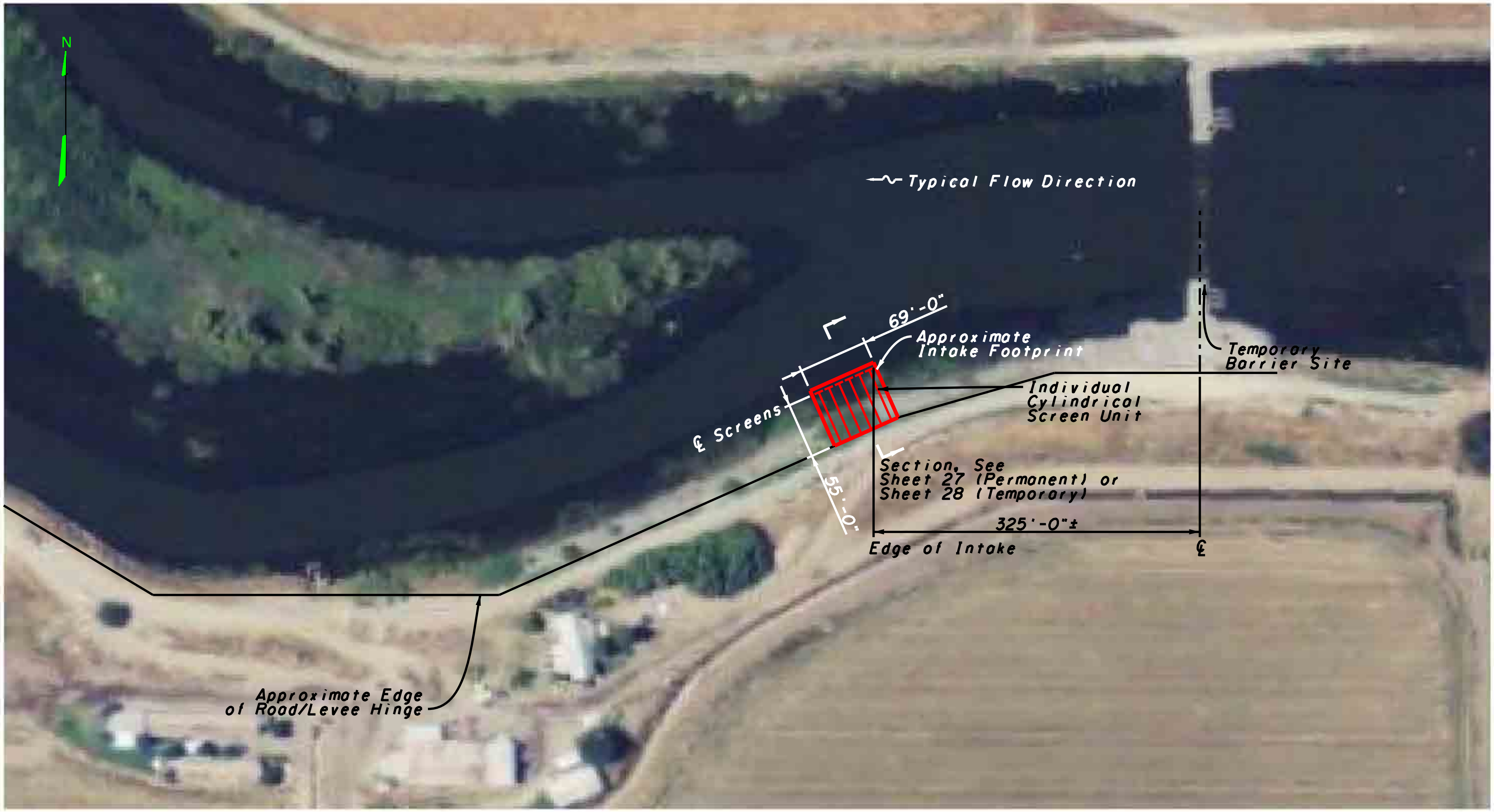
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
MIDDLE RIVER PUMP SITE
SITE CROSS–SECTION
DEB LAYOUTS 16 TO 20

SPEC. No.
DRAWING No.
REV. | SHEET No. 21



1" = 50'
SCALE OF FEET

THINK SAFETY – ACT SAFELY

DESIGNED	CHECKED	APPROVAL RECOMMENDED:	DATE:
DRAWN	REVIEWED	APPROVAL RECOMMENDED:	DATE:
SUBMITTED:		APPROVED:	DATE:

REV.	DATE	DESCRIPTION	SUB.	APP'D

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

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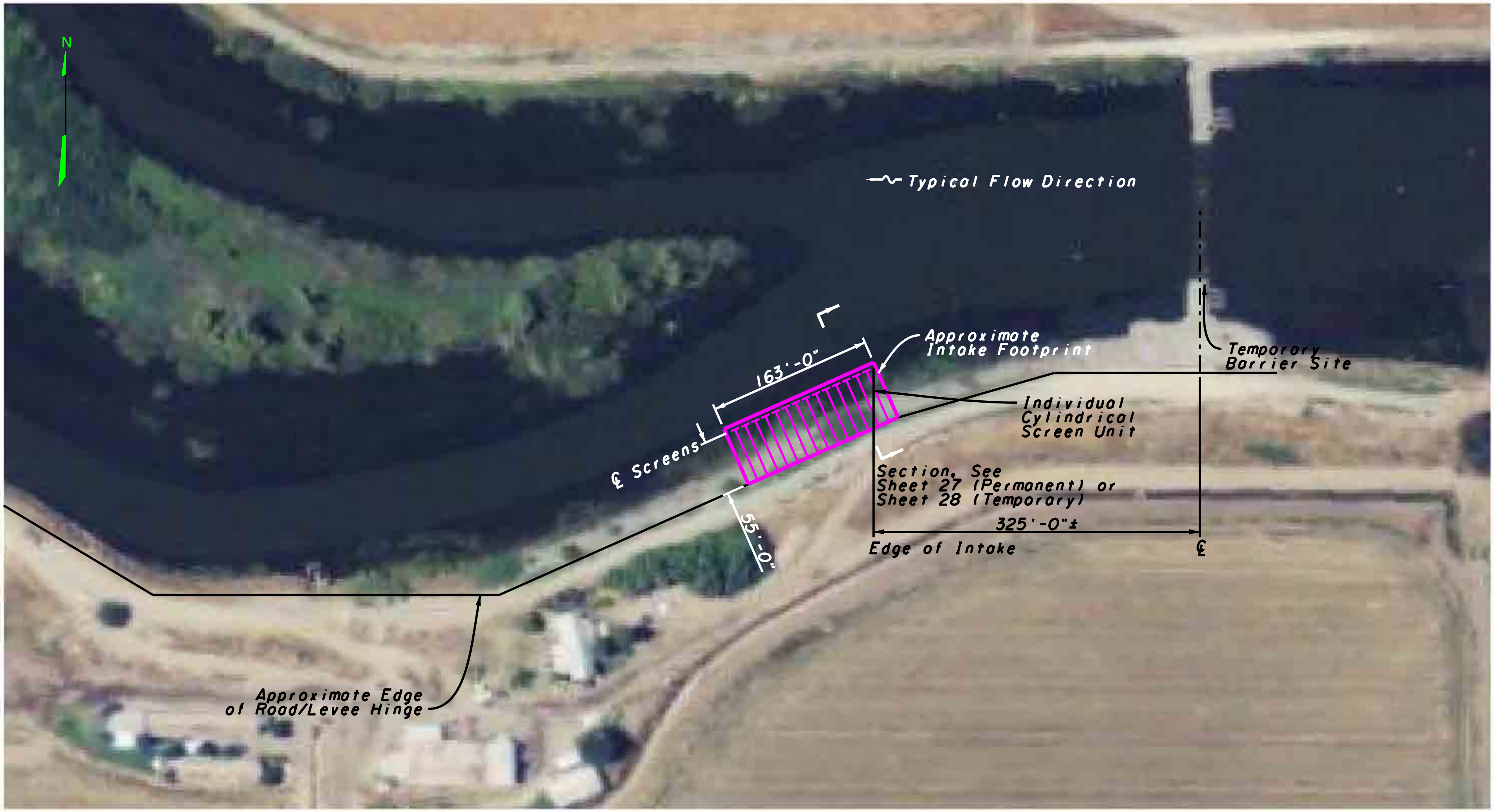
SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
MIDDLE RIVER PUMP SITE
50 CFS CAPACITY
DEB LAYOUT 21 & 26

SPEC. No.
DRAWING No.
REV.
SHEET No. 22



1" = 50'
50 0 50 100 150 200
SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

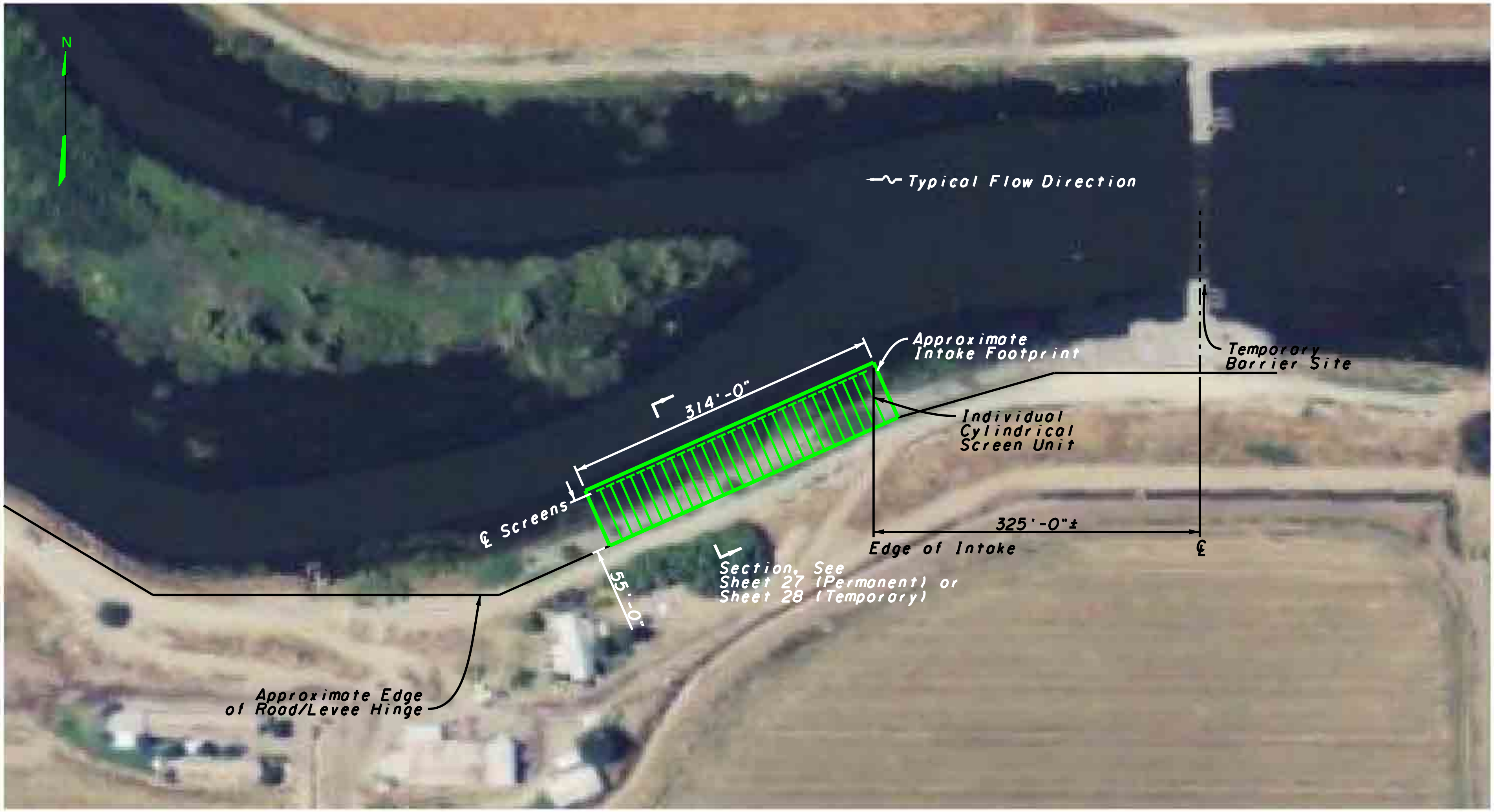
DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
MIDDLE RIVER PUMP SITE
125 CFS CAPACITY
DEB LAYOUT 22 & 27

SPEC. No.
DRAWING No.
REV. | SHEET No. 23



1" = 50' SCALE OF FEET 50 0 50 100 150 200

THINK SAFETY – ACT SAFELY

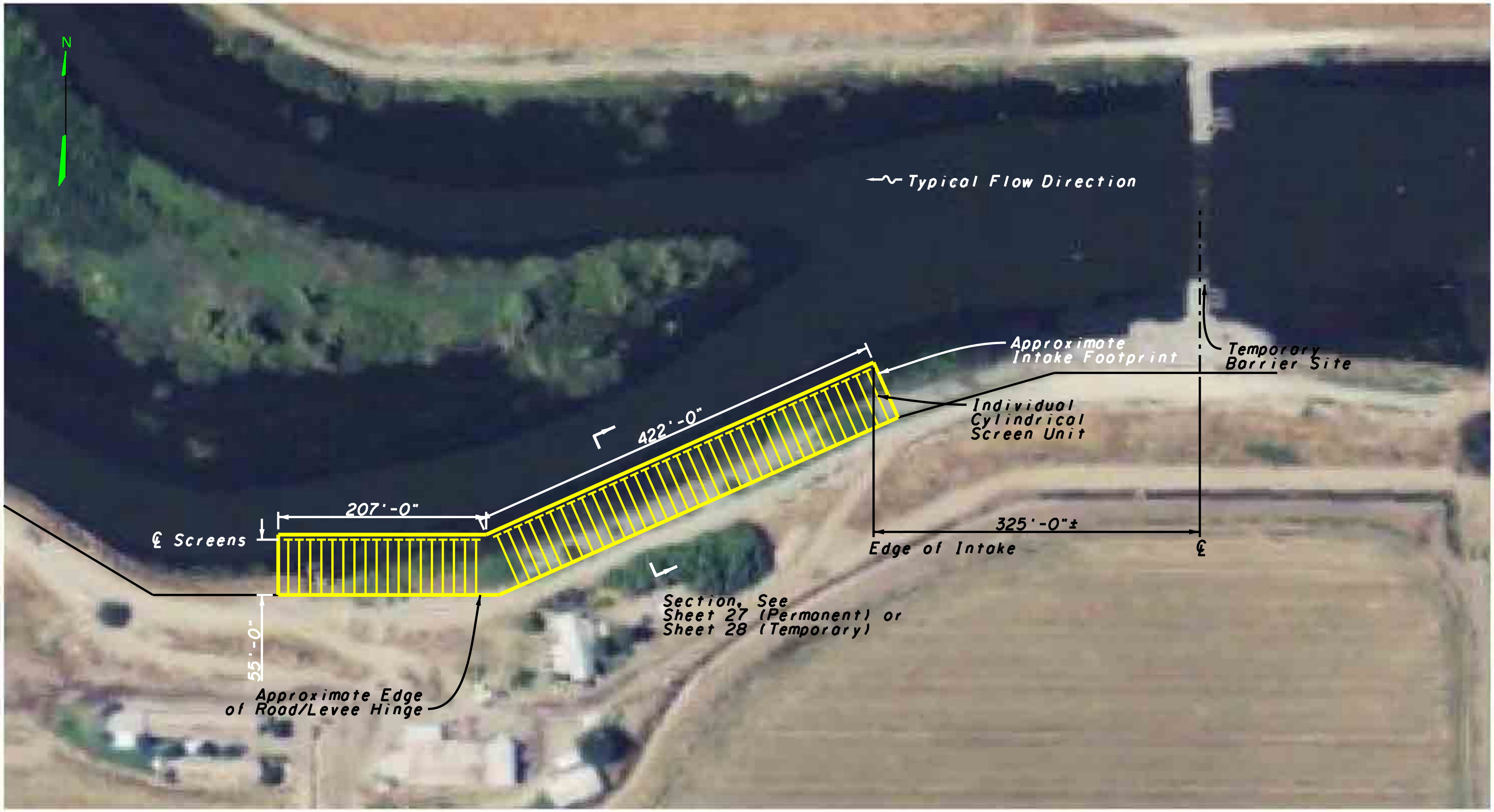
REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:
APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
MIDDLE RIVER PUMP SITE
250 CFS CAPACITY
DEB LAYOUT 23 & 28

