San Joaquin River Restoration Program
Fish Passage Evaluation Plan

Task 3, Volume I
Technical Memorandum
Alternative Concepts for Fish Passage Barriers

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Division of Integrated Regional Water Management
South Central Region Office

San Joaquin River Restoration Program
Fish Passage Evaluation

Task 3, Volume I

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Abbreviations and Acronyms

CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVFPB	Central Valley Flood Protection Board
DFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
EBCS	Eastside Bypass Control Structure
FDC	flow duration curve
FMWG	Fisheries Management Work Group
fps	feet per second
HEC-RAS	Hydrologic Engineering Center’s River Analysis System
LSJLD	Lower San Joaquin Levee District
LSJRFCP	Lower San Joaquin River Flood Control Project
MBCS	Mariposa Bypass Control Structure
MNWR	Merced National Wildlife Refuge
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
O&M	operation and maintenance
Reclamation	U.S. Bureau of Reclamation
SJRRP	San Joaquin River Restoration Program
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1. Introduction

This technical memorandum describes the final phase (Task 3) of the *Fish Passage Evaluation Plan* performed for the San Joaquin River Restoration Program (SJRRP). The purpose of the *Fish Passage Evaluation Plan* is to inform the SJRRP of fish passage improvement conceptual designs for structures that have been identified as fish passage barriers. Task 3 focuses on site-specific projects that will support the reintroduction of Chinook salmon to the San Joaquin River. The structures evaluated as a part of Task 3 are divided into two groups – Group 1 (higher priority) and Group 2 (lower priority). Structure priority was based on the severity of the barrier, and the established priorities of the SJRRP. The structures and groupings are shown in Figure 1 and include:

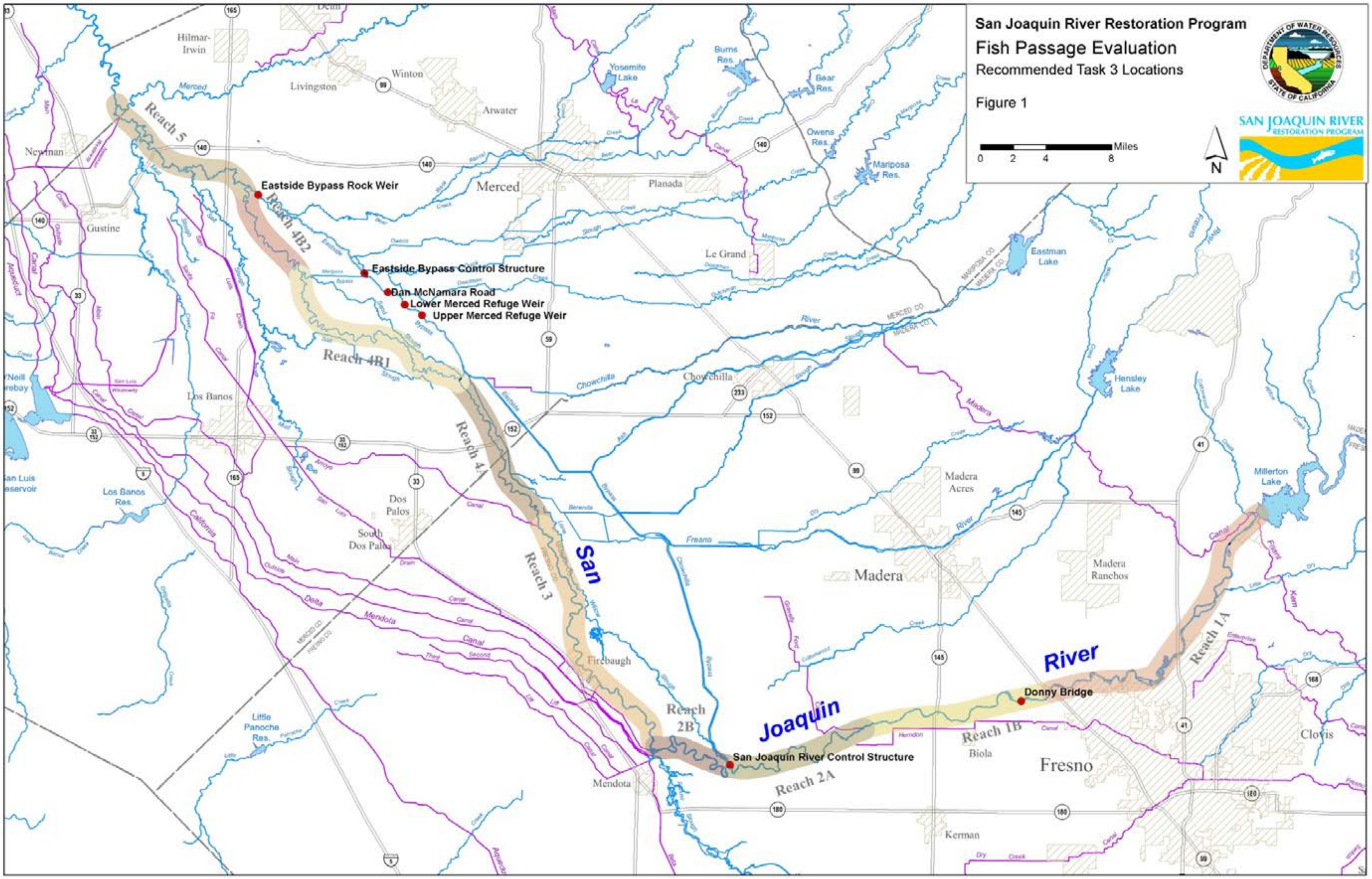
- Group 1.
    - Eastside Bypass Control Structure.
    - Lower Merced National Wildlife Refuge Weir (Weir #1).
    - Upper Merced National Wildlife Refuge Weir (Weir #2).
    - Dan McNamara Road.
- Group 2.
    - Eastside Bypass Rock Weir.
    - San Joaquin River Control Structure.
    - Donny Bridge.

The Group 1 structures are located along the Eastside Bypass, a flood control channel constructed by the California Department of Water Resources (DWR) in the 1960s (Figure 1). The purpose of the Eastside Bypass is to accommodate flows in excess of the San Joaquin River channel capacity during flood events. In relation to the SJRRP, the Eastside Bypass may serve as a potential migration route for Chinook salmon and may subsequently be a critical pathway for the SJRRP in meeting the restoration goals of the program. As a result, developing conceptual design improvements for structures in the Eastside Bypass is a critical component in accomplishing SJRRP goals. The Eastside Bypass can be described as having "Upper" (upstream), "Middle," or "Lower" (downstream) reaches, and is referenced in this way in this memorandum.

In 2015, the SJRRP developed a revised framework for implementation (Framework) that establishes a realistic schedule for a series of actions based upon the best available technical, biological, schedule, and funding information. Actions include improving fish passage at various barriers along the river. Based on SJRRP priorities, Task 3 is divided into two technical memorandum volumes. Volume I describes the conceptual designs for Group 1 structures that will improve passage conditions on portions of the Eastside Bypass at key barriers. This memorandum comprises the Task 3 Volume I deliverable to the SJRRP. Task 3 Volume II will include the conceptual designs for Group 2 structures and will be provided as a separate deliverable.

This memorandum summarizes the current site conditions, the conceptual design criteria, and the conceptual alternative designs and associated costs for each of the Group 1 structures.

Figure 1 **Task 3 Structures Location Map**



1.1 Task 3 Objectives

This memorandum will present three to four conceptual designs to improve fish passage at each of the Group 1 structures. All of the Task 3 Group 1 conceptual designs must meet the following objectives:

- Provide unimpeded fish passage for spring-run and fall-run adult Chinook salmon with consideration to Restoration and flood flows.
- Minimize impacts on flood operations and do not increase the current water surface elevation at the design-flood capacity.
- Provide provisions within the designs to account for ground subsidence.

In addition to those general objectives, the conceptual designs for the Group 1 structures were developed with their own set of objectives and design criteria based on the goals of the SJRRP. The design criteria (described in “Section 3 Design Criteria”) used to develop each conceptual design considered the hydrology resulting from a variety of flow-routing alternatives, the fish-passage design criteria used for other SJRRP projects, ongoing ground subsidence, and the permit requirements of the Central Valley Flood Protection Board and other agencies.

1.2 Conceptual Design Packages

The proposed fish passage improvement conceptual designs for the Group 1 structures are presented in Appendix B (Eastside Bypass Control Structure), Appendix C (Dan McNamara Road), and Appendix D (Merced Wildlife Refuge Weirs) as individual conceptual design packages. Each conceptual design package includes:

- Conceptual-level drawings.
- A hydraulic analysis to determine fish passage design and flood compliance.
- Cost estimates for construction and implementation.
- Potential future operations and maintenance needs.
- Benefits and constraints.
- Future design considerations.

1.3 Timeline

The framework indicates that the modifications to the structures in Group 1 are scheduled to be implemented by 2020. The timing and implementation of the modifications to the structures in Group 2 have not been determined by the SJRRP. Other structures that were not included in Group 1 or Group 2, but were initially identified as potential barriers, include Mendota Dam, Sack Dam, San Joaquin River Reach 4B Headgates, Mariposa Bypass Control Structure, and the Mariposa Drop Structure. While these structures were identified as potential barriers, they are part of the Arroyo Canal, Reach 2B, and Reach 4B site-specific projects, and will be evaluated as part of those projects.

1.4 Stakeholder Workshop

After preparing the Task 3 conceptual designs, DWR’s South Central Region Office held a workshop on July 16, 2015, to solicit initial feedback from SJRRP agencies about each of the conceptual designs. The workshop’s focus was on the identification of the risks, benefits, opportunities, constraints, and critical unknowns relating to fish passage of adult Chinook salmon for the Group 1 structures. Attendees included representatives from DWR, U.S. Bureau of Reclamation (Reclamation), National Marine Fisheries

Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and California Department of Fish and Wildlife (DFW).

There were three major categories of feedback that were provided during the workshop, including fisheries, general engineering/construction, and flood. The categories of the general comments received include:

- **Fisheries**: The potential risks for other fish species (e.g., non-jumping species) not to pass, predation (adult and juvenile), gate operations at control structures impeding passage, juvenile out-migration confusion, and adult stranding.
- **Engineering and Construction**: The potential removal of access of public roads, construction considerations during restoration or flood flows, and suggested changes to some of the conceptual designs. Those changes will be considered during the next phase of design.
- **Flood**: Flood and gate operation uncertainty, as well as levee stability.

In addition to the verbal feedback received during the workshop, written comments on the draft Task 3 report were received. Several of the comments referred to the SJRRP overall goals and objectives for fish passage, including the species and timing of passage, as well as specific comments regarding how the fish-passage design criteria were applied. Given that these designs were conceptual, and for the planning level only, some comments could be addressed within the final draft of this report, while others were noted but will be addressed in the next level of design.

2. Background

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and California's Central Valley Project Friant Division contractors. After more than 18 years of litigation, the lawsuit, known as *NRDC et al. v. Kirk Rodgers et al.*, reached a stipulation of settlement (Settlement). The settling parties, including NRDC, Friant Water Users Authority, the U.S. Department of the Interior, and the U.S. Department of Commerce, agreed on the terms and conditions of the Settlement, which was subsequently approved on October 23, 2006. The Settlement requires the settling parties to provide adequate flows and perform structural modifications as necessary to ensure fish passage during the migration periods of both spring-run and fall-run Chinook salmon, as well as other native fish in the river. The Settlement establishes two primary goals:

1. **Restoration Goal**: To restore and maintain fish populations in "good condition" in the main stem of the San Joaquin River below Friant Dam to the confluence with the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.
2. **Water Management Goal**: To reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

Projects identified within the Settlement under the Restoration Goal and for which channel and structural improvement projects are needed include:

- Mendota Pool Bypass and Reach 2B Channel Improvements Project (Reach 2B Project).
- The Arroyo Canal Fish Screen and Sack Dam Fish Passage Project.
- Reach 4B, Eastside and Mariposa Bypass Channel and Structural Improvements Project (Reach 4B Project).

The SJRRP implementing agencies that would execute the actions in the Settlement include Reclamation, USFWS, NMFS, DFW, and DWR. The implementing agencies organized a SJRRP Management Team and associated work groups to begin work implementing the Settlement (San Joaquin River Restoration Program 2010a). Under the SJRRP, the Fisheries Management Work Group (FMWG) is responsible for planning and coordinating the efforts to implement the sections in the Settlement related to maintaining fish in good condition, reintroducing the Chinook salmon, obtaining self-sustaining fish populations that meet the Restoration Goal, and ensure adequate fish passage.

A major deliverable of the FMWG was the development of the *Fisheries Management Plan*, which was a primary step in the Restoration Goal planning process. It lays out a structured approach to adaptively manage the reintroduction of Chinook salmon and other fishes. Action F5 of the *Fisheries Management Plan* recommends that fish passage be sufficient at all structures and potential barriers (San Joaquin River Restoration Program 2010b). To this end, the FMWG established a habitat objective to provide passage conditions that allow the migration of 90 percent of adult and 70 percent of juvenile Chinook salmon to successfully pass into a suitable upstream and downstream habitat during specific flow schedules and water-year types (with an exception for the critical-low water-year type, as defined in the Settlement). For guidance and accuracy, the Settlement provides flow schedules and water-year types that the SJRRP must consider in its implementation of the improvement actions that will be accomplished to support the Restoration Goal.

During the development of the *Fisheries Management Plan*, the FMWG requested that DWR develop the *Fish Passage Evaluation Plan* to evaluate any potential structural barriers to fish migration in the main channel of the San Joaquin River and the bypass system. The goal of the plan was to identify potential fish passage barriers and passage improvements for migrating adult Chinook salmon. The *Fish Passage Evaluation Plan* included an evaluation of the potential barriers using common passage criteria. Potential barriers were also modeled to simulate flow hydraulics that included water depth, flow velocity, and water-surface drop to determine the jump height. The hydraulic model results were compared to swimming abilities of an adult Chinook salmon to determine an ideal range of passage flows. The *Fish Passage Evaluation Plan* supports Action F5 in the *Fisheries Management Plan* (San Joaquin River Restoration Program 2010b) by providing the SJRRP with the information needed to identify improvement projects that will aid in successful fish passage. The *Fish Passage Evaluation Plan* was divided into three different tasks.

2.1 Task 1

Task 1 included the identification and limited data collection of potential fish passage barriers, as well as the identification of fundamental passage criteria, to allow an initial evaluation of potential barriers. The structures were visited to develop site descriptions and to collect field observations, photographs, and measurements. Field observations were then applied to a flow chart assessment using general passage criteria, which resulted in the identification of potential barriers for further study. Each of the structures was color-coded into categories for identification purposes. Any structures that were not categorized as a barrier were green, structures creating a definite barrier were red, and any structures that required more information to determine if the structure was a barrier were gray. The Task 1 background and methods were reported in the November 2010 Annual Technical Report Appendix A, Section 25 (San Joaquin River Restoration Program, 2010c). Forty-nine potential barriers were evaluated during Task 1, with 28 structures identified as adequate for passage (green), 13 ranked as potential barriers needing more analysis (gray), and eight definite barriers (red). The results from Task 1 are presented in the draft 2011 Annual Technical Report, Appendix B, Section 20 (California Department of Water Resources 2011a).

2.2 Task 2

Task 2 was completed as two separate efforts and included additional data collection and the hydraulic evaluation of the potential fish passage barriers that were identified for further study in Task 1. The first effort focused on 14 of the structures within the San Joaquin River and portions of the Eastside Bypass downstream of Sand Slough. The goal of this effort was to determine the extent to which a structure was a barrier to migrating adult Chinook salmon (California Department of Water Resources 2012). Field surveys and hydraulic models were developed to determine the hydraulic constraints of each structure. The hydraulic results were compared to fish-passage criteria for adult salmon to determine the range of suitable flows for passage and help prioritize structures for modification to improve passage. The second effort was a separate evaluation, the Task 2 Addendum (California Department of Water Resources 2014), and included the remaining six potential barriers within the Chowchilla Bypass and Upper Eastside Bypass. The results from Task 2 were incorporated into the updated framework.

2.3 Task 3

Task 3, which is the focus for this memorandum, is the final phase of the *Fish Passage Evaluation Plan*. Task 3 includes the development of conceptual designs presented as alternatives to improve or modify the structures that were determined to be a fish passage impediment during Task 1 or Task 2. The conceptual designs proposed under Task 3 will be used by the SJRRP to assist with determining structural modification priorities and preferred designs for implementation. It is important to note that the focus fish for the Task 3 conceptual designs is the adult Chinook salmon. Task 3 aims to develop fish passage improvement projects that need to be implemented in order to achieve the Restoration Goal of restoring and maintaining fish populations.

To identify the structures for which to prepare conceptual designs under Task 3, the results from Task 1 and Task 2 were compared to the Framework goals and objectives. The purpose of this comparison was to identify needed fish passage improvement projects and data gaps within the SJRRP. The Framework provides a threshold for key structures requiring improvements as those that impede passage at flows more than 350 cubic feet per second (cfs) (structures that impede passage at flows less than 350 cfs are not considered for improvement). Based on this threshold and the necessary fish passage projects and SJRRP data gaps, conceptual designs were prepared for the identified improvement projects. While some of the projects will not be completed for 10 years to 20 years based on projections in the Framework, DWR has prepared this Task 3 memorandum on the development of conceptual designs to remove the current fish passage constraints for migrating adult Chinook salmon at key structures.

The key Group 1 structures evaluated as a part of Task 3 include the Eastside Bypass Control Structure, Lower Merced National Wildlife Refuge Weir (Weir #1), Upper Merced National Wildlife Refuge Weir (Weir #2), and Dan McNamara Road. All four projects are located in the Middle Eastside Bypass, which bypasses Reach 4B1 of the San Joaquin River. The Middle Eastside Bypass runs from the divergence of the Eastside Bypass and Reach 4B1 to the Eastside Bypass Control Structure (Figure 1).

The goal of Task 3, Volume I is to provide conceptual designs to help support the selection of a preferred alternative for Group 1 structures identified in the Framework. Once preferred alternatives are selected, the SJRRP intends to construct the improvements for the Group 1 structures by 2020.

3. Design Criteria

Each conceptual design must meet criteria for flow, fish passage, flood capacity, and ground subsidence in order to meet restoration goals. The following sections describe the design criteria developed by the SJRRP for flow, fish passage, flood capacity, and ground subsidence for the conceptual designs proposed in this Task 3 analysis.

3.1 Flow (Hydrology)

Flow rate is an important limiting factor for fish passage design. Each conceptual design must consider the anticipated range of restoration and flood flows through the Middle Eastside Bypass and Group 1 key structures so that the SJRRP fish passage goals can be met. The Settlement calls for releases of Restoration Flows, which were initiated in 2014 and are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. Allowable flow rates can also be constrained and determined by fish passage requirements of hydrology, such as flow pulses needed for migration and sensory inputs. The selection of the appropriate range of design flows was critical to ensure that the conceptual designs best support fish passage and migration needs. There were several components that were considered when developing the flow-design criteria for the Task 3 conceptual designs, including Restoration flows requirements, fish passage flow range, migration periods of fish, and flow-routing alternatives. These components were used to determine the recommendations for design-flow range for the conceptual designs.

The following sections provide a summary of the steps taken to determine design-flow recommendations for the conceptual designs. A comprehensive description of the development of the flow (hydrology) criteria is provided in Appendix A.

3.1.1 Restoration Flows

The Settlement requires releases of water from the Friant Dam to achieve the Restoration Goals and provides hydrographs to define these releases in varying types of water years. The hydrographs in the Settlement identify “Base Flows” in each water-year type as well as defines releases up to an additional 10 percent of the applicable hydrograph flows as “Buffer Flows.” Base Flows and Buffer Flows needed to meet the Restoration Goal are collectively referred to as “Restoration Flows.” The Settlement dictates that the ultimate goal for the full volume Restoration Flows, once all Restoration Projects are completed, is 4,500 cfs. The hydrographs provided in the Settlement provide the flow schedule for the volume and pattern of Restoration Flow releases. To date, the full volume of Restoration Flows has not been released because channel and structural modifications need to be constructed before the full Restoration Flows can be safely discharged.

In addition to the Restoration Flows specified in the Settlement, the Framework provides a revised approach to implementing the Settlement and the San Joaquin River Restoration Settlement Act. The Framework identifies flow management, conveyance, adult migration paths, and fish passage and transportation guidelines, among other actions to implement and accomplish the Restoration Goal (San Joaquin River Restoration Program 2015a). The Framework also provides information on the potential flow-routing options through the San Joaquin River and the Eastside Bypass. This information in the

Framework was used to develop projections on the anticipated Restoration Flows in the Middle Eastside Bypass and the Group 1 key structures analyzed in Task 3.

3.1.2 Flow Routing Alternatives

The flows within the San Joaquin River and bypass system are highly regulated, controlled by flow releases from Friant Dam and the diversion structures along the river and bypass systems. Future operational decisions and Restoration Flow routing through the San Joaquin River and bypass systems will determine the success of adult Chinook salmon migration and the SJRRP. But, the routing of Restoration Flows will vary depending on the completion of the SJRRP channel and structural modifications. The two projects that will have the most impact on the flow routing of Restoration Flows, and that will attract the upstream migration of adult Chinook salmon to the migration pathway, are the Reach 2B Project and Reach 4B Project, described in “Section 2.” Those projects and their improvement alternatives, described in the Framework, will be referred to as the Reach 2B/4B project alternatives.

As specified in the Framework, the main stem reaches of the San Joaquin River have similar routing assumptions for all of the Reach 2B/4B project alternatives. But, the proposed routing of Restoration Flows for the Reach 4B project alternatives impacts the design flows for the Group 1 structures in the Eastside Bypass. For the Reach 4B project alternatives, flows can either be diverted into the San Joaquin River Reach 4B1 channel, or the Eastside Bypass, or a combination of both. At the time of this analysis, a preferred Reach 4B project alternative had not been selected by the SJRRP. As a result, this analysis assumes that Restoration Flows will be diverted into the Eastside Bypass, and considers the migratory pathway assumed in the Framework. Based on the Framework, by 2020, migrating fish will pass through Reach 5 of the San Joaquin River, into the Eastside Bypass near Bear Creek (through the Lower and Middle Eastside Bypass sections), into Reach 4A of the San Joaquin River at Sand Slough, and then up through Reach 3, Reach 2, and Reach 1. Ultimately, based on current assumptions, the Eastside Bypass will be used to bypass Reach 4B of the San Joaquin River for the SJRRP. This represents the most probable flow-routing alternative based on current available information.

3.1.3 Migration Periods

The adult migration period for spring-run Chinook salmon was assumed to be from February 1 through June 1, and the fall run from September 1 through December 1. The adult migration period is the time when adult salmonids move upstream through the SJRRP area, and need to safely pass through the structures to reach their holding and spawning locations. The design-flow range is inclusive of flows that would typically occur during the two migration periods.

3.1.4 Fish Passage Design-Flow Range

The fish passage design-flow range is the lowest and highest streamflow for which migrating salmon are expected to be present, migrating, and dependent on the proposed facility for safe passage. The acceptable range of design flows is determined based on hydrologic characteristics of the river, which are used to estimate the statistical flow recurrence intervals of the watercourse. Typically, the upper passage flow limit (highest flow) determines the allowable maximum water velocity, which is defined as the 1 percent exceedance flow. The lower passage flow limit (lowest flow) determines the allowable minimum depth of water, which is defined as the 50 percent exceedance flow or 3 cfs, whichever is higher.

These design criteria are based on the *Culvert Criteria for Fish Passage* (California Department of Fish and Game 2002) guidelines referenced within the *California Salmonid Stream Habitat Restoration Manual* (California Department of Fish and Game 2010). This design criteria methodology was specified by DFW and was used for determining the passage flow limits for the Task 3 conceptual designs. This method is specific for the State. This passage range is different from the NMFS guidelines, which were developed for "generic guidance" for permitting under the Endangered Species Act, Federal Power Act, and Magnuson-Stevens Fishery Conservation and Management Act (National Marine Fisheries Service 2011).

3.1.5 Hydrographs and Flow Duration Curves

To ensure that an appropriate range of flows was considered for the design-flow range, Restoration Flow hydrographs were simulated using two methods sequentially, a hydrologic model, and a Microsoft Excel spreadsheet. First, a RiverWare model developed by Reclamation was used to develop hydrographs for multiple flow scenarios in the San Joaquin River from Friant Dam. The model considered variable inflow and outflow conditions based on the full historical record of flow from October 1, 1921, to September 30, 2003, and projects future flows based on SJRRP routing plans. The model was also based on the assumption that full Restoration Flows would be available, and included the assumption that all of the major Restoration Projects had been implemented. The results of the model were provided in Microsoft Excel format to DWR staff, which used the information to project flows and develop hydrographs for the reaches of the SJRRP and Eastside Bypass.

Based on the selected routing alternative and the developed restoration flow hydrographs, flow duration curves (FDCs) were developed for the Group 1 structures. FDCs are graphs that indicate the percentage of time that flow in a specified location is likely to equal or exceed a specified flow. The FDCs were used to determine the flow limits at the Group 1 structures that meet DFW guidelines for fish passage. Two sets of FDCs were developed. The first set was for the Eastside Bypass Control Structure (EBCS). The second was for the Middle Eastside Bypass, which encompasses the Merced National Wildlife Refuge (MNWR) weirs and the Dan McNamara Road projects.

For the Middle Eastside Bypass and EBCS, FDCs were developed for three flow-volume scenarios. Each flow-volume scenario assumes the same flow route, which sends Restoration and flood flows down the Middle Eastside Bypass and through the EBCS, but represents other variables in the flow decisions and operations of the SJRRP. Primarily, the scenarios represent varying volumes of flow assumed through each Group 1 structure.

- Scenario 1 assumes the full (unconstrained) Restoration Flows of 4,500 cfs from the Friant Dam and implementation of Reach 2B/4B Projects.
- Scenario 2 assumes constrained Restoration Flows of 2,000 cfs from the Friant Dam, constrained flows in Reach 2B (projects only implemented to allow for 2,000 cfs through Reach 2B), and constrained flows in Reach 4B Projects (projects not implemented, requiring use of Lower Eastside Bypass).
- Scenario 3 assumes the unconstrained Restoration Flows of 4,500 cfs from the Friant Dam, unconstrained flows in Reach 2B (projects have been implemented to allow full Restoration Flow), and constrained flows in Reach 4B Projects (projects not implemented, requiring use of Lower Eastside Bypass).

Additional information on the assumptions for each flow volume scenario is provided in Appendix A. The flow-volume scenario FDCs were used to determine the flow limits that meet DFW flow recurrence interval guidelines for fish passage at each Group 1 structure. The FDCs are provided in Appendix A. The DFW recurrence interval guidelines are described in "Section 3.1.4 Fish Passage Design-Flow Range." The low and high fish-passage flows for the three flow-routing scenarios for the Group 1 structures are shown in Table 3-1.

Table 3-1 Lower and Upper Passage Flows for Adult Chinook Salmon by Flow Scenario

Structure	Scenario 1		Scenario 2		Scenario 3	
	50% Lower Passage Flow[a] (cfs)	1% Upper Passage Flow (cfs)	50% Lower Passage Flow (cfs)	1% Upper Passage Flow (cfs)	50% Lower Passage Flow (cfs)	1% Upper Passage Flow (cfs)
Middle Eastside Bypass Structures[b]	0 (3)	9,737	155	10,214	85	9,679
Eastside Bypass Control Structure	0 (3)	7,559	155	8,155	85	8,014

Notes:
cfs = cubic feet per second
[a] Minimum 3 cubic feet per second qualifies.
[b] Middle Eastside Bypass structures constitute the flow duration curves for Lower Merced Refuge Weir, Upper Merced Refuge Weir, and Dan McNamara Road.

3.1.6 Design-Flow Recommendations

The SJRRP has determined that the Reach 4B Project would not be constructed and would not receive full Restoration Flows for at least 15 years. Because of this, as well as the uncertainty in the final flow-routing decision, and the ability of the Middle Eastside Bypass to support fish at lower flows, a combination of the flows and scenarios were used to specify the upper and lower design-flow limits for the conceptual designs. Table 3-2 presents the design-flow limits that were used to develop the conceptual designs for the Task 3 Group 1 structures.

Table 3-2 Group 1 Design Flows for Full Restoration Flows

Structure	Full Project Design Flows	
	50% Lower Passage Flow (cfs)[a]	1% Upper Passage Flow (cfs)[b]
Middle Eastside Bypass Structures[c]	85	9,737
Eastside Bypass Control Structure	85	7,559

Notes:
cfs = cubic feet per second
[a] Base flows within the Middle Eastside Bypass could be as low as 45 cfs. Next phase of design will determine the final low flow limit.
[b] Reach 4B Project, Alternative 3, routing assumed.
[c] Middle Eastside Bypass structures constitute the flow duration curves for Lower Merced Refuge Weir, Upper Merced Refuge Weir, and Dan McNamara Road.

The upper design-flow limit is from the FDC for Scenario 1. This scenario assumes full project implementation of the Reach 4B Project alternative that allows for Restoration Flows more than 475 cfs to be diverted into the Eastside Bypass. Because flows from Scenario 1 are 3 cfs or less, which is much less than enough to support fish populations, the lower design-flow limit is from Scenario 3. This scenario assumes that all flood flows and Restoration flows up to 4,500 cfs will be diverted into the Eastside Bypass. Both the upper and lower design-flow limits use hydrographs based on full Restoration Flows of

4,500 cfs. Using a combination of scenario flows provides an estimated range of flood routing rules for the Reach 4B Project alternatives. The next phase of design will determine the final low flow and high flow limits.

As shown in Table 3-2, the design flows exceed the maximum Restoration Flows of 4,500 cfs. This is because the flow exceedance analysis included Restoration and flood flows, a procedure that is defined in the fish passage guidelines. Flood flows are discussed in more detail in “Section 3.3 Flood Capacity” and “Section 4.2.1 LSJRFCP Flood Operations.” Specific details regarding the scenario routing assumptions and FDC development are included in Appendix A.

3.2 Fish Passage

Each conceptual design must meet established fish-passage criteria for upstream migrating adult Chinook salmon. Other life stages, as well as other native fish, were not specifically considered in the development of the conceptual designs. The following documents were referenced during the development of the conceptual designs:

- *Fisheries Handbook of Engineering Requirements and Biological Criteria*, U.S. Army Corps of Engineers, North Pacific Division, 1991. (Bell, 1991).
- *California Salmonid Stream Habitat Restoration Manual*, Volume 2, 4th Edition, (California Department of Fish and Game 2010).
- *Anadromous Salmonid Fish Passage Facility Design* (National Marine Fisheries Service 2011).
- *Rock Ramp Design Guidelines* (U.S. Bureau of Reclamation 2007).

The fish-passage design criteria for adult Chinook salmon (jump, depth, and velocity) is based on the criteria used for the SJRRP Reach 2B (the latest dated July 28, 2011) and Reach 4B site-specific projects, as well as design criteria from the DFW, U. S. Army Corps of Engineers (USACE), NMFS, and Reclamation. Each conceptual design must meet the criteria shown in Table 3-3.

Table 3-3 Fish-Passage Design Criteria for Adult Chinook Salmon

Minimum Depth of Flow (ft)	Maximum Recommended Structure Jump Height (ft)	Recommended Design Velocity Range (fps)[a]
1.0	1.0	1.5 – 4.0

Notes:
fps = feet per second, ft=feet
[a] Design velocity is based on the type of fish facility and could be greater for culverts. If culverts are recommended, follow the design velocities in Table 7-1 from National Marine Fisheries Service (National Marine Fisheries Service 2011).

For depth, all conceptual designs allow for a minimum flow depth of one foot at the lowest design flow. For jump, the conceptual designs must minimize the need for jumping. Where this is not possible, the conceptual design was designed to ensure that the water surface elevation difference upstream and downstream of a fish passage feature was kept at or below the maximum jump height of 1.0 foot.

Fishway-specific velocity criterion were used for each conceptual design, and are described in Appendices B, C, and D. Generally, the conceptual designs meet the velocity criterion of 5.0 feet per second (fps), but the design velocity can differ depending on the type of fish passage facility. For example, for the EBCS, the bays of the structure function similarly to concrete box culverts. As a result, the NMFS passage criteria for culverts, which allow a maximum flow velocity of 6.0 fps, apply to this structure. The velocities for each of the conceptual designs were kept below the maximum design velocity through the design water-surface profile, and for a range of flows. But, in some cases, design features that cause abrupt changes in the water surface profiles, such as drop weirs or structures, caused the velocities to exceed the maximum design velocity. These design features will need to be refined during the next phase of design.

For each conceptual design, hydraulic modeling and analysis were required to ensure that the fish-passage criteria were met. This included evaluating depth, velocity, and hydraulic drop for a range of flows. The software used to complete the hydraulic modeling was the Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 4.1.0 developed by USACE. The HEC-RAS model simulates one-dimensional flow that assumes steady, gradually-varied flow. Each of the conceptual designs was modeled using modified versions of base models originally developed by Tetra Tech, Inc. to support the SJRRP. Generally, the models use topographic mapping based on light detection and ranging information that was collected in 2008, in addition to bathymetry data that were collected in 2010 and 2011. The hydraulic models were developed to assess each of the conceptual designs independently, but all of the models use the same boundary conditions derived from the base model.

3.3 Flood Flow Capacity

The conceptual designs must minimize impacts on the flood system. The Central Valley Flood Protection Board requires that structures produce less than a 0.1-foot rise in flood elevations at the design-flow capacity. The existing flood flow capacity at each Group 1 structure is listed in Table 3-4, by reach and structure. The flood capacities are based on the schematic of design-flood capacity flows from the operation and maintenance (O&M) manual for the Lower San Joaquin River Flood Control Project (LSJRFCP) (U.S, Army Corps of Engineers 1967 [Amended in 1978]).

Table 3-4 Flood Flow Capacity for Group 1 Structures

Reach	Structure	Flood Flow Capacity(cfs)
Middle Eastside Bypass	Eastside Bypass Control Structure	8,000
Middle Eastside Bypass	Dan McNamara Road	16,500
Middle Eastside Bypass	Lower Merced Refuge Weir	16,500
Middle Eastside Bypass	Upper Merced Refuge Weir	16,500

Note:
cfs = cubic feet per second

To show that each conceptual design met the 0.1-foot rise requirement, hydraulic models were used to simulate the water surface profile at the flood capacity flows with and without the installation of each conceptual design. All of the conceptual designs achieved this requirement. A few of the conceptual designs added significant amounts of material as fill into the flood channel, which reduced the capacity at flood flows. For these conceptual designs, additional channel and floodplain grading is proposed to maintain existing capacity and the water surface elevation at flood capacity flows to within 0.1 foot. The conceptual designs did not consider possible decreases in channel capacity at flows less than the maximum flood flows.

3.4 Ground Subsidence

Ground subsidence in the project area has caused the ground elevation to decrease over time. Recent monitoring conducted by Reclamation shows that subsidence rates within the vicinity of the San Joaquin River and bypass system have ranged from approximately 0.15 foot to 0.75 foot per year from December 2011 through December 2013 (San Joaquin River Restoration Program, 2015b). The Middle Eastside Bypass is located on the boundary of the subsidence area, with the greatest impacted areas upstream within the Upper Eastside Bypass and Chowchilla Bypass. Subsidence has caused the channel near the area of the Group 1 structures to flatten. Subsidence may also cause more sediment erosion from the upstream portion of the bypass to deposit near the Group 1 structures. As a result, the subsidence in the area may impact how sediment is transported through the reach, the resulting channel hydraulics, and the local channel flood capacity. Because of this, the SJRRP requires that ground subsidence be considered in all future improvement projects, assuming a subsidence rate for 25 years.

The conceptual designs consider subsidence based on the methodology and guidance provided in the preliminary draft Technical Memorandum No. SUB-1 Subsidence Design Criteria for the SJRRP (U.S. Bureau of Reclamation 2013b), which is currently being updated by Reclamation. The total amount of subsidence that will be considered for the Group 1 structures is 1.25 feet, which is based on an assumed subsidence rate of 0.05 foot per year during a 25-year period.

4. Existing Conditions

An analysis was conducted on the existing condition of each existing Group 1 structure to develop the conceptual designs. The analysis involved reviewing as-built drawings, hydraulic design, performance data, and operational data, as well as site visits to confirm operational assumptions. The following section provides a brief description of each Group 1 structure and its current operating conditions. The analysis performed for each Group 1 structure is detailed in Appendices B, C, and D.

4.1 Structure Descriptions

The Group 1 structures are located within the Eastside Bypass, which is part of the LSJRFCP that provides flood control for the region. The LSJRFCP includes the Chowchilla Bypass, Eastside Bypass, and the Mariposa Bypass. The LSJRFCP is operated and maintained by the Lower San Joaquin Levee District (LSJLD). The LSJRFCP is designed to prevent flood damages by taking peak flood flows from the San Joaquin River near Mendota and directing the flows down the Chowchilla Bypass and Eastside Bypass. The bypass system was designed as a trapezoidal flood-control channel with a low-flow channel and levees on the banks to assist in flood flow conveyance. Levees within this section of the bypass vary in height from about 7 feet to 10 feet.

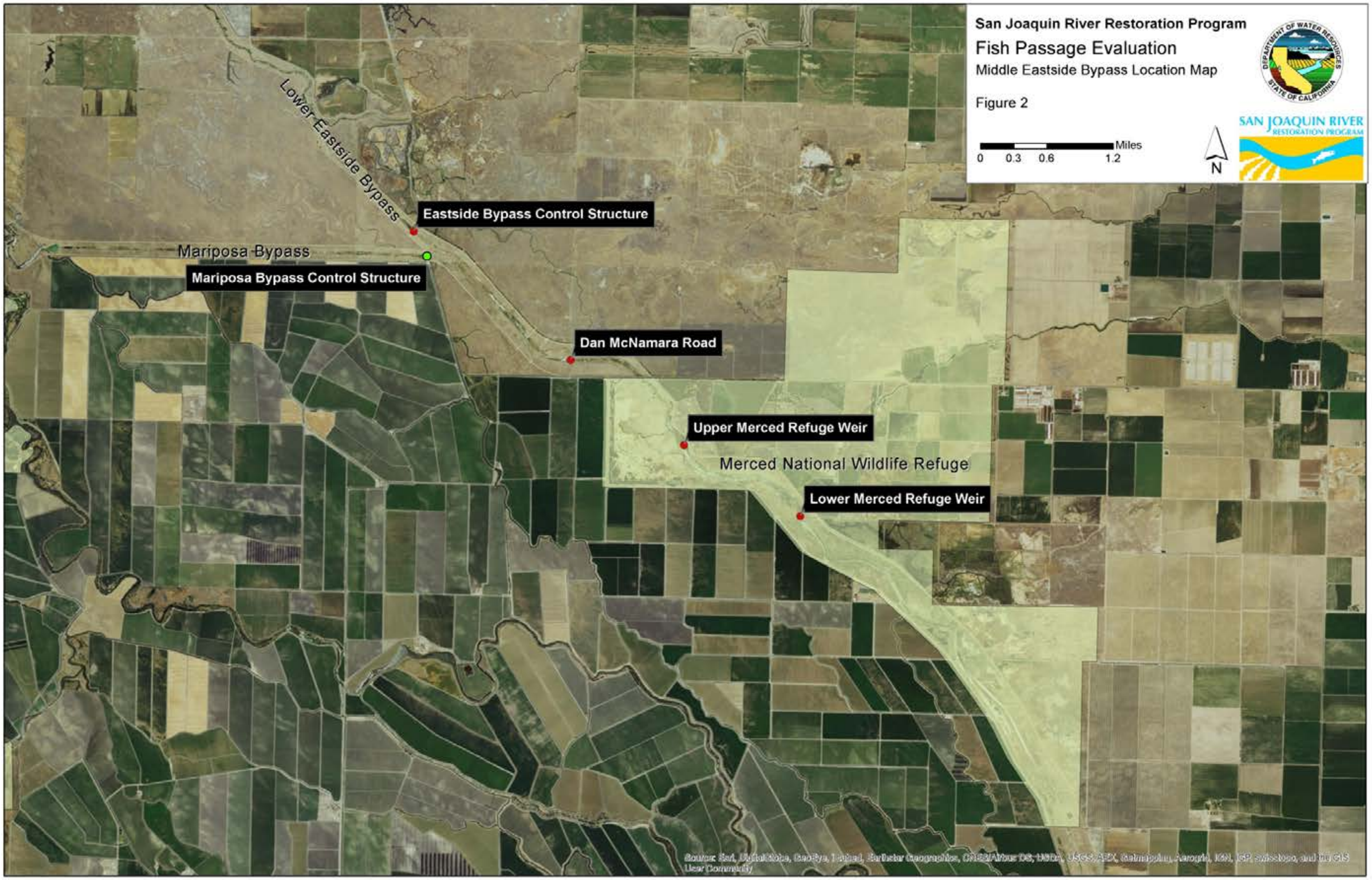
The Group 1 structures, which include the EBCS, Dan McNamara Road, and the MNWR weirs, are located within Merced County and the Middle Eastside Bypass. Figure 2 provides a location map that shows the Group 1 structures in the Middle Eastside Bypass. The Middle Eastside Bypass extends from the Sand Slough connector channel to the Eastside Bypass Control Structure. Flood flows from Reach 4A of the San Joaquin River and the Chowchilla Bypass can be diverted into the bypass system at the head of this reach. The Group 1 structures are within about 6 miles of each other, with the EBCS being the farthest downstream.

4.1.1 Eastside Bypass Control Structure

The EBCS is located within the Middle Eastside Bypass approximately 1,100 feet downstream of the head of the Mariposa Bypass. The EBCS functions integrally with the Mariposa Bypass Control Structure (MBCS) to control the division of flows between the Eastside Bypass and the Mariposa Bypass. These flows are subject to the O&M rules set forth by the LSJRFCP.

The EBCS is a control structure that is divided into six 20-foot gated bays and is nearly 70-feet long measured longitudinally (Photo 1). The bays have radial gates, operated manually, with notches on the bay walls at the inlets for boards. The boards are placed into the bays to control the water surface elevation upstream of the EBCS to route flood flows into the MBCS. These boards are currently in place at each bay inlet at a height of approximately 4 feet. At the downstream end of the concrete apron there is a 2-foot high concrete sill and a layer of riprap in the channel downstream for erosion protection.

Figure 2 **Middle Eastside Bypass Location Map**



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Photo 1 **Eastside Bypass Control Structure from the Mariposa Bypass Control Structure Looking Downstream at the Eastside Bypass**

4.1.2 Dan McNamara Road

Dan McNamara Road is a low-flow crossing, located within the Eastside Bypass, less than 2 miles upstream from the EBCS, and is accessible from Sandy Mush Road (Photo 2). The low-flow road crossing is a Merced County public road. The gravel-armored road has a culvert located at the center of the Eastside Bypass low-flow channel. The culvert has limited capacity, so the road is frequently overtopped when there are flood flows, which occur every 4 to 5 years. The road is closed by the County when the depth of water in the road reaches several inches. When the road floods the County establishes a detour that directs traffic, from Sandy Mush Road or Dan McNamara Road, onto the right bank levee of the Eastside Bypass.

4.1.3 Merced National Wildlife Refuge Weirs

There are two weirs in the Eastside Bypass operated by the USFWS within the MNWR. The Lower Merced Weir (Photo 3) is less than 1 mile south of the Sandy Mush Road and approximately 1.4 miles downstream of the Upper Merced Weir (Photo 4). Of the two weirs, the Lower Merced Weir is slightly longer and taller. The two weirs were constructed to divert water from the bypass into the MNWR to irrigate its wetlands. The MNWR is dependent on the available water sources from three supplies, the Merced Irrigation District, the bypass, and groundwater. Water that is diverted from the bypass for irrigation of the MNWR wetlands is generally opportunistic, and is available from either upstream MNWR drainage inputs or flood flows. The flows are diverted into the wetlands by installing wooden boards to raise the water surface elevations in the pool between the two weirs. This allows the water in the bypass to flow into an earthen irrigation channel on the left side of the overbank within the West Wetlands. A mobile gator pump is at the end of the irrigation channel and pumps water into the West Wetlands. The boards are typically placed for diversions from September through March. Figure 3 shows the boundary (shown in orange) and location of the MNWR wetland and irrigation facilities.

Photo 2 Dan McNamara Road when Partially Overtopped

Photo 3 **Lower Merced Weir Looking Downstream Toward the West (Left) Bank**

Photo 4 **Upper Merced Weir Looking Downstream toward the East (Right) Bank**

4.2 Operational Constraints

This section describes the operational constraints of the flood-control bypass system and the current impediments to upstream fish passage in the bypass.

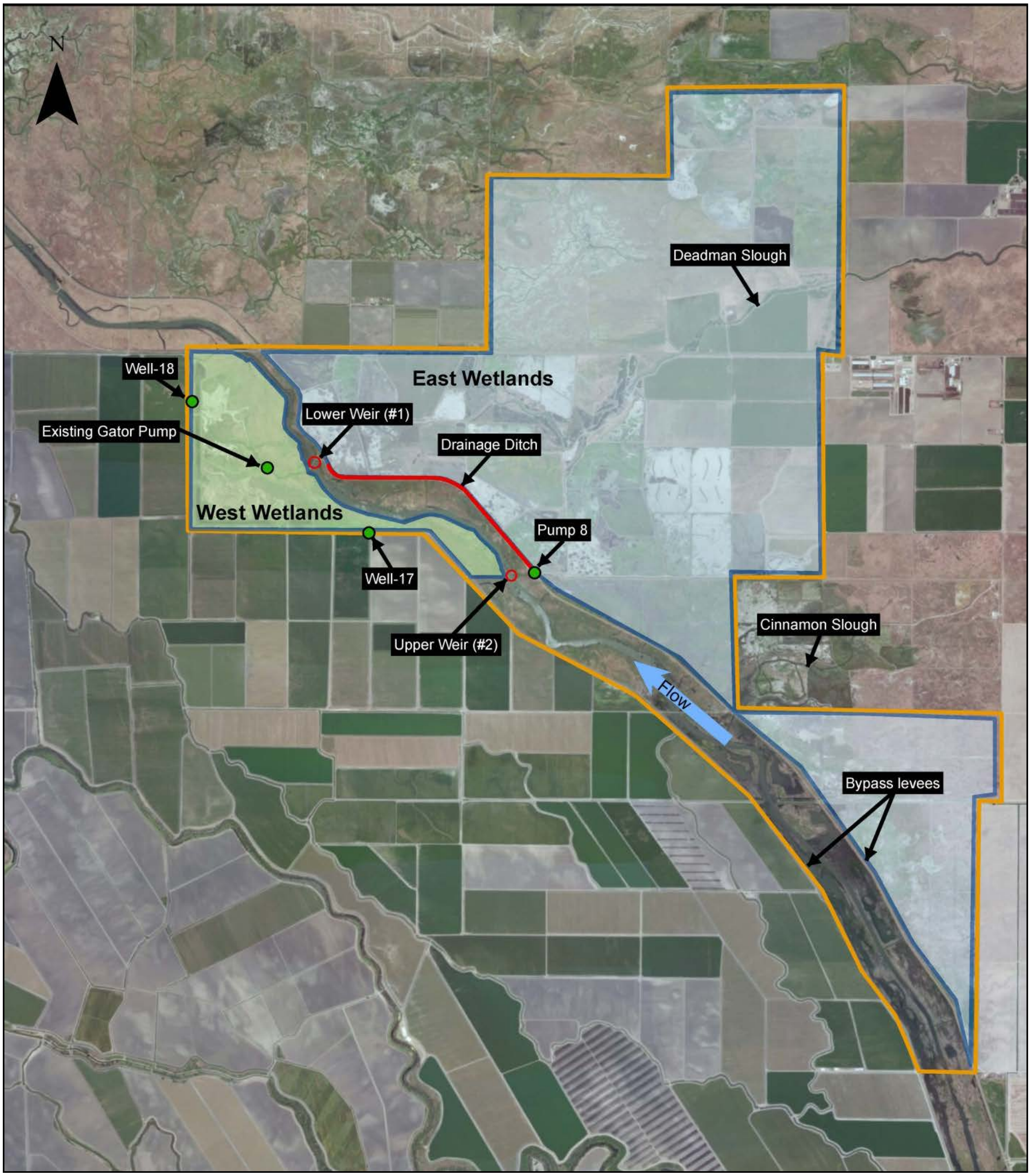
4.2.1 LSJRFCP Flood Operations

The gate operations for the EBCS have a significant impact on the overall performance of the bypass system for flood flow conveyance because they determine the amount of flow that is allocated into either the Lower Eastside Bypass or the Mariposa Bypass. The Eastside Bypass typically has flood flows during wet years, making the migration of adult Chinook salmon possible while the EBCS gates are in operation. During periods of flooding, the MNWR weirs' boards are typically removed in order to maintain the flood capacity of the bypass.

The Eastside Bypass design flow between Sand Slough and the Mariposa Bypass is 16,500 cfs. Any flood flow that exceeds 16,500 cfs within the Eastside Bypass at the Mariposa Bypass must be divided between the Lower Eastside Bypass and the Mariposa Bypass (California Department of Water Resources 1969). Flood flow routing through the ESBC is dictated by the O&M manual for the LSJRFCP (California Department of Water Resources 1969). The manual stipulates that the first 8,500 cfs of flood flow should be diverted through the MBCS, which is performed by closing the radial gates at the EBCS. When flows at the MBCS exceed 8,500 cfs, the flood flows are sent down the EBCS and split between the two bypass channels. The LSJLD does have some flexibility in making routing decisions.

The O&M procedures are typically performed during rain events to provide enough flood flow capacity within the Lower Eastside Bypass for incoming flows from downstream tributaries from the Merced County Stream Group, which consists of Deadman Creek, Owens Creek, and Bear Creek. During snow melt events, with little or no tributary incoming flows into the Lower Eastside Bypass, flood flows are typically directed into the Eastside Bypass first and allowed to freely flow into the Mariposa Bypass without operation of the EBCS gates.

Figure 3 **Merced National Wildlife Refuge Wetlands and Irrigation Facilities**



4.2.2 Fish Passage Constraints

Fish passage is currently impeded for upstream migrating adult Chinook salmon within the Eastside Bypass at all four of the Group 1 structures. Without improvements to these structures, fish passage within the Middle Eastside Bypass would be impeded for flows of less than 3,000 cfs.

Upstream migrating fish would first encounter the riprap downstream of the EBCS sill, which limits the ability of salmonids to jump over the sill. A sufficient pool to allow for migrating fish to jump over the sill and over the EBCS boards at the upstream end of the structure is not achieved until flows exceed 700 cfs.

The next potential barrier to migrating fish is Dan McNamara Road. Velocities within the culvert at the road exceed 6 fps for flows less than 50 cfs, so migrating fish would need to pass over the road. Sufficient flow depth over the road does not occur until flows exceed 600 cfs.

Once the fish are able to pass Dan McNamara Road, they will encounter the MNWR weirs. Because the MNWR weirs have boards in during a majority of the period when spring-run and fall-run adult Chinook salmon are migrating, it is assumed that passage will not occur until the Lower Merced Weir is overtopped and there is sufficient depth over the weir. This does not occur until flows exceed about 3,000 cfs. Because the Upper Merced Weir is submerged at flows more than about 700 cfs, passage at the Upper Merced Weir would be unimpeded once fish have migrated past the Lower Merced Weir.

Unimpeded flow ranges, developed during Task 2, are listed in Table 4-1 (California Department of Water Resources 2012). These structures need to be improved because they do not meet the fish passage criteria set forth in Table 3-3 for the flow range specified in Table 3-2.

Table 4-1 Unimpeded Fish Passage Range of Flows

Structure	Adult Chinook Salmon Unimpeded Passage Range (cfs)
Eastside Bypass Control Structure	700 – 8,500[a]
Dan McNamara Road	600 – 4,500[a]
Merced Refuge Weir #1, Lower[b]	3,000 – 8,500[a]
Merced Refuge Weir #2, Upper[b]	700 – 8,500[a]

Notes:
cfs = cubic feet per second
[a] This is the largest flow that was modeled; the unimpeded passage flow could be much greater.
[b] The flow range assumes that boards are installed at the weir during migration.

5. Conceptual Designs

The conceptual designs for the Group 1 structures are briefly summarized in the following sections. As described in "Section 3 Design Criteria," the conceptual designs meet the design criteria for flow, fish passage, and flood capacity. Detailed descriptions of the conceptual designs and methods used to determine the conceptual design alternatives are provided in Appendices B, C, and D for each structure, respectively.

5.1 Eastside Bypass Control Structure

Four conceptual design alternatives were developed for the EBCS. The conceptual design alternatives present solutions for the flow, fish passage, and flood capacity issues present at this location. The following sections briefly describe the conceptual designs proposed for the EBCS. The conceptual design development, criteria, analysis, and recommendations are described in detail in Appendix B.

In developing the conceptual design alternatives at the EBCS, the current gate operations and assumptions of the EBCS during flood events were assumed to remain unchanged. The upstream migratory pathway for all of the conceptual designs assumed that the Restoration Flows, flows up to 4,500 cfs, would flow through the EBCS without the need for gate closure at the EBCS. But, during a wet year, when flood flows occur during fish migration, it is possible that the gates on the EBCS would need to be closed. While gate closure has not known to have occurred and is highly unlikely, for planning purposes, it was assumed that gate closure may occur one or two times in every 5 years during the spring-run migration period. Gate closure is considered a future possibility based on Restoration Flow volumes and routing. Gate closures could occur for several days, to weeks or months, and would prevent upstream passage through the EBCS.

5.1.1 Alternative EBCS-1 – Structure Modification and Rock Ramp

This fish passage conceptual design would consist of modifying the EBCS by removing boards at the EBCS inlet, notching the downstream sill, and constructing a rock ramp downstream of the notch to provide a fishway entrance into the EBCS (Attachment B, Section 15.1.1, Figure 4). This conceptual design assumes that during Restoration Flows, fish would migrate through the EBCS and that the gates on the EBCS would be fully open. Migrating fish would enter the rock ramp about 250 feet downstream the EBCS sill, eliminating the current jump barrier at flows less than 700 cfs. The longitudinal slope of the rock ramp would be 0.01 foot/foot. The rock ramp design simulates a roughened channel fishway that is lined with rocks and boulders to provide hydraulic diversity. The ramp would be configured with a low flow v-notch to ensure adequate depth at the low-passage design flow. The notch at the downstream sill would be located within the center of the EBCS and would be 32 feet wide and 2 feet deep. In addition, the boards at the EBCS inlet would be removed, which eliminates the second jumping barrier at flows below 700 cfs where the migrating fish would exit.

5.1.2 Alternative EBCS-2 – Grade Control

This fish passage conceptual design would consist of adding a series of weirs downstream of the EBCS (Attachment B, Section 15.1.1, Figure 8). Each weir would be constructed of either sheet piles or cast-in-place concrete. The weirs would inundate the EBCS, which would provide sufficient depth to allow for fish to pass over the downstream sill at the low design flow. A series of seven weirs that would be cast-in-place concrete or sheet piles would be placed within the channel beginning, at the most upstream weir, approximately 780 feet downstream of the EBCS. These weirs would be individual structures that would have native streambed material that would be backfilled between each weir. This design would allow the water surface elevation to be incrementally increased to provide fish passage. For this conceptual design, an estimated minimum of 300 feet of spacing was assumed between the weirs.

5.1.3 Alternative EBCS-3 – Bypass Fishway

This fish passage conceptual design would consist of adding a bypass fishway channel to provide an alternate route for fish to pass through the EBCS when passage is impeded and is less than 700 cfs (Attachment B, Section 15.1.1, Figure 15). The Eastside Bypass main channel flow would be split between the bypass fishway channel path leading to the fishway exit and the EBCS gates. The fishway would penetrate the existing earthen headwall on northeast side of the EBCS. Three culverts, similar to the existing EBCS, will be constructed to continue to provide vehicular traffic access. To retain the ability for the EBCS to be operated as designed, the culverts will be equipped with slots for stoplogs that can be put into place during flood flows, if needed.

The fishway channel will have a trapezoidal channel shape with a 10-foot bottom width and a varying depth of about 6 feet, on average, from the bank to the channel invert. The channel will have a chute and pool configuration with each of the sections approximately 60 feet. Between the pool and chute section will be a series of rock bands that will be used to stabilize the channel. The proposed fishway channel substrate will be constructed of engineered streambed material that will be a combination of rounded boulders, cobble, gravel, and course sand.

5.1.4 Alternative EBCS-4 – Vertical-Slot Fishway

This fish passage conceptual design would consist of constructing a vertical-slot fishway adjacent to the EBCS (Attachment B, Section 15.1.1, Figure 19). The fishway would be designed to allow for fish passage at flows less than 700 cfs when passage is impeded. The vertical-slot fishway would be located adjacent to the bays of the EBCS, and would have a fishway entrance located within the EBCS wingwall that is just downstream of the sill. Similar to the bypass fishway, this conceptual design is at the same location on the right bank, and the fishway would need to penetrate the existing earthen headwall at the EBCS. The fishway would be constructed within the earthen headwall, requiring the fishway side walls to be constructed as tall as the current EBCS concrete bays. A grated top would be added to provide access for vehicle traffic and to provide natural light to the fishway. The fishway headwall would be made of smooth concrete and would match the existing structure headwall. The fishway headwall would need to key into the EBCS and would require some modification to the existing headwall to allow for the proper anchoring to be placed. The sections of earthen headwall would be armored with round cobble the same size as the current armoring.

Part XII of the DFG *California Salmonid Stream Habitat Restoration Manual* (Fish Passage Design and Implementation Section) is the primary guidance that was used to size the fishway. The dimensions for a vertical-slot fishway are fixed depending on the slot size. The vertical slot width for this fishway would be 1 foot wide, resulting in pool dimensions of 10 feet in length by 8 feet in width with a 1-foot drop between pools. Based on the current elevations upstream and downstream, the fishway length would be approximately 80 feet and would consist of six pools and two exit pools.

5.2 Dan McNamara Road

Three conceptual design alternatives were prepared for Dan McNamara Road. The conceptual design alternatives present solutions for the flow, fish passage, and flood capacity issues present at this location. The following sections briefly describe the conceptual designs proposed for Dan McNamara Road. The conceptual design development, criteria, analysis, and recommendations are described in detail in Appendix C.

5.2.1 Alternative DMR-1 – Modified Low Flow Crossing with 5-Barrel Box Culvert

This fish passage conceptual design for Dan McNamara Road would consist of replacing the existing road and culvert with five pre-cast concrete box culverts that would each be 12 feet wide and 12 feet tall (Attachment B, Section 15.1.2, Figures 4 and 5). The new culverts would be designed so that flows more than 1,150 cfs will pass over the road, at which point traffic would be rerouted as it is currently during road flooding events. This would allow vehicle access during most restoration flows with the exception of the spring pulse for several restoration water-year types. The new road would be approximately 40 feet wide and its elevation would be approximately 4 feet higher than the existing road grade. To meet flood requirements and to improve the sediment transport and hydraulics through the culverts, approximately 1,000 feet of the main channel would be graded upstream and downstream of the crossing.

5.2.2 Alternative DMR-2 – Crossing Removal

This fish passage conceptual design would consist of completely removing and abandoning Dan McNamara Road from the Eastside Bypass. The Restoration Flow easement for the Eastside Bypass at the existing Dan McNamara Road has already been acquired by Reclamation. Abandoning the crossing would include removing the existing culverts and roadway embankment, and constructing a cul-de-sac (Attachment B, Section 15.1.2, Figure 10). After the road was removed, channel excavation would be needed to restore the original bypass channel slope. Closing the road would require that traffic be re-routed onto other public roads to get from one side of the bypass to the other.

5.2.3 Alternative DMR-3 – Crossing Removal with Modified Detour

Similar to Alternative DMR-2, this fish passage conceptual design would include removing the existing culvert crossing. But, instead of rerouting traffic onto existing public roads, this alternative includes improving the existing detour for Dan McNamara Road (Attachment B, Section 15.1.2, Figure 15). The goal of improving the existing detour would be to provide access that is equal to or better than what exists on the levee from Dan McNamara Road to Sandy Mush Road. The levee would be expanded to provide for a 60-foot rural roadway, which would be wider than the existing Dan McNamara Road. The existing detour easement varies in width from 135 feet to 175 feet, so additional right-of-way may need to be acquired to accommodate the improved levee. In addition, portions of the adjacent Deadman Creek, and its associated infrastructure, would need to be relocated. Improvements to the bypass levee to allow for a wider road would need to meet USACE and Merced County improvement and specification standards.

5.3 Merced National Wildlife Refuge Weirs

Three conceptual design alternatives were prepared for the MNWR weirs. The conceptual design alternatives present solutions for the flow, fish passage, and flood capacity issues present at this location.

The following sections briefly describe the conceptual designs proposed for MNWR weirs. The conceptual design development, criteria, analysis, and recommendations are described in detail in Appendix D.

5.3.1 Alternative MNWR-1 – Direct Pumping from East Wetlands to West Wetlands

Under this alternative, the lower and upper weirs would be removed from the bypass channel and the channel would be regraded at the weir locations to remove accumulated debris. Water deliveries for irrigation of the West Wetlands would be conveyed by directly pumping the drainage water from the East Wetlands using the MNWR's existing pipeline network and pump system (Attachment B, Section 15.1.3, Figure 6). The pump system would generally provide the MNWR with a water supply that is equivalent to what it has now. But, if irrigation water is delivered to the MNWR via the Eastside Bypass, additional measures, such as the use of the existing mobile gator pump, may be needed. To accommodate the use of the mobile gator pump, the existing ditch that serves the West Wetlands would be excavated to match the invert of the bypass channel.

5.3.2 Alternative MNWR-2 – Screened Pump Intake in the West Wetlands

Under this alternative, similar to Alternative MNWR-1, both weirs would be removed and the channel would be regraded at the locations of the two weirs. A fixed-screened intake and pump station would be constructed to provide the MNWR with a water supply equivalent to its current supply (Attachment B, Section 15.1.3, Figure 8). The pump station would be a permanent facility located within the channel to minimize construction disturbance to the wetlands. This facility would contain one pump rated to lift 10 cfs over a head of approximately 20 feet.