SPEC. No.
DRAWING No.
REV. SHEET No. 24



1" = 50'

50 0 50 100 150 200

SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:

DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:

SUBMITTED: | APPROVED: DATE:

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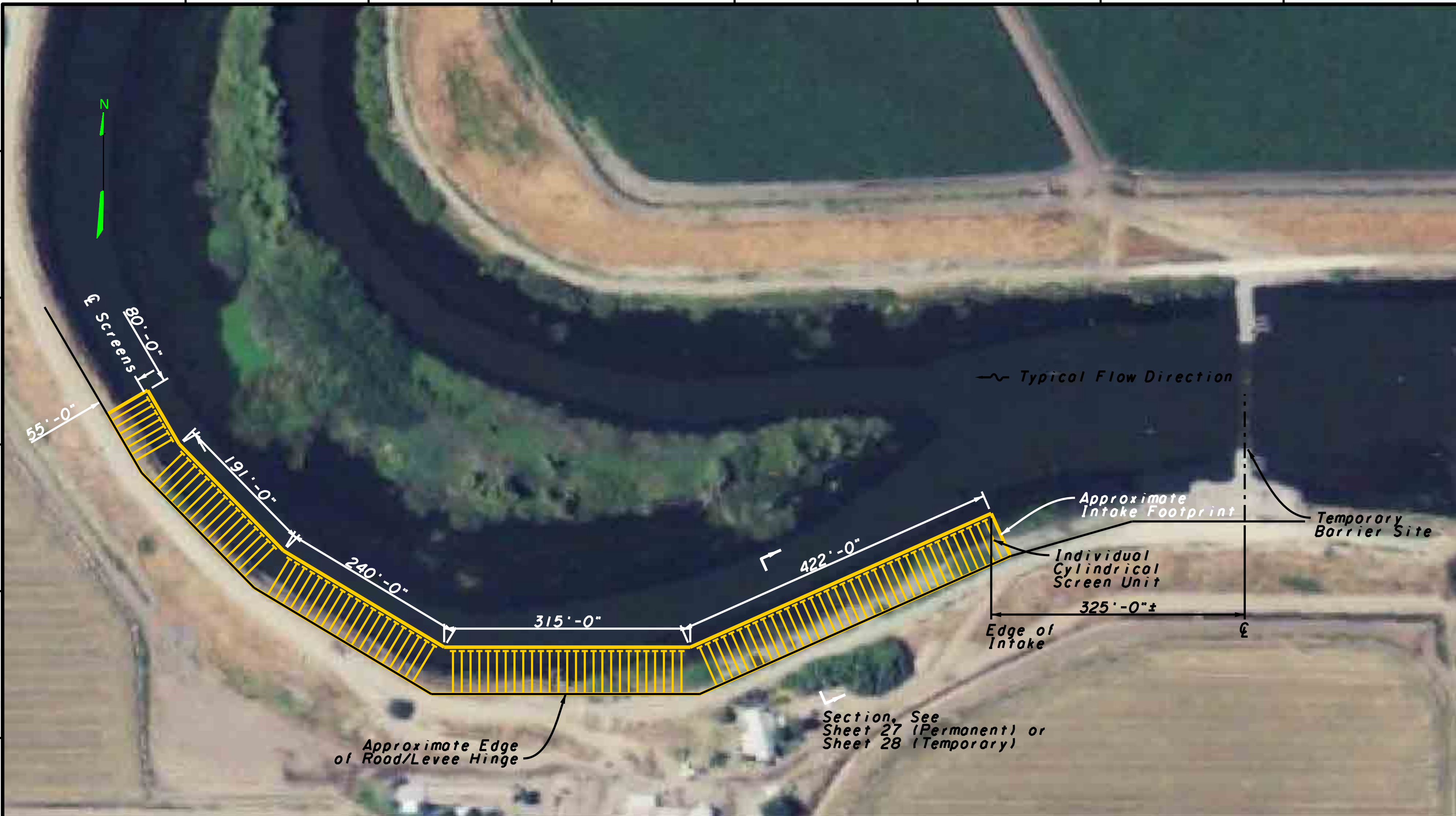
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
MIDDLE RIVER PUMP SITE
500 CFS CAPACITY
DEB LAYOUT 24 & 29

SPEC. No.

DRAWING No.

REV. | SHEET No. 25



1" = 60'

SCALE OF FEET: 60 0 60 120 180 240

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: | DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: | DATE:
SUBMITTED: | APPROVED: | DATE:

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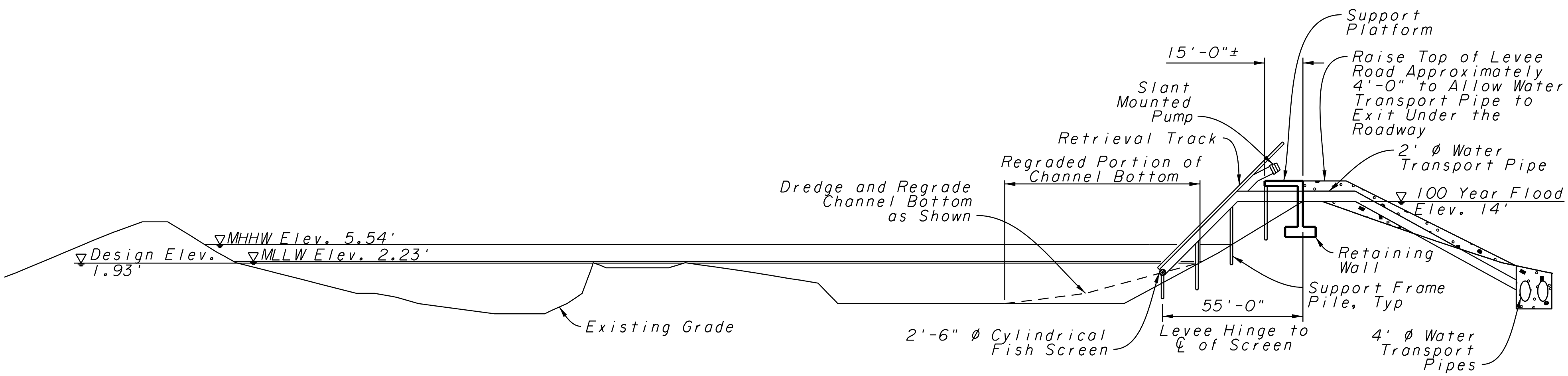
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
MIDDLE RIVER PUMP SITE
1000 CFS CAPACITY
DEB LAYOUT 25 & 30

SPEC. No.
DRAWING No.
REV. | SHEET No. 26



SECTION

Scale: 1" = 20'

NOTES

1. This section is shown with a 2:1 vertical exaggeration.
2. Maximum 2:1 slope of fill on land side of levee.

1" = 20' SCALE OF FEET 20 0 20 40 60 80

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

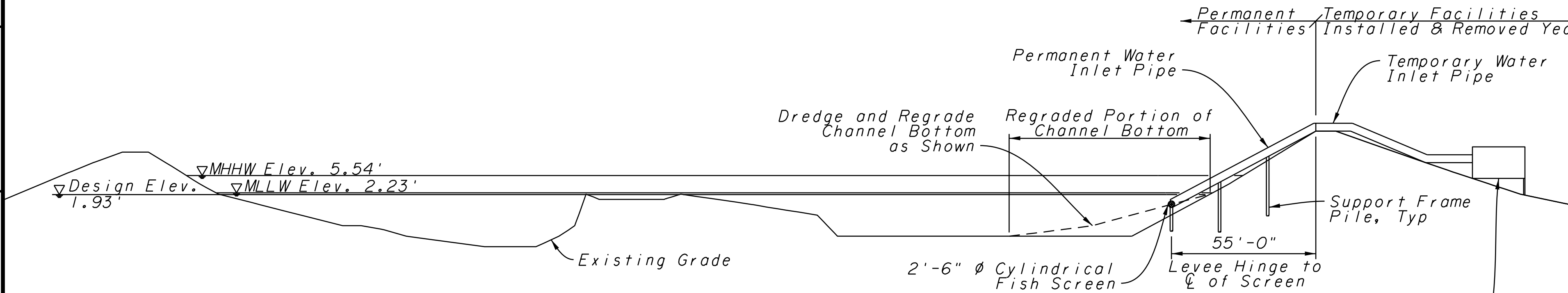
DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT CYLINDRICAL INTAKE
MIDDLE RIVER PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 21 TO 25

SPEC. No.
DRAWING No.
REV. SHEET No. 27



SECTION

Scale: 1" = 20'

NOTES

1. This section is shown with a 2:1 vertical exaggeration.
2. 100-Year Flood Elevation is 14 ft (NAVD 88, CA State Plane Zone 3)

1" = 20' — SCALE OF FEET: 20, 0, 20, 40, 60, 80

THINK SAFETY - ACT SAFELY

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

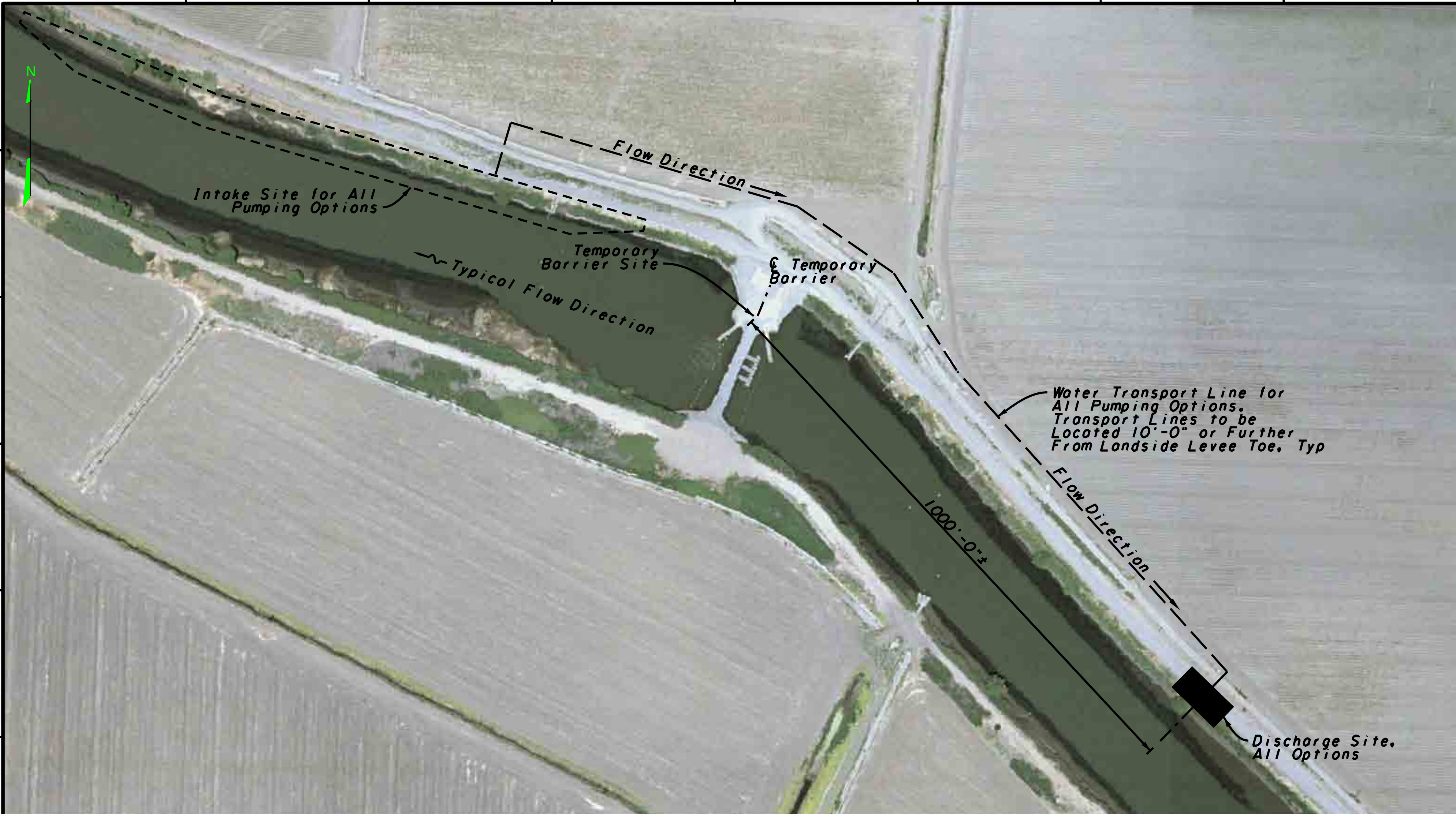
SOUTH DELTA LOW HEAD PUMP STUDY
TEMPORARY CYLINDRICAL INTAKE
MIDDLE RIVER PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 26 TO 30

DESIGNED	CHECKED	APPROVAL RECOMMENDED:	DATE:
DRAWN	REVIEWED	APPROVAL RECOMMENDED:	DATE:
SUBMITTED:		APPROVED:	DATE:

REV.	DATE	DESCRIPTION	SUB.	APP'D

REG. STAMP

SPEC. No.
DRAWING No.
REV. | SHEET No. 28



1" = 80' 80 0 80 160 240 320
SCALE OF FEET

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

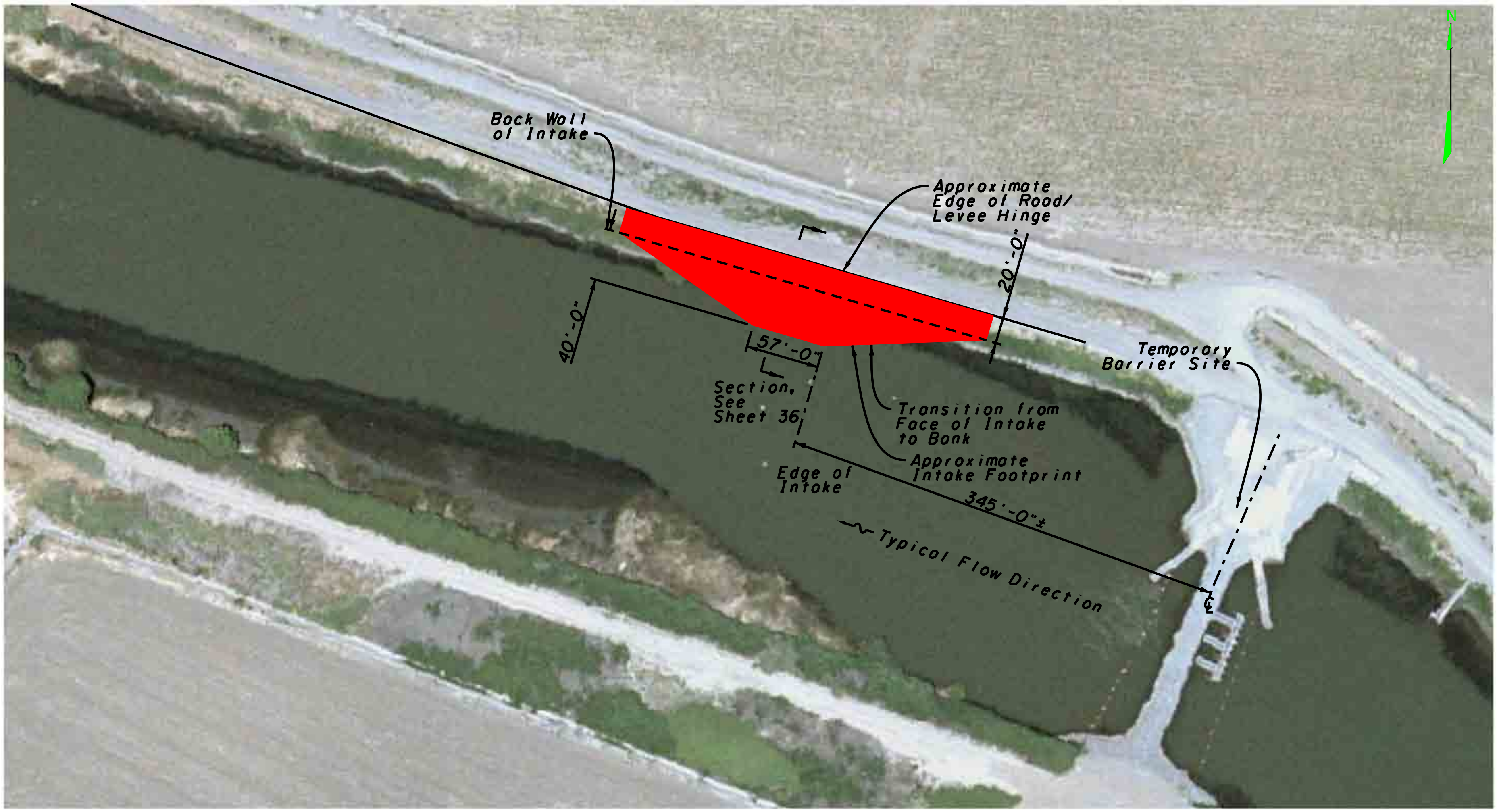
DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

REGISTERED PROFESSIONAL ENGINEER · STATE OF CALIFORNIA
REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT AND TEMPORARY INTAKE
OLD RIVER PUMP SITE
SITE PLAN
DEB LAYOUTS 31 TO 45

SPEC. No.
DRAWING No.
REV. | SHEET No. 29



1" = 40' SCALE OF FEET 40 0 40 80 120 160

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

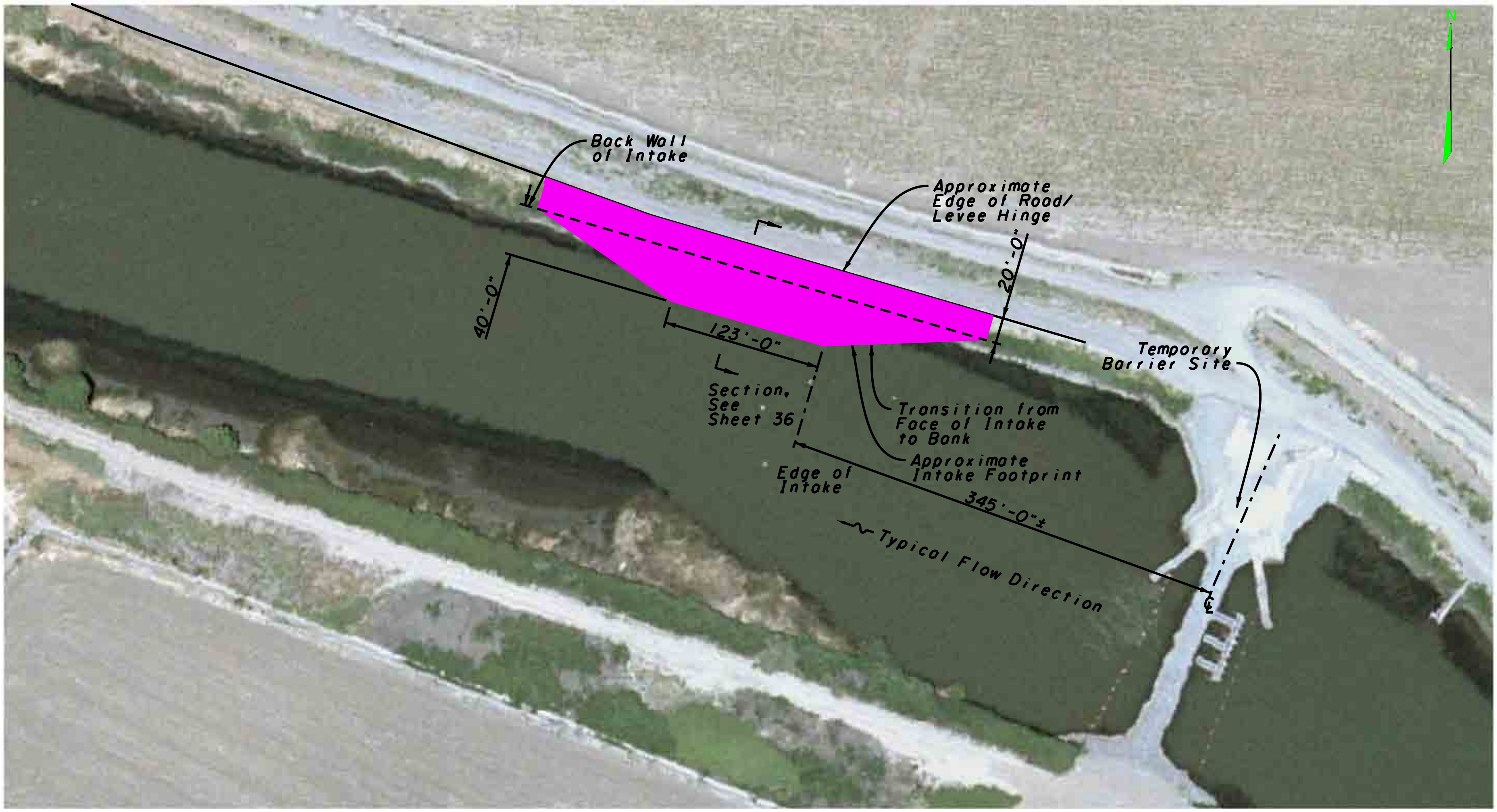
DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:
APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

REG. STAMP — REGISTERED PROFESSIONAL ENGINEER — STATE OF CALIFORNIA

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
OLD RIVER PUMP SITE
50 CFS CAPACITY
DEB LAYOUT 31

SPEC. No.
DRAWING No.
REV. SHEET No. 30



1" = 40'

40 0 40 80 120 160

SCALE OF FEET

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

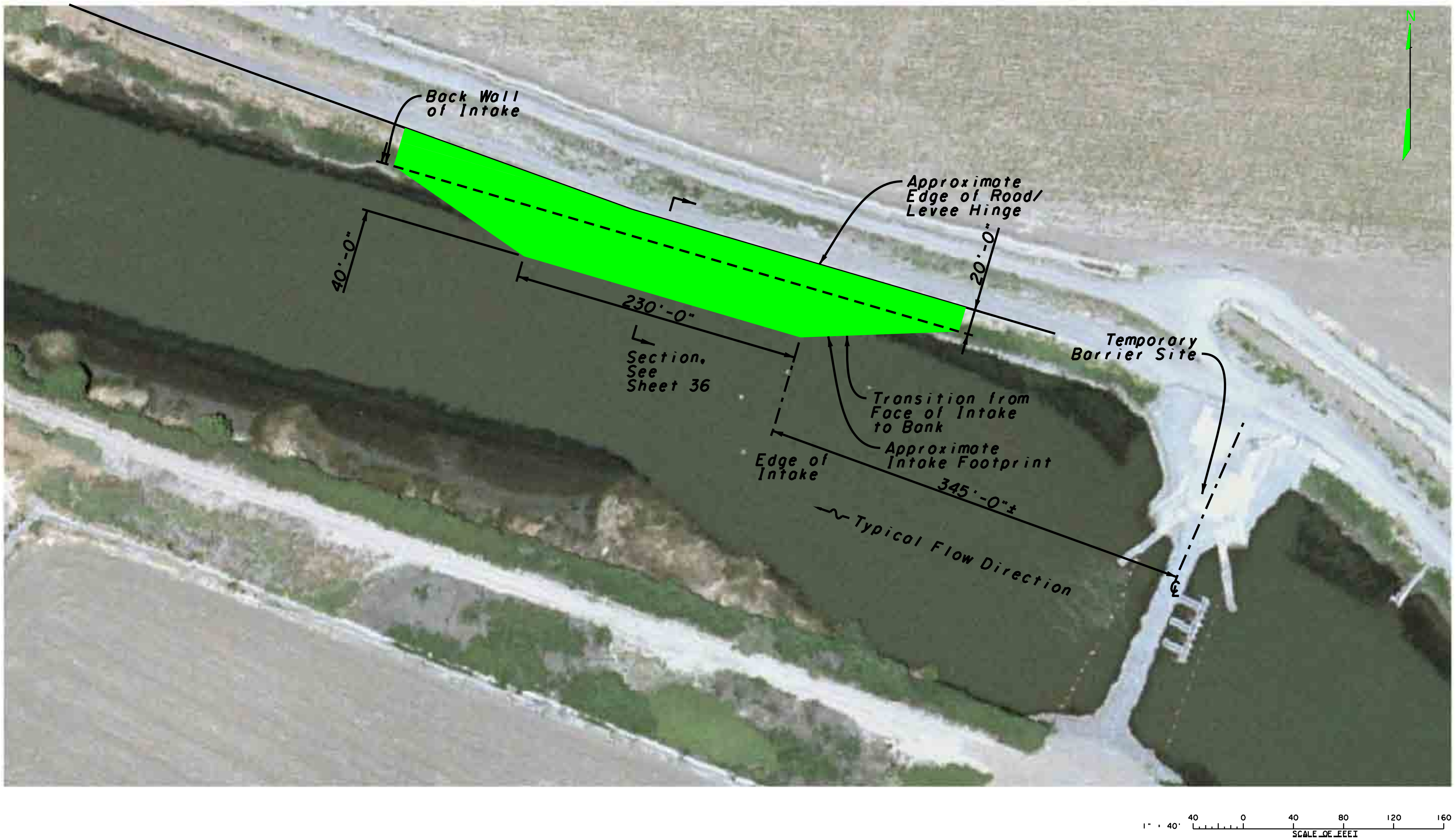
DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

REGISTERED PROFESSIONAL ENGINEER — STATE OF CALIFORNIA
REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
OLD RIVER PUMP SITE
125 CFS CAPACITY
DEB LAYOUT 32

SPEC. No.
DRAWING No.
REV. | SHEET No. 31



THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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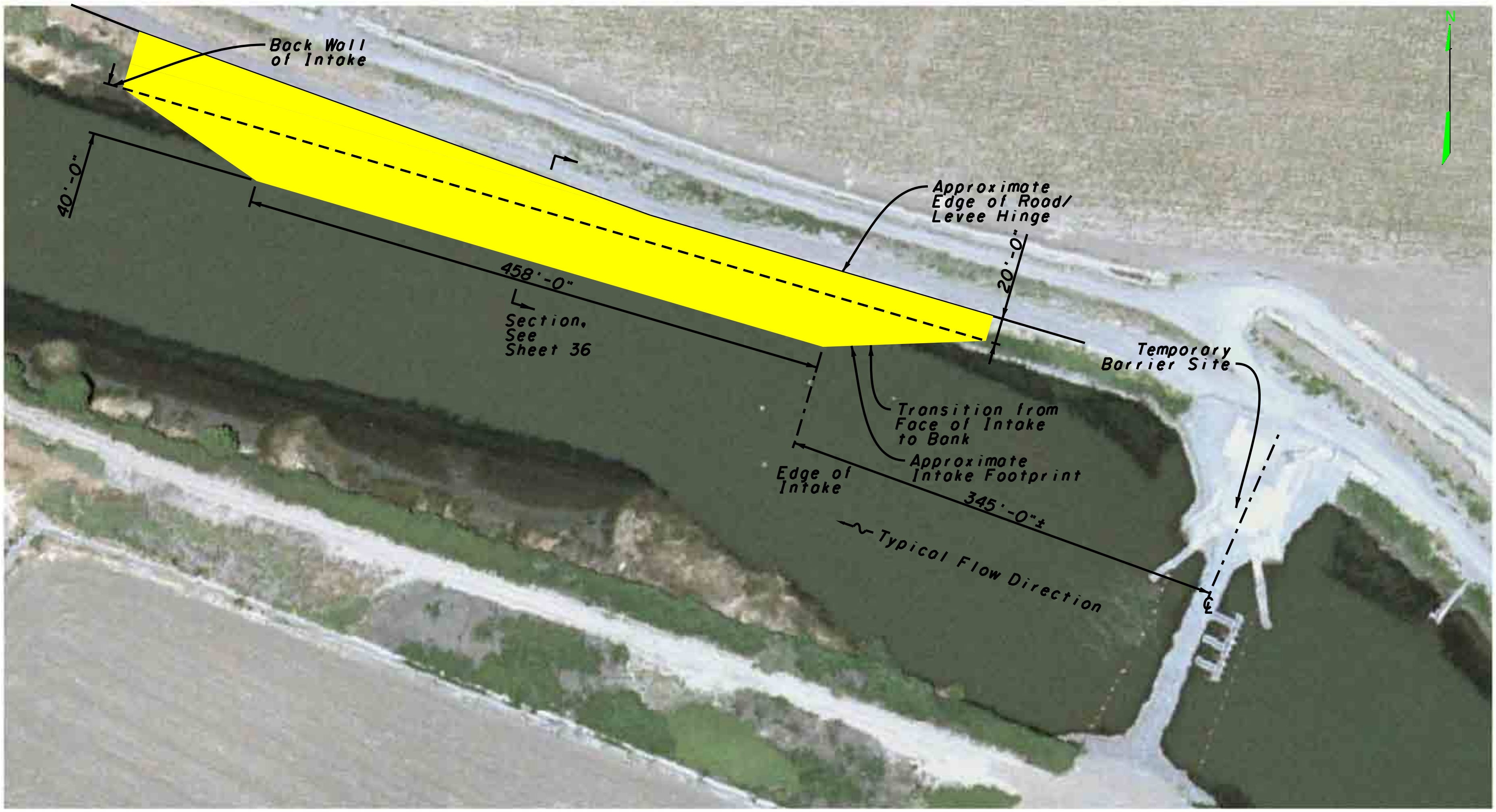
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
OLD RIVER PUMP SITE
250 CFS CAPACITY
DEB LAYOUT 33