5.3.3 Alternative MNWR-3 – Rock/Boulder Weir

Under this alternative, portions of the existing weir, such as the metal grating and miscellaneous structural steel, would be removed and replaced with a series of rock weirs to allow passage (Attachment B, Section 15.1.3, Figure 9). The first rock weir would be placed at the same elevation of the existing weir to allow the MNWR gator pump to continue operating as it does now. The first rock weir would be stabilized with a 20-foot-deep anchored sheet pile. It would also have an upstream berm sloped at a ratio of 3:1 for additional stability.

The hydraulic drop between the successive rock weirs would be about 1 foot, resulting in six stepped rock weirs and six pools. The slope from the upstream to the downstream weir, where it meets the existing channel grade, would be about 3 percent. The distance between each weir would be approximately 33 feet for a total distance of 198 feet. In between successive weirs, there would be engineered pools of approximately 2-feet depth for resting. The weirs would be in the planform of an arch or chevron with the apex pointing upstream. The apex of the weir would have an angle of 120 degrees. To avoid excessive upstream backwater effects and downstream scour, the side slopes of the weir should not exceed a ratio of 5:1. The side slopes would come together to form a v-notch in each weir to allow flow depths sufficient to provide passage at low flows.

5.4 Benefits and Consequences

In an effort to develop a variety of fish passage facilities that address the passage constraints at each structure, each conceptual design is unique and has its own set of benefits and consequences. Table 5-4 summarizes the conceptual design alternatives’ facility type, upstream passage path, benefits, and consequences. More detailed information on the benefits and consequences for each conceptual design are summarized in the conceptual design packages in Appendices B, C, and D.

Table 5-4 Comparison of Benefits and Consequences for Each Conceptual Design Alternative

Conceptual Design Alternative	Passage Type	Upstream Passage Path	Benefits[a]	Consequences[a]
Eastside Bypass Control Structure				
EBCS-1 Structure Modification and Rock Ramp	Natural, Culvert	Through rock ramp into existing EBCS bays	• Removes current jumping barriers. • Fish passage remains in channel, so there is no confusion during juvenile outmigration.	• Fish swim through the EBCS. • Removing the boards changes the flood flow routing into the Mariposa Bypass and EBCS overall capacity. • Velocities during flood flows within the EBCS exceed the velocity fish-passage criterion. • Potential barrier during gate operations on the EBCS.
EBCS-2 Grade Control	Weir, Culvert	Over weirs into EBCS culvert bays	• Removes current jumping barriers and fish swim through the EBCS. • In channel, so no confusion during juvenile outmigration.	• Could change Restoration Flow and flood flow routing into Mariposa Bypass. • Velocities during flood flows within the EBCS exceed the velocity fish-passage criterion. • Potential barrier during gate operations. • Not friendly for non-jumping fish species. • Creates a large pool between the weir and the EBCS.
EBCS-3 Bypass Fishway	Natural	Through nature like channel	• Friendly for non-jumping fish species • Bypasses EBCS for passage	• Gates on fishway for flood operations are needed. • Fish passage entrance could be hard to find.
EBCS-4 Vertical-Slot Fishway	Fish Ladder	Through fish ladder	• Bypasses EBCS for passage.	• Gates on fishway for flood operations are needed. • Fish passage entrance could be hard to find. • Not friendly for all fish species. • May need auxiliary flow.
Dan McNamara Road				
DMR-1 Low Flow Crossing with Culvert	Weir, Culvert	Through culverts or over road	• Maintains current public access.	• Potential stranding issues. • Crossing will be closed during higher Restoration Flows. • May add higher maintenance costs.
DMR-2 Crossing Removal	Removal	Channel	• Removes barrier.	• Removes public access to Dan McNamara Road from Sandy Mush Road. • Traffic may be rerouted up to 25 miles to maintain access.
DMR-3 Crossing Removal with Detour	Removal	Channel	• Removes barrier. • Maintains public access. • Improves the existing levee.	• Limits ability to improve levees in the future. • Relocates Deadman Creek.

Conceptual Design Alternative	Passage Type	Upstream Passage Path	Benefits[a]	Consequences[a]
Merced National Wildlife Refuge Weirs				
MNWR-1 Direct Pumping	Removal	Channel	• Removes barrier, restores channel. • Improves conveyance of flood flows within the bypass	• Refuge would need to use the existing gator pump for irrigation water that is from the Eastside Bypass.
MNWR-2 Screened Pump Intake	Removal	Channel	• Removes barrier, restores channel. • Improves conveyance of flood flows within the bypass. • Allows gator pump to be used anywhere as needed.	• Potential silting of the pump intake. • Irrigation deliveries in the Eastside Bypass must be above 20 cfs. • Scour of the Eastside Bypass channel would reduce ability to pump for irrigation. • Potential for straying during low flows.
MNWR-3 Rock/Boulder Weir	Natural	Over weirs	• Removes barrier.	• Permanent fixed pool elevation upstream of the weir. • Increases water surface elevation upstream, reducing channel capacity • Not friendly for non-jumping fish species.

Notes:

cfs = cubic feet per second, DMR = Dan McNamara Road, EBCS = Eastside Bypass Control Structure, MNWR = Merced National Wildlife Refuge

[a] Benefits and consequences consider the comments received at the stakeholder workshop held on July 16, 2015 by California Department of Water Resources (DWR). Attendees included representatives from DWR, U.S. Bureau of Reclamation, National Marine Fisheries Service, California Department of Fish and Wildlife, and U.S. Fish and Wildlife Service.

6. Cost Estimates

The costs were developed based on similar construction projects in the San Joaquin Valley. The costs include construction-related items such as permitting, regulatory compliance, environmental compliance (including the California Environmental Quality Act), construction management, program implementation, and construction contingency. Cost percentages are shown in the tables of Appendices B, C, and D.

These cost estimates assume that construction would occur in dry conditions. Completing construction when there is Restoration Flows or flood flows (i.e., wet conditions) would add considerable costs. Annual O&M costs were not developed, but are discussed in the following section. A summary of projected capital costs for each conceptual design alternative is provided in Table 6-1.

Table 6-1 Summary of Capital Costs for Conceptual Design Alternatives

Conceptual Design Alternative	Title	Capital Cost
Eastside Bypass Control Structure		
EBCS-1	Structure Modification and Rock Ramp	$3.4 million
EBCS-2	Grade Control	$5.1 million
EBCS-3	Bypass Fishway	$8.8 million
EBCS-4	Vertical-Slot Fishway	$4.6 million
Dan McNamara Road		
DMR-1	Modified Low Flow Crossing with 5-Barrel Box Culvert	$6.5 million
DMR-2	Crossing Removal	$1.9 million
DWR-3	Crossing Removal with Modified Detour	$17.0 million
Merced National Wildlife Refuge		
MNWR-1	Direct Pumping from East Wetlands to West Wetlands	$3.9 million
MNWR-2	Screened Pump Intake in the West Wetlands	$1.4 million
MNWR-3	Rock/Boulder Weir	$2.4 million

Notes:
DMR = Dan McNamara Road, EBCS = Eastside Bypass Control Structure, MNWR = Merced National Wildlife Refuge

The estimated quantities, costs, and the preliminary engineering drawings are not intended for bidding or construction purposes, because final designs may result in changes to any or all quantities and costs. Each conceptual design has a line-item cost estimate that is documented within the conceptual design packages located in Appendices B, C, and D.

7. Operations and Maintenance

O&M requirements can decrease agency resources, and may be a factor in deciding on the improvements chosen for implementation. At this stage of conceptual design, annual O&M costs were not included in the total project cost for each alternative. But, the O&M needs of the conceptual designs can be anticipated based on the type of structure and general assumptions that can be made about each type of improvement. As a result, the conceptual designs were categorized based on facility type and the related O&M considerations for each facility type are summarized in this section. Table 7-1 provides the facility type for each conceptual design alternative. Appendices B, C, and D provide a more detailed discussion of the potential O&M requirements for each conceptual design.

Table 7-1 Facility Type for each Conceptual Design Alternative

Conceptual Design Alternative	Description	Facility Type
Eastside Bypass Control Structure		
EBCS-1	Structure Modification and Rock Ramp	Natural and Culvert
EBCS-2	Grade Control	Weir and Culvert
EBCS-3	Bypass Fishway	Natural
EBCS-4	Vertical-Slot Fishway	Fish Ladder
Dan McNamara Road		
DMR-1	Low Flow Crossing with Culvert	Weir and Culvert
DMR-2	Crossing Removal	Removal
DWR-3	Crossing Removal with Detour	Removal
Merced National Wildlife Weirs		
MNWR-1	Direct Pumping	Removal
MNWR-2	Screened Pump Intake	Removal
MNWR-3	Rock/Boulder Weir	Natural

Notes:
DMR = Dan McNamara Road, EBCS = Eastside Bypass Control Structure, MNWR = Merced National Wildlife Refuge

7.1 Removal

Removal of the existing fish passage barrier is typically the preferred improvement option. After the structure is removed, the channel would be restored to mimic the natural channel slope and shape. Because the channel restoration would occur within the Eastside Bypass, minimal annual maintenance is assumed and would likely become part of the current channel maintenance program. Conceptual designs that include structure removal typically also include other improvements, such as adding roads to maintain access, or pumps to maintain irrigation deliveries. These additional components of the conceptual designs will add O&M costs to the agencies that will manage these facilities.

7.2 Natural

To ensure unimpeded fish passage, nature-like fishways, such as rock ramps or bypass channels, would be preferred over fishways that require active operation. Natural fishways simulate a natural channel and require minimal annual O&M. Because the Group 1 structures are located within a flood control facility, the proposed nature-like fishways at the EBCS will be operated with gates during floods, as needed. In addition, the occasional extreme flood event that exceeds the design-flood capacity of the bypass may move the material within the nature-like fishway, which would then likely require repairs. Because flood events that exceed the design capacity are rare, it is assumed that these costs would be a one-time occurrence and not an annual O&M cost.

7.3 Culvert

The annual maintenance costs for the proposed and existing culverts are assumed to be minimal, but could include repairs to the embedded material within the culvert, replacing riprap, and standard annual road maintenance and inspection. Annual maintenance could also include removal of large debris from the culverts, as needed.

7.4 Weir

Annual maintenance for weirs may include clearing of debris and sediment, if needed. Additional costs are possible for the Dan McNamara Road low-flow crossing after flood events that exceed the design capacity. These costs would not likely occur on an annual basis.

7.5 Vertical-Slot Fishway

Annual O&M assumptions for the vertical-slot fishway should include the need for staff to be present during most, or all, of the upstream migration of adult salmonids. This type of fishway needs to be clear of debris and sediment to function properly, so routine maintenance would be needed. Proposed flood gates at the fishway would be operated during flood events that require full gate closure on the EBCS. Operation of the fishway gates would be dependent on flood-flow events and would not be an annual occurrence.

8. Summary of Results and Next Steps

To provide unimpeded passage for fish along their migratory pathway and connectivity to the San Joaquin River and bypass system, improvements are needed at key fish passage barriers. Four barriers were identified as Group 1 structures, and are included as Task 3, Volume I of the *Fish Passage Evaluation Plan*. The SJRRP Framework has established a goal that improvements for the Group 1 structures will be constructed in 2019. To address fish passage issues at the Group 1 structures, conceptual designs were developed that, at a minimum, will improve fish passage for adult Chinook salmon. In addition, several conceptual designs that were developed could also potentially improve fish passage for other fish species and life stages.

Conceptual designs of the Group 1 structures included bypass fishways, weirs, rock ramps, and structure removal. In general, all of the conceptual designs satisfy the fish-passage criteria for depth, velocity, and jump for the design range of flows, as well as the flood-capacity criterion. Because a final flow-routing decision for the Reach 4B project has not been selected, hydrology was simulated for three SJRRP flow-routing scenarios. The flow-routing scenarios were used to identify the range of design flows for use in developing the conceptual designs. If the flow-routing alternatives change, the final design of the conceptual designs may require use of a different range of design flows or changes to the design so that it still meets the fish-passage criteria. In addition, the SJRRP is currently developing design guidelines for fish passage of all SJRRP projects, so the next phase of design will need to ensure these criteria are met.

The capital cost of the improvements ranged from approximately $1.4 million for structure removal to $17 million for structure removal and levee improvements. In general, capital costs for bypass fishways, rock ramps, or culverts were between $2.4 million and $8.8 million. These costs do not include O&M or modifications to the designs to allow for passage of other species and life stages. Additionally, the determination of the final SJRRP flow-routing decision could significantly increase costs.

The next step is for the SJRRP to select one or two preferred conceptual design alternatives for each Group 1 structure and to develop preliminary engineering designs. The designs must meet the SJRRP design criteria for fish passage facilities and incorporate the full range of design flows, including consideration of the anticipated short- and long-term Reach 4B Project flow-routing decision. The selection of a preferred conceptual design alternative and further development of the conceptual designs will be completed in a separate effort.

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Appendix A. Hydrology Design Criteria Development

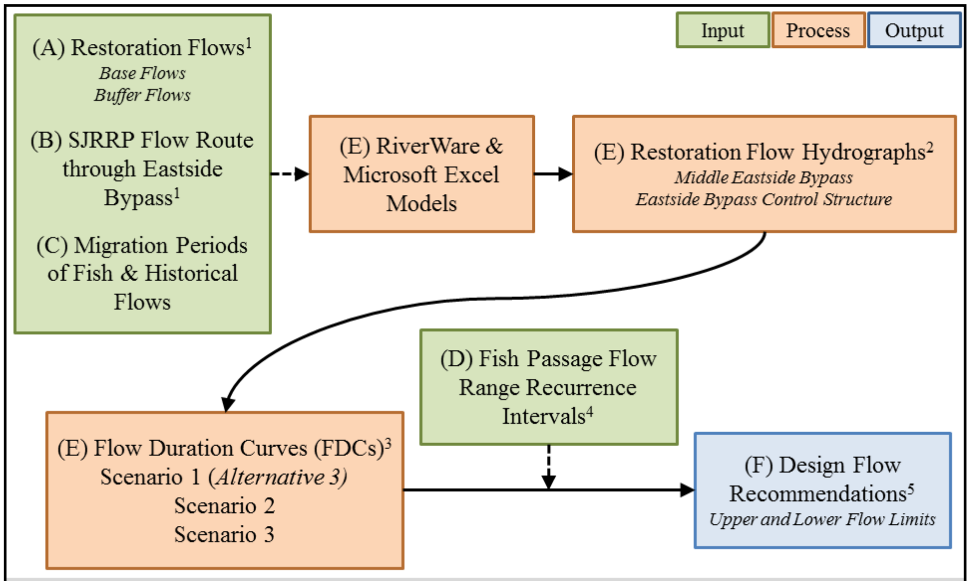
1.0 Introduction

Appendix A explains the development of the hydrology-related design criteria used to evaluate and design the conceptual designs proposed in the *Fish Passage Evaluation Plan*, Task 3, Volume I technical memorandum.

For each conceptual design, the primary goal was to meet the fish passage needs of the San Joaquin River Restoration Program (SJRRP). As part of that process, available information about SJRRP anticipated flow routes and volumes were accumulated and analyzed to develop a set of flow-design criteria. The selection of the appropriate range of design flows was critical to ensure that the conceptual designs best support fish passage and migration needs. The Settlement calls for releases of Restoration Flows, which are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. In addition to Restoration Flows, other components that were considered include fish passage flow range, migration periods of fish, and flow routing alternatives. These components were used to determine the recommendations for design-flow range for the Task 3 conceptual designs.

The following sections describe the components that were considered when developing the design-flow range. Figure A-1 provides a flow chart of the design criteria process.

Figure A-1 **Flow Chart on the Development of the Design Flow Recommendations**



Notes:
1. Restoration Flows and routing assumption based on SJRRP alternatives identified in Framework.
2. Restoration Flow hydrographs based on full flow record from October 1, 1921, to September 30, 2003.
3. FDCs for each flow volume Scenario developed for Middle Eastside Bypass and Eastside Bypass Control Structure.
4. Recurrence intervals specified by DFW guidelines.
5. Determined using FDCs and DFW recurrence interval specifications.

2.0 Restoration Flows

In 2006, the lawsuit known as *Natural Resources Defense Council et al. v. Kirk Rodgers et al*., reached a stipulation of settlement (Settlement). The Settlement requires releases of water from Friant Dam to achieve the Restoration Goals, and provides hydrographs to define these releases in varying types of water years. The hydrographs in the Settlement identify “Base Flows” in each water year type as well as defines releases up to an additional 10 percent of the applicable hydrograph flows as “Buffer Flows.” Base and Buffer flows needed to meet the Restoration Goal are collectively referred to as “Restoration Flows.” The Settlement dictates that the ultimate goal for the full volume Restoration Flows, once all Restoration Projects are completed, is 4,500 cubic feet per second (cfs). The hydrographs provided in the Settlement provide the flow schedule for the volume and pattern of Restoration Flow releases. To date, the full volume of Restoration Flows has not been released because channel and structural modifications need to be constructed before the full Restoration Flows can be safely conveyed.

In addition to the Restoration Flows specified in the Settlement, the SJRRP developed a revised framework for implementation (Framework). The Framework provides a revised approach to implementing the Settlement. The Framework identifies flow management, conveyance, adult migration paths, and fish passage and transportation guidelines, among other actions to implement and accomplish the Restoration Goal. The Framework also provides information on the potential flow routing options through the San Joaquin River and the Eastside Bypass, in the interim, before all of the improvements are completed. This information in the Framework was used to develop projections on the anticipated Restoration Flows in the bypass.

3.0 Flow Routing Alternatives

The flows within the San Joaquin River and bypass system are highly regulated, controlled by flow releases from Friant Dam and the diversion structures along the river and bypass systems. Future operational decisions and Restoration Flow routing through the San Joaquin River and bypass systems will determine the success of adult Chinook salmon migration and the SJRRP. But, the routing of Restoration Flows will vary depending on the completion of the SJRRP channel and structural modifications. The two projects that will have the most impact on the flow routing of Restoration Flows, and that will attract the upstream migration of adult Chinook salmon to the migration pathway, are the Reach 2B Project and Reach 4B Project, described in “Task 3, Volume I, Section 2.3.” These projects and their improvement alternatives, described in the Framework, will be referred to as the Reach 2B/4B project alternatives.

As specified in the Framework, the main stem reaches of the San Joaquin River have similar routing assumptions for all of the Reach 2B/4B project alternatives. But, the proposed routing of Restoration Flows for the Reach 4B project alternatives impacts the design flows for the Group 1 structures in the Eastside Bypass. For the Reach 4B project alternatives, flows can either be diverted into the San Joaquin River Reach 4B1 channel, the Eastside Bypass, or a combination of both. At the time of this analysis, a preferred Reach 4B project alternative had not been selected by the SJRRP. As a result, this analysis assumes that Restoration Flows will be diverted into the Eastside Bypass, and considers the migratory pathway assumed in the Framework. Based on the Framework, by 2020, migrating fish will pass through Reach 5 of the San Joaquin River, into the Eastside Bypass near Bear Creek (through the Lower and Middle Eastside Bypass sections), into Reach 4A of the San Joaquin River at Sand Slough, and then up through Reach 3, Reach 2, and Reach 1. Ultimately, based on current assumptions, the Eastside Bypass will be used to bypass Reach 4B of the San Joaquin River for the SJRRP. This represents the most probable flow-routing alternative based on current information.

4.0 Migration Periods

The adult migration period for spring-run Chinook salmon was assumed to be from February 1 through June 1, and the fall-run from September 1 through December 1. The adult migration period is the time when adult salmonids move up through the SJRRP area and need to safely pass through the structures to reach their holding and spawning locations. The design-flow range is inclusive of flows that would typically occur during the spring-run and the fall-run migration periods. The design-flow range is also based on the historical flow record, from October 1921 to September 2003. The flow record provides valuable information about the historical flow in the river and expectations of flow during the specified migration periods.

5.0 Fish-Passage Design-Flow Range

The fish-passage design-flow range is the lowest and highest streamflow for which migrating salmon are expected to be present, migrating, and dependent on the proposed facility for safe passage. The acceptable range of design flows is determined based on hydrologic characteristics of the river, which are used to estimate the statistical flow recurrence intervals of the watercourse. Typically, the upper passage-flow limit (highest flow) determines the allowable maximum water velocity, which is defined as the 1 percent exceedance flow. The lower passage-flow limit (lowest flow) determines the allowable minimum depth of water, which is defined as the 50 percent exceedance flow or 3 cfs, whichever is higher.

These design criteria are based on the *Culvert Criteria for Fish Passage* (California Department of Fish and Game 2002) guidelines referenced within the *California Salmonid Stream Habitat Restoration Manual* (California Department of Fish and Game 2010). This design criteria methodology was specified by the California Department of Fish and Wildlife (DFW) and was used for determining the passage flow limits for the Task 3 conceptual designs. This method is specific for the State. This passage range is different from the National Marine Fisheries Service (NMFS) guidelines, which were developed for “generic guidance” for permitting under the Endangered Species Act, Federal Power Act, and Magnuson-Stevens Fishery Conservation and Management Act (National Marine Fisheries Service 2011).

6.0 Hydrographs and Flow Duration Curves

To ensure that an appropriate range of flows was considered for the design-flow range, Restoration Flow hydrographs were simulated using two methods, a hydrologic model and a Microsoft Excel spreadsheet.

A RiverWare hydrologic model developed by the U.S. Bureau of Reclamation was used to produce hydrographs for a flow scenario (Scenario 1, described in the next section) that sends Restoration Flows down the San Joaquin River from Friant Dam. The RiverWare model assumes full Restoration Flows (4,500 cfs) and implementation of major Restoration Projects. As a result, the model provides results that simulate “future” flows based on the SJRRP routing plans, and simulates the flow such that there are no SJRRP project-related flow constraints. The model considers variable inflow and outflow conditions based on the full historical record of flow from October 1, 1921, to September 30, 2003, and projects future flows based on SJRRP routing plans. Flood flows are included in the historical record and are included in the Scenario 1 hydrograph.

Because the RiverWare model only simulates full Restoration Flows with no constraints (i.e., a future case scenario), two other scenarios (Scenario 2 and Scenario 3, described in the following sections) were developed to represent interim flow routing options, where Restoration Flows are released prior to complete SJRRP project implementation. These scenarios represent an interim Restoration Flow with varying levels of Reach 2B/4B Project implementation. A Microsoft Excel-based model was developed to simulate the hydrology for these interim condition scenarios. The Excel-based model utilizes inputs from an “existing conditions” RiverWare model run, which models flows in the river as far as Reach 2B. The California Department of Water Resources staff modified the Excel-based model to provide the hydrology at Reach 2B and downstream, including the Eastside Bypass. The Excel-based model simulates the flow and flood routing within, and downstream, of Reach 2B based on the flow conditions specified for each scenario. To account for flood inflows from the San Joaquin River tributaries into the bypass system, supplemental hydrographs were developed for the Lower and Middle Eastside bypasses from data in the “existing conditions” RiverWare model run. These supplemental hydrographs were needed to simulate flood routing through the Group 1 structures with the Excel-based model.

Based on the selected routing alternative and the developed hydrographs for each flow scenario, flow duration curves (FDCs) were developed for the Group 1 structures. FDCs are graphs that indicate the percentage of time that flow in a specified location is likely to equal or exceed a specified flow. The FDCs were used to determine the flow limits at the Group 1 structures that meet DFW guidelines for fish passage. Two sets of FDCs were developed. The first set was for the Eastside Bypass Control Structure (EBCS). The second was for the Middle Eastside Bypass, which encompasses the Merced National Wildlife Refuge weirs and the Dan McNamara Road projects.

For the Middle Eastside Bypass and EBCS, FDCs were developed for three flow-volume scenarios. Each flow-volume scenario assumes the same flow route, which is that Restoration and flood flows will be sent down the Middle Eastside Bypass and through the EBCS. The flow volume scenarios also represent other variables in the flow decisions and operations of the SJRRP. Primarily, the scenarios represent different levels of constraints in Reach 2B and Reach 4B of the San Joaquin River, based on the level of implementation of the Restoration Projects in the reaches.

- Scenario 1 assumes the full (unconstrained) Restoration Flows of 4,500 cfs from Friant Dam, and implementation of Reach 2B/4B Projects.
- Scenario 2 assumes constrained Restoration Flows of 2,000 cfs from Friant Dam, constrained flows in Reach 2B (projects only implemented to allow for 2,000 cfs through Reach 2B), and constrained flows in Reach 4B Projects (projects not implemented, requiring use of Lower Eastside Bypass).
- Scenario 3 assumes the unconstrained Restoration Flows of 4,500 cfs from Friant Dam, unconstrained flows in Reach 2B (projects have been implemented to allow full Restoration Flow), and constrained flows in Reach 4B Projects (projects not implemented, requiring use of Lower Eastside Bypass).

The purpose of the varying scenarios is to capture a variety of potential flow volume routing options that may be implemented in future SJRRP efforts. In relation to the FDC development, the scenarios are primarily concerned with the flows passing through the Middle Eastside Bypass and the Lower Eastside Bypass. This is because flows passing through the Middle Eastside Bypass constitute the flows traveling through the Merced National Wildlife Refuge weirs and the Dan McNamara Road projects. Flows passing through the Lower Eastside Bypass constitute the flows travelling through the EBCS.

The scenarios and resulting analysis were used to choose the most conservative design-flow scenario with which to prepare the design criteria and conceptual designs. The following sections describe the three flow-volume routing scenarios and the methodology used to develop the FDCs for each scenario.

6.1 Flow Routing – Scenario 1

This scenario represents a future case in which the full Restoration Flow is released from Friant Dam and all of the Reach 2B/4B Projects have been implemented (i.e., flows are unconstrained in Reach 2B or Reach 4B). This scenario was simulated with the RiverWare model with three alternatives, which represent varying uses of the Middle and Lower Eastside bypasses. Table A-1 provides a summary of Scenario 1 assumptions and the details of each of the three alternatives.

Of the three alternatives, Alternative 3 was the most appropriate for the analysis for the Task 3 conceptual designs. Alternative 3 is the only option that consistently sends Restoration Flows down into the Lower Eastside Bypass. Alternative 2 diverts the majority (the first 8,500 cfs) of the flood and Restoration Flows from the Middle Eastside Bypass into the Mariposa Bypass. As a result, the flow frequency and magnitude in the Lower Eastside Bypass, under Alternative 2, is reduced. This means design-flow limits for Lower Eastside Bypass fish passage facilities for Alternative 2 would be lower than those for Alternative 3 and would primarily be based on flood flows, which are rare over 8,500 cfs. Alternative 1 does not utilize the Lower Eastside Bypass for Restoration Flows, meaning it is not an ideal scenario to

Table A-1 Summary of Scenario 1, Alternatives 1, 2, and 3

Item	**Scenario 1**		
	Alternative 1	**Alternative 2**	**Alternative 3**
Friant Releases	4,500 cfs	4,500 cfs	4,500 cfs
Hydrographs Constraints	Restoration flows are unconstrained from Friant Dam. Reach 2B flows are unconstrained. Reach 4B flows are unconstrained.		
Reach 2B/4B Project Assumptions	All projects implemented. Reach 2B and Reach 4B have been restored.		
Restoration Flows			
Chowchilla Bifurcation			
SJR Reach 2B, 3, 4A	first 4,500 cfs[a]	first 4,500 cfs[a]	first 4,500 cfs[a]
Chowchilla Bypass & Upper Eastside Bypass	next 5,500 cfs	next 5,500 cfs	next 5,500 cfs[b]
Sand Slough Bifurcation			
SJR Reach 4B1	4,500 cfs	0 cfs	first 475 cfs
Middle Eastside Bypass[c]	flood flows	4,500 cfs + flood flows	remaining flows
Mariposa Bifurcation			
Mariposa Bypass (to SJR Reach 4B2)	0 cfs	first 8,500 cfs	30% of additional flow
Lower Eastside Bypass[d]	flood flows	remaining flows	first 2,500 cfs

Notes:
cfs = cubic feet per second, SJR=San Joaquin River
[a] Minimum 50 cfs required to avoid drying of the river.
[b] Flows remaining after 10,000 cfs, as well as unavoidable flooding, will be split 50/50 between the San Joaquin River and Chowchilla Bypass, unless there is flooding in Reach 3.
[c] Encompasses the Merced National Wildlife Refuge weirs and the Dan McNamara Road project.
[d] Encompasses the Eastside Bypass Control Structure.

include for development of the design criteria. To capture a broad range of reasonable flows, Alternative 3 is recommended to be considered for Scenario 1 for developing the upper and lower design-flow limits.

The RiverWare model run results for Scenario 1 at each major flow interchange (Chowchilla Bypass, Sand Slough, and Mariposa Bifurcation Structures) were used to develop FDCs for each structure in Group 1. The "Eastside Sand Slough Return Outflow" location results were used to represent the flows through the upper and lower Merced National Wildlife Refuge weirs and Dan McNamara Road, while the "Mariposa Bypass Control Outflow 2" location results were used to represent the flows through the EBCS. The resulting FDCs for Scenario 1 are provided in Exhibit A.

6.2 Flow Routing – Scenario 2

This scenario represents a future case where modified (reduced) Restoration Flows are released from Friant Dam, and the Reach 2B/4B Projects have not been implemented (i.e., flows are constrained in Reach 2B and Reach 4B). This scenario represents a situation in which the Restoration Projects would not be completed for 10 years to 15 years, but the SJRRP may release 2,000 cfs or more as interim Restoration Flows. The interim flow was determined based on an assumed Reach 2B levee capacity of 2,000 cfs. Table A-2 provides a summary of the Scenario 2 assumptions.

Table A-2 Summary of Scenario 2

Item	Description
Friant Releases	2,000 cfs
Hydrographs Constraints	Restoration Flows are constrained from Friant Dam. Reach 2B flows are constrained. Reach 4B flows are constrained.
Reach 2B/4B Project Assumptions	Projects have only been implemented to allow for 2,000 cfs through Reach 2B. Reach 4B has not been restored.
Restoration Flows	
Chowchilla Bifurcation	
SJR Reach 2B, 3, 4A	first 2,000 cfs[a]
Chowchilla Bypass and Upper Eastside Bypass	remaining flows
Sand Slough Bifurcation	
SJR Reach 4B1	0 cfs
Middle Eastside Bypass[b]	all flows
Mariposa Bifurcation	
Mariposa Bypass (to SJR Reach 4B2)	30 percent of additional flow
Lower Eastside Bypass[c]	first 2,500 cfs

Notes:
cfs=cubic feet per second, SJR = San Joaquin River
[a] Minimum 50 cfs required to avoid drying of the river.
[b] Encompasses the Merced National Wildlife Refuge weirs and the Dan McNamara Road project.
[c] Encompasses the Eastside Bypass Control Structure.

Even though the flow volume assumptions represent an interim SJRRP flow solution, Scenario 2 relies substantially on the Middle and Lower Eastside bypasses to contain the Restoration Flows. The Excel-based model was used to simulate the hydrographs through the Group 1 structures and to develop FDCs for each structure in Group 1. The “Eastside Bypass at Sand Slough” hydrograph results were used to represent the flows through the upper and lower Merced National Wildlife Refuge weirs and Dan McNamara Road. The “Eastside Bypass downstream Mariposa” hydrograph results were used to represent the flows through the EBCS. The resulting FDCs for Scenario 2 are provided in Exhibit A.

6.3 Flow Routing – Scenario 3

This scenario represents a future case where full Restoration Flows are released from Friant Dam, Reach 2B projects have been implemented (i.e., flows are unconstrained), and Reach 4B projects have not been implemented (i.e., flows are constrained). This scenario represents a situation in which the Restoration Projects would not be completed for 10 years to 15 years, but the SJRRP may release 4,500 cfs of Restoration Flows. The Restoration Flow was determined based on an assumed Reach 2B levee capacity of 4,500 cfs. All other routing and hydrologic assumptions for Scenario 3 are the same as the assumptions in Scenario 2. Table A-3 provides a summary of the Scenario 3 assumptions.

Similar to Scenarios 1 and 2, Scenario 3 relies substantially on the Middle and Lower Eastside bypasses to contain the Restoration Flows. The Excel-based model was used to simulate the hydrographs through the Group 1 structures and to develop FDCs for each structure in Group 1. The “Eastside Bypass at Sand Slough” hydrograph results were used to represent the flows through the upper and lower Merced National Wildlife Refuge weirs and Dan McNamara Road. The “Eastside Bypass downstream Mariposa” hydrograph results were used to represent the flows through the EBCS. The resulting FDCs for Scenario 3 are provided in Exhibit A.

Table A-3 Summary of Scenario 3

Item	Description
Friant Releases	4,500 cfs
Hydrographs Constraints	Restoration Flows are unconstrained from Friant Dam. Reach 2B flows are unconstrained. Reach 4B flows are constrained.
Reach 2B/4B Project Assumptions	Projects have been implemented in Reach 2B to allow for full restoration flow. Reach 4B has not been restored.
Restoration Flows	
Chowchilla Bifurcation	
SJR Reach 2B, 3, 4A	first 4,500 cfs[a]
Chowchilla Bypass and Upper Eastside Bypass	remaining flows
Sand Slough Bifurcation	
SJR Reach 4B1	0 cfs
Middle Eastside Bypass[b]	all flows
Mariposa Bifurcation	
Mariposa Bypass (to SJR Reach 4B2)	30 percent of additional flow
Lower Eastside Bypass[c]	first 2,500 cfs

Notes:

cfs=cubic feet per second, SJR = San Joaquin River

[a] Minimum 50 cfs required to avoid drying of the river.

[b] Encompasses the Merced National Wildlife Refuge weirs and the Dan McNamara Road project.

[c] Encompasses the Eastside Bypass Control Structure.

6.4 Scenario Design-Flow Limit Recommendations

The flow-volume scenario FDCs were used to determine the flow limits that meet DFW flow-recurrence interval guidelines for fish passage at each Group 1 structure. The FDCs are provided in Exhibit A. The low and high fish-passage flows for the three flow routing scenarios for the Group 1 structures are shown in Table A-4.

Table A-4 **Lower and Upper Passage Flows for Adult Chinook Salmon, by Flow Scenario**

Structure	Scenario 1		Scenario 2		Scenario 3	
	50% Lower Passage Flow[a] (cfs)	1% Upper Passage Flow (cfs)	50% Lower Passage Flow (cfs)	1% Upper Passage Flow (cfs)	50% Lower Passage Flow (cfs)	1% Upper Passage Flow (cfs)
Middle Eastside Bypass Structures[b]	0 (3)	9,737	155	10,214	85	9,679
Eastside Bypass Control Structure	0 (3)	7,559	155	8,155	85	8,014

Notes:
cfs = cubic feet per second
[a] Minimum 3 cubic feet per second qualifies.
[b] Middle Eastside Bypass structures constitute the FDCs for Lower Merced Refuge Weir, Upper Merced Refuge Weir, and Dan McNamara Road.

7.0 Design-Flow Recommendations

The SJRRP has determined that the Reach 4B Project would not be constructed and would not receive full Restoration Flows for 10 years to 15 years. Because of this, as well as the uncertainty in the final flow routing decision, a combination of the flows and scenarios were used to specify the upper and lower design-flow limits for the conceptual designs. Table A-5 presents the design-flow limits that were used to develop the conceptual designs for the Task 3 Group 1 structures.

Table A-5 **Group 1 Design Flows for Full Restoration Flows**

Structure	Full Project Design Flows	
	50% Lower Passage Flow (cfs)	1% Upper Passage Flow (cfs)[a]
Middle Eastside Bypass Structures[b]	85	9,737
Eastside Bypass Control Structure	85	7,559

Notes:
cfs = cubic feet per second
[a] Reach 4B Project, Alternative 3, routing assumed.
[b] Middle Eastside Bypass structures constitute the FDCs for Lower Merced Refuge Weir, Upper Merced Refuge Weir, and Dan McNamara Road.

The upper design-flow limit is from the FDC for Scenario 1. This scenario assumes full project implementation of the Reach 4B Project alternative that allows for Restoration Flows more than 475 cfs to be diverted into the Eastside Bypass. Because flows from Scenario 1 are 3 cfs or less, which is much less than enough to support fish populations, the lower design-flow limit is from Scenario 3. This scenario assumes that all flood flows and Restoration Flows up to 4,500 cfs will be diverted into the Eastside Bypass. Both the upper and lower design-flow limits use hydrographs based on full Restoration Flows of 4,500 cfs.

As shown in Table A-5, the design flows exceed the maximum Restoration Flows of 4,500 cfs. This is because the flow exceedance analysis included Restoration and flood flows.

Exhibit A. Flow Duration Curves

Flow Duration Curves for the Middle Eastside Bypass

Figure A-2 **Scenario 1, Middle Eastside Bypass**

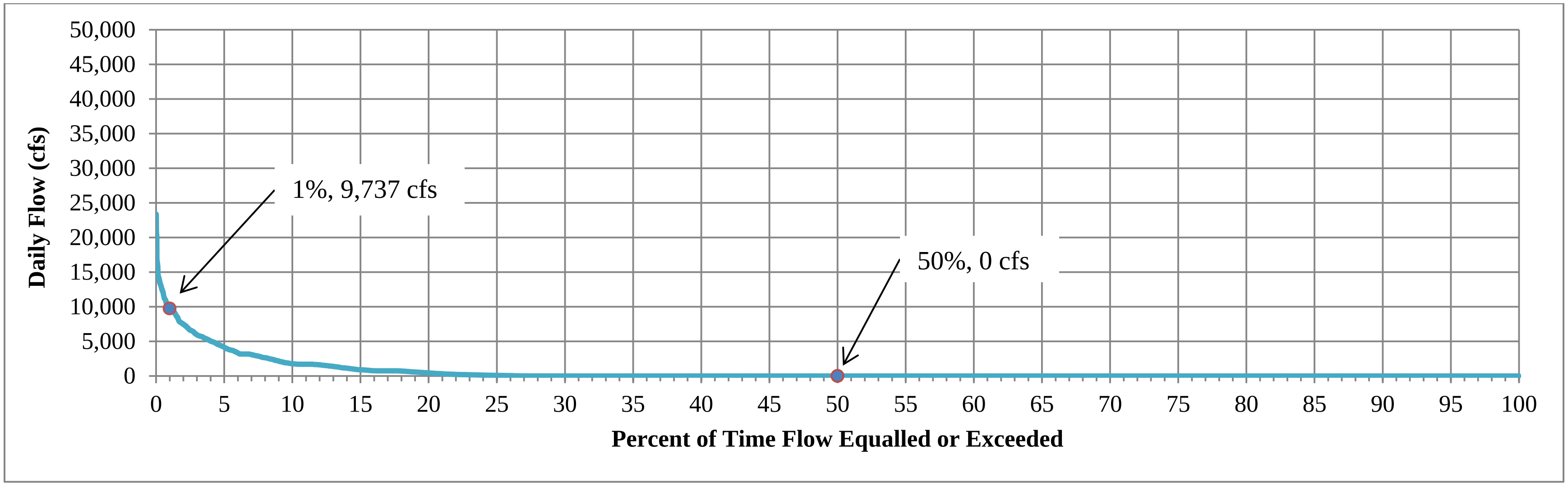


Figure A-3 **Scenario 2, Middle Eastside Bypass**

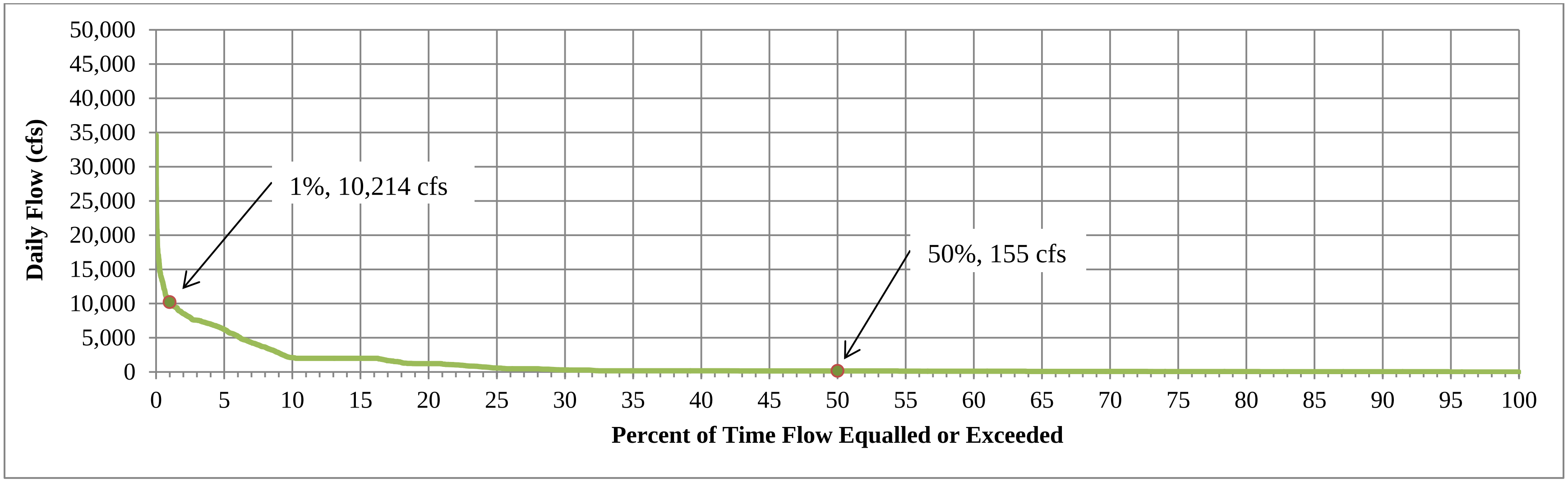
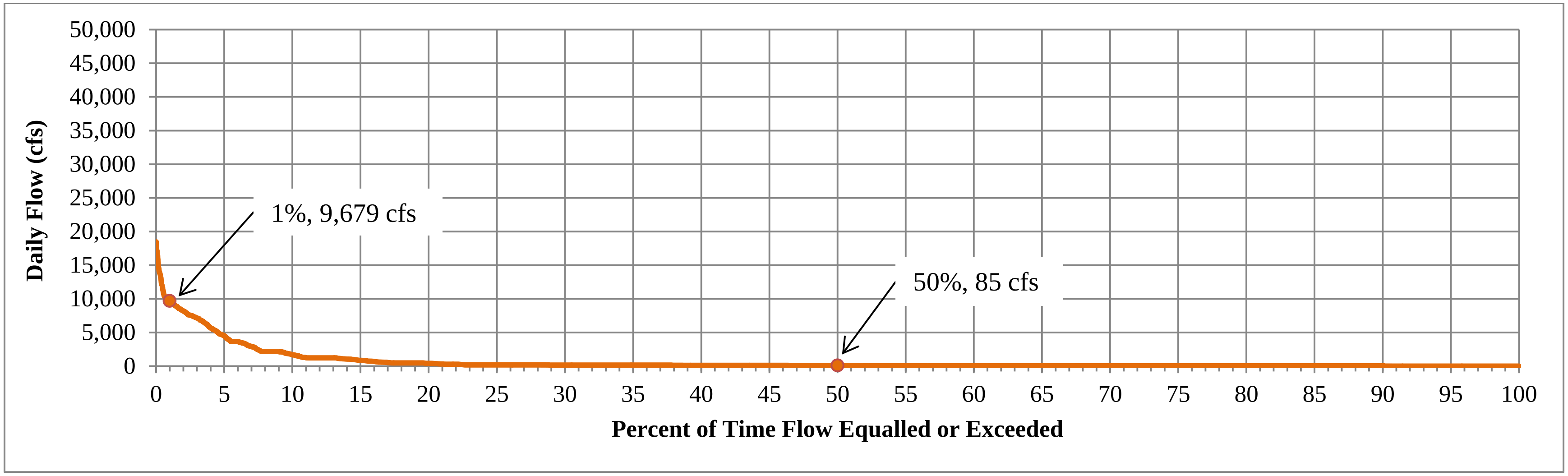


Figure A-4 **Scenario 3, Middle Eastside Bypass**



Flow Duration Curves for the Eastside Bypass Control Structure

Figure A-5 **Scenario 1, Eastside Bypass Control Structure**

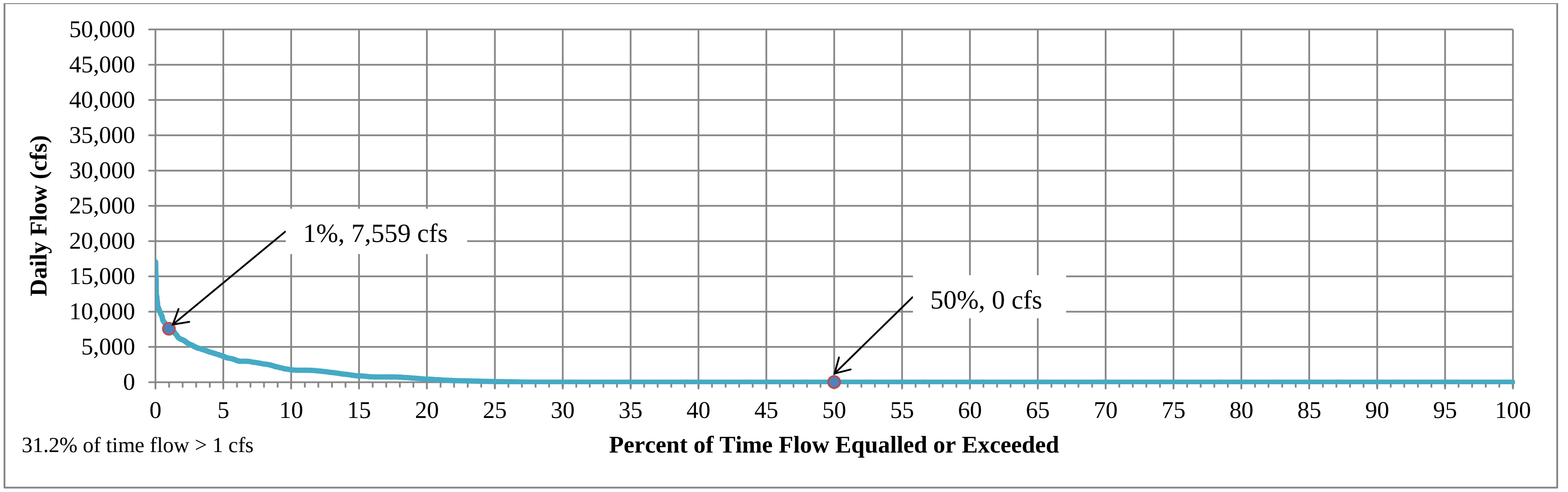
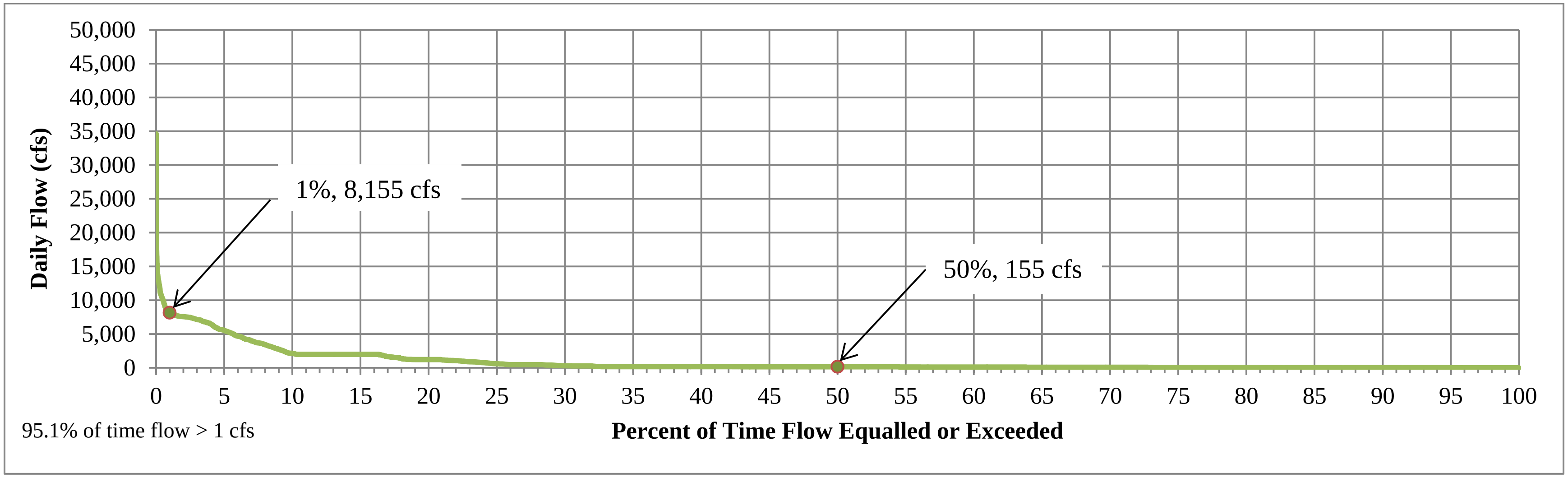
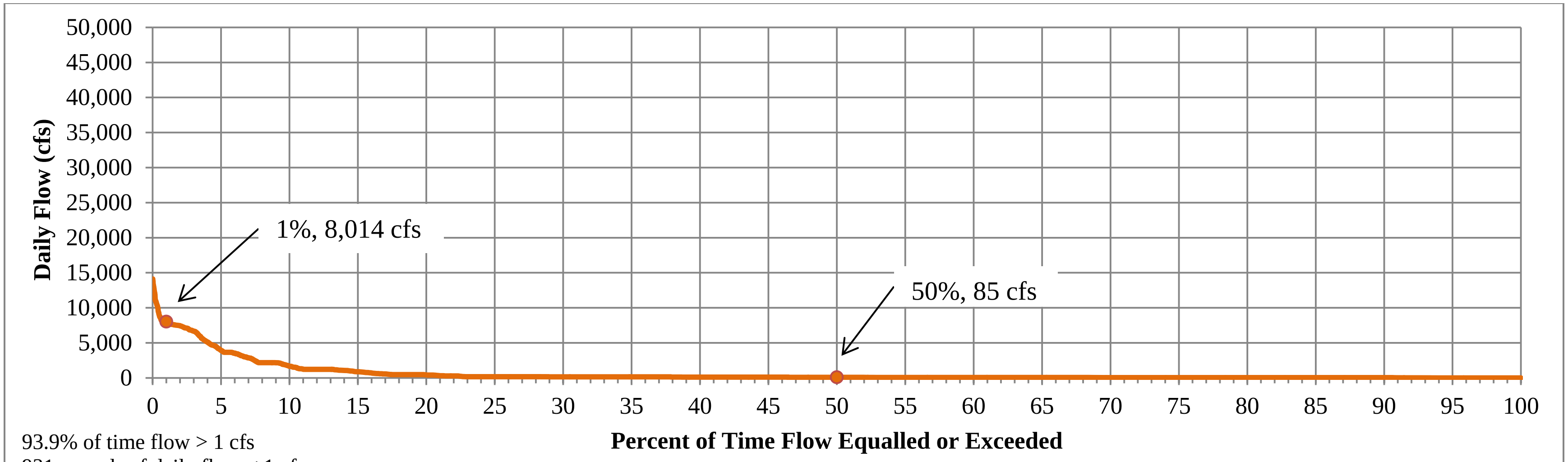


Figure A-6 Scenario 2, Eastside Bypass Control Structure



95.1% of time flow > 1 cfs

Figure A-7 Scenario 3, Eastside Bypass Control Structure



93.9% of time flow > 1 cfs
931 records of daily flow < 1 cfs

Appendix B. Alternative Design Package, Eastside Bypass Control Structure

Four design alternatives to provide fish passage at the Eastside Bypass Control Structure (EBCS) were considered and are included in this package. The conceptual designs include:

- Alternative EBCS-1 – Structure Modification and Rock Ramp.
- Alternative EBCS-2 – Grade Control.
- Alternative EBCS-3 – Bypass Fishway.
- Alternative EBCS-4 – Vertical-Slot Fishway.

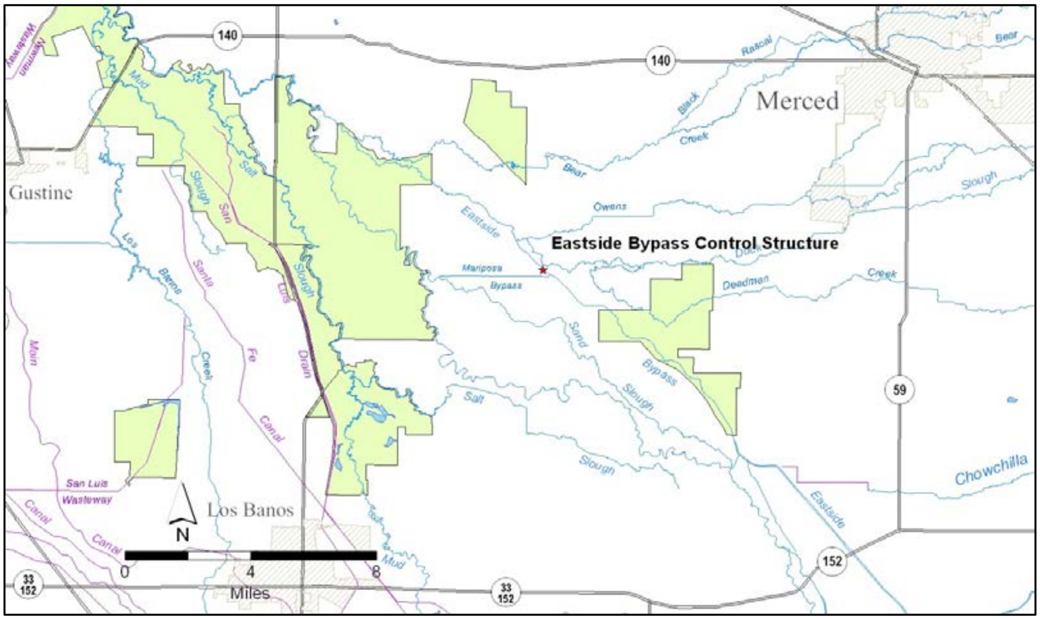
1.0 Site Assessment

The following sections provide an overview of the site conditions at the EBCS, including the location and description, channel characteristics, flood operations, and the fish passage constraints.

1.1 Location and Description

The EBCS is located in Merced County, California (Figure B-1). The project site can be accessed by State Route 59 and West Sandy Mush Road. The EBCS is located on the Eastside Bypass approximately 1,100 feet downstream of the head of the Mariposa Bypass (Photo B-1). The EBCS is an essential part of the Lower San Joaquin River Flood Control Project (LSJRFCP) and is operated to maintain essential flood control function for the region. The LSJRFCP includes the Chowchilla Bypass, Eastside Bypass, and the Mariposa Bypass. The LSJRFCP is operated and maintained by the Lower San Joaquin Levee District (LSJLD). The LSJRFCP is designed to prevent flood damages by taking peak flood flows from the San Joaquin River near Mendota and directing the flows down the Chowchilla and Eastside bypasses.

Figure B-1 Eastside Bypass Control Structure Location Map



The EBCS functions integrally with the Mariposa Bypass Control Structure (MBCS) to control the division of flows between the Eastside Bypass and the Mariposa Bypass (Figure B-1). The flows through the EBCS are subject to operation and maintenance (O&M) rules set forth by the LSJRFCP.

The EBCS has six concrete bays with radial gates that are operated manually by hoist motor. Each bay measures 19 feet high and 20 feet wide, with a total structure height of approximately 21.5 feet and a total width from one side of the structure to the other of 130.3 feet (Photo B-2). The bays have notches on the inlet of the bay walls for boards. Boards are inserted to raise the invert of the structure up to the level of the adjacent channel. These boards were designed to adjust for subsidence, so as subsidence occurs, the boards will be removed to lower the structure invert to maintain its flow capacity (California Department of Water Resources 1969). Currently, the boards have an average height of 4 feet (Photo B-3).

The bays are 45.5 feet in length, measured longitudinally, with a 15-foot concrete apron measured from the bay outlet to the channel downstream. In each bay, there are six 2-foot by 2-foot by 4-foot concrete block baffles approximately 45 feet from the bay inlet (Photo B-2). The EBCS has a maintenance road that crosses over the downstream end of the gate bays. At the downstream end of the concrete apron is a short sill that is about 2-feet tall and 1-foot wide (Photo B-4) (California Department of Water Resources 2012). The channel is armored with riprap just downstream of the sill. Beyond the riprap is a pool that was measured to have a depth of 8 feet from the thalweg of the channel, about 30 feet downstream of the sill (California Department of Water Resources 2012).

Photo B-1 Eastside Bypass Control Structure from the Mariposa Bypass Control Structure looking Downstream in the Eastside Bypass

Photo B-2 Structure Bay with Baffles Looking Upstream from Bay Outlet

Photo B-3 Boards Located at the Structure Inlet at the Radial Gate Seal

Photo B-4 Downstream Sill and Rip Rap Located at the Structure Outlet

1.2 Channel Characteristics

The overall bypass channel width from the center of the levees is approximately 600 feet, which is constricted by the EBCS. The low-flow portion of the bypass channel is approximately 170 feet wide. The channel upstream of the EBCS consists of short annual grasses in the main channel with tall annual grasses in the floodplain. The bypass was designed as a trapezoidal channel with a low-flow channel at the centerline with levees on the banks to convey flood flows. Levees within this section of the bypass vary in height from approximately 10 feet upstream of the EBCS to approximately 7 feet downstream of the EBCS.

The bypass is experiencing regional subsidence that varies within the bypass and surrounding areas. The EBCS is experiencing regional ground subsidence at a rate ranging from about 0.05 foot to 0.3 foot per year (California Department of Water Resources 2013). The channel is subsiding at a much greater rate upstream within the Upper Eastside Bypass (0.5 foot per year to nearly 1 foot per year) compared to subsidence at the structure. The result is a flatter channel slope within the Middle Bypass compared to a much steeper slope of the channel upstream. Given that subsidence is occurring at a greater rate upstream when compared to the EBCS, water depths at the structure will be greater in the future than current conditions.

1.3 Physical Constraints

Improvements at the EBCS may be impacted by the existing bypass infrastructure. Figure B-2 displays some of the physical constraints at the site. On the right bank (based on the view of a person looking downstream), there is an underground siphon that conveys water in the Eastside Canal from the north side to the south side of the Mariposa and Eastside bypasses. The siphon is located upstream of the control structure and may limit construction within the channel. There is also an overflow structure for Owens and Deadman creeks on the right bank that is located approximately 180 feet downstream of the EBCS (Photo B-5). This structure will be referred to as the Owens Creek Overflow Structure. It was originally referred to as the Deadman Creek Drainage Ditch Structure within the O&M manual for the LSJRFCP (U.S. Army Corps of Engineers 1967 [Amended in 1978]) which is shown in Figure B-2. On the left bank, there is a control building that houses the control equipment for the EBCS gates and the utilities for the building.

Figure B-2 **Eastside Bypass As-Built Drawing for the Structure, with Physical Constraints Identified**

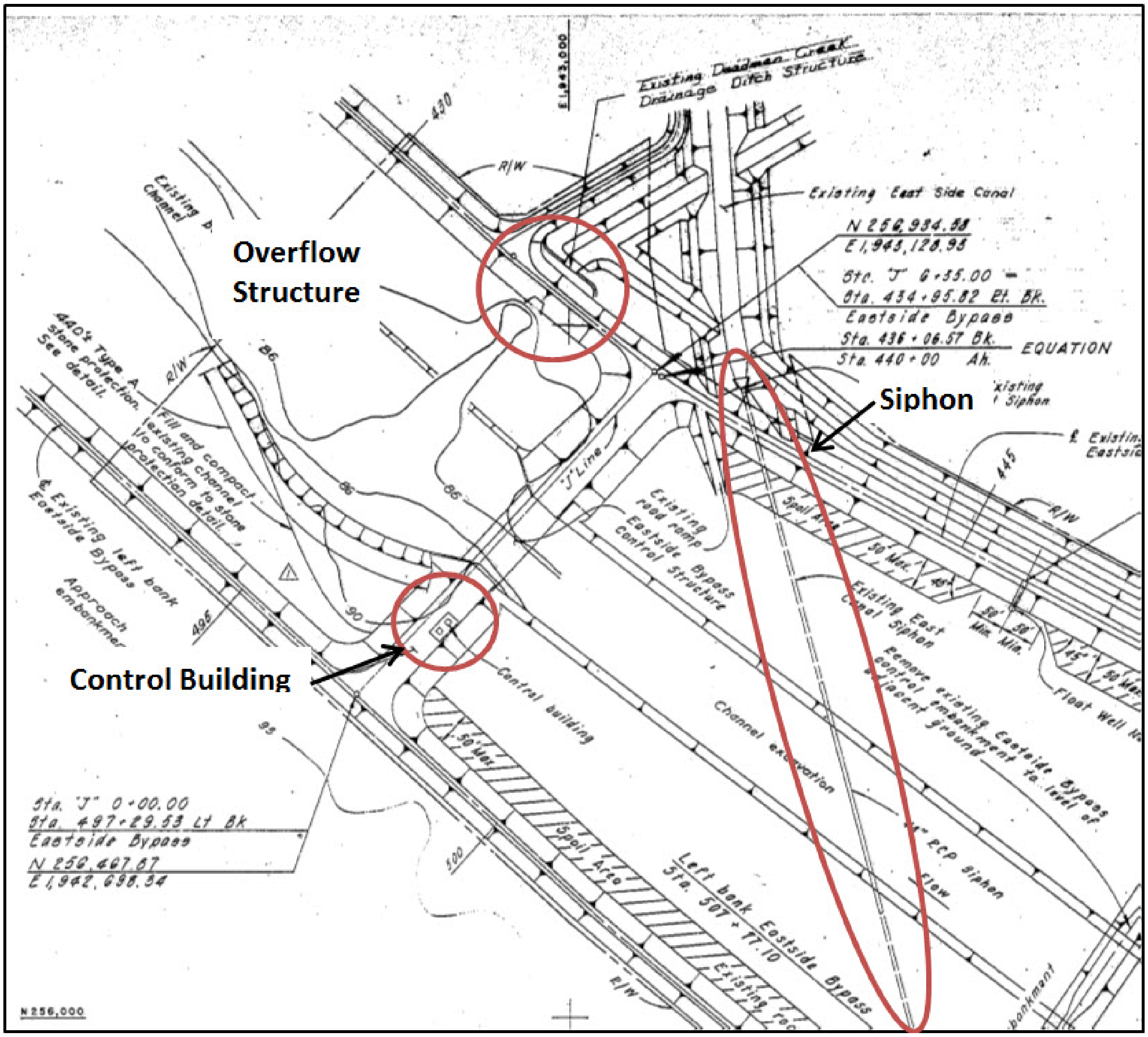


Photo B-5 Owens Creek Overflow Structure Downstream the EBCS on the Right Bank

1.4 Flood Operations

The gate operations for the EBCS have a drastic impact on the overall performance of the bypass system for flood flow conveyance. The operations of the gates determine the amount of flow that is allowed to flow into either the Lower Eastside Bypass or the Mariposa Bypass. Flood flow through the structure is dictated by the O&M manual for the LSJRFCP (U.S. Army Corps of Engineers 1969). The design capacity of the bypass upstream of the EBCS is 16,500 cubic feet per second (cfs). But, just downstream of the EBCS, it has a capacity of 8,000 cfs. The manual stipulates that the first 8,500 cfs of flood flow upstream of the EBCS should be diverted through the MBCS – a scenario that is created by closing the radial gates at the EBCS. But, even if the EBCS gates are not operated, when flood flows within the Eastside Bypass begin to reach 2,500 cfs to 3,000 cfs, they will begin to flow through the MBCS and enter into the Mariposa Bypass. Any flood flow that is more than the 16,500 cfs design flow capacity upstream of the EBCS is divided between the Lower Eastside Bypass and the Mariposa Bypass (U.S. Army Corps of Engineers 1969). The EBCS is almost always not operated in accordance with the O&M manual. Typically during floods, the gates are kept open initially to allow flood flows to continue down the Lower Eastside Bypass. The bypass typically has flood flows approximately one year out of every five years, with potential gate closure to route all the flood flow down the Mariposa Bypass. The EBCS becomes a total barrier to the migration of adult Chinook salmon while the EBCS gates are operating or closed.