SPEC. No.
DRAWING No.
REV. | SHEET No. 32



1" = 40' 40 0 40 80 120 160 SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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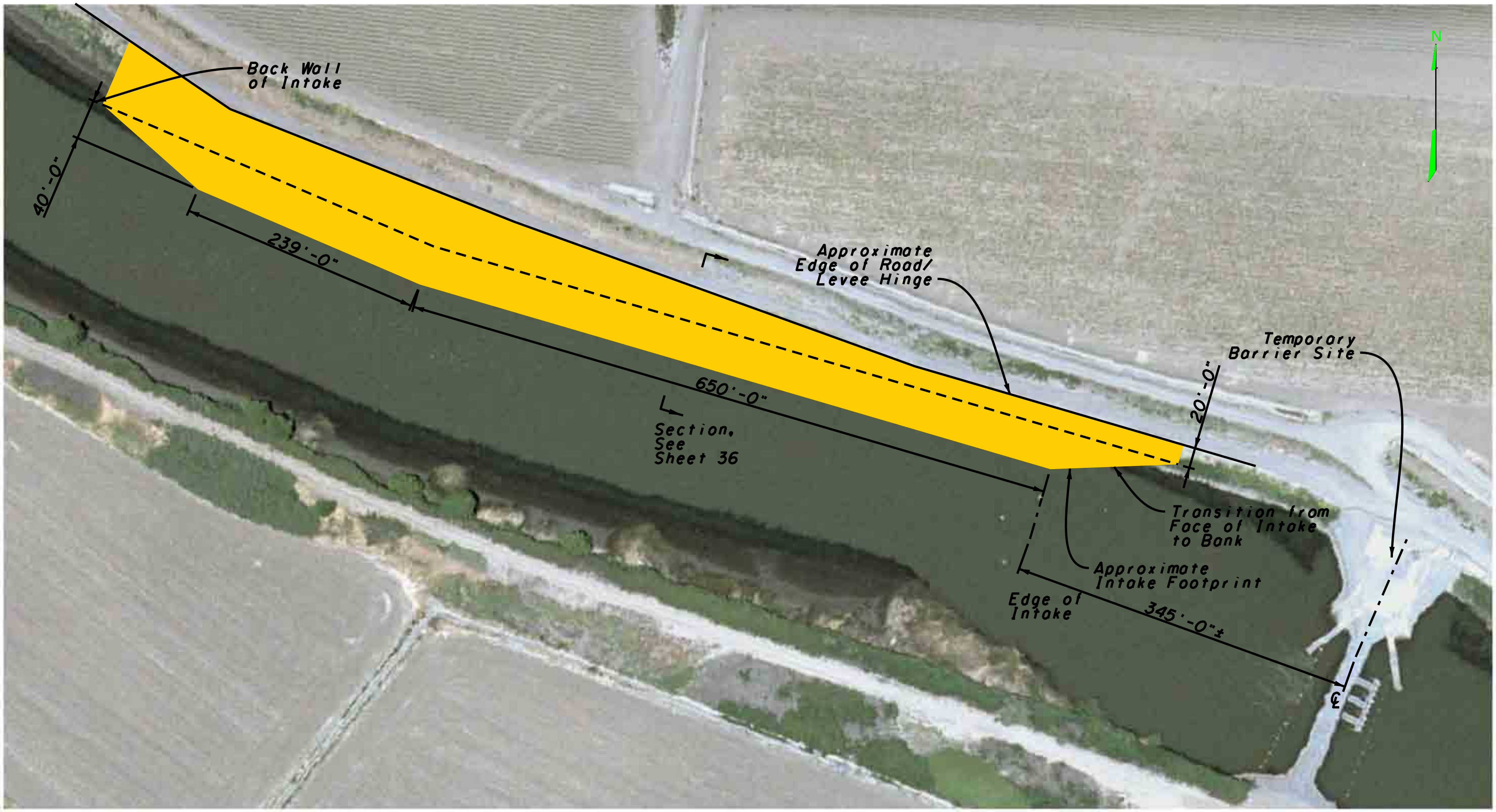
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
OLD RIVER PUMP SITE
500 CFS CAPACITY
DEB LAYOUT 34

SPEC. No.
DRAWING No.
REV. SHEET No. 33



1" = 50' SCALE OF FEET 50 0 50 100 150 200

THINK SAFETY - ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / APPROVAL RECOMMENDED: DATE:
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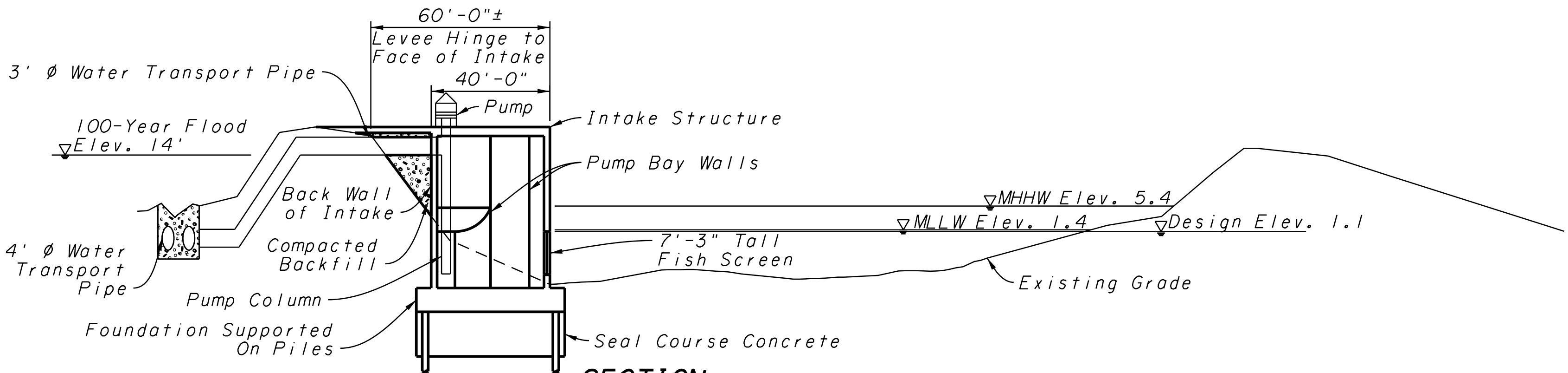
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
OLD RIVER PUMP SITE
1000 CFS CAPACITY
DEB LAYOUT 35

SPEC. No.
DRAWING No.
REV. SHEET No. 35



SECTION

Scale: 1" = 20'

Sta. 4+00

Note: This section is shown with a 2:1 vertical exaggeration.

1" = 20' 20 0 20 40 60 80 SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED: / APPROVAL RECOMMENDED: DATE: / APPROVAL RECOMMENDED: DATE: / APPROVED: DATE:

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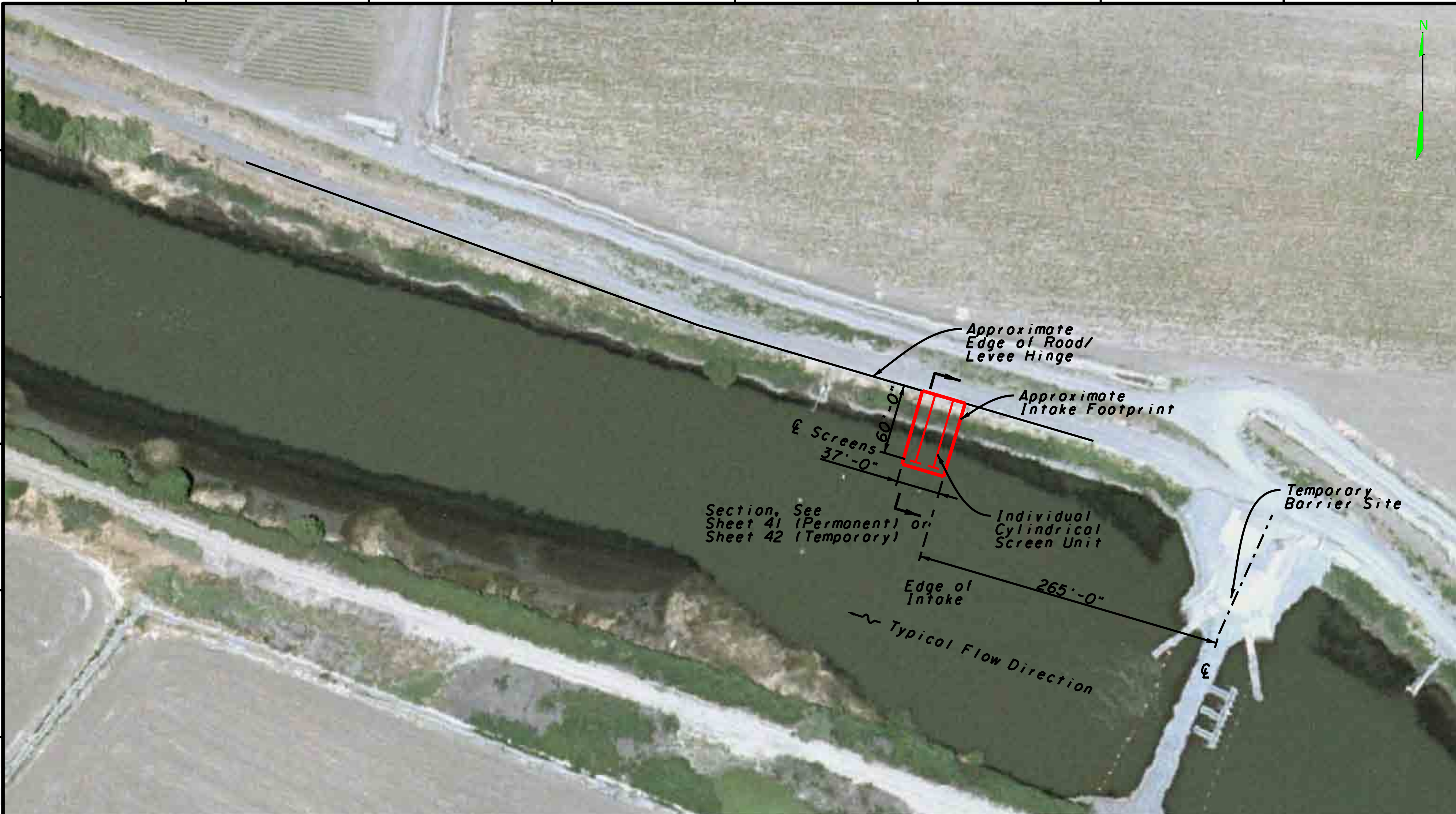
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT FLAT SCREEN INTAKE
OLD RIVER PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 31 TO 35

SPEC. No.
DRAWING No.
REV. SHEET No. 35



THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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STATE OF CALIFORNIA
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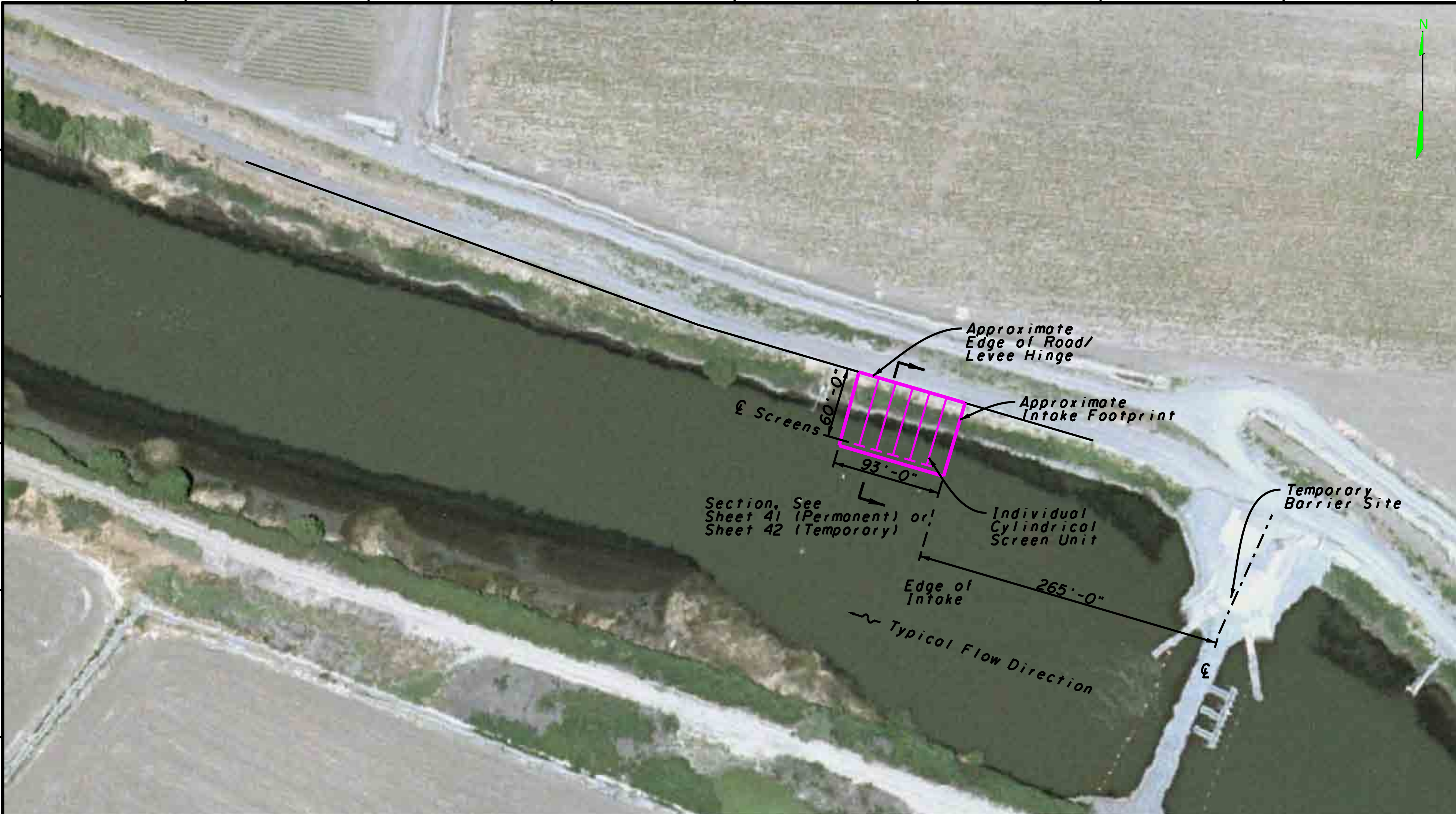
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
OLD RIVER PUMP SITE
50 CFS CAPACITY
DEB LAYOUT 36 & 41

SPEC. No.
DRAWING No.
REV. SHEET No. 36



1" = 40' 40 0 40 80 120 160 SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

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STATE OF CALIFORNIA
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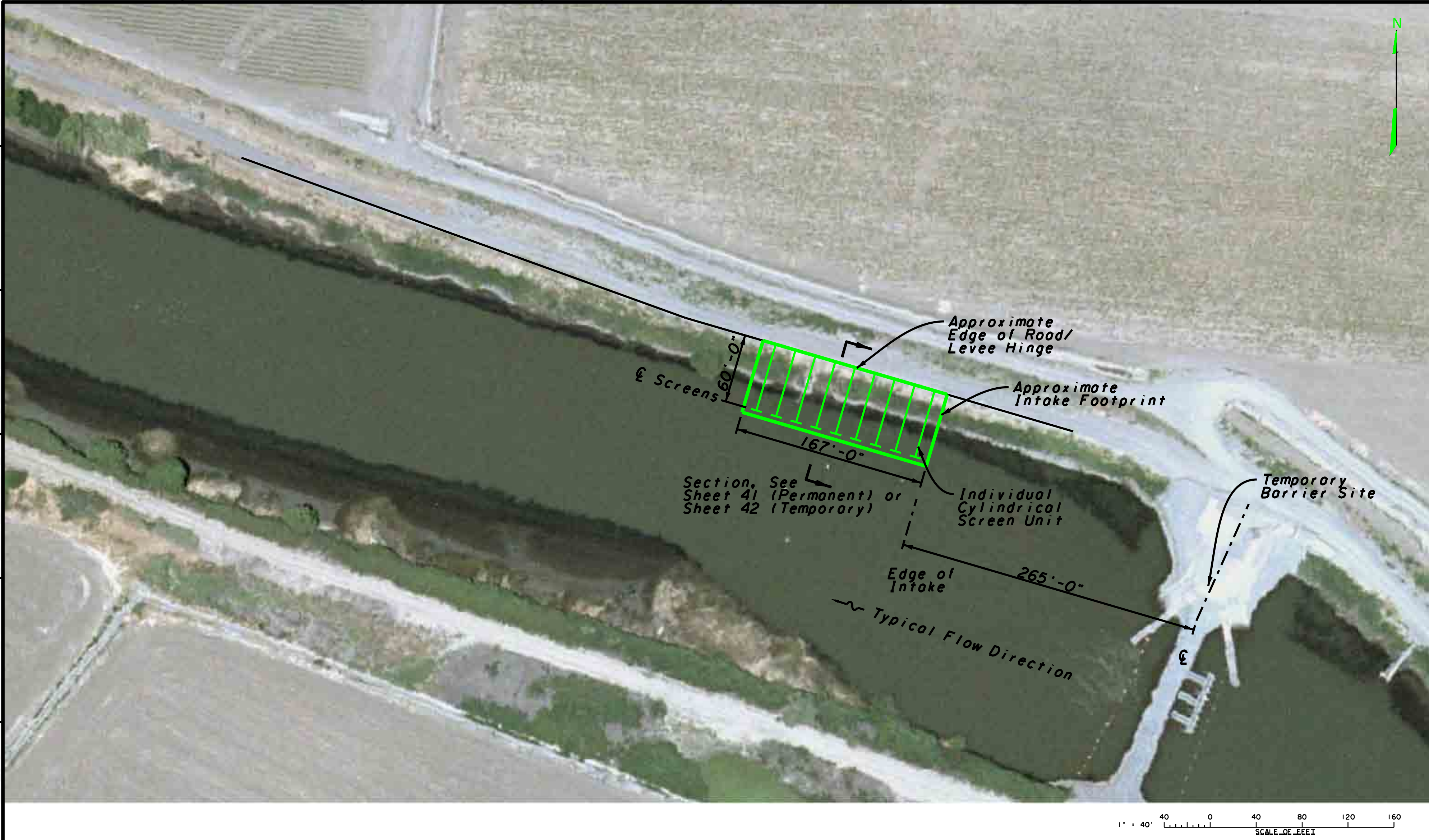
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
OLD RIVER PUMP SITE
125 CFS CAPACITY
DEB LAYOUT 37 & 42

SPEC. No.
DRAWING No.
REV. SHEET No. 37



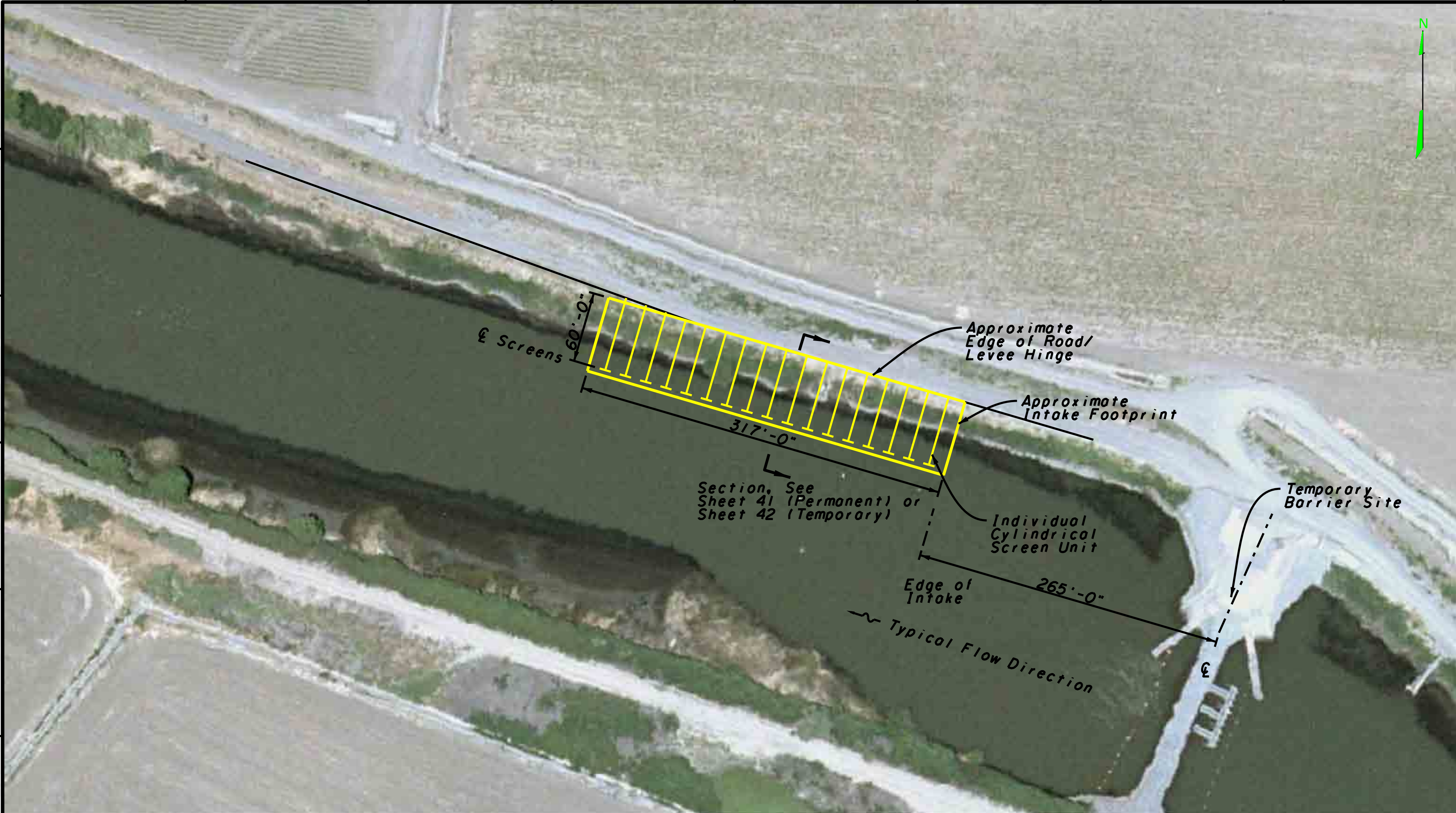
THINK SAFETY – ACT SAFELY

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
OLD RIVER PUMP SITE
250 CFS CAPACITY
DEB LAYOUT 38 & 43

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | DRAWN | REVIEWED | SUBMITTED:
APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:
REG. STAMP
SPEC. No.
DRAWING No.
REV. SHEET No. 38



1" = 40'

40 0 40 80 120 160

SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / APPROVAL RECOMMENDED: DATE:

DRAWN / REVIEWED / APPROVAL RECOMMENDED: DATE:

SUBMITTED: / APPROVED: DATE:

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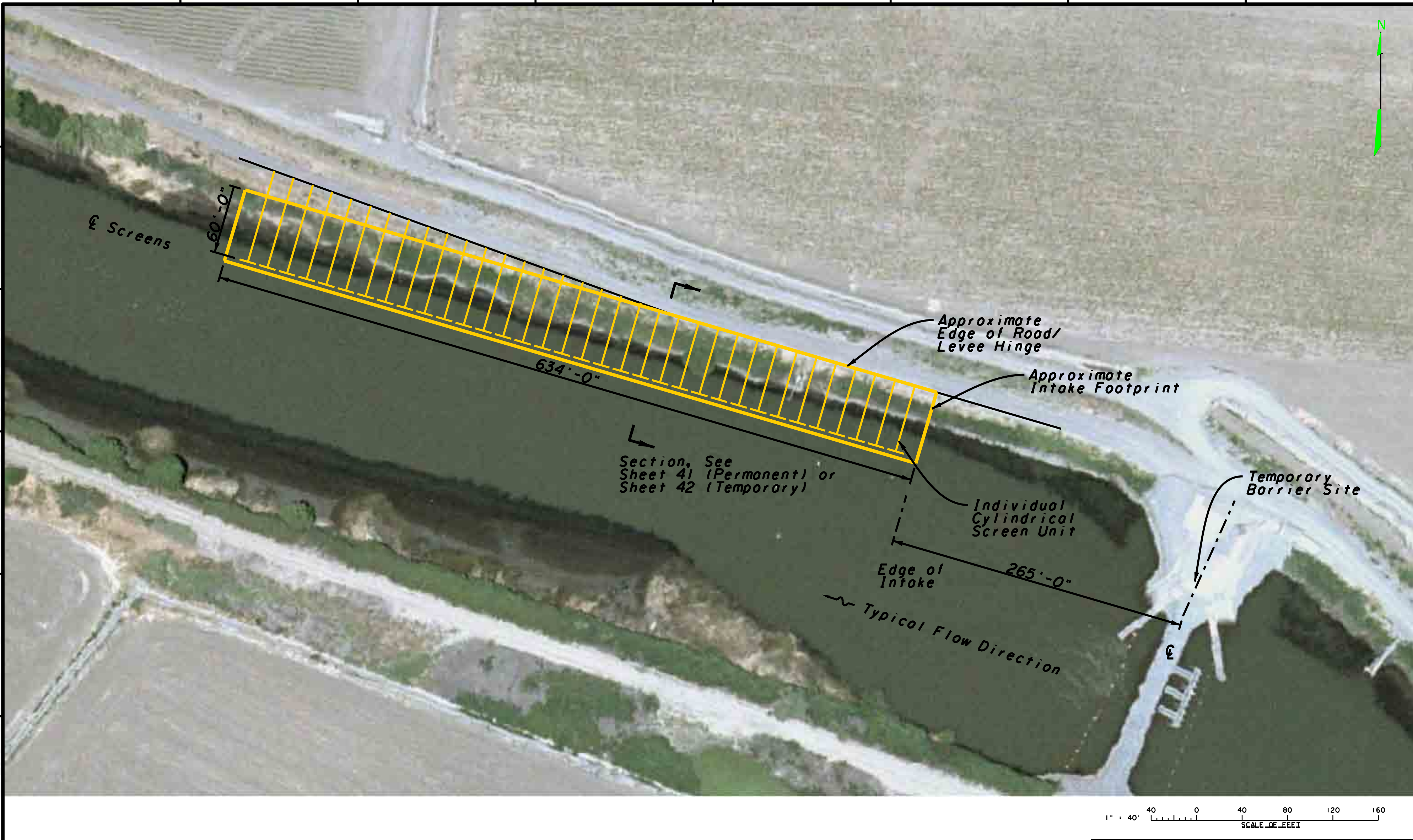
SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
OLD RIVER PUMP SITE
500 CFS CAPACITY
DEB LAYOUT 39 & 44

SPEC. No.

DRAWING No.

REV. SHEET No. 39

VI:
\$\$\$\$\$PRFNAME\$\$\$\$\$\$\$\$\$
\$\$\$DATE\$\$\$\$
\$\$\$DESIGNFILESPECIFICA\$\$\$\$
\$\$\$\$\$DESIGNFILESPECIFICATION\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$



THINK SAFETY – ACT SAFELY

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

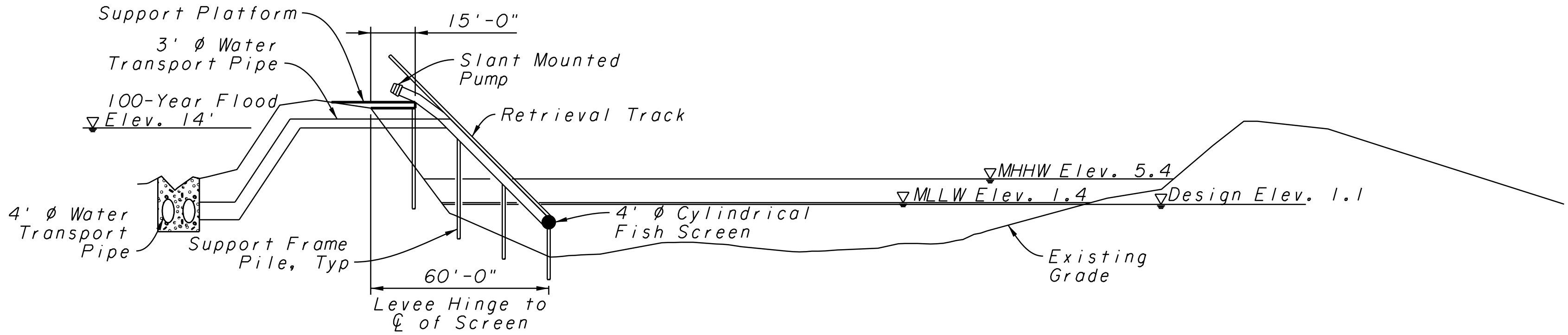
SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT & TEMPORARY CYLINDRICAL SCREEN INTAKES
OLD RIVER PUMP SITE
1000 CFS CAPACITY
DEB LAYOUT 40 & 45

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:

REG. STAMP

SPEC. No.
DRAWING No.
REV. SHEET No. 40



SECTION

Scale: 1" = 20'

Sta. 4+00

Note: This section is shown with a 2:1 vertical exaggeration.