1.5 Fish Passage Constraints

The EBCS currently does not meet regulatory agency fish passage criteria for adult Chinook salmon at flows less than 700 cfs (California Department of Water Resources 2012). This is primarily because of the lack of sufficient pool depth for jumping over the sill and the boards. Once flows exceed 700 cfs, the sill and boards have enough depth for migrating fish to pass.

2.0 General Design Criteria

The design for each alternative must meet criteria for flow, fish passage, subsidence, and flood capacity. General design criteria applicable to all of the alternatives are discussed in this section. Additional design criteria for a specific fishway will be discussed within the alternative design description. The fish passage design criteria and guidelines are consistent with the California Department of Fish and Wildlife (DFW) and the National Marine Fisheries Service (NMFS) guidelines. Specific criteria for the restoration fish passage projects were developed through a series of stakeholder workshops; but, they were never finalized by the San Joaquin River Restoration Program (SJRRP). It is recommended that DWR meet with the regulatory agencies to finalize the criteria at this structure. For the purposes of the report, the general criteria to guide the design of the project components are discussed here.

2.1 Flow

Flows through any passage facility for the EBCS will be designed to ensure unimpeded passage for flows between 85 cfs and 7,559 cfs. These flows were determined in accordance with the *California Salmonid Stream Habitat Restoration Manual*, which specifies that the upper and lower design flows for adult Chinook salmon to pass unimpeded be based on a flow exceedance analysis of 1 percent and 50 percent exceedance flows. At the high passage design flow for adult anadromous salmonids, defined as the 1 percent exceedance flow, the objective is to avoid excessive water velocities and turbulence. At the low passage design flow, defined as the 50 percent exceedance flow, the objective is to provide sufficient water depth (California Department of Fish and Game 2010). For the EBCS, exceedance flows were determined using flow duration curves that were based on hydrographs of expected flow releases for the SJRRP through the bypass.

2.2 Fish Passage

The fish passage design criteria for adult Chinook salmon (jump, depth, and velocity) is based on the criteria used for the SJRRP Reach 2B and Reach 4B site-specific projects and design criteria developed by DFW, U. S. Army Corps of Engineers (USACE), NMFS, and U.S. Bureau of Reclamation. Each design alternative must meet the required criteria shown in Table B-1. In addition to the fish passage criteria in Table B-1, criteria based on a specific type of fish passage structure will be applied, depending on the alternative. These criteria will be specified in the respective alternatives.

Table B-1 Fish Passage Design Criteria for Adult Chinook

Minimum Depth of Flow (ft)	Maximum Recommended Hydraulic Drop (ft)	Recommended Design Velocity (fps)[a]
1	1.0	1.5-4.0

Notes:
ft = feet, fps = feet per second
[a] Design velocity is based on the type of fish facility and could be greater for culverts (as much as 6 fps). If culverts are recommended follow the design velocities in Table 7-1 (National Marine Fisheries Service 2011).

A summary of how each of the criteria will be applied is provided in the following paragraphs.

2.2.1 Minimum Depth of Flow

Depth within the fishway will need to meet a depth criterion of 1.0 foot.

2.2.2 Maximum Recommended Hydraulic Drop

The designs will ensure that any structures that require an adult Chinook salmon to jump will have a maximum water-surface difference over the structure of no more than 1.0 foot.

2.2.3 Recommended Design Velocity

The SJRRP fish passage design table recommends design velocities for fish facilities average between 1.5 feet per second (fps) to 4 fps. This range of velocities is essentially recommended to be at or less than the cruising speed of 3.4 fps, for an adult Chinook salmon. This limits the stress to the fish in order to preserve their energy to pass other obstacles, and to protect the overall health of the fish. The designs will try to achieve the lower velocity limit but will try not to exceed the maximum upper limit of 4 fps. If a fishway is greater than 300 feet in length and the average velocity is greater than 2 fps, additional measures to facilitate fish passage, such as adding resting pools, may be required.

2.3 Subsidence

The designs must account for ground subsidence consistent with the methodology and guidance provided in the preliminary draft *Technical Memorandum No. SUB-1 Subsidence Design Criteria* (U. S. Bureau of Reclamation 2013) for the SJRRP, except as noted. The technical memorandum estimated the total amount of subsidence assumed during the 25-year design life of the project at the road location is 1.25 feet. But, based on recent monitoring, the total amount of subsidence over the next 25 years could be between 4 feet and 6 feet. The subsidence rates and lifespan may be modified as necessary based on ongoing monitoring efforts.

2.4 Flood Capacity

The EBCS design-flood capacity of 8,000 cfs is based on the schematic of design-flood capacity flows in the final design report (California Department of Water Resources 1969). But, in rare flood events, the LSJLD has sent more than 13,000 cfs through the EBCS. Design alternatives must ensure no adverse impact to the current flood control system. It must be demonstrated through hydraulic modeling that each alternative will produce less than a 0.1-foot rise in flood elevations at the design flow capacity based on the Central Valley Flood Protection Board (CVFPB) criterion.

3.0 Conceptual Designs

The EBCS serves as a critical flood control facility in the LSJRFCP. Alternatives that modify the structural components of the EBCS will need approvals from the USACE, the CVFPB, and LSJLD before any modifications to the EBCS can be made. Some of the alternatives have similar elements but the design and hydraulics are different.

Because the EBCS is a flood control facility, the current gate operations during flood events are assumed to remain unchanged. The upstream migratory pathway for all the alternatives assumes that the

Restoration Flows, flows up to 4,500 cfs, would flow through the EBCS without the need for gate closure at the EBCS. But, during a wet year, when flood flows occur during fish migration, it is possible for the gates on the EBCS to be closed. It is estimated that gate closure is possible during the spring-run migration period, considering the Restoration Flow routing, around 1 percent of the flow record. Gate closures could occur over several days, to weeks and months, and would prevent upstream passage through the EBCS.

Currently, two of the four alternatives described in the following sections, depend on upstream passage through the existing EBCS gates. Only two alternatives provide a bypass to the EBCS gates. The two alternatives can also be blocked off at the fishway exit so that these facilities could be closed to allow for the district to operate as needed. If these facilities gates are closed in tandem with EBCS gate closure during flood events, upstream fish migration would be impeded. The following sections summarize the conceptual designs for the EBCS. The conceptual design alternatives developed for the EBCS include:

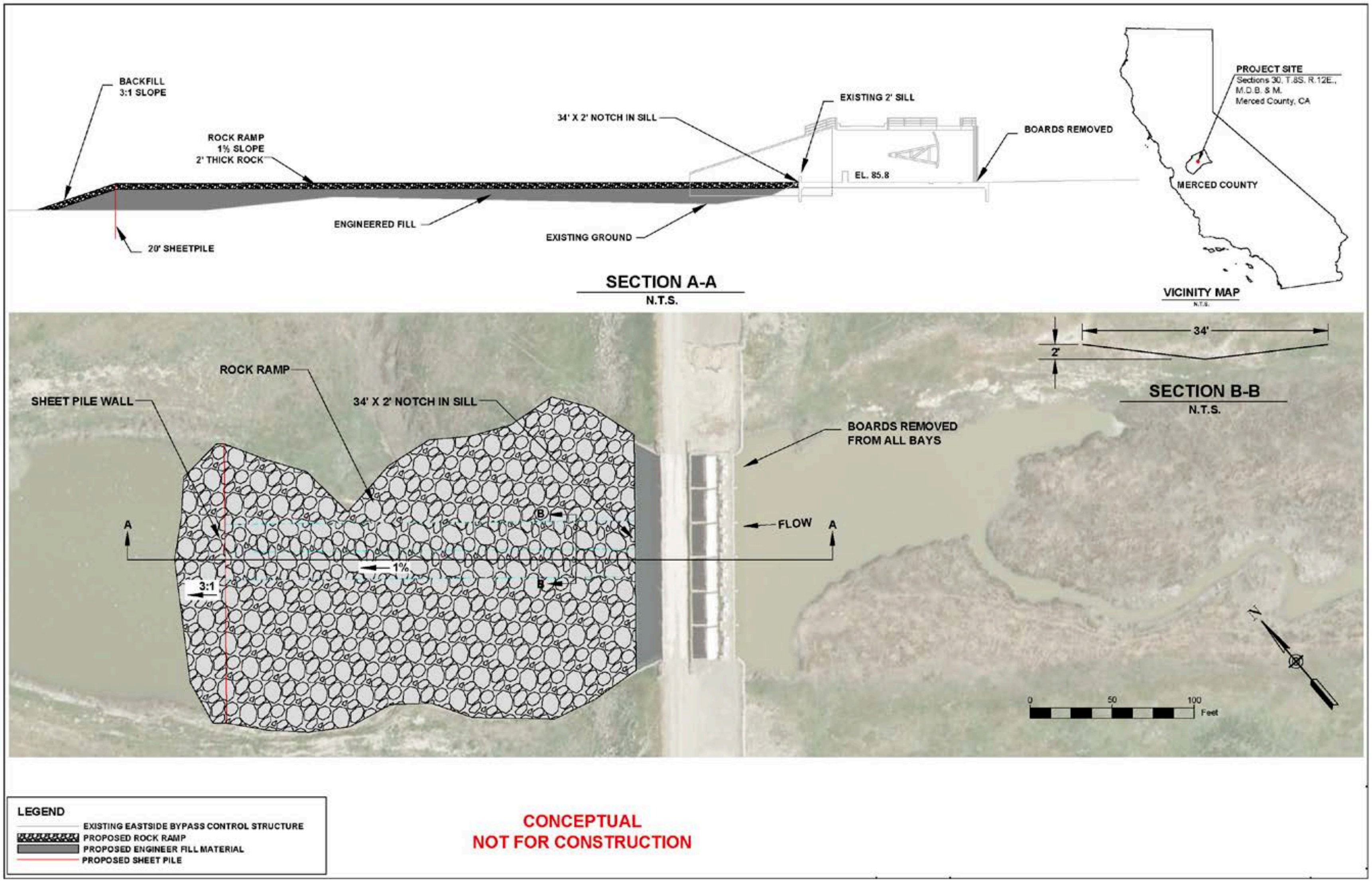
- Alternative EBCS-1 – Structure Modification and Rock Ramp.
- Alternative EBCS-2 – Grade Control.
- Alternative EBCS-3 – Bypass Fishway.
- Alternative EBCS-4 – Vertical-Slot Fishway.

The Owens Creek Overflow Structure, that is located just downstream of the EBCS, has the potential to attract migrating salmon. That would result in fish straying into the Owens or Deadman creeks. Developing exclusion designs for lateral structures located on the Eastside Bypass that would result in straying of migrating fish is outside the scope of Task 3, but may need to be completed for future design phases.

3.1 Alternative EBCS-1 – Structure Modification and Rock Ramp

This fish passage improvement design alternative consists of modifying the EBCS by notching the downstream sill, removing boards at the EBCS inlet, and constructing a rock ramp downstream of the notch to provide a fishway entrance (Figure B-3). A portion of the sill near the center bays will be cut into a v-shaped notch that is approximately 2 feet deep with a top width of 34 feet (Figure B-3, Attachment A). The rock ramp will begin just downstream of the v-notch. This alternative assumes that during Restoration Flows fish are migrating through the EBCS, and the gates on the EBCS are fully open. When gates are closed to route flood waters into the MBCS, fish passage would be impeded and fish would have to hold downstream of the structure until the gates are opened.

Figure B-3 **Alternative EBCS – 1 – Structure Modification and Rock Ramp, Plan and Profile View**



To prevent migrating salmon from needing to jump into the EBCS, a rock ramp will be constructed downstream of the sill to raise the water surface to provide sufficient depth for fish entering the notch at the sill at the lower design flow. The rock ramp will be 250 feet long and will include a low-flow channel that will be v-shaped with a top width of 24 feet and a depth of 2 feet. The proposed longitudinal slope of the rock ramp is 1 percent. To improve the hydraulic conditions at the transition between the sill and rock ramp, a resting pool may be needed.

The median diameter (D50) of the rock is estimated to determine the average rock size for the rock ramp to form an erosion resistant layer that will remain stable throughout the flow profile of the channel. For cost estimating purposes, a Class IV grouted riprap was assumed to help stabilize the ramp when the gates are being operated.

At the current design slope, the rock ramp would meet the existing channel invert at a distance more than 800 feet downstream and fill in a deep pool. Because this would fill in a large portion of the bypass channel and potentially impact flood conveyance, the ramp, as currently designed, will not meet the existing channel invert (daylight), so the ramp will be shorter in length. Sheet piles roughly 8 feet in height will be driven approximately 20 feet into the channel bed and backfilled with engineered fill to provide stability at the end of the rock ramp. This will result in a large pool just downstream of the sheet pile, which may allow for fish to hold during gate operations. But, discussions with fisheries agencies also have raised concerns about potential predation of out-migrating juvenile salmon.

3.1.1 Hydraulic Analysis

A one-dimensional model using Hydrologic Engineering Center's River Analysis System (HEC-RAS) was developed from a calibrated model to evaluate the flow, flood capacity, and fish passage design criteria for the conceptual alternative. The existing model was modified to include the design of the rock ramp, notch in the sill, and board removal. A Manning's coefficient of 0.033 was used for the entire range of flow based on the assumption that the ramp would be constructed of smooth grouted riprap. The model was used to simulate depth and velocity for a range of flows assuming a steady-flow condition.

3.1.1.1 Flow

This fishway facility is designed to provide unimpeded passage for flows between 85 cfs and 7,559 cfs. For this alternative, flows more than 4,500 cfs are assumed to be flood flows, so fish passage during these flood flows will depend on how the EBCS will be operated. This design assumes that fish will either be migrating through the EBCS during floods or holding downstream the EBCS if the gates are closed. The flow modeled for criteria compliance included the lower design flow limit of 85 cfs, the upper design flow limit of 7,559 cfs, and the flood capacity flow of 8,000 cfs.

3.1.1.2 Fish Passage

Table B-2 summarizes the HEC-RAS hydraulic results upstream and downstream of the sill, within the rock ramp for the upper and lower design flow limit, as well as at intermediate flows of 2,500 cfs, and 4,500 cfs. Figure B-4 shows the hydraulic profiles for the same flows, and Figure B-5 shows a three dimensional flow profile at the low design flow of 85 cfs. Figure B-6 shows the velocity profiles at those same flows. The hydraulic modeling indicates that the velocity within the rock ramp is no more than 4 fps and, in general, the velocities within the EBCS exceed the 5 fps culvert velocity criterion (National Marine Fisheries Service 2011) for flows ranging between 5,000 cfs and 7,559 cfs. Velocities at the sill notch continue to exceed 5 fps for flows ranging between 600 cfs and 1,400 cfs, and for flows ranging between 5,000 cfs and 7,559 cfs. These velocity increases occur during flow transitions and are likely to improve as the design is further refined. Additional features such as resting pools may be required to improve hydraulic conditions and fish passage.

At the current condition, when flows are more than 6,500 cfs within the culvert bays of the EBCS, the velocity design criterion is exceeded. The intention of this velocity criterion and its applicability at this location should be discussed with the regulatory fishery agencies to determine if the velocities at flood flows would rule out this alternative, which assumes fish passage within the EBCS bays during these flows.

Table B-2 Proposed Modifications Hydraulic Results

Location	Model Station	Flow (cfs)	WSE(ft)	Average Velocity (fps)	Flow Depth (ft)
Upstream of the Sill	55426.5	85	87.7	1.3	1.9
		2,500	91.9	4.1	6.1
		4,500	94.6	4.7	8.8
		7,559	96.7	6.1	10.9
At the Sill	55426	85	87.4	3.9	1.6
		2,500	91.9	4.4	6.1
		4,500	94.6	4.9	8.8
		7,559	96.7	6.4	10.9
Downstream of the Sill	55425.5	85	87.4	3.9	1.6
		2,500	91.9	4.4	6.1
		4,500	94.6	4.9	8.8
		7,559	96.7	6.4	10.9
Rock Ramp	55376	85	86.9	3.9	1.6
		2,500	91.9	2.4	6.6
		4,500	94.7	2.4	9.4
		7,559	96.9	2.8	11.6

Notes:
cfs = cubic feet per second, fps = feet per second, ft = feet, WSE = water surface elevation

Figure B-4 **Water Surface Profiles for Design Conditions**

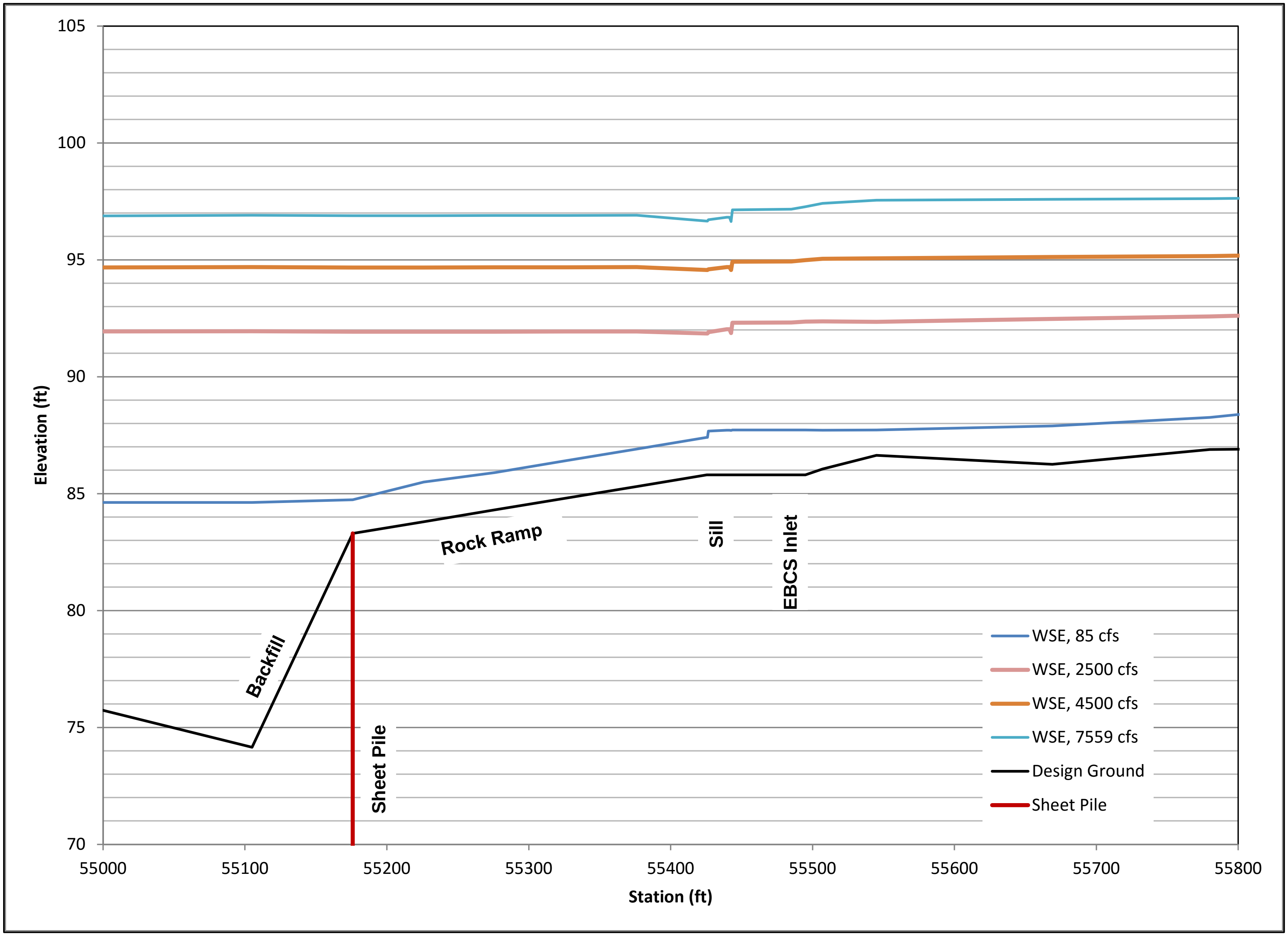


Figure B-5 Model Simulated Flow at 85 Cubic Feet per Second

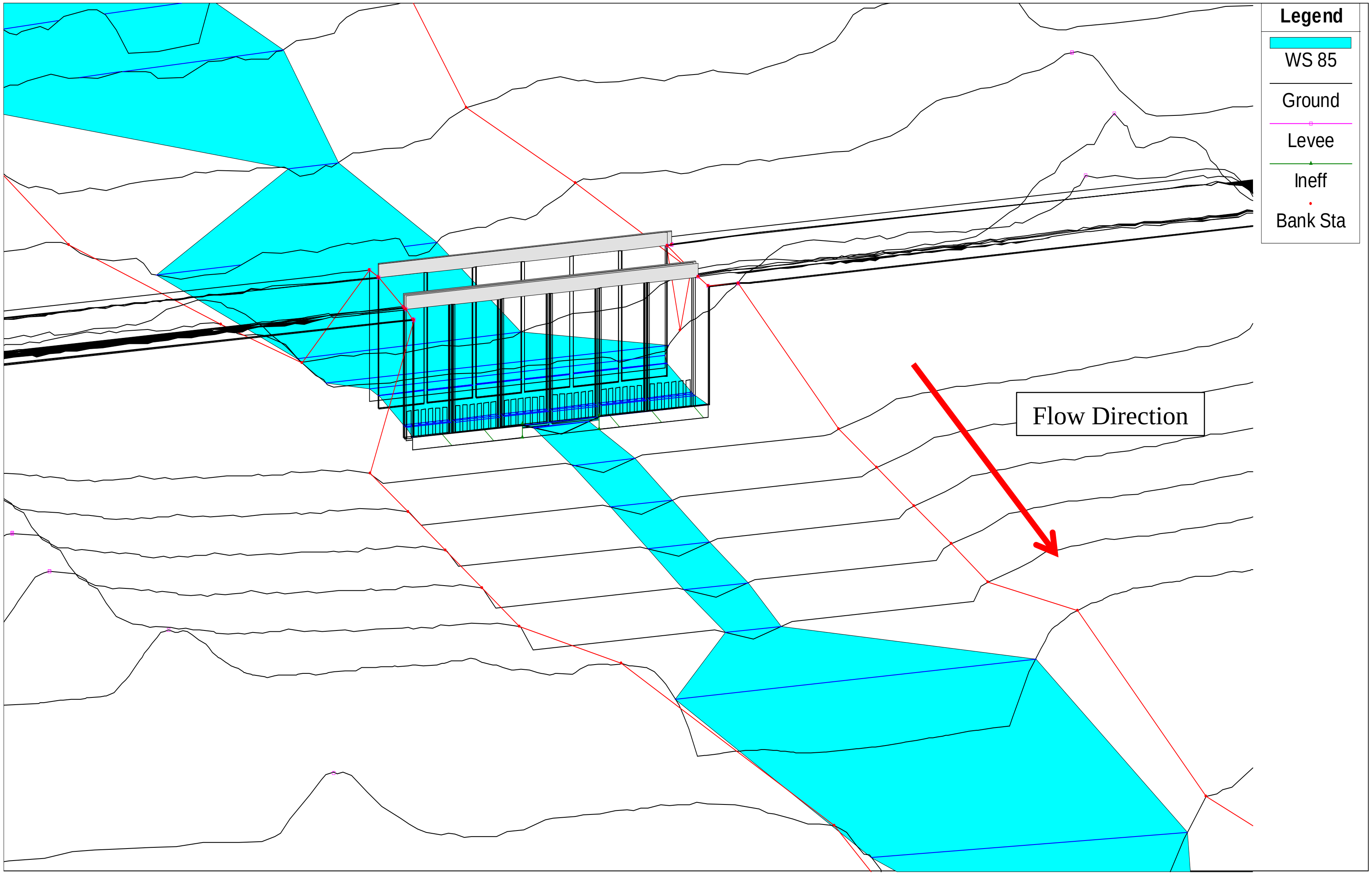


Figure B-6 **Main Channel Average Velocity Profiles for Design Conditions**

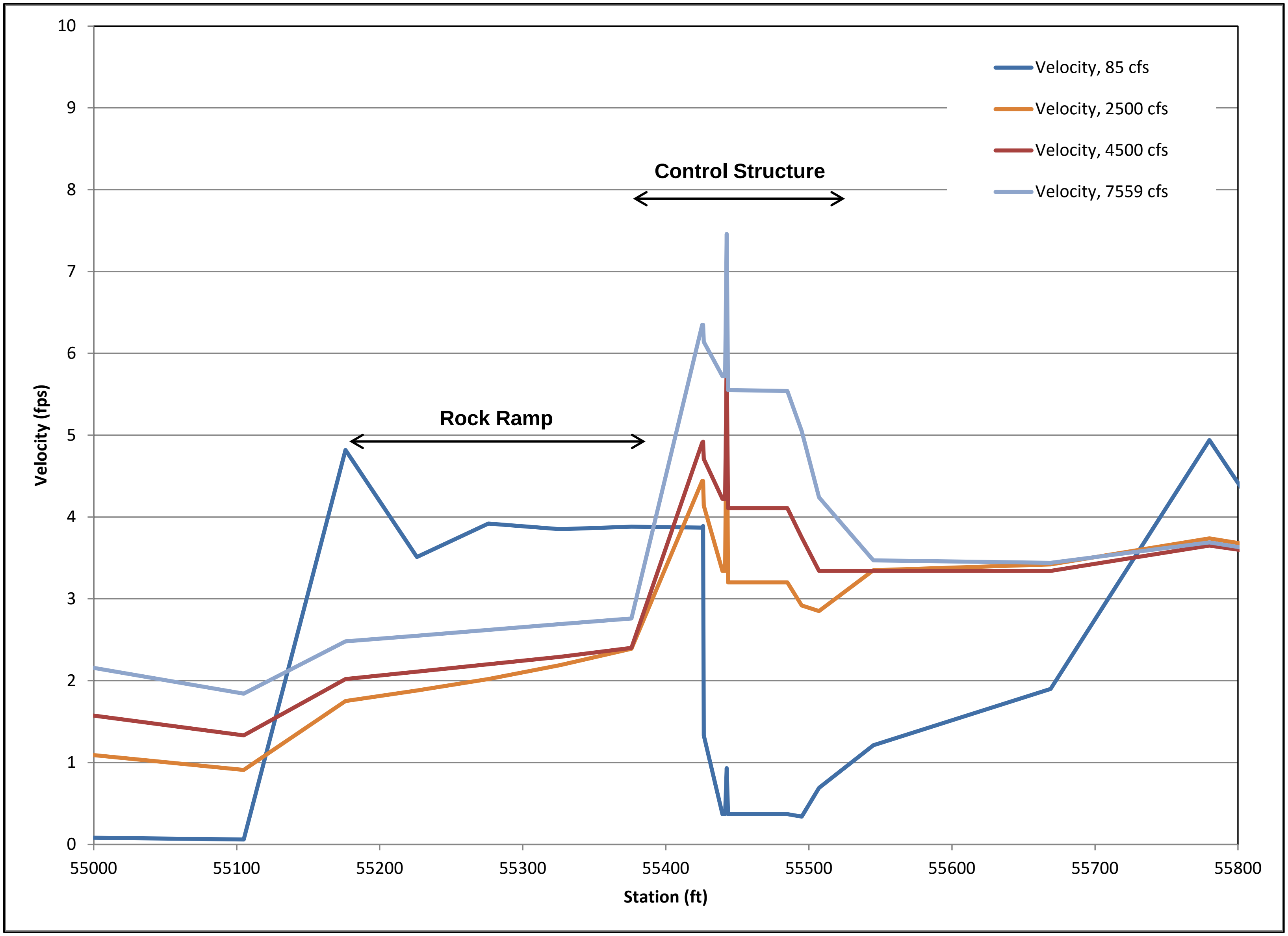
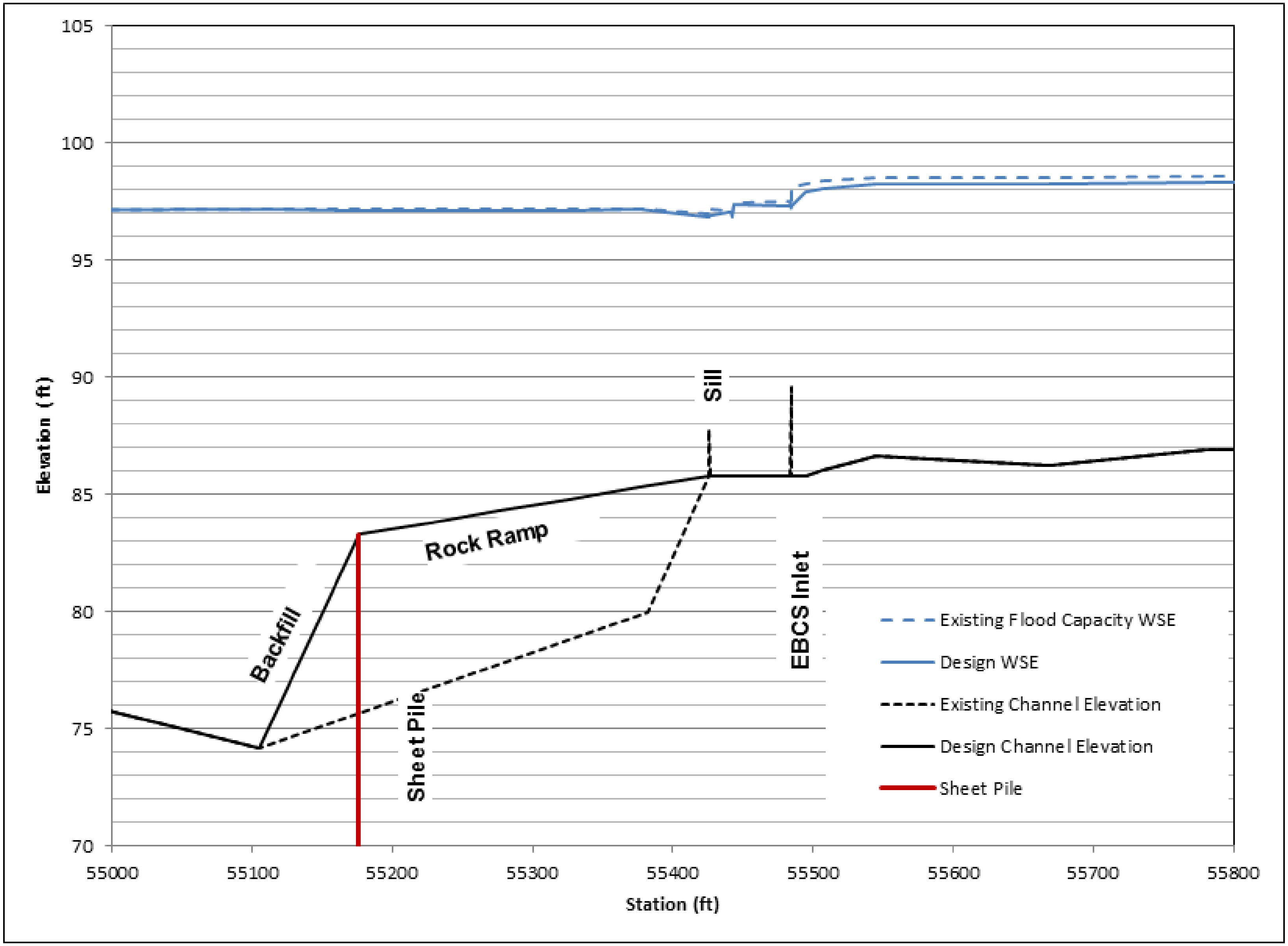


Figure B-7 **Water Surface Profile for Flood Condition**



3.1.1.3 Flood Capacity

The design flood capacity of the levees within this reach of the bypass is 8,000 cfs. The water-surface profiles generated from the hydraulic models for the existing condition and the design alternative were compared to ensure that there is less than 0.1 foot in water surface elevation (Figure B-7 and Table B-3). Provided that the roughness does not increase in the rock ramp, the design alternative model water surface profile for 8,000 cfs is lower than the existing condition, and as a result, meets the design criterion.