1" = 20' — SCALE OF FEET (20, 0, 20, 40, 60, 80)

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED: | CHECKED: | DRAWN: | REVIEWED: | SUBMITTED:

APPROVAL RECOMMENDED: DATE:

APPROVAL RECOMMENDED: DATE:

APPROVED: DATE:

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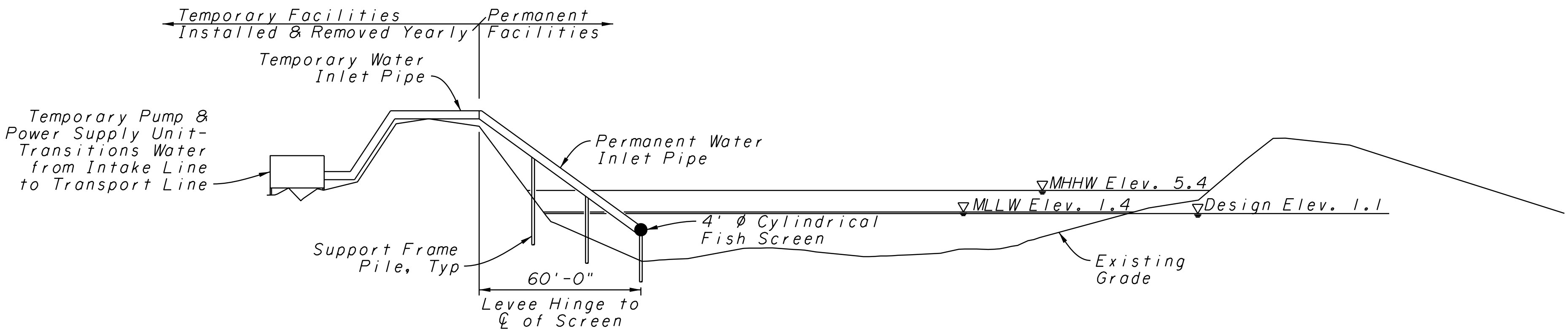
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
PERMANENT CYLINDRICAL INTAKE
OLD RIVER PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 36 TO 40

SPEC. No.
DRAWING No.
REV. | SHEET No. 41

$$$$$DESIGNFILESPECIFICATION$$$$$$$$$$$$$$$$

VI= $$$$$PRFNAME$$$$$$$$$ $$$DATE$$$$ $$$DESIGNFILESPECIFICA$$$$



SECTION

Scale: 1" = 20'

Sta. 4+00

NOTES

1. This section is shown with a 2:1 vertical exaggeration.
2. 100-Year Flood Elevation is 14 ft (NAVD 88, CA State Plane Zone 3)

1" = 20' 20 0 20 40 60 80 SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:

APPROVAL RECOMMENDED: DATE:

APPROVAL RECOMMENDED: DATE:

APPROVED: DATE:

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DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
TEMPORARY CYLINDRICAL INTAKE
OLD RIVER PUMP SITE
SITE CROSS-SECTION
DEB LAYOUTS 41 TO 45

SPEC. No.

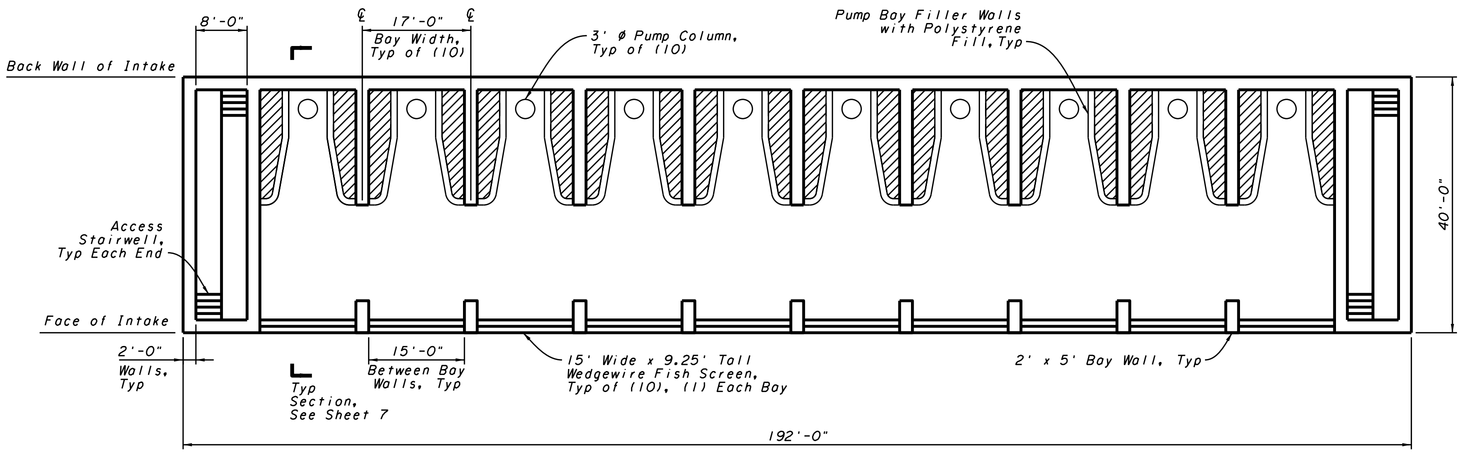
DRAWING No.

REV. SHEET No. 42

$$$$$DESIGNFILESPECIFICATION$$$$$$$$$$$$$$$$

VI:

$$$$$PRFNAME$$$$$$$$$$ $$$DATE$$$$ $$$DESIGNFILESPECIFICA$$$$



PLAN

Scale: 1" = 10'

1" = 10' 10 0 10 20 30 40 SCALE OF FEET

THINK SAFETY - ACT SAFELY

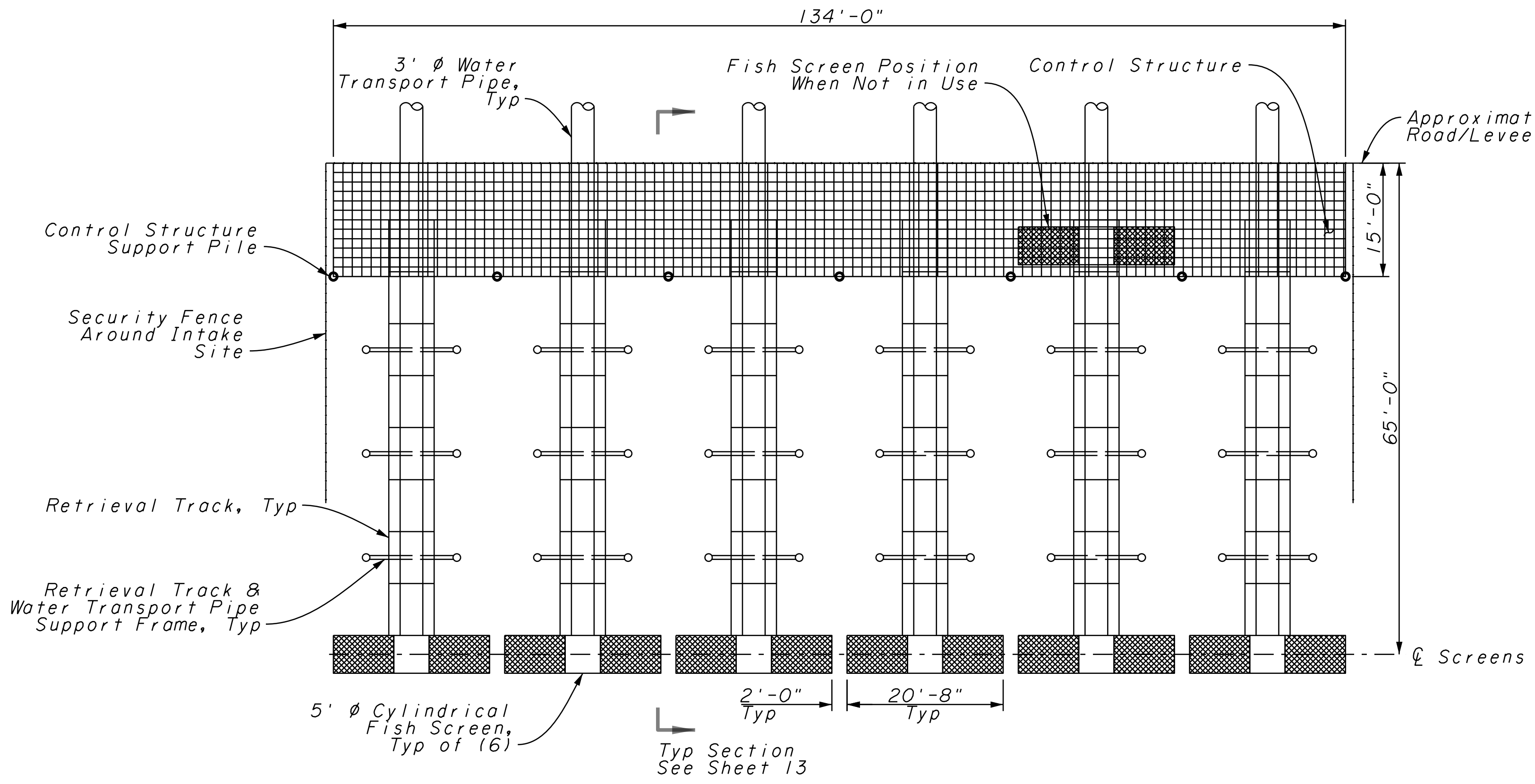
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
BASIS OF DESIGN INTAKE PLAN
GRANT LINE CANAL PUMP SITE
250 CFS CAPACITY
PERMANENT FLAT PANEL INTAKE
DEB LAYOUT 3

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | APPROVAL RECOMMENDED: DATE:
DRAWN | REVIEWED | APPROVAL RECOMMENDED: DATE:
SUBMITTED: | APPROVED: DATE:
REG. STAMP

SPEC. No. | DRAWING No. | REV. | SHEET No. 43



PLAN

Scale: 1/8" = 1'-0"

1/8" = 1' — 10 0 10 20 30 — SCALE OF FEET

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:

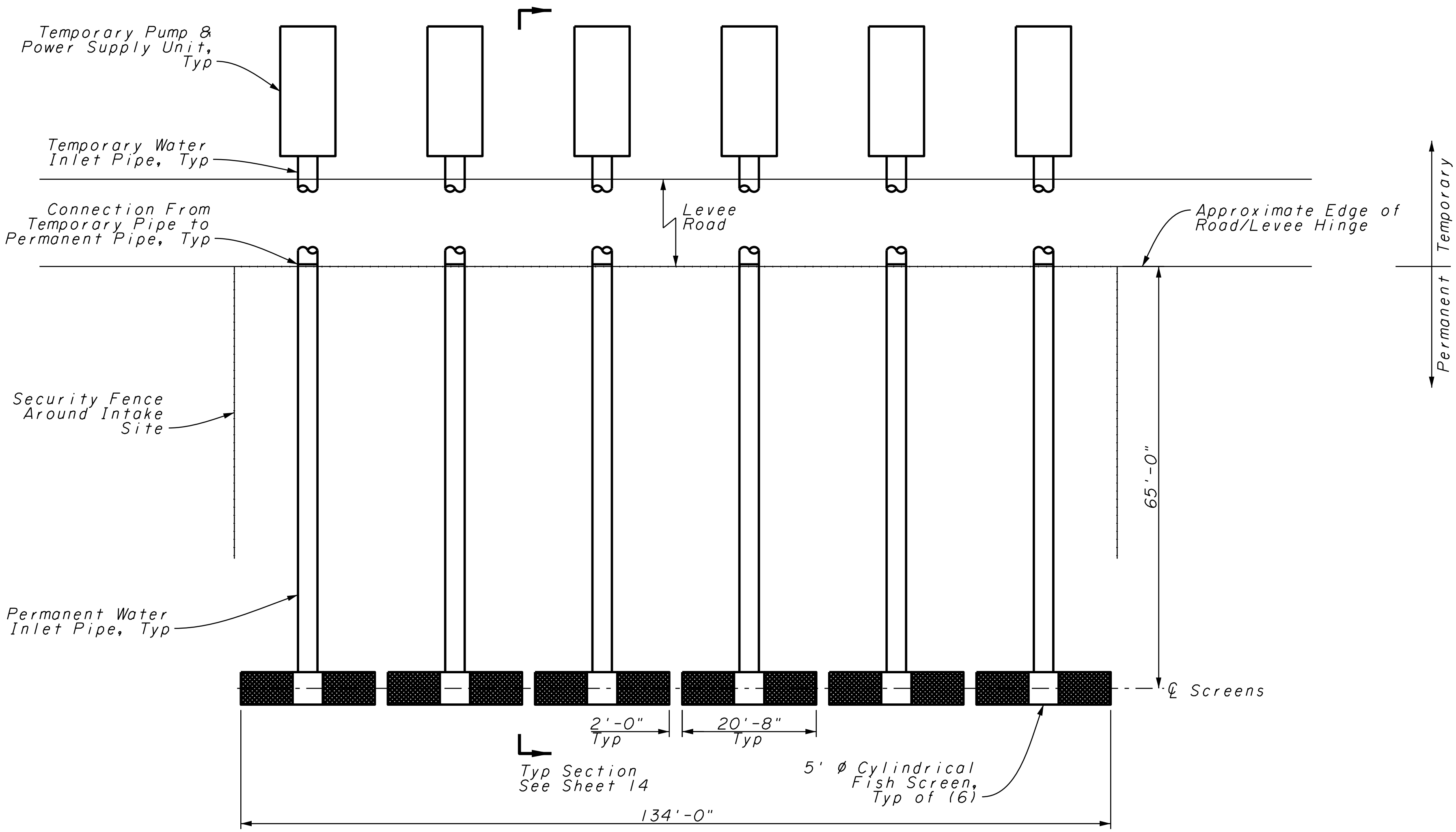
APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

REG. STAMP

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
BASIS OF DESIGN INTAKE PLAN
GRANT LINE CANAL PUMP SITE
250 CFS CAPACITY
PERMANENT CYLINDRICAL INTAKE
DEB LAYOUT 8

SPEC. No.
DRAWING No.
REV. SHEET No. 44



PLAN

Scale: 1/8" = 1'-0"

1/8" = 1' 10 0 10 20 30 SCALE OF FEET

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED / CHECKED / DRAWN / REVIEWED / SUBMITTED:

APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

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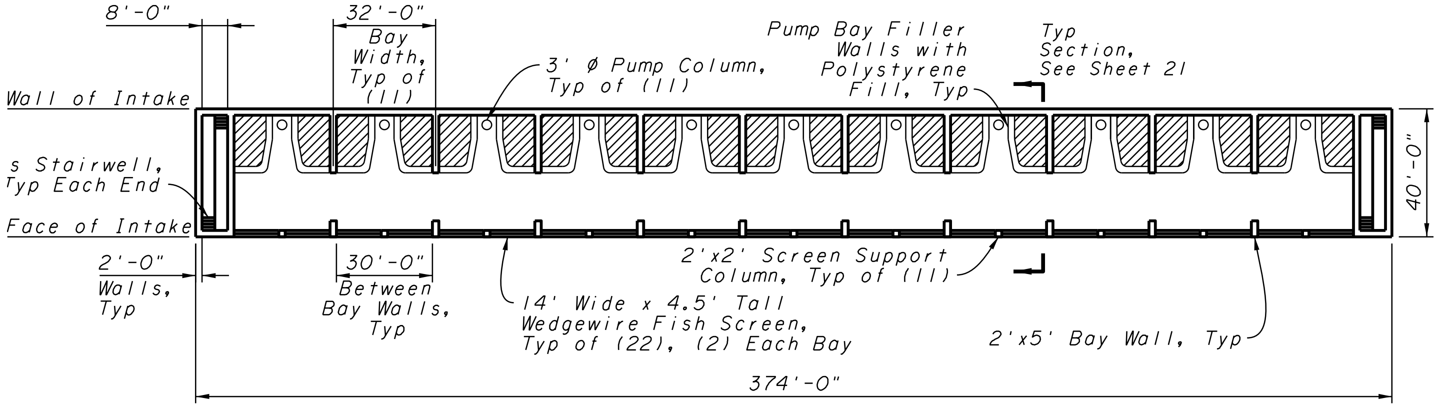
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

THINK SAFETY – ACT SAFELY

SOUTH DELTA LOW HEAD PUMP STUDY
BASIS OF DESIGN INTAKE PLAN
GRANT LINE CANAL PUMP SITE
250 CFS CAPACITY
TEMPORARY CYLINDRICAL INTAKE
DEB LAYOUT 8

SPEC. No.
DRAWING No.
REV. SHEET No. 45



PLAN

Scale: 1" = 20'

1" = 20' — 20 0 20 40 60 80 SCALE OF FEET

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED: CHECKED: DRAWN: REVIEWED: SUBMITTED:

APPROVAL RECOMMENDED: DATE: APPROVAL RECOMMENDED: DATE: APPROVED: DATE:

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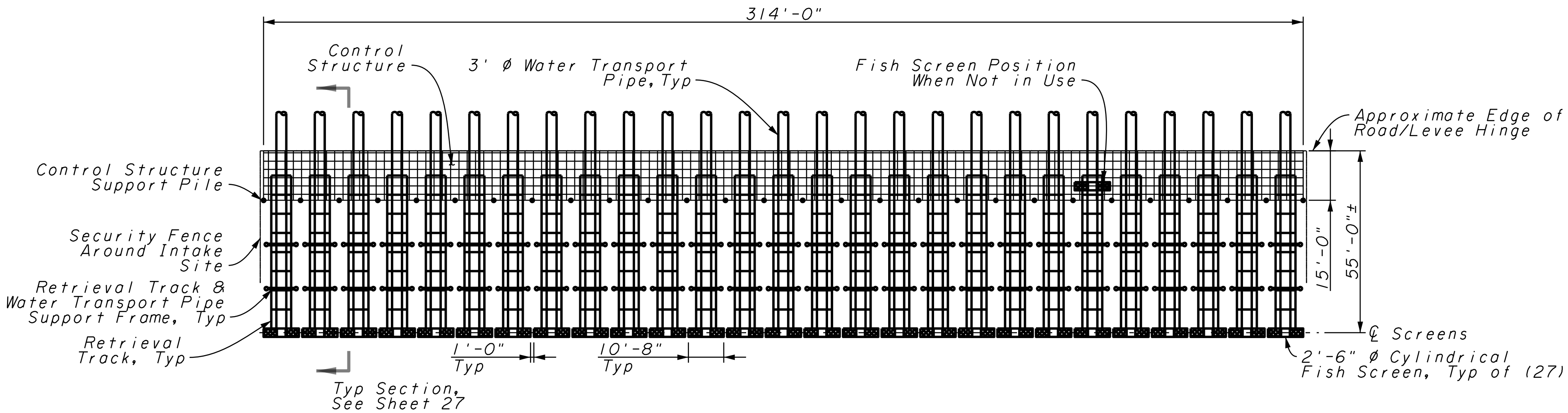
THINK SAFETY - ACT SAFELY

SOUTH DELTA LOW HEAD PUMP STUDY
BASIS OF DESIGN INTAKE PLAN
MIDDLE RIVER PUMP SITE
250 CFS CAPACITY
PERMANENT FLAT SCREEN INTAKE
DEB LAYOUT 18

SPEC. No. DRAWING No. REV. SHEET No. 46



PLAN

Scale: 1/16" = 1'-0"

1/16" = 1' 10 0 10 20 30 40 50 60 70 SCALE OF FEET

THINK SAFETY - ACT SAFELY

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
BASIS OF DESIGN INTAKE PLAN
MIDDLE RIVER PUMP SITE
250 CFS CAPACITY
PERMANENT CYLINDRICAL SCREEN INTAKE
DEB LAYOUT 23

DESIGNED	CHECKED	APPROVAL RECOMMENDED:	DATE:
DRAWN	REVIEWED	APPROVAL RECOMMENDED:	DATE:
SUBMITTED:		APPROVED:	DATE:

REV. | DATE | DESCRIPTION | SUB. | APP'D

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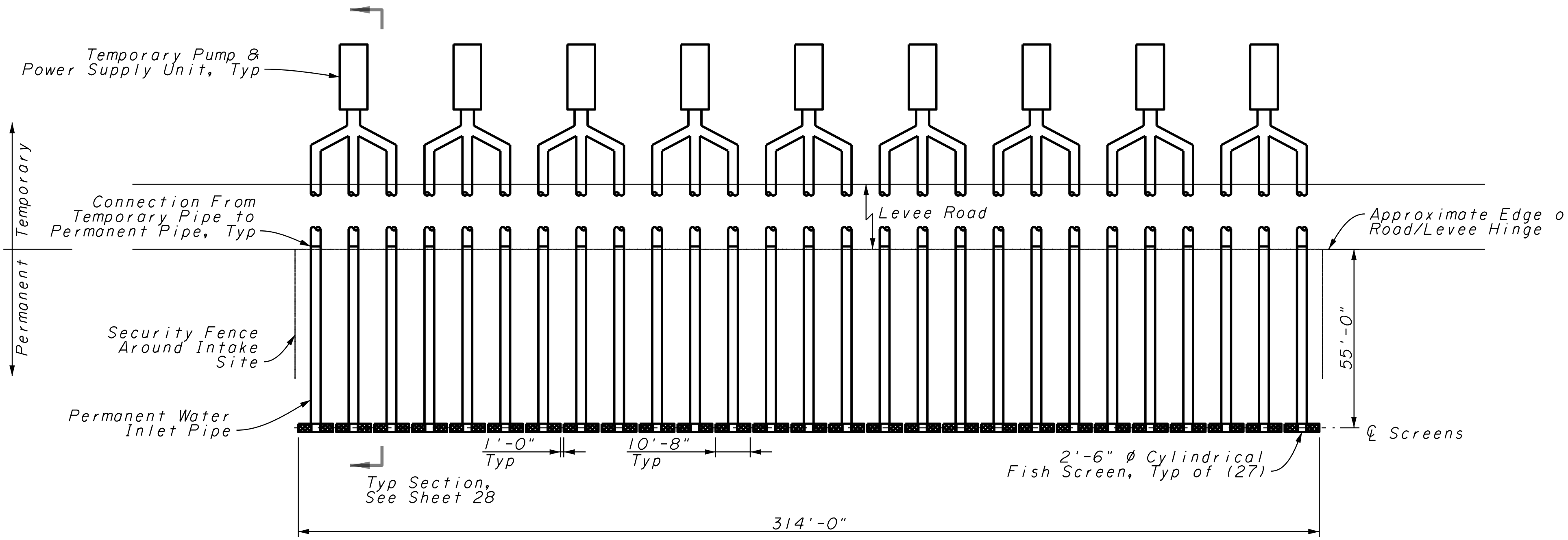
SPEC. No. | DRAWING No. | REV. | SHEET No. 47

VI •
\$\$\$\$\$PRFNAME\$\$\$\$\$\$\$\$\$
\$\$\$DATE\$\$\$\$
\$\$\$DESIGNFILESPECIFICA\$\$\$\$
\$\$\$\$\$DESIGNFILESPECIFICATION\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$



PLAN

Scale: 1/16" = 1'-0"

1/16" = 1' — SCALE OF FEET: 10 0 10 20 30 40 50 60 70

THINK SAFETY – ACT SAFELY

REV.	DATE	DESCRIPTION	SUB.	APP'D

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APPROVAL RECOMMENDED: DATE:
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:

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STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

SOUTH DELTA LOW HEAD PUMP STUDY
BASIS OF DESIGN INTAKE PLAN
MIDDLE RIVER PUMP SITE
250 CFS CAPACITY
TEMPORARY CYLINDRICAL SCREEN INTAKE
DEB LAYOUT 28

SPEC. No.
DRAWING No.
REV. SHEET No. 48

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Appendix C

Permitting and Environmental Compliance

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Memorandum

Date:	April 7, 2011
To:	Robert Pedlar California Department of Water Resources, Bay-Delta Office 1416 Ninth Street Sacramento, CA 95814
From:	Gregg Roy, Jennifer Pierre, and Lesa Erecius
Subject:	**Environmental Considerations for South Delta Low Head Pump System**

The following information was compiled to address your request for information about the potential environmental requirements associated with the placement of temporary or permanent pump systems at select sites in the south Delta to encourage flow to improve water quality. The information is presented separately for the permanent and temporary pump systems and is further divided into an overall discussion of the potential impacts and mitigation, and a specific discussion about permitting approach.

Summary

The analysis of environmental considerations has been based on current requirements of the Title 14. Chapter 3, of the California Code of Regulations and Division 13, of the California Public Resource Code (CEQA Guidelines), our extensive experience working in the south Delta for the temporary barriers project (TBP) and the South Delta Improvements Project, various site visits over the years, and review of conceptual drawings and modeling outputs provided by DWR. Both permanent and temporary pumping systems are considered to be a modification of the currently implemented TBP and environmental considerations of this modification would require minor modifications to existing permits and mitigation obligations.

Overall, the permanent systems would require that DWR provide mitigation for the footprint of the new pumping systems in addition to the mitigation already in place for the TBP. This could be accomplished at a bank, such as was done at Kimball Island for the TBP. The temporary pumping systems would not require additional mitigation for species, but the installation and removal of these systems each year could result in air quality effects that could require mitigation above and beyond what is currently require for the TBP. However, some components of the temporary facilities would be left in place year-round on the crown of the levee to ease installation in subsequent years and minimize construction-related effects.

Project Description and Purpose

The Low Head Pump Salinity Control Study would consist of installing temporary pump systems, or permanent pumping systems near the Middle River (MR), Grant Line Canal (GLC) and/or Old River at Tracy (ORT) temporary barriers.

The purpose of the project is to improve water circulation and quality in the interior southern Delta for the purpose of improving flows and controlling salinity to comply with the State Water Resources Control Board's agricultural salinity standards for the South Delta.

Project Alternatives

As part of the Low Head Pump Salinity Control Study, four alternative locations, for either permanent or temporary pump system placement in July through October, are being considered: MR; GLC, ORT, or MR and ORT. Additionally, under each of these alternatives, different pumping rates are being considered: 250, 500, or 1000 cubic feet per second [cfs]).

Middle River Pumping

Under this alternative, pump systems would be installed, either permanently or temporarily, with intake downstream and discharge upstream of the MR barrier (MRB) and run 24 hours per day at 250, 500, or 1000 cfs while the temporary barriers are in place.

Grant Line Canal Pumping

Under this alternative, pump systems would be installed, either permanently or temporarily, with intake downstream and discharge upstream of the GLC barrier and run 24 hours per day at 250, 500, or 1000 cfs while the temporary barriers are in place.

Old River at Tracy Pumping

Under this alternative, pump systems would be installed, either permanently or temporarily, with intake downstream and discharge upstream of the ORT barrier and run 24 hours per day at 250, 500, or 1000 cfs while the temporary barriers are in place.

Middle River and Old River Pumping

Under this alternative, pump systems would be installed, either permanently or temporarily, with intake downstream and discharge upstream of the MRB and with intake downstream and discharge upstream of the ORT barrier. All pumps would run simultaneously 24 hours per day at 125, 250, or 500 cfs while the temporary barriers are in place.

Environmental Considerations

Permanent Pump Systems

This section provides a summary assessment of the environmental impacts and permitting requirements for the low-head permanent pump system.

Impacts and Potential Mitigation Obligations

This section provides a summary of the potential environmental impacts (physical and biological) that may occur if the permanent low-head pump system is constructed and operated. The results of this assessment are shown in Table 1.

Also shown for comparison in Table 1 are potential impacts and mitigation commitments for a temporary pump system. Environmental considerations for a temporary pump system are presented on Page 13. These impacts could change as more detailed information regarding construction and operation of the pump system is developed. The impacts included in Table 1 assume the following regarding construction and operation of the permanent pump system:

- Project construction would require up to a year;
- Project construction would require the temporary installation of a cofferdam and dewatering within the cofferdam;
- Pump system would be operated 24 hours per day from July 1 to October 31;
- Pump system operation would require a high voltage power source. This power would need to be brought in from the nearest Western Area Power Administration (WAPA) service lines, which could be several miles or more from the MR, ORT and GLC barrier sites. As such, it would be necessary to install multiple power poles and tie in to existing WAPA lines;
- To the extent possible, staging areas used for construction of the MR, ORT, and/or GLC barriers would also be used for the installation of the permanent pump system at these locations. However, it may be necessary to establish new or additional staging areas, as would be the case for pump system installation at GLC under the 1000 cfs pumping scenario, for example, and this has been taken into account in assessing impacts;
- With the exception of water conveyance pipelines, most of the pump systems would be confined to the crown and landside of the levee; and
- All of the MR permanent pump systems would require channel dredging for the intakes to meet flow requirements.

Table 1. Potential Impacts—Low Head Pump Salinity Control Study (Permanent vs. Temporary Pump Systems)

Permanent Pump System	Temporary Pump System	Mitigation/Environmental Commitment
AESTHETICS		
Temporary Changes in Views during Project Construction	Temporary Changes in Views during Project Construction/Removal	*This potential impact would be less than significant and therefore would not require mitigation.*
Create a New Source of Light or Glare	Create a New Source of Light or Glare	• Construct structures with low-sheen and non-reflective surface materials (PP[1]) Apply minimum lighting standards (PP,TP[2])
Temporary Changes in Nighttime Lighting in the Proposed Project Area during Project Operation	Temporary Changes in Nighttime Lighting in the Proposed Project Area during Project Operation	• Apply minimum lighting standards (PP, TP)
Permanent Changes in Views	Permanent Changes in Views	• Reduce visibility of new structures (PP, TP) • Construct structures with low-sheen and non-reflective surface materials (PP, TP)
AGRICULTURAL RESOURCES		
Temporary Conversion of Prime Farmland during Construction/Installation	Temporary Conversion of Prime Farmland during Construction/Installation	• Return disturbed areas to pre-project conditions (PP, TP)
Permanent Conversion of Prime Farmland		*Project is not expected to result in substantial conversion of prime farmland*
AIR QUALITY		
Conflict with Applicable Air Quality Plan or Regulation	Conflict with Applicable Air Quality Plan or Regulation	*Project would not result in population and/or employment growth, and therefore it is not inconsistent with applicable air quality plans. This potential impact would be less than significant and therefore would not require mitigation.*
Generation of Criteria Pollutants during Project Construction	Generation of Criteria Pollutants during Project Installation/Removal	*This potential impact would likely be less than significant and therefore would not require mitigation.*

Permanent Pump System	Temporary Pump System	Mitigation/Environmental Commitment
Generation of Criteria Pollutants during Project Operation	Generation of Criteria Pollutants during Project Operation	• Utilize aqueous diesel fuel (PP, TP) • Install a Diesel Particulate Filter (PP, TP) • Utilize a diesel oxidation catalyst (PP, TP) • Install other after-treatment products (PP, TP) • Require the pump system be electric or alternatively fueled (PP, TP)
Generation of Criteria Pollutants during Project Construction or Operation, Resulting in a Cumulative Air Quality Impact	Generation of Criteria Pollutants during Project Construction or Operation, Resulting in a Cumulative Air Quality Impact	• Utilize aqueous diesel fuel (PP, TP) • Install a Diesel Particulate Filter (PP, TP) • Utilize a diesel oxidation catalyst (PP, TP) • Install other after-treatment products (PP, TP) • Require the pump system be electric or alternatively fueled (PP, TP)
Generation of Diesel Particulate Matter Emissions during Project Construction or Operation, Resulting in an Increased Health Risk	Generation of Diesel Particulate Matter Emissions during Project Construction/Removal or Operation, Resulting in an Increased Health Risk	• Utilize aqueous diesel fuel (PP, TP) • Install a Diesel Particulate Filter (PP, TP) • Utilize a diesel oxidation catalyst (PP, TP) • Install other after-treatment products (PP, TP) • Require the pump system be electric or alternatively fueled (PP, TP) • Locate pump system as far from sensitive receptors as possible (PP, TP)
Generation of Odors during Project Construction and Operations	Generation of Odors during Project Installation/Removal and Operations	• Locate the pump systems as far from sensitive receptors as possible (PP, TP) • Encase the pump system (may be specified for noise) (PP, TP) • Require the pump system be electric or alternatively fueled (PP, TP)

Permanent Pump System	Temporary Pump System	Mitigation/Environmental Commitment
BIOLOGICAL RESOURCES		
Disturbance of Active Swainson's Hawk Nests	Disturbance of Active Swainson's Hawk Nests	• Conduct surveys to locate Swainson's hawk nest sites (PP, TP) • Minimize Project-Related Disturbances within ¼ Mile of Active Swainson's Hawk Nest Sites (PP, TP)
Loss or Disturbance of Raptor Nests	Loss or Disturbance of Raptor Nests	• Conduct Surveys to Locate Raptor Nest Sites (PP, TP) • Minimize Project-Related Disturbances within ¼ Mile of Active Nest Sites (PP, TP)
Loss or Disturbance of Migratory Bird Nests	Loss or Disturbance of Migratory Bird Nests	• Avoid and Minimize Effects on Nesting Birds (PP, TP)
Potential Injury or Mortality of Western Pond Turtle	Potential Injury or Mortality of Western Pond Turtle	• Conduct preconstruction surveys (PP, TP) • Install Exclusion Fencing for Western Pond Turtle (PP, TP)
Loss or Disturbance of Western Pond Turtle Habitat *(degree of impact would increase w/increasing flow regime [pumping capacity] because footprint would increase)*	Loss or Disturbance of Western Pond Turtle Habitat *(degree of impact would increase w/increasing flow regime [pumping capacity] because footprint would increase)*	• Install Exclusion Fencing for Western Pond Turtle (PP, TP)

Permanent Pump System	Temporary Pump System	Mitigation/Environmental Commitment
Loss or Disturbance of Special-Status Plants		• Conduct preconstruction surveys • Locations of special-status plants in proposed construction areas will be recorded using a global positioning system unit and flagged • Establish an adequate buffer area to exclude activities that would directly remove or alter the habitat of an identified special-status plant population or result in indirect adverse effects on the species • Install a temporary, plastic mesh–type construction fence (Tensor Polygrid or equivalent) at least 1.2 meters (4 feet) tall around any established buffer areas to prevent encroachment by construction vehicles and personnel. A qualified biologist will determine the exact location of the fencing
Pile-driving Effects on Fish		• Conduct pile driving with a vibratory driver (PP)
Decreased Water Quality and Increased Aquatic Habitat Disturbance During Project Construction *(degree of impact would increase w/increasing flow regime [pumping capacity] because footprint would increase)*	Decreased Water Quality and Increased Aquatic Habitat Disturbance During Project Construction/Removal	• Implement Turbidity Monitoring During Construction (PP) • Implement Turbidity Monitoring During Construction/Removal (TP)
Fish Harassment and Displacement During Project Construction	Fish Harassment and Displacement During Project Construction/Removal	• Environmental Awareness Program for Construction Personnel (PP,TP)
Fish Harassment and Displacement During Project Operation	Fish Harassment and Displacement During Project Operation	*This potential impact would likely be less than significant and therefore would not require mitigation.*

Permanent Pump System	Temporary Pump System	Mitigation/Environmental Commitment
CULTURAL RESOURCES		
Damage to or Destruction of As-Yet-Unidentified Cultural Resources, Including Human Remains		• Stop Work and Evaluate the Significance of Inadvertent Discoveries; Devise Treatment Measures as Needed (PP)
GEOLOGY AND SOILS		
Accelerated Erosion during Project Construction	Accelerated Erosion during Project Construction and Removal	• Prepare and implement a SWPPP (PP, TP)
Potential Structural Damage from Development on Materials Subject to Liquefaction		*This potential impact would be less than significant and therefore would not require mitigation.*
Potential Structural Damage from Development on Expansive Soils		*This potential impact would be less than significant and therefore would not require mitigation.*
GREENHOUSE GAS EMISSIONS		
Generation of GHG Emissions from Project Construction	Generation of GHG Emissions from Project Construction/Removal	*This potential impact would likely be less than significant and therefore would not require mitigation.*
Generation of GHG Emissions from Project Operation	Generation of GHG Emissions from Project Operation	• Require the pump system be electric or alternatively fueled (PP, TP)
Conflict with Applicable GHG Reduction Plan or Regulation	Conflict with Applicable GHG Reduction Plan or Regulation	• Require the pump system be electric or alternatively fueled (PP, TP)
HAZARDS AND HAZARDOUS MATERIALS		
Inadvertent Release of Hazardous Materials during Project Construction and Operation	Release of Hazardous Materials during Project Construction, Operation and Removal	• Prepare and implement a Hazardous Materials Management Program (PP, TP)
HYDROLOGY AND WATER QUALITY		
Accelerated Erosion During Project Construction	Accelerated Erosion during Project Construction and Removal	• Prepare and implement SWPPP (PP, TP) • Implement Turbidity Monitoring During Construction (PP) • Implement Turbidity Monitoring During Construction and Removal (TP)

Permanent Pump System	Temporary Pump System	Mitigation/Environmental Commitment
Inadvertent Release of Hazardous Materials to Adjacent Water Body during Construction	Inadvertent Release of Hazardous Materials to Adjacent Water Body during Construction/Removal	• Prepare and implement a Hazardous Materials Management Program (PP, TP)
LAND USE AND PLANNING		
Conflict with Existing Zoning for Agricultural Use *(degree of impact would increase w/increasing flow regime [pumping capacity] because footprint would increase)*	Conflict with Existing Zoning for Agricultural Use *(degree of impact would increase w/increasing flow regime [pumping capacity] because footprint of delivery pipeline would increase)*	• Avoid agricultural lands to the greatest extent possible (PP, TP)
Incompatible with Existing Adjacent Land Uses *(degree of impact would increase w/increasing flow regime [pumping capacity] because footprint would increase)*	Incompatible with Existing Adjacent Land Uses *(degree of impact would increase w/increasing flow regime [pumping capacity] because footprint of pipeline would increase*	• Avoid agricultural lands to the greatest extent possible (PP, TP)
MINERAL RESOURCES		
None		
NOISE		
Exposure of Noise-Sensitive Land Uses to Project Construction Noise	Exposure of Noise-Sensitive Land Uses to Project Construction/Removal Noise	• Employ noise-reducing construction measures (PP, TP)
Exposure of Noise-Sensitive Land Uses to Project Operation Noise	Exposure of Noise-Sensitive Land Uses to Project Operation Noise	• Employ noise-reducing operational measures (PP, TP)
POPULATION AND HOUSING		
None		
PUBLIC SERVICES		
None		
RECREATION		
None		

Permanent Pump System	Temporary Pump System	Mitigation/Environmental Commitment
TRANSPORTATION/TRAFFIC		
Temporary Increase in Traffic during Construction	Temporary Increase in Traffic during Construction/Removal	*This potential impact would be less than significant and therefore would not require mitigation.*
UTILITIES AND SERVICE SYSTEMS		
Generation of Solid Waste during Project Construction		*This potential impact would be less than significant and therefore would not require mitigation.*
Increase in Power Consumption during Project Operation	Increase in Power Consumption during Project Operation	*This potential impact would be less than significant and therefore would not require mitigation.*
Temporary Disruption of Electricity Service		• Coordinate power outages and notify potentially affected utility users of the temporary loss of electricity.
Disruption to Underground Utility Lines during Excavation Activities		• Existing underground utility lines at excavation sites will be identified prior to construction and underground utility lines will be avoided or relocated in coordination with the utility company or service provider.

[1]PP: permanent pump system
[2]TP: temporary pump system

Permitting Process

Assuming the impacts described above, Table 2 provides an overview of the environmental permits that may be required for the construction and operation of the permanent pump system. The actual permits that would be required and the time to acquire them would depend on the actual estimated effects of the final proposal and coordination with resource and regulatory agencies. This also assumes that there would be no need to re-consult on the CVP/SWP Long Term Operations BOs (OCAP) primarily because there are no expected increased effects on federally-listed species resulting from the proposed annual July through October system operation. However, the NMFS and FWS may require that re-consultation is necessary to address the minor changes in the project description of the BOs that would occur as a result of modifying the TBP. As described above, the estimates included in Table 2 assume that the pump system would be included as an amended project description for the temporary barriers, similar to previous modifications (i.e., MRB raise). As such, permit documents would be abbreviated and would indicate that implementation of the pump system would be a modified component of the overall TBP. Should this be unacceptable to the regulatory agencies, timeline to obtain these permits would likely increase.

Table 2. Regulatory Compliance Permits and Approvals for Permanent Pump System

Authority/Agency	Permit/Approval	Timeline	Trigger
U.S. Army Corps of Engineers	Clean Water Act Section; 404/ Rivers and Harbors Act, Section 10	NWP: up to 3 months IP: up to 8 months[1]	Work within waters of the United States; Construction of any structure in or over any navigable water of the United States, or any other work affecting the course, location, condition, or physical capacity of these waters.
California Department of Water Resources	CEQA	Addendum: 1 month Supplemental IS/MND: 4 months	Potential impacts to the physical environment
U.S. Fish and Wildlife Service	ESA Take Permit (Section 7 consultation)	9 months[2]	Potential effects on delta smelt or its designated critical habitat
National Marine Fisheries Service	ESA Take Permit (Section 7 consultation) Magnusson-Stevens Act, EFH Consultation	12 months[2]	Potential take of steelhead, winter-run and spring-run Chinook salmon, green sturgeon or effects to designated critical habitat
California Department of Fish and Game	Incidental Take Permit	9 months[2]	Potential take of delta smelt, longfin smelt, spring-run Chinook salmon, or Swainson's hawk
California Department of Fish and Game	Streambed Alteration Agreement	6 months	Construction activity within waterside hinges of the levee
Central Valley Regional Water Quality Control Board	Section 401 Certification or Waiver	Up to 12 months[3]	Work within waters of the United States
San Joaquin Valley Air Pollution Control District	Emission Reduction Credit Lease	Up to 5 months	Particulate and exhaust emission impacts beyond established thresholds

ESA = federal Endangered Species Act.
CESA = California Endangered Species Act.
EFH = Essential Fish Habitat.
[1] If an individual permit is required, NEPA documentation may also be required.
[2] This timeline assumes that no re-consultation on OCAP is necessary.
[3] This timeline assumes the RWQCB does not issue a permit until NMFS and FWS issue BOs

Temporary Pump System

This section provides a summary of the environmental impacts and permitting requirements for the low-head temporary pump system. The description of environmental considerations for the temporary pump system assumes these pumps would be placed on the levee adjacent to the barrier(s) during the irrigation season while the agricultural barriers are in place. There would be no permanent fill associated with the pump system and any in-water structures would be removed upon removal of the barriers. Some components of the pump facilities may be left in place on the crown of the levee to facilitate ease of installation in subsequent years.

Summary of Impacts and Potential Mitigation Obligations

Table 1 provides a summary of the potential environmental impacts that may occur if the temporary low-head pump system is constructed and operated; potential mitigation obligations are also included. These impacts could change as more detailed information regarding construction and operation of the pump system is developed. The impacts included in Table 1 assume the following regarding construction and operation of the temporary pump system:

- Installation of the pump system would occur in the spring and would require up to 90 days the first year. After the first installation, subsequent annual installation would likely require less time because some infrastructure may remain in place after the pump system is removed;;
- Pump system would be operated 24 hours per day from July 1 to October 31;
- To the extent possible, staging areas used for construction of the MR, ORT, and/or GLC barriers would also be used for installation of the temporary pumps at these locations; and
- Skid-mounted pumps would be located along the levee crown and hooked up, via temporary water conveyance pipes. Water conveyance pipes would be located on the waterside of the levee and would be designed to avoid entrainment of fish that could be present between July and October.
- All in-water features would be removed and re-installed each year.

Permitting Process

Based on preliminary discussions with the U.S. Army Corps of Engineers and California Department of Fish and Game, it is assumed that the placement and operation of temporary pump systems would not require permits for federal Clean Water Act, California Fish and Game Code Section 1602, or other in-water effects regulated by these agencies. Based on this input and assuming that there would be no need to re-consult on OCAP, it is assumed that consultation under the federal Endangered Species Act (ESA) would also not be required primarily because there are no expected increased effects on federally-listed species during the proposed annual July through October operation period. As such, the only potential effects are related primarily to noise and pollutant emissions that would occur when the pump systems are placed and operated (Table 3). However, the NMFS and FWS may require that re-consultation is necessary to address the minor changes in the project description of the BOs that would occur as a result of modifying the TBP. If this were to occur, the permitting requirements for the temporary pump system would likely be the same as those described above for the permanent pump system.

Table 3. Regulatory Compliance Permits and Approvals for Temporary Pump System

Authority/Agency	Permit/Approval	Trigger
California Department of Fish and Game	Incidental Take Permit	Potential effects on Swainson's hawk
San Joaquin Valley Air Pollution Control District	Emission Reduction Credit Lease	Particulate and exhaust emission impacts beyond established thresholds

ESA = federal Endangered Species Act.
CESA = California Endangered Species Act.