Table B-3 WSE Difference between the Design and the Existing Condition

Station	Design Condition WSE (ft)	Existing Condition WSE (ft)	WSE Difference (ft)
55105	97.2	97.2	0
55495	97.9	98.2	-0.3
55545	98.2	98.5	-0.3
55780	98.3	98.6	-0.3
55993	98.4	98.7	-0.3
56435	98.5	98.7	-0.2
59095	98.8	99.0	-0.2

Notes:
ft = feet, WSE = water surface elevation

3.1.2 Ground Subsidence

Subsidence is likely to increase water depths at the fishway approximately 0.5 foot to 1 foot of depth during the next 25 years. As depths increase, the area downstream of the structure (the tailwater control) will be subsiding at a slower rate than the channel upstream of the EBCS. Design changes to the rock ramp to account for future subsidence may not be needed if the tailwater stays the same or increases. Additional analysis of the changes in the localized impacts to the hydraulics and sediment transport within the reach is needed.

3.1.3 Operations and Maintenance

During Restoration Flows, the radial gates within the EBCS are assumed to be fully open. When there are flood flows (flows more than 4,500 cfs), one or more of the radial gates may be partially or fully closed in order to regulate the flow volume into the Lower Eastside Bypass. This is especially important when tributary inflows downstream of the EBCS to the Lower Eastside Bypass exceed the design capacity and may potentially threaten the integrity of the levees. By operating the radial gates, flood flows can be routed into the Mariposa Bypass to reduce flood risks in the Lower Eastside Bypass. Gate closures would impede the passage of fish through the EBCS.

The notched sill and the rock ramp channel may collect debris over time, so it is crucial to keep the notch clean by removing any debris. The rock ramp will need to be monitored to determine if the rock needs to be replenished, modified, or replaced after larger flow events.

3.1.4 Cost Estimate

The cost estimate to construct the rock ramp and modify the EBCS is approximately $3.4 million. The cost estimate worksheet is located in Attachment B and includes:

- Clearing and grubbing the site.
- Excavation of the channel.
- Grouted rock and engineered fill for the rock ramp.
- Sheet pile to stabilize the rock ramp.
- Demolition of the EBCS sill and reconstruction of the sill with a v-notch.

To meet the flood criterion, this design assumes approximately 620 cubic yards of channel excavation to grade the channel and remove material to key in the ramp material into the channel banks. A majority of the ramp material will be engineered fill that is compacted for the foundation of the rock ramp. This material estimate includes an additional 25 percent for compaction. The cost for extending the ramp to meet the elevation of the channel downstream, resulting in the filling of the pool downstream of the EBCS, is not included. If the pool is filled with the same material as the rock ramp, the project costs would increase significantly.

The cost of the material for the rock ramp uses the median rock size volume and includes grouting the rock to protect from erosion. The sheet pile wall cost estimate is based on a sheet pile depth of 20 feet for the length of the channel plus approximately 40 feet to key into the channel bank.

The cost estimate to add a v-notch to the EBCS sill includes demolition of the sill and reconstructing the sill. Costs for general construction include an estimated $50,000 for items such as permitting and dust control. Contingencies for design, field costs, and contract costs are included in the cost estimate, and total approximately 50 percent of the overall cost of the alternative.

3.1.5 Benefits and Consequences

Removing the boards at the EBCS inlet, notching the sill, and providing a rock ramp at the entrance of the EBCS not only provides passage for adult Chinook salmon, but should also provide passage for non-jumping fish species.

This alternative modifies the existing structure, which includes removing the boards within the EBCS. This has the potential to significantly change the hydraulics within the Eastside Bypass upstream of the EBCS, as well as how flow is routed to the Mariposa Bypass. The permitting agencies and the LSJRLD will need to be consulted to ensure this is a viable alternative. Other alternatives that provide the same passage without modifying the structure may be preferred over this alternative solely based on the flood protection needs of the LSJRFCP.

3.1.6 Future Design Considerations

The following design considerations are for the next phase of design and will require coordination with the LSJRLD and the fisheries agencies. If this alternative becomes the preferred alternative, the following elements would need to be considered and refined during the next phase of design.

3.1.6.1 Hydraulic Diversity

For ramps that do not include hydraulic diversity, the guidelines for maximum velocity for culverts would apply. Because the rock ramp is between 200 feet and 300 feet long, the maximum velocity allowed based on the guidelines could be as low as 2 fps. The next phase of design should consider adding some more complexity to create more hydraulic diversity and velocity shadows. This can be done using large protrusion boulders, or adding wider spots, or resting pools in the low-flow channel to create slower velocity regions.

3.1.6.2 Pool Downstream of the EBCS

The benefit and consequences of the large pool downstream of the EBCS will need to be discussed with the fishery agencies. This design assumes the pool is needed to provide a location for the fish to hold during gate closure. If this option is not desired, and predation to out-migrating juveniles is more of a concern than providing a location for a holding pond, then the pool may need to be filled. The pool could be filled by extending the rock ramp to meet the existing channel invert downstream. This would stabilize the ramp and would eliminate the need for the sheet piles. The project costs would increase significantly because of the amount of materials that would be needed to fill the pool.

3.1.6.3 EBCS Gate Operations

Coordination with the LSJLD is essential to confirm the current operations of the gates and flood-flow routings. When all six radial gates are closed, this alternative would impede fish passage through the EBCS. In addition, model simulations of the board operations at low flows show that fish passage would be impeded. Partial gate closure (gates between the open or closed position) should be evaluated if this alternative is selected for implementation.

3.1.6.4 Sediment Transport

Modifications to the EBCS and main channel, as well as changes caused by subsidence, may potentially alter the sediment transport in the area. Sediment load studies need to be conducted before and after the construction to understand how future geomorphic changes may impact the structure, and to determine if retrofits to the structure and alternative are needed.

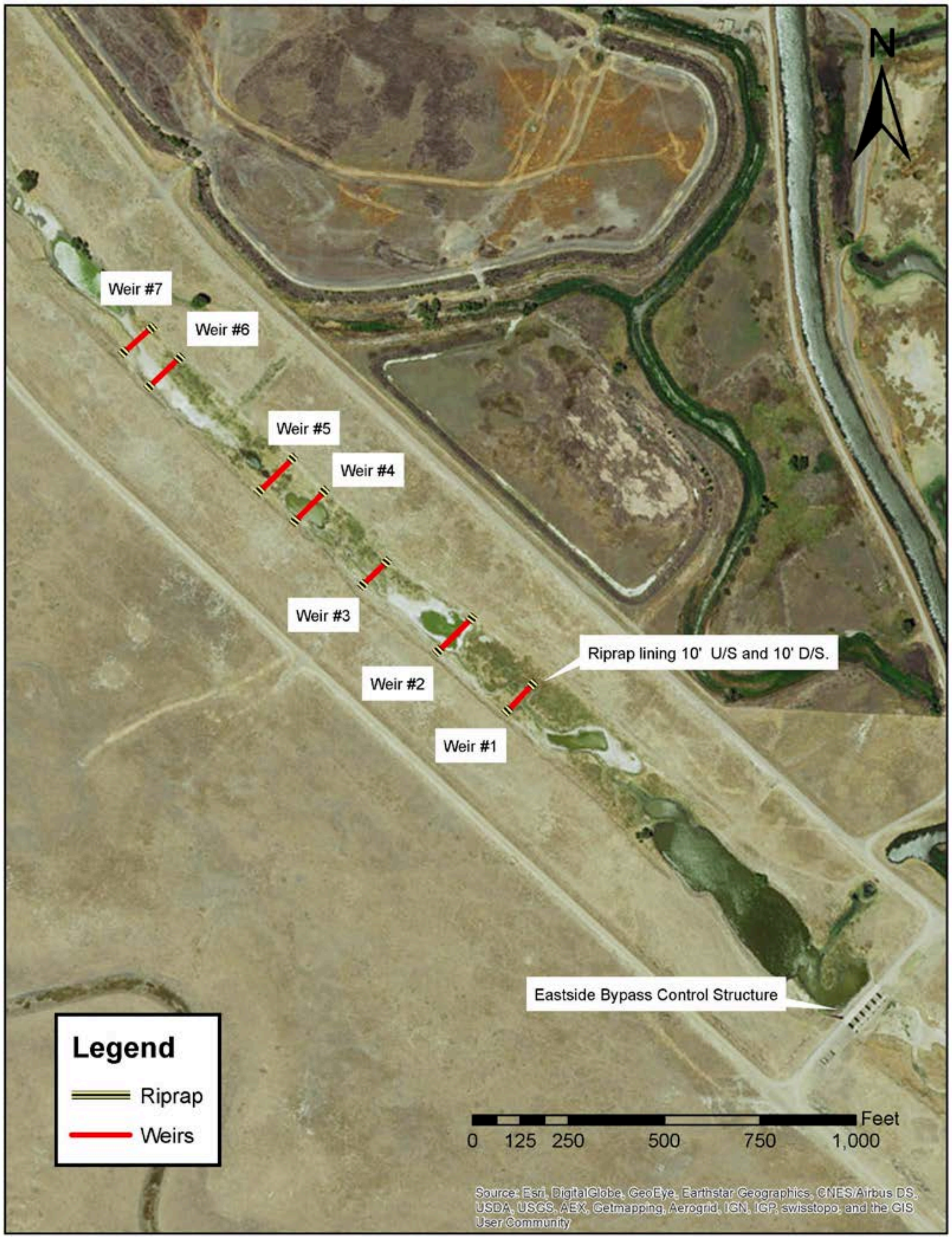
3.2 Alternative EBCS-2 – Grade Control

This fish passage improvement design alternative consists of adding a series of weirs downstream of the EBCS, constructed of either sheet piles or cast-in-place concrete, to backwater the EBCS to a sufficient depth to provide for fish passage over the sill at the low-design flow.

This alternative assumes that all gates on the EBCS are fully opened during Restoration Flows, the boards at the structure inlet are removed, and that no changes to the existing structure, including the sill or baffles, are needed. The EBCS will still need to operate during flood flows. This alternative will not impact those operations. But, gate closure at the EBCS would impede fish passage.

A series of seven weirs that are cast-in-place concrete or sheet piles would be placed within the channel beginning, at the most upstream weir, approximately 1,150 feet downstream of the EBCS (Figure B-8). These weirs are individual structures that will have native streambed material that will be backfilled between each weir. This design will allow the water surface elevation to be incrementally increased to

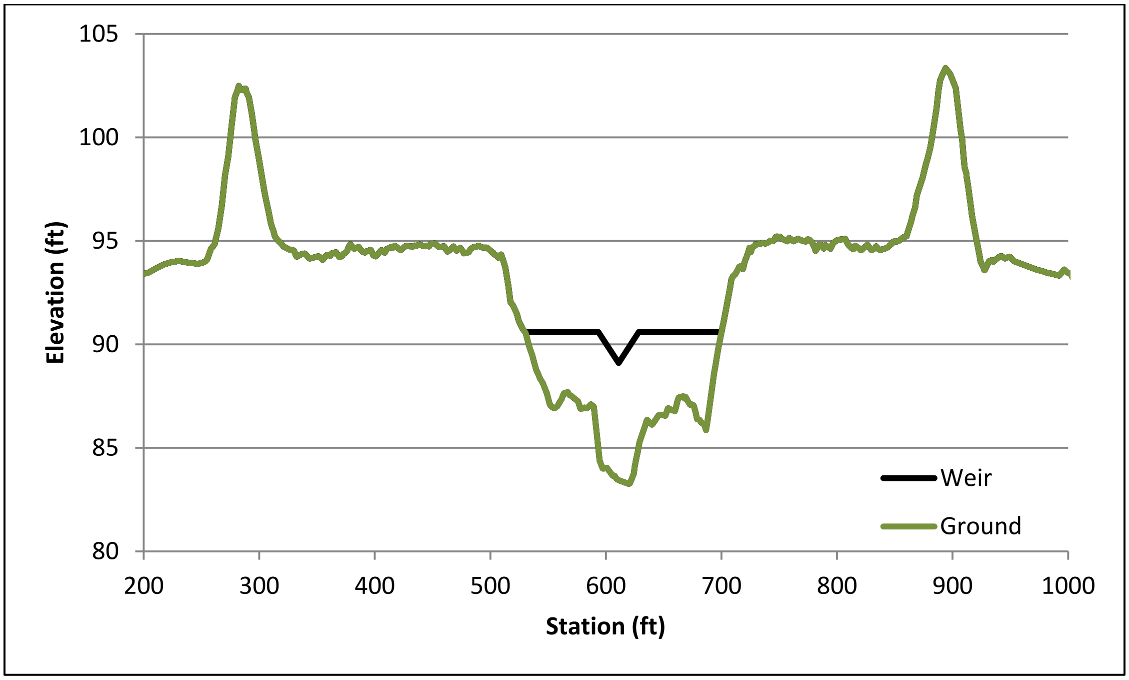
Figure B-8 **Location of Grade Control Structures**



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

provide fish passage. The location of the weirs was determined from the existing channel "pool and chute" configuration, but could be spaced much closer to reduce predation between the weirs, if needed. For this conceptual design, the weirs are spaced between 100 feet and 300 feet apart. Bank protection was also added 10 feet upstream and downstream of each of the weirs to prevent scour. The most upstream weir top elevation is 90.6 feet to provide an upstream water surface elevation of 90.7 feet at the EBCS boards (average top elevation of 89.6 feet). Each weir has a low-flow notch to allow for sufficient depth at 85 cfs. The v-notch has a top width of 35 feet and is 1.5 feet deep. Figure B-9 is an example of the weir that would be constructed at the most upstream location.

Figure B-9 **Example of Weir Design (Most Upstream Weir)**



3.2.1 Hydraulic Analysis

A one-dimensional model using HEC-RAS was developed from a calibrated model, previously developed for existing conditions, to ensure that the conceptual alternative meets the criteria for flow, fish passage, flood capacity, and subsidence. The existing model was modified by adding the grade control structures. The model was used to simulate depth and velocity for a range of flows assuming a steady-flow condition.

3.2.1.1 Flow

This fishway facility is designed to provide unimpeded passage for flows between 85 cfs and 7,559 cfs. For this alternative, flows over peak attraction flow releases of 4,500 cfs are assumed to be flood flows. Fish passage during these flood flows will depend on how the EBCS will be operated during flood flows because gate closure would impede passage. This design assumes that fish will either be migrating through the EBCS during floods or holding downstream the EBCS if the gates are closed. The flow modeled for criteria compliance includes the lower design-flow limit of 85 cfs, the upper design-flow limit of 7,559 cfs, and the flood capacity flow of 8,000 cfs.

3.2.1.2 Fish Passage

The hydraulic conditions for the alternative will need to meet the general criteria in Table B-1 for minimum flow depth of 1.0 foot, velocity of 4 fps, and recommended hydraulic drop of 1.0 foot.

Figures B-10 and B-11 display the water surface elevation and the velocities through the weirs for the design flows. The velocities within the channel and over the weirs are below 4 fps and meet fish passage criteria.

Figure B-10 Grade Control Water Surface Elevation (WSE) Profile Within the Channel

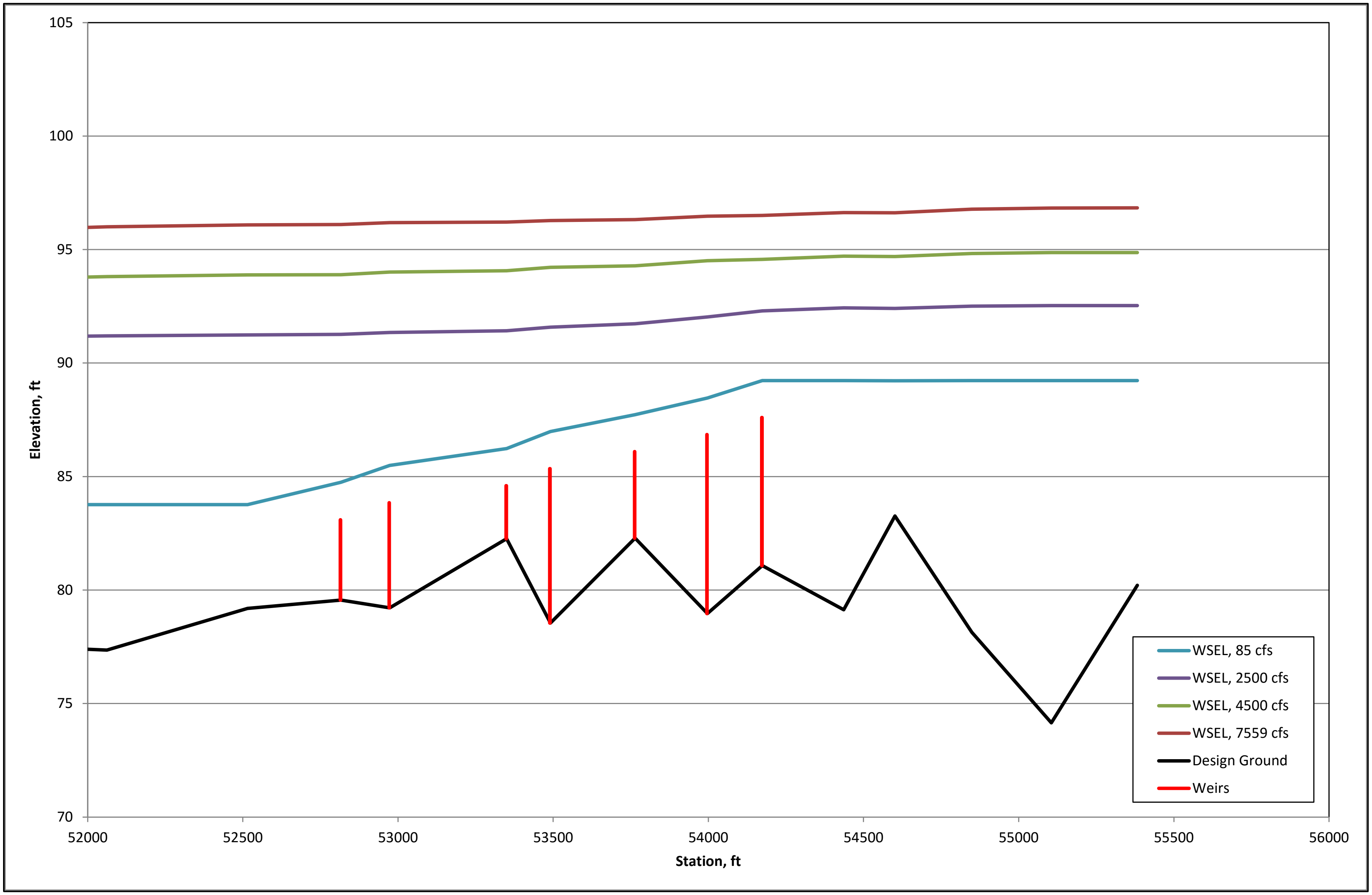
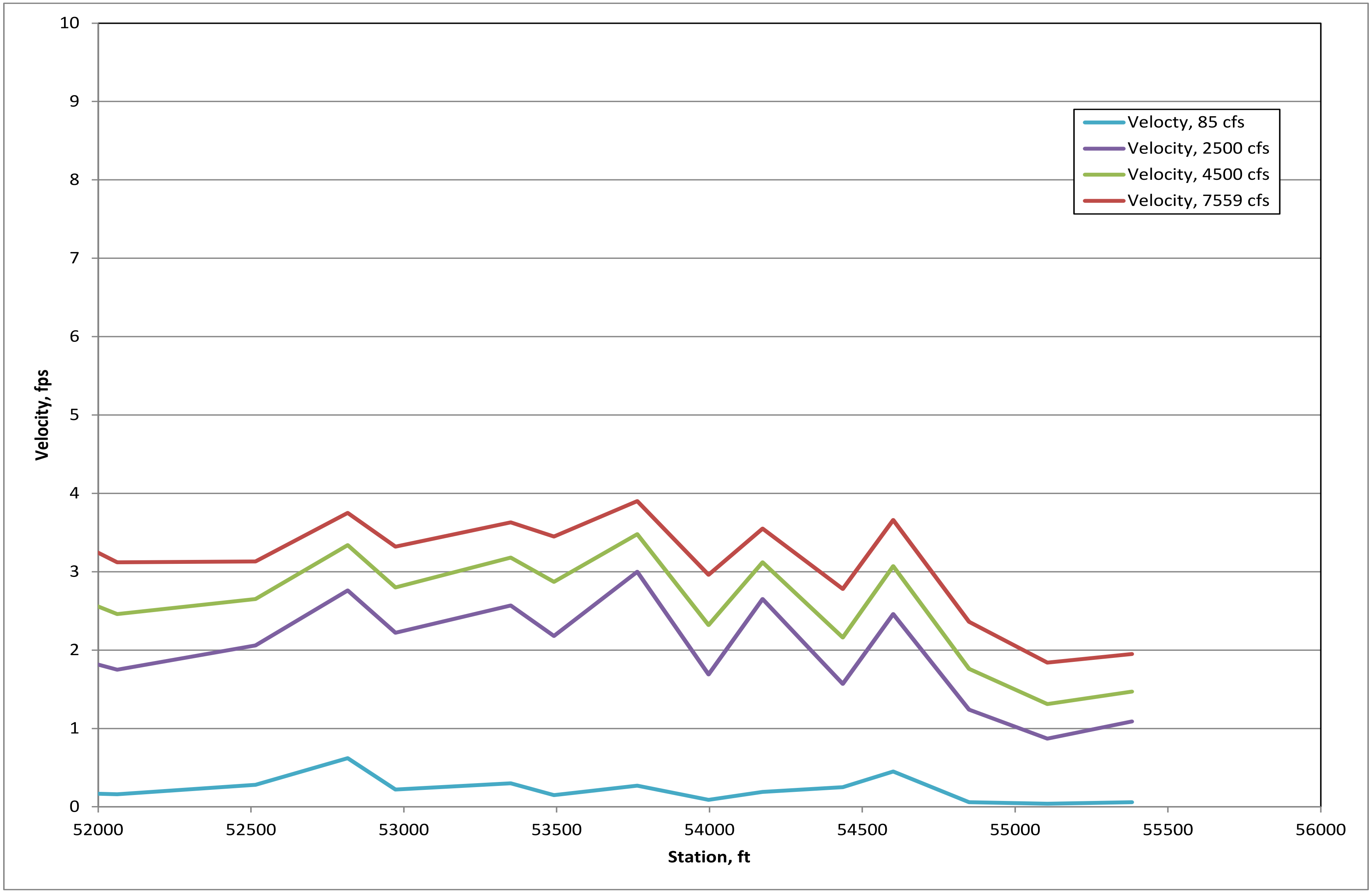


Figure B-11 **Main Channel Average Velocity Profiles for Design Conditions**



3.2.1.3 Flood Capacity

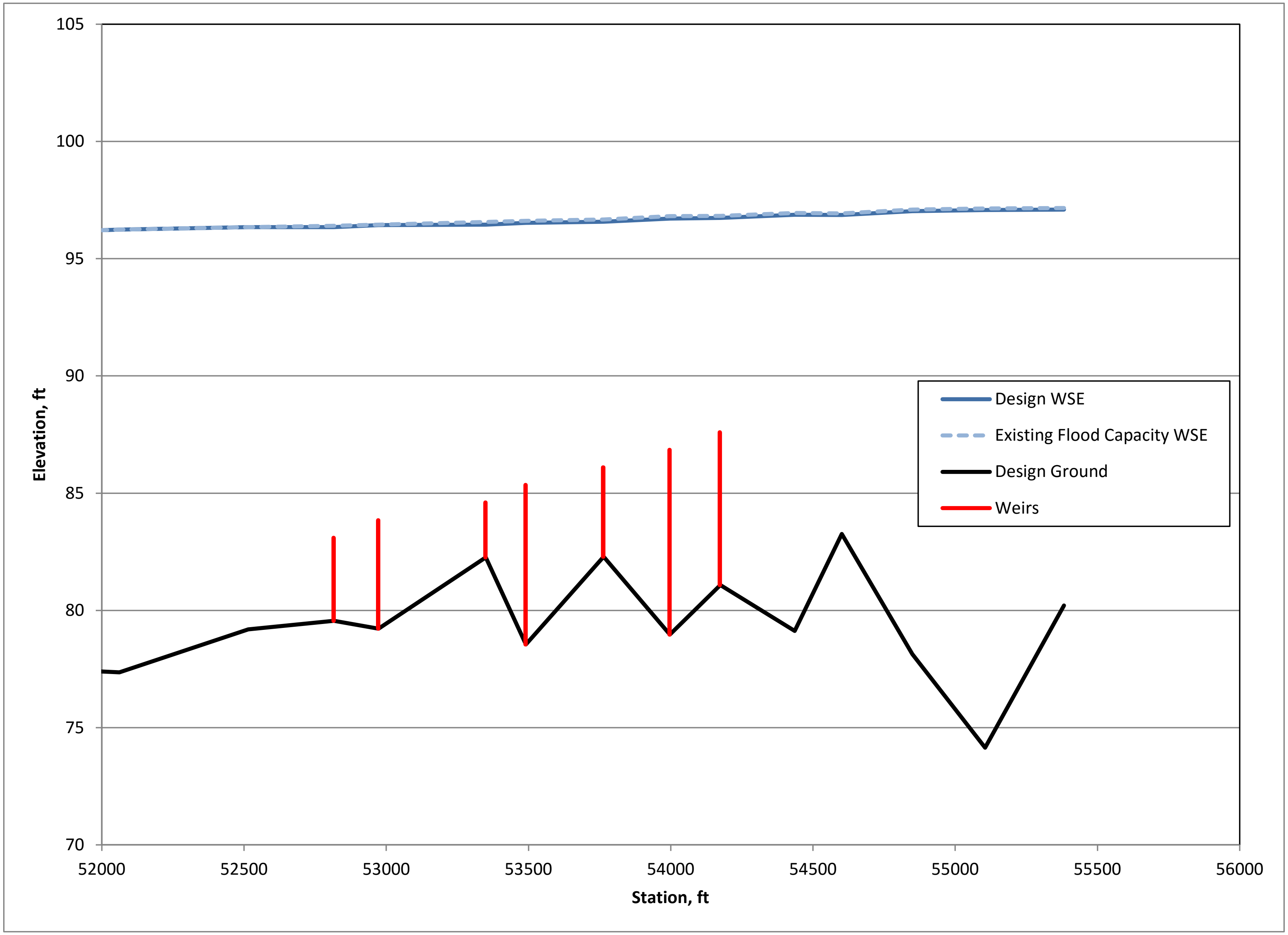
The design flood-flow capacity of the levees within this reach of the bypass is 8,000 cfs. The water surface profiles generated from the hydraulic models for the existing condition and the design alternative were compared to ensure that there is less than 0.1 foot in water surface elevation (Figure B-12 and Table B-4). The alternative model water surface profile for 8,000 cfs is lower than the existing condition, and, as a result, meets the design criterion.

Table B-4 WSE Difference between the Design and Existing Condition

Station	Design Condition WSE (ft)	Existing Condition WSE (ft)	WSE Difference (ft)
54849	97.1	97.1	0.0
54436	96.8	96.9	-0.1
54174	96.7	96.8	-0.1
53997	96.7	96.8	-0.1
53764	96.5	96.7	-0.2
53491	96.5	96.6	-0.1
53350	96.5	96.6	-0.1
52973	96.4	96.4	-0.0
52816	96.3	96.4	-0.1
52515	96.3	96.3	0.0

Note:
ft = feet, WSE - water surface elevation

Figure B-12 **Grade Control Flood Capacity Flows, 8,000 Cubic Feet per Second, through the Structure**



3.2.2 Ground Subsidence

Similar to Alternative EBCS-1, it is likely that water depths will increase and further create backwater conditions that would enhance fish passage.

3.2.3 Operations and Maintenance

Similar to Alternative EBCS-1, the general operation of the EBCS during Restoration Flows also assumes that the control structure gates are fully opened during salmon migration. The maintenance of the EBCS and levees is completed by the LSJLD and would likely continue. The weirs would occasionally need to be monitored for scouring.

3.2.4 Cost Estimate

The cost estimate to construct the grade control structures is approximately $5.1 million. The cost estimate worksheets are located in Attachment B. Similar to Alternative EBCS-1, this cost includes miscellaneous construction costs and contingencies and includes:

- Clearing and grubbing the site.
- Five individual sheet pile weirs.
- Engineered compacted fill upstream the weirs.

The cost to construct each weir was estimated based on a "typical weir" configuration based on site-specific topography. The weir material is assumed to be vinyl or aluminum and is based on a depth of 20 feet and the channel width, plus approximately 40 feet for keying into the channel banks.

3.2.5 Benefits and Consequences

By constructing a series of grade-control structures to eliminate the fish passage barrier at the EBCS, this alternative does not make modifications to the physical structure of the EBCS, with the exception of removing the boards from the inlet during Restoration Flows. If the sediment or hydraulic conditions change over time or excessive scour occurs downstream of the weirs, the weirs could become barriers themselves. Similar to Alternative EBCS-1, gate operations may impact the migration of salmon. If emergency gate closure occurs during the upstream migration, then excessive delay of a salmon run is possible.

3.2.6 Future Design Considerations

The following design considerations are for the next phase of design and will require coordination with the LSJRLD and the fisheries agencies. If this alternative becomes the preferred alternative, the following elements would need to be considered and refined during the next phase of design.

3.2.6.1 Weir and Foundation Designs

The weirs include a single v-notch that could cause excessive velocity. Future designs could consider a double compound v-weir that would provide sufficient depth at low passage flow and a gentler sloping crest once depths are greater than 1.0 foot. In addition, orifices could be added to the weirs to allow for non-leaping, but strong swimming, fish to swim through and to also drain the pools if the bypass would ever need to be dried. The specifications for the weir foundations are currently based on similar weir designs completed for the Reach 2B project. If this design moves forward, additional assessment of the foundation and bank protection to reduce scour and ensure stability will be necessary.

3.2.6.2 Impacts to Routing

Currently, the sill of the EBCS is the hydraulic control within the structure. By raising the water surface elevation at low flows to be at least 1 foot over the weir, it will create a pool upstream and through the structure, which will continue into the Middle Eastside Bypass. With the boards removed from the EBCS inlet, the water surface elevation should remain lower than the invert of the Mariposa Bypass and not change the routing of flows. A hydraulic assessment of the interaction between the Lower, Middle and Mariposa bypasses should be completed if this design moves forward.

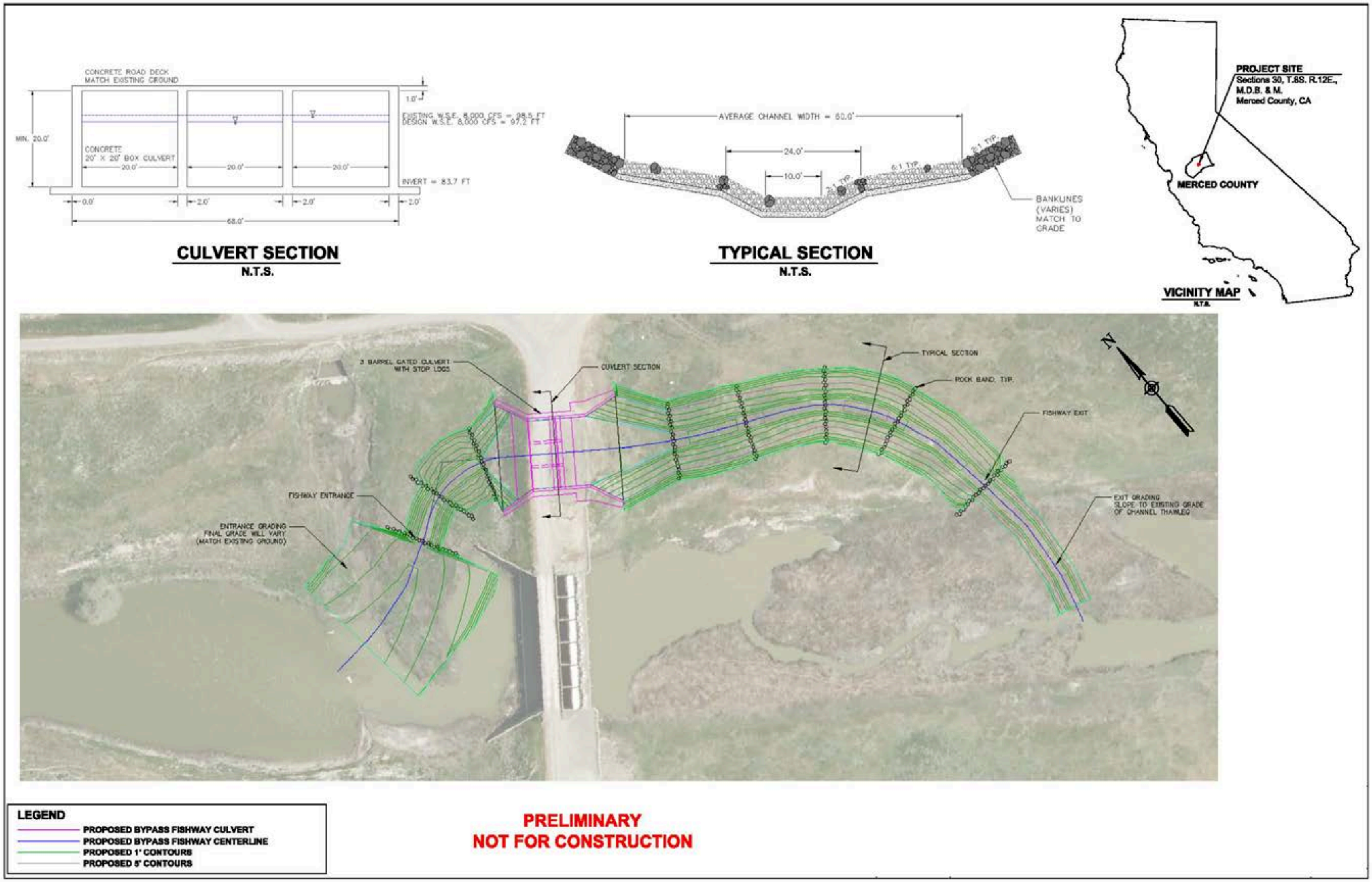
3.3 Alternative EBCS-3 – Bypass Fishway

Under this alternative, a chute and pool roughened channel fishway would bypass the EBCS to provide an alternate route for fish passage. To allow for the LSJLD to operate during flood operations, the fishway must have the ability to be closed. This alternative assumes that flow will typically be split between the EBCS and the fishway, so gates are assumed to be fully open on the EBCS during Restoration Flows. Gate closure on the fishway or EBCS could occur, but fish passage was not assessed for those conditions. The boards at the EBCS are assumed to remain in place at the EBCS inlet, so that the flexibility to adjust the boards remains and will allow the structure to operate as it does now.

The bypass fishway is located in the current overbank of the bypass within the levees. The fishway will be cut into the right overbank and grading will connect the fishway entrance and exit to the bypass channel. The fishway will penetrate the existing earthen headwall on the northeast side of the EBCS. Three culverts, similar to the existing EBCS, will be constructed to continue to provide vehicular traffic access. Instead of radial gates, the culverts will be equipped with slots for stoplogs. A plan view of the fishway and control structure, and the typical cross sections for the culverts and channel, are shown in Figure B-13.

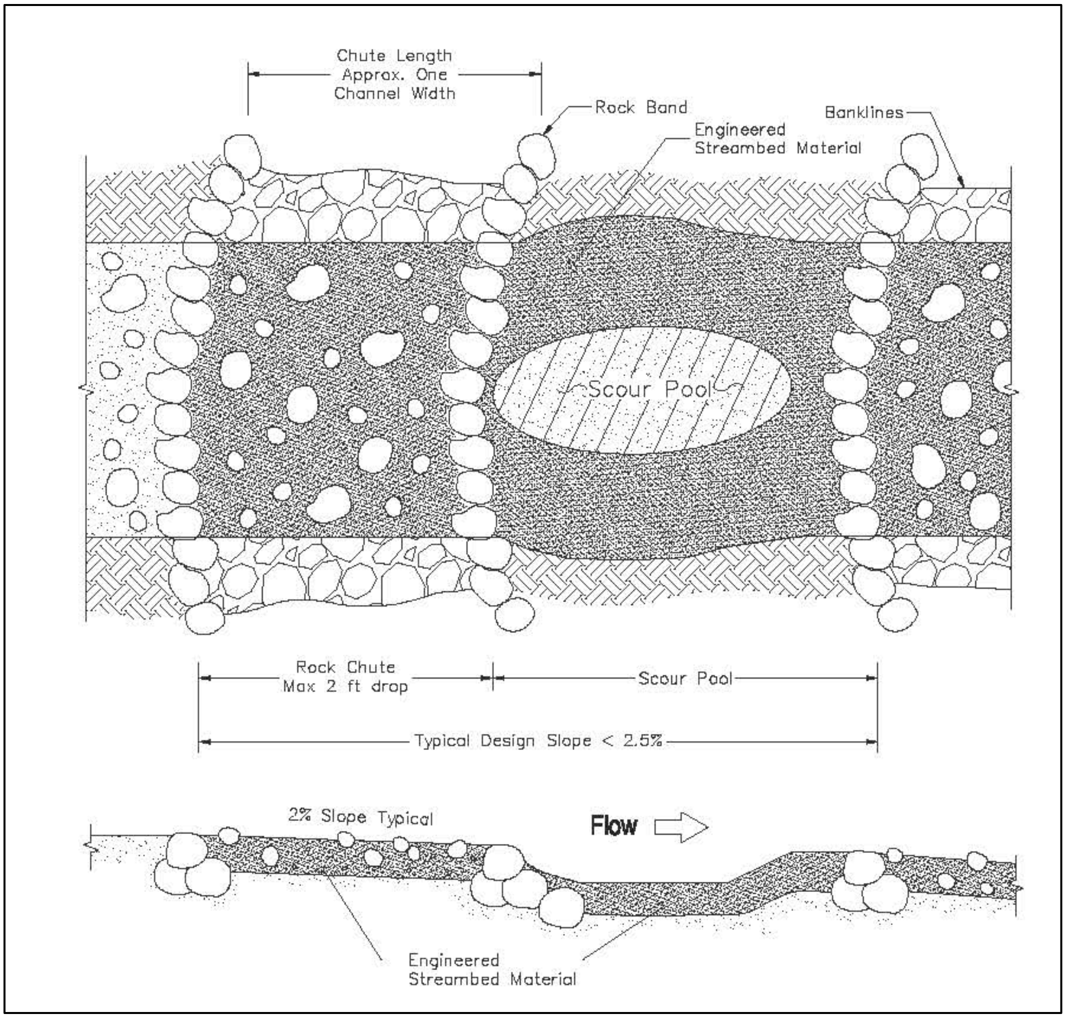
The fishway is designed to provide as much attraction flow through the fishway channel as possible. The drop from the fishway exit to the entrance is approximately 5.5 feet and the total length of the fishway is approximately 625 feet. The fishway channel will have a trapezoidal channel shape with a 10-foot bottom width and a varying depth of about 6 feet on average from the bank to the channel invert. The channel will be in a chute and pool configuration similar to what is shown in Figure B-14 (California Department of Fish and Game 2010). Between the pool and chute sections will be a series of rock bands that will be used to stabilize the channel.

Figure B-13 **Alternative EBCS-3 - Bypass Fishway, Plan and Section Views**



The proposed fishway channel substrate will be constructed of engineered streambed material (ESM) that will be a combination of rounded boulders, cobble, gravel, and course sand. The banks will be lined with a mix of rock slope protection that is similar to the ESM. The rock bands will be angular boulders between 2.5 feet to 4 feet in diameter.

Figure B-14 **Typical Fishway Plan and Profile**



3.3.1 Hydraulic Analysis

A one-dimensional model using HEC-RAS was developed from a calibrated model, previously developed for existing conditions, to ensure that the conceptual alternative meets the criteria for flow, fish passage, flood capacity, and subsidence. The existing model was modified by grading the proposed roughened channel into the right overbank and simulating flow through the proposed three-barrel culvert.

3.3.1.1 Flow

The hydraulic model was used to simulate the split of flow between the fishway and the EBCS. Table B-5 summarizes the percentage of the total flow within the fishway. For simplicity, all figures and discussion referencing flow will report the flow prior to the split of flow between the Eastside Bypass and the fishway.

Table B-5 Modeled Split Flow

Flow Prior to Split (cfs)	Average Flow within Fishway (cfs)	Average Percent of Flow
45	45	100%
85	85	100%
100	100	100%
250	142	57%
500	192	38%
1000	295	30%
2000	505	25%
3000	706	23%
4500	1150	25%
6000	1700	28%
8000	2470	31%

Note:
cfs = cubic feet per second

3.3.1.1 Fish Passage

The hydraulic conditions for the alternative will need to meet the general criteria in Table B-1 for minimum flow depth of 1.0 foot, velocity of 4 fps, and recommended hydraulic drop of 1.0 foot. The modeled water-surface profiles simulated for the design condition for flows ranging from 85 cfs to 7559 cfs are shown in Figure B-15. Figure B-16 shows average channel depth is greater than 1.0 foot at 85 cfs within the fishway. Figure B-17 shows the average channel velocity within the fishway is less than 4 fps, with the exception of a single cross section upstream of culvert at 250 cfs, and the upstream-most cross section at 4,500 cfs. These exceedance are at hydraulic transitions, and can be further refined at the next design phase, if needed. Lower velocity resting pools were added to the fishway. Without the resting pools, the fishway would need to have average velocities of less than 2 fps.

An attraction flow between 5 percent and 10 percent of the fish passage design high flow is recommended by the guidelines. Table B-5 displays the flow split between the EBCS and the fishway for the specified design flows. The fishway flow split is greater than 10 percent of the flow, so it complies with the guidelines for providing the appropriate attraction flows.

Figure B-15 Fishway Water Surface Elevation (WSE) Profile

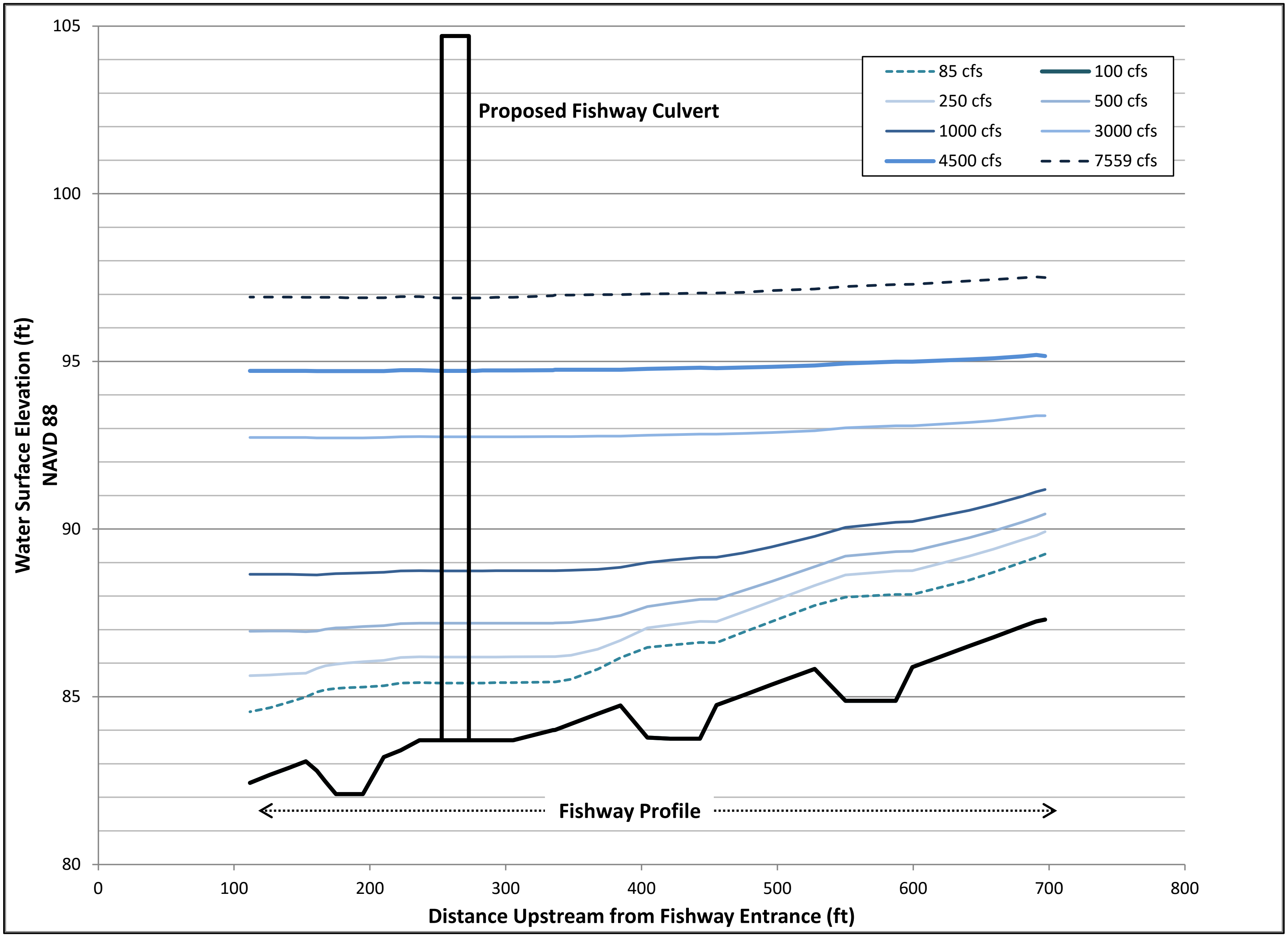


Figure B-16 **Fishway Water Depths**

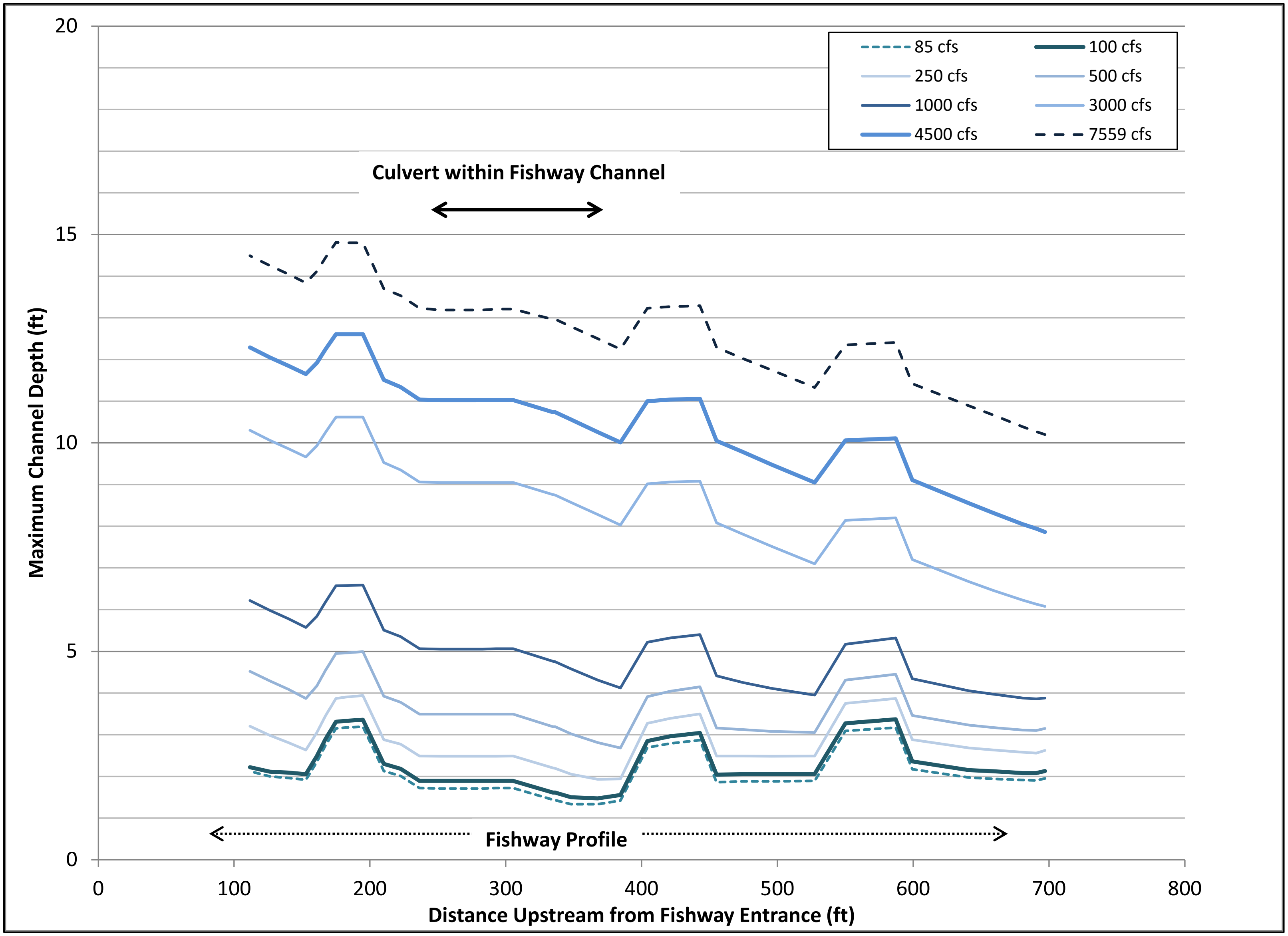
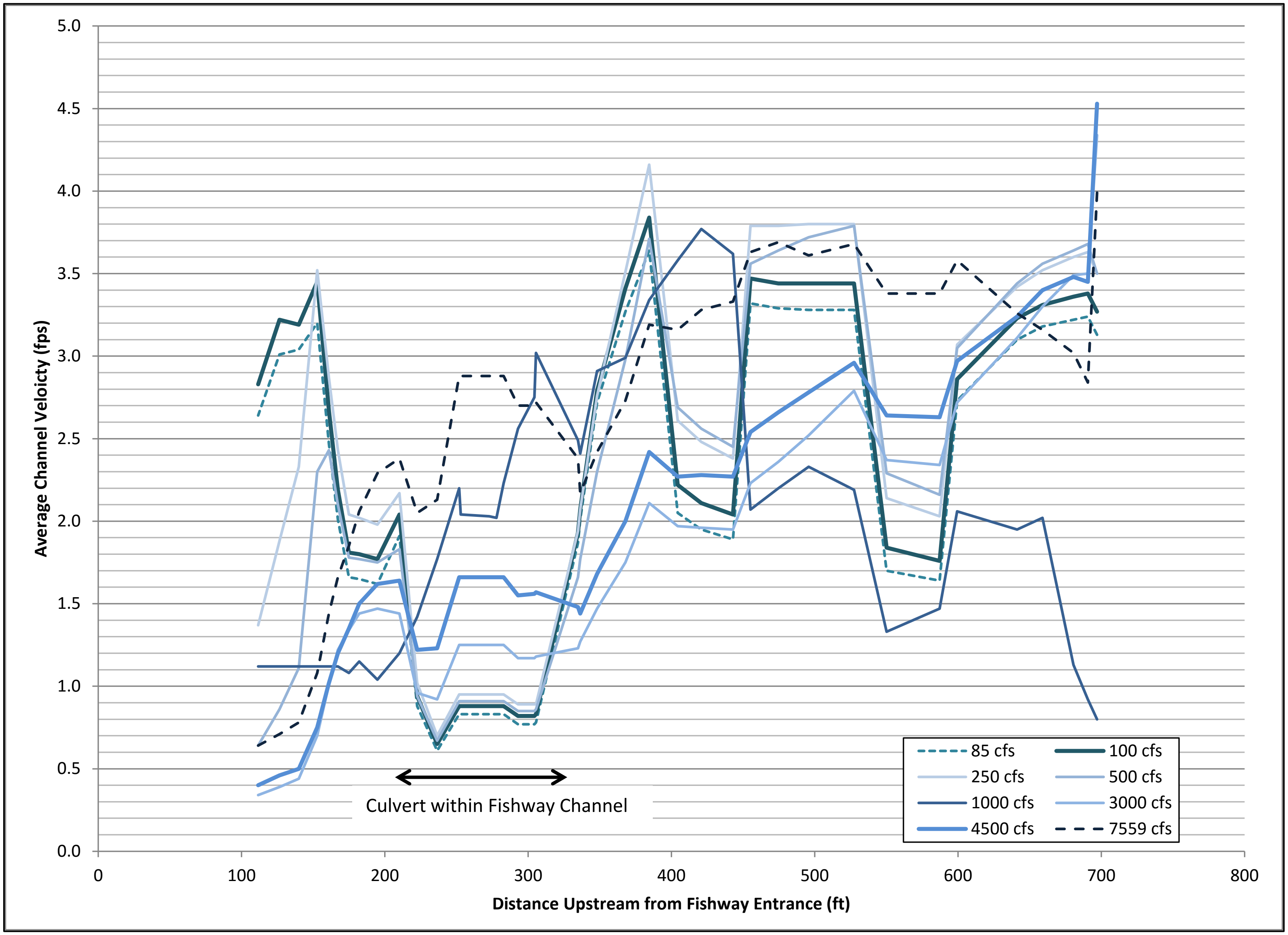


Figure B-17 **Fishway Velocities**



3.3.1.2 Flood Capacity

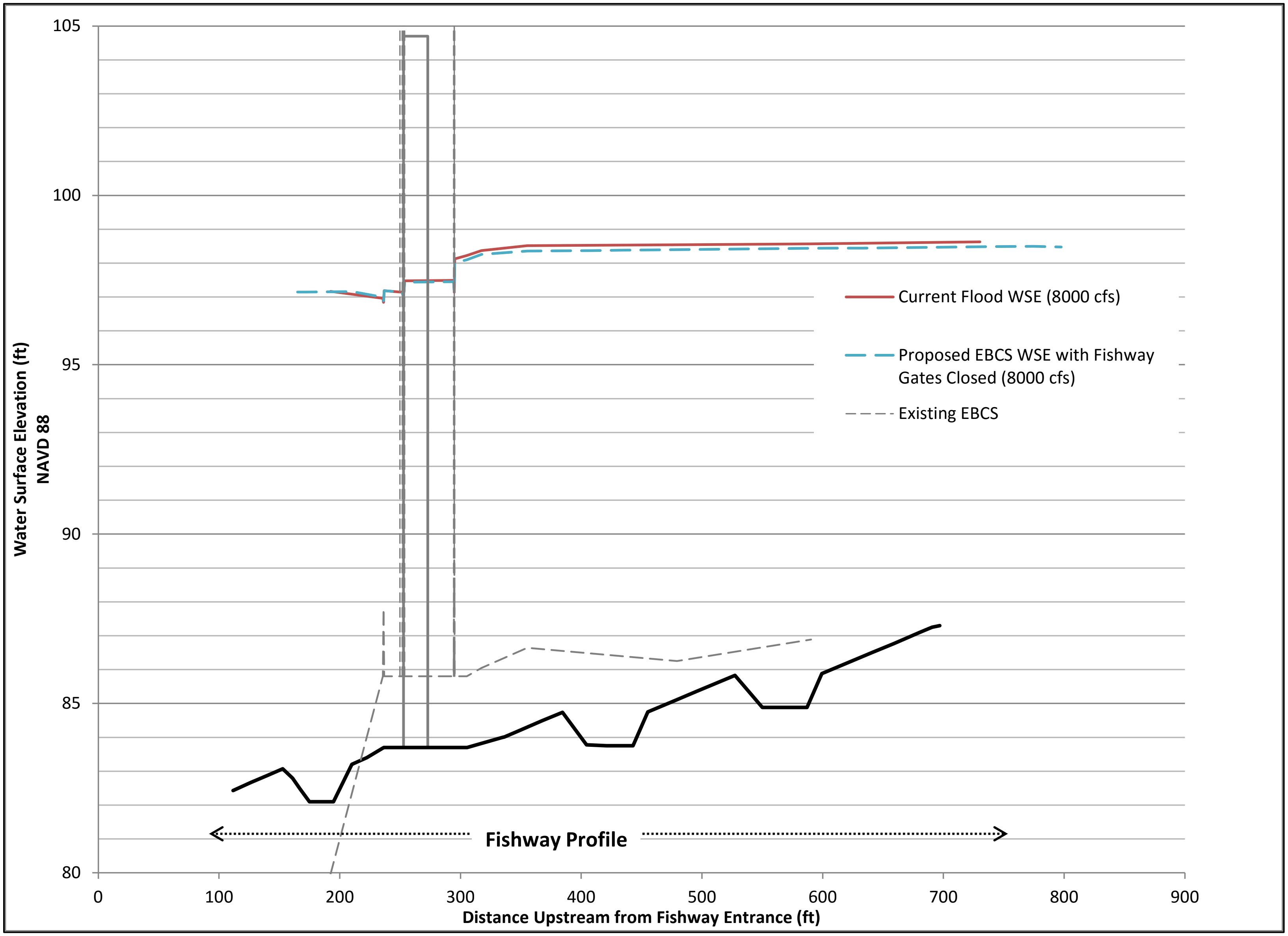
The design flood capacity of the levees within this reach of the bypass is 8,000 cfs. The water surface profiles generated from the hydraulic models for the existing condition and the design alternative were compared to ensure that there is less than 0.1 foot in water surface elevation (Table B-6 and Figure B-18). Because the flow is assumed to be split between the fishway and the EBCS, the maximum water surface between the flow split was used to reflect the alternative design condition. The water surface elevation at 8,000 cfs shows that the water surfaces are slightly decreasing or remaining the same when compared to existing conditions.

Table B-6 WSE Difference between the Design and the Existing Condition, Split Flow

Station	Design Condition			Existing Condition	WSE Difference (ft)
	Fishway WSE (ft)	Eastside Bypass WSE (ft)	Maximum WSE (ft)	Eastside Bypass WSE (ft)	
55780	98.0	98.0	98.0	98.5	-0.5
55669	97.8	98.0	98.0	98.5	-0.5
55545	97.8	97.9	97.9	98.5	-0.6
55507	97.5	97.9	97.9	98.4	-0.5
55495	97.2	97.8	97.8	98.2	-0.4
55485	97.2	97.7	97.7	98.1	-0.4
55426.5	97.0	97.2	97.2	97.2	0.0
55382	97.1	97.2	97.2	97.2	0.0
55105	97.1	97.2	97.2	97.2	0.0

Notes:
ft = feet, WSE = water surface elevation

Figure B-18 **Flood Capacity Flows at 8,000 Cubic Feet per Second**



3.3.2 Ground Subsidence

This alternative is flexible because of the nature of the roughened channel design. If the fishway entrance becomes perched as a result of subsidence, the fishway channel could be extended downstream in the future.

3.3.3 Operations and Maintenance

The general operation of the facility during Restoration Flows assumes that the EBCS gates are fully opened during salmon migration, so flows would be split between the fishway and the control structure. When flows exceed normal Restoration Flows of 4,500 cfs, the EBCS would likely be operated as it has been in the past with potential gate closure or partial gate closure to route flows into the Mariposa Bypass, or eliminate flows into the Eastside Bypass if there are concerns about the downstream bypass capacity being exceeded by downstream tributary flood inflows. Slots are included on the culverts to allow for stop logs to be placed and the fishway to be closed off during flood events, as needed.

The maintenance of the EBCS by the LSJLD would likely continue and it is assumed that no changes to the current maintenance procedures are needed. The fishway would initially need monitoring to ensure that sediment is not building up within the channel, or that the bed material is not eroding and in need of repair.

3.3.4 Cost Estimate

The cost estimate to construct the bypass fishway is approximately $8.8 million. The cost estimate worksheets are located in Attachment B. Similar to Alternative EBCS-1, this includes miscellaneous construction costs and contingencies and includes:

- Clearing and grubbing the site.
- Grading the existing channel.
- Excavation for the bypass fishway channel.
- Constructing a series of culverts.

Site preparation costs include clearing and grubbing at the construction site. It also includes offsite disposal of any waste generated, and transport of any excavated materials. The cost estimate for the fishway includes excavation of the EBCS embankment and the grading of the existing Eastside Bypass Channel to 2.5 feet lower than proposed finished profile elevation. This will allow for installation of the fishway rock lining. The costs for the roughened channel fishway channel rock bands, ESM, and the bank rock include freight charges to transport rock to the project site.

Costs for the culverts include three 20-foot by 20-foot cast-in-place concrete culverts, installation of a roadway over the culverts, stoplog gates, and a foundation.

3.3.5 Benefits and Consequences

The primary benefit of this alternative is that migrating fish would have the ability to bypass the EBCS. In addition, the pool and chute fishway design will allow migrating fish to rest and provide hydraulic diversity with multiple passage pathways throughout the fishway. The fishway could also allow for other native fish migration. Additional analysis, and possibly design changes, may be needed to determine when other native fish passage would occur.

3.3.6 Future Design Considerations

The following design considerations are for the next phase of design and will require coordination with the LSJRLD and the fisheries agencies. If this alternative becomes the preferred alternative, the following elements would need to be considered and refined during the next phase of design.

3.3.6.1 Fishway Flow Control

Flows into the fishway would need to be controlled to maintain the current flood operations of the EBCS. There are several different ways to control flow into the fishway. These could include constructing a gated control structure at the fishway exit (traditional design) and entrance. The location of the control structure(s) will ultimately depend on flood operational needs, and when fish will be migrating through the fishway. The addition of structures would not impact the overall design capacity of the bypass fishway, but would be an additional element of design and would add to the project cost, depending on the option.

3.3.6.2 Fishway Attraction Flow

The fishway will need to ensure that there is sufficient attraction flow and the location of the entrance is placed where there is opportunity to allow for fish to bypass the EBCS when it is a barrier. The current fishway design has a channel invert elevation that provides more than a 10 percent attraction flow, as per the guidance recommendations. Additional attraction flow may be needed. Fishery agencies should be consulted to determine if the current design achieves the intent of the design guidance and will not confuse or strand migrating fish. Another consideration when determining the location of the fishway entrance is whether there is potential for migrating fish to miss the fishway and as a result be stranded when the EBCS is a barrier.

3.3.6.3 Fishway Flood Operation

Because this fishway is located within the floodplain and levees of the LSJFCP, the fishway design needs to consider the O&M of the EBCS to ensure the ability to convey flood flows. There is a need to maintain the current function of the EBCS and be able to follow the current operations within the LSJLD O&M manuals. The design, as proposed, includes the ability to close the culverts with stop logs so that the EBCS can be operated as it is now. If there is potential for migrating fish to be present when the EBCS gates are closed, the fishway may need to remain open to ensure safe upstream passage. Additional analysis needs to be done to evaluate if fish passage criteria would be met if some, or all, of the culverts bays were left open when the EBCS is being operated, or is closed.

3.4 Alternative EBCS-4 – Vertical-Slot Fishway

This alternative consists of constructing a vertical-slot fishway adjacent to the EBCS to provide an alternate route for fish passage when passage is impeded, or when the gates are closed on the EBCS. The design of the fishway is based on the guidance provided in the *California Salmonid Stream Habitat Restoration Manual* (California Department of Fish and Game 2010) and the *Anadromous Salmonid Passage Facility Design* documentation by the NMFS (National Marine Fisheries Service 2011). The fishway will be designed to focus on the flows less than 700 cfs when passage is impeded.

Similar to the bypass fishway alternative, this alternative assumes that all gates on the EBCS are fully opened during Restoration Flows, that boards at the structure inlet remain in place as they are now, and that no changes to the existing structure, including the sill and baffles, are needed.

The vertical-slot fishway will be located adjacent to the bays of the EBCS and will have a fishway entrance located within the EBCS wingwall just downstream of the sill (Figure B-19). Similar to the bypass fishway, this alternative has the same location on the right bank, and the fishway will need to penetrate the existing earthen headwall at the EBCS. The fishway will be constructed within the earthen headwall, so the fishway side walls will be constructed to be as tall as the current EBCS concrete bays. A grated top will be added to provide access for vehicle traffic and provide natural light to the fishway. The fishway headwall will be smooth concrete and will match the existing structure headwall. The sections of earthen headwall will be armored with round cobble the same size as the current armoring.

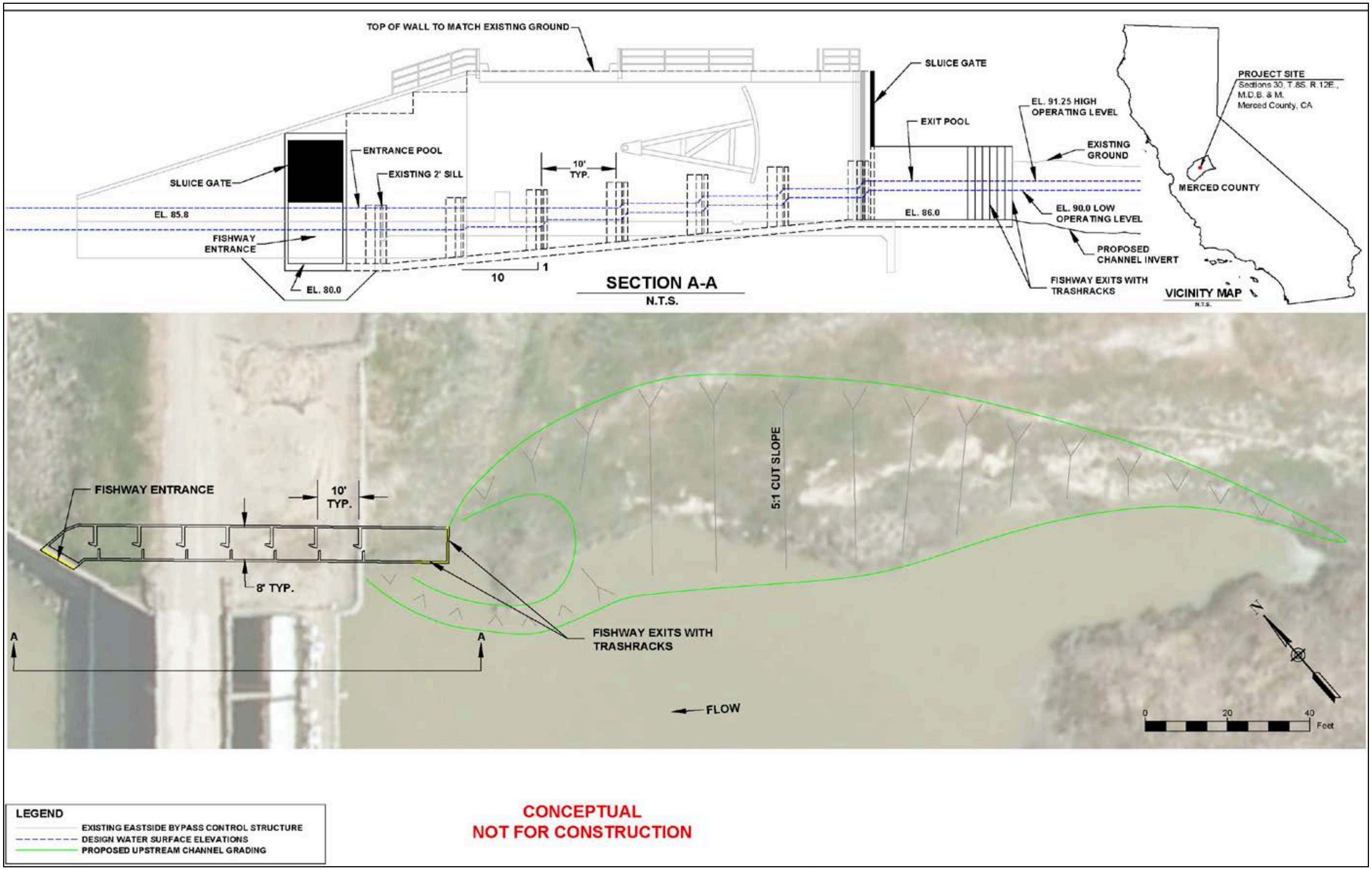
Part XII of the *California Salmonid Stream Habitat Restoration Manual* (California Department of Fish and Game 2010) is the primary guideline that was used to size the fishway. The dimensions for a vertical-slot fishway are fixed depending on the slot size. The vertical-slot width will be 1 foot wide, resulting in pool dimensions of 10 feet in length by 8 feet in width. The invert of the fishway exit will be at 86 feet, which is slightly higher than the current apron elevation of the EBCS at 85.8 feet.

The difference between the water surface elevation upstream and downstream of the EBCS at 85 cfs is approximately 5.4 feet based on the hydraulic model simulations. With a 1-foot drop between each pool, a minimum of six pools will be required to accommodate the overall drop. As a result, the invert elevation at the exit will be 6 feet below the existing apron elevation (Figure B-19).

The length of the EBCS, from the entrance to the downstream sill at the outlet, is approximately 69.5 feet. According to design specifications for hydraulic drop and length, as detailed in section 4.7.2.2 of the *Anadromous Salmonid Passage Facility Design* (National Marine Fisheries Service 2011), the fishway exit also requires that the length of the exit channel upstream of the exit control section to be a minimum of two standard fishway pools, which would add 20 feet to the total fishway length. As a result, the total length of the fishway for the six pools plus the two exit pools equals 80 feet. The fishway also includes sluice gates at the entrance and exit that will be closed for flows more than 700 cfs, and to isolate the fishway from the EBCS during flood operations, if needed.

The Eastside Bypass main channel will be graded so that the main channel flow will be split with the artificial channel path leading to the fishway exit and the EBCS. The location of the fishway entrance and exit will need to ensure that fish stranding does not occur and that the fishway maintains connectivity with the mainstem of the Eastside Bypass.

Figure B-10 EBCS-4 – Vertical Slot Fishway – Plan and Profile Views



3.4.1 Hydraulic Analysis

Design of each alternative will need to meet the general design criteria, including design flow, fish passage, flood capacity, and subsidence. A hydraulic model to simulate the fishway facility was not developed because a one-dimensional model does not capture the hydraulics within the fishway. But, the existing hydraulic model was used to simulate the water surface elevations, depth, and velocity to determine the fishway design. The model assumes that the EBSC gates are open when flows are being routed into the fishway, but it did not simulate the flow split between the fishway and EBSC. The assumptions used to develop the project condition hydraulic model to meet the criteria are discussed in the following sections.

3.4.1.1 Flow

The fishway is designed to ensure unimpeded passage for flows between 85 cfs and 700 cfs. The design incorporates a sluice gate at the fishway exit that can be closed when flows exceed 700 cfs. Upstream migration when the fishway is closed is assumed to continue through the EBCS. The flow modeled to determine the water surface elevation included the lower design-flow limit of 85 cfs, the impeded fish passage flow limit of 700 cfs, and the upper design-flow limit of 7,559 cfs.

3.4.1.2 Fish Passage

Flows for the existing condition at the EBCS were simulated using a one-dimensional hydraulic model to determine the water surface elevation at the fishway exit. As a result, for 700 cfs, the WSE is approximately 91.25 feet, and is 90 feet for 85 cfs (Figure B-20). At the invert elevation of 86 feet, the flow depth in the fishway is 5.25 feet at 700 cfs. At 85 cfs, the flow depth in the fishway is 4 feet (Figure B-21). Because the fishway design is based on standard dimensions that have been designed to meet the California guidelines, it is assumed that the fishway meets all the criteria for fish passage.

Figure B-20 **Water Surface Elevation (WSE) Profile within the Eastside Bypass**

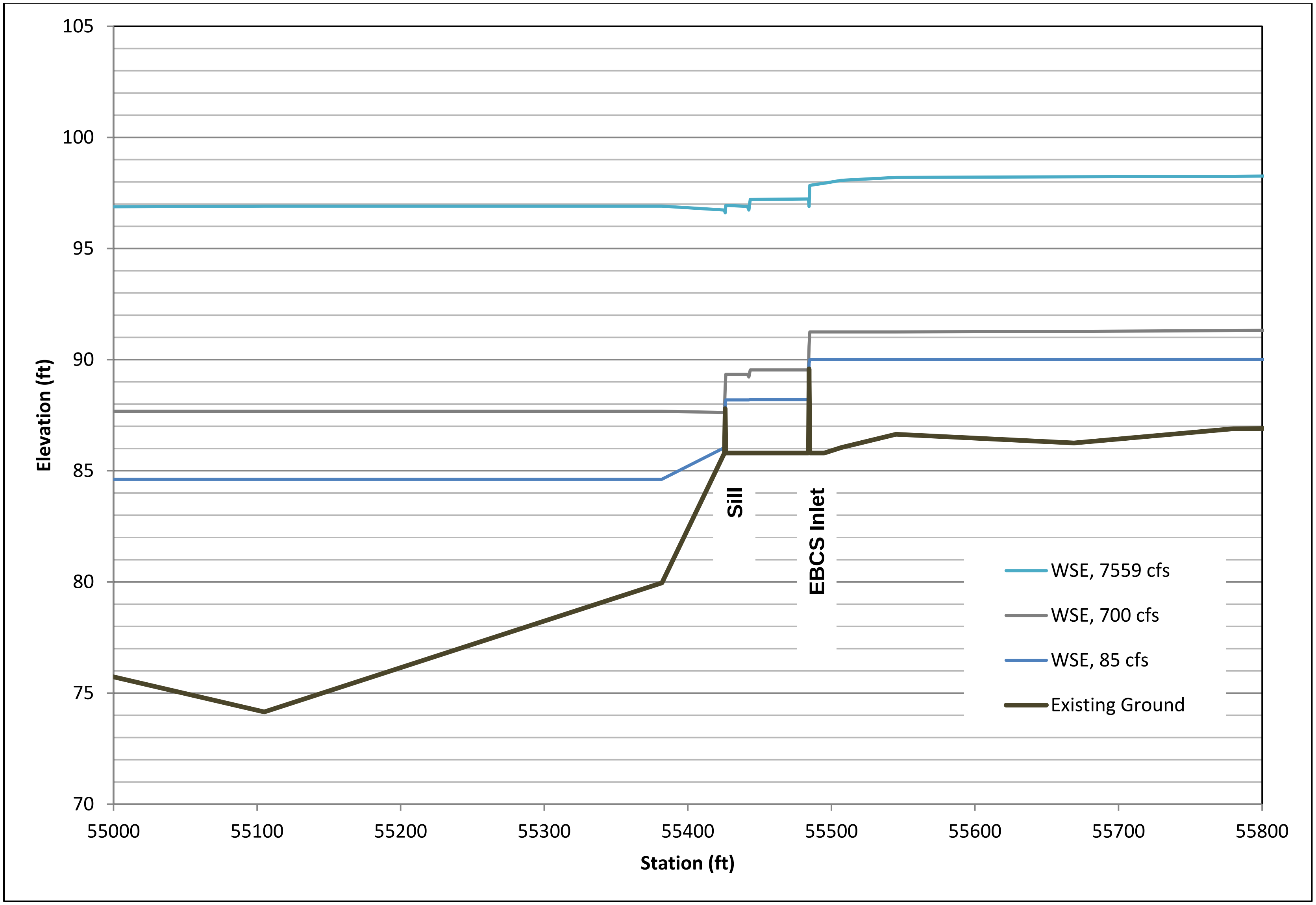
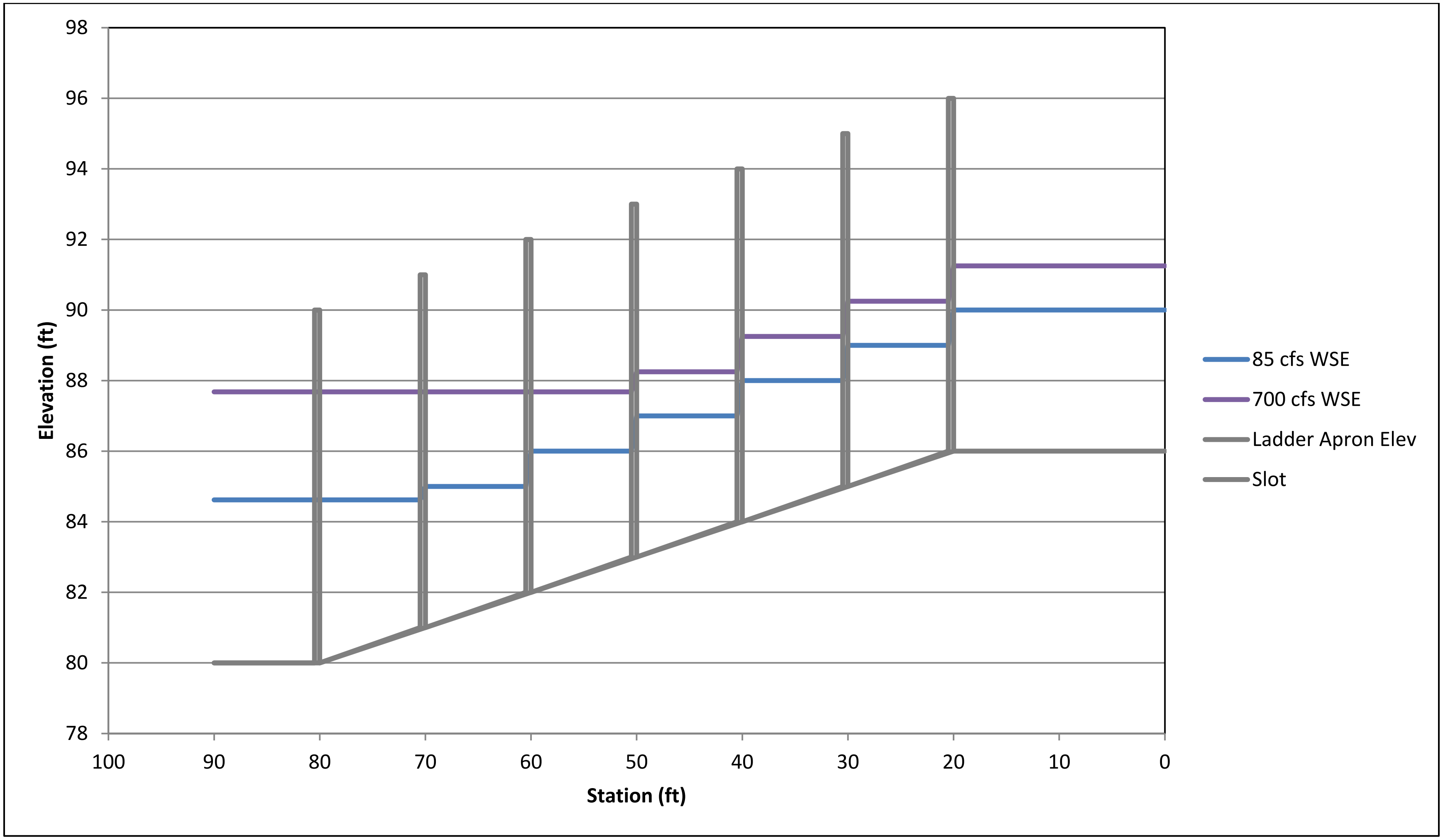


Figure B-21 **Fishway Water Surface Elevation Profile within the Ladder**



Equation XII-11 from the DFG guidelines was used to estimate the slot flow through the proposed fishway based on the estimated flow depths at 85 cfs and 700 cfs. The maximum vertical drop should be 1 foot. The water depth at 700 cfs is 5.25 feet, so the fishway slot flow was calculated to be 32 cfs. The flow through the slots of the ladder is 24 cfs, when the total flow through the EBCS is 85 cfs.

The fishway needs enough flow to attract migrating fish into the fishway. There are no specific fishway entrance flow criteria, so both guidance documents were referenced to see if the flow within the fishway at 85 cfs through 700 cfs would be reasonable. It is recommended to have a minimum of 5 percent attraction flow into the fishway (National Marine Fisheries Service 2011). Bates (1992) sets a typical fishway to have 3 percent to 10 percent of the stream flow at the high fish passage design flow (California Department of Fish and Game 2010). The fishway flow is estimated to be 32 cfs at 700 cfs, which provides about 4.5 percent attraction flow. At 85 cfs, the attraction flow is 28 percent. For conceptual design, the need for auxiliary flow could add significant costs for this alternative.

Figure B-21 displays the assumed water surface elevations within the fishway. Backwater is present within the fishway at 700 cfs, but this design assumes that this is not going to impact the attraction flow or passage through the fishway.

3.4.1.3 Flood Capacity

This alternative was not modeled in HEC-RAS, but it is assumed that the water surface elevation at flood flows will be similar as Alternative EBCS-3 and will remain the same.

3.4.2 Ground Subsidence

The vertical-slot fishway allows for a range of flows and water surface elevations, and may help with accounting for ground subsidence. Even though the entrance and exit are fixed at a specific invert elevation, the hydraulic control is provided by the narrow full-depth slots between the pools.

3.4.3 Operations and Maintenance

The general operation of the facility during Restoration Flows assumes that the control structure gates are fully opened during salmon migration, so flows would be split between the fishway and the control structure until flows exceed 700 cfs. The fishway would be closed at flows more than 700 cfs and passage would be through the EBCS.

The maintenance of the control structure by the LSJLD would likely continue and it is assumed that no changes to the current maintenance procedures are needed. The fishway would need monitoring to ensure that the fishway is being cleaned, that sediment is not building up within the exit and entrance channels and fishway, or that the bed material within the exit and entrance channels is not mobile or in need of repair. The fishway channel bed and bank material will be sized to prevent possible erosion or movement, to minimize O&M.

The channel and fishway structures may need to be periodically cleaned during fish migration or after large flood events. Clearing of debris from the fishway could be done by either hand or larger construction equipment. Depending on the type of control structure at the fishway exit and entrance, maintenance may be needed for these facilities. It is assumed that maintenance would be to check the structure prior to adult Chinook salmon migration periods and would occur again at the end of the runs.

Repairs to the facility may be needed as the mechanisms age. That timing would depend on the type of control structures implemented.

3.4.4 Cost Estimate

The cost to construct the vertical-slot fishway is estimated to be $4.6 million. The cost estimate worksheets are located in Attachment A. Similar to Alternative EBCS-1, this includes miscellaneous construction costs and contingencies. The cost estimate includes:

- Clearing and grubbing the site.
- Grading of the existing channel and excavation for the fishway.
- Demolition of the EBCS right bank wingwall, headwall, footings and part of the sill, and reconstruction of those features.
- Construction of the vertical-slot fishway.

The vertical-slot fishway requires demolition of the existing structure and excavation and grading of the existing Eastside Bypass channel. The excavation cost includes the demolition of the existing earthen levee, stone slope protection, metal handrails, wingwall, headwall, and footings. The fill cost includes using the stockpile from the site excavation, plus additional imported fill, for a 25 percent compaction loss rate. Additional cost to reconstruct the EBCS wingwall, headwall, metal handrails, and riprap slope protection are included. The vertical-slot fishway material estimate is for reinforced concrete and includes costs for the metal trash racks, grating above the fishway, handrails where needed, and a sluice gate at the fishway entrance and exit. The fishway exit cost estimate includes a cobble gabion mattress for the exit slope down to the Eastside Bypass channel invert elevation for easy maintenance and protection from erosion.

3.4.5 Benefits and Consequences

The vertical-slot fishway is commonly used to accommodate salmon and steelhead trout and is more friendly for non-jumping fish species. The vertical-slot fishway was chosen because it provides better hydraulic conditions for more flows. When tailwater elevations are low, the vertical-slot fishway will continue to accommodate fish passage. The water surface elevation varies at the EBCS for different flows, unlike a dam or weir that would have a constant water surface elevation, within the upstream pool. The vertical slot can accommodate the varying changes in the water surface elevation present at the EBCS.

Overall, a vertical-slot fishway is typically designed for the focus fish species and is not as accommodating to other fish species. The fishway could actually become a barrier to some of the native fish species. But, this structure is a bypass structure and would only be operating during a specific time and flow range. There may be opportunities for other fish species to pass through the EBCS depending on its operation.

3.4.6 Future Design Considerations

The following design considerations are for the next phase of design and will require coordination with the LSJRLD and the fisheries agencies. If this alternative becomes the preferred alternative, the following elements, as well as those common with Alternative EBCS-1, would need to be considered and refined during the next phase of design.

3.4.6.1 Design Flow Range

The difference in water surface elevation may need to be evaluated over the full operational range to determine the maximum hydraulic drop. It may not be at 85 cfs. If operation of the fishway is desired when gates are partially opened (or closed) the hydraulic drop across the EBCS will likely be greater than 5.4 feet and additional slots will be needed.

3.4.6.2 Fishway Attraction Flow

Similar to Alternative EBCS-3, the fishway will need to ensure that there is sufficient attraction flow and the location of the entrance is placed where there is opportunity to allow for fish to bypass the EBCS when it is a barrier. Fishery agencies should be consulted to determine if the current design achieves the intent of the design guidance and will not confuse or strand migrating fish. In addition, the location of the fishway entrance should consider if there is potential for migrating fish to miss the fishway and, as a result, be stranded when the EBCS is a barrier.

4.0 References

California Department of Fish and Game. 2010. Fourth Edition. California Salmonid Stream Habitat Restoration Manual. California Department of Fish and Game. Wildlife and Fisheries Division.

California Department of Water Resources. 1969. Lower San Joaquin River Flood Control Project. Final Design Report. California Department of Water Resources, Division of Design and Construction Design Branch.

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U.S. Bureau of Reclamation. 2013. Technical Memorandum No. SUB-1. Subsidence Design Criteria for the San Joaquin River Restoration. USBR Mid-Pacific Region.

Attachment A – Cost Estimates

Table B-a.1 EBCS – 1 – Structure Modification and Rock Ramp, Cost Estimate Worksheet

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 1

FEATURE:

Cost Estimate
Fish Passage Task 3
Eastside Bypass Control Structure
Alternative EBCS-1 - Structure Modification And Rock Ramp
October 2016

PROJECT:

San Joaquin River Restoration Program

WOID:	SJRRB	**ESTIMATE LEVEL:**	Conceptual
REGION:	Pacific	**PRICE LEVEL:**	2016

FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\ESBP CS\[Alt. 1 Struct. Mod. and Rock Ramp_f.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		1	AC	$ 11,000	$ 11,000
	2	Site Excavation and disposal offsite		620	CY	$ 65	$ 40,300
	3	Engineered, compacted fill with offsite material		8140	CY	$ 70	$ 569,800
	4	Demo existing concrete sill		11	CY	$ 600	$ 6,600
	5	Construct concrete sill with V-notch		8	CY	$ 1,900	$ 15,200
	6	Single-wall, anchored, sheet pile wall		3400	EA	$ 45	$ 153,000
	7	Rock Ramp - (Grouted) Riprap Class IV (27" size)		6700	TON	$ 90	$ 603,000
	8	Cement Grout		833	CY	$ 210	$ 174,930
	9	Dewater		1	LS	$ 10,000	$ 10,000
		Subtotal					**$ 1,600,000**
		Other Construction Related Items					
	10	Dust Control		1		$ 40,000	$ 40,000
	11	SWPPP		1		$ 20,000	$ 20,000
	12	Permits		1		$ 10,000	$ 10,000
	13	Worker Protection		1		$ 10,000	$ 10,000
		Subtotal					**$ 80,000**
	14	Mobilization		5	PCT	LS	$ 83,000
	15	Design Contingency		15	PCT	LS	$ 253,170
		Contract Cost					**$ 2,000,000**
		Contingencies (25%)					$ 500,000
		Field Costs					**$ 2,500,000**
		Non-contract costs (35%)					$ 900,000
		Construction Cost					**$ 3,400,000**
		Project Total					**$ 3,400,000**

QUANTITIES		**PRICES**	
BY Amanda Peisch-Derby	**CHECKED** Josh Bannister	**BY** Josh Bannister	**CHECKED** Alexis Phillips-Dowell
DATE PREPARED 10-21-2016	**PEER REVIEW** Anna Wu	**DATE PREPARED** 10-21-2016	**PEER REVIEW** Vu Thai

Table B-a.2a EBCS – 2 – Grade Control, Cost Estimate Worksheet (Sheet 1 of 2)

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 2

FEATURE:

Cost Estimate
Fish Passage Task 3
Eastside Bypass Control Structure
Alternative EBCS-2 - Grade Control Structures
October 2016

PROJECT:
San Joaquin River Restoration Program

WOID: SJRRB
ESTIMATE LEVEL: Conceptual
REGION Pacific
PRICE LEVEL: 2016
FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\ESBP CS\[Alt. 2 Grade Control Structures f.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		1	AC	$ 11,000	$ 11,000
	2	Typical Weir - Single-wall, anchored (details on sheet 2)		7	EA	$ 330,000	$ 2,310,000
	3	Engineered, compacted fill with offsite material U/S of weirs		1000	CY	$ 70	$ 70,000
		Subtotal					**$ 2,400,000**
		Other Construction Related Items					
	4	Dust Control		1		$ 40,000	$ 40,000
	5	SWPPP		1		$ 20,000	$ 20,000
	6	Permits		1		$ 10,000	$ 10,000
	7	Worker Protection		1		$ 10,000	$ 10,000
		Subtotal					**$ 80,000**
	8	Mobilization		5	PCT	LS	$ 125,000
	9	Design Contingency		15	PCT	LS	$ 404,000
		Contract Cost					**$ 3,000,000**
		Contingencies (25%)					$ 800,000
		Field Costs					**$ 3,800,000**
		Non-contract costs (35%)					$ 1,300,000
		Construction Cost					**$ 5,100,000**
		Project Total					**$ 5,100,000**

QUANTITIES		PRICES	
BY John Yang	**CHECKED** Alexis Phillips-Dowell	**BY** Dag Fanta	**CHECKED** Vu Thai
DATE PREPARED October 3, 2016	**PEER REVIEW** Vu Thai	**DATE PREPARED** October 3, 2016	**PEER REVIEW** Alexis Phillips-Dowell

Table B-a.2b EBCS – 2 – Grade Control, Cost Estimate Worksheet (Sheet 2 of 2)

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET__2__ OF __2__

FEATURE: Cost Estimate Fish Passage Task 3 Eastside Bypass Control Structure Alternative EBCS-2 - Grade Control Structures (Typical Weir) October 2016	**PROJECT:** San Joaquin River Restoration Program **WOID:** SJRRB **ESTIMATE LEVEL:** Conceptual **REGIO** Pacific **PRICE LEVEL:** 2016 **FILE:** P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\ESBP CS\[Alt. 2 Grade Control Structures f.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Sheet Pile Weir (Single Structure)					
	1	Clearing and Grubbing (1)		1	AC	$ 11,000	$ 11,000
	2	Onsite earthwork for anchor system (Remove and recompact) (2)		1000	CY	$ 35	$ 35,000
	4	Vinyl or Aluminum Sheet Piles (Single CMI ShoreGaurd Flat Panel) (3)		3700	SF	$ 7	$ 25,900
	5	Deliver materials (CMI Atlanta, GA - 1 truck) (4)		1	EA	$ 5,000	$ 5,000
	6	Construct driving guide and use as whales (5)		1	LS	$ 52,000	$ 52,000
	7	Sheet pile installation (single sheet 20 ft deep x 223 ft) (6)		3700	SF	$ 14	$ 51,800
	8	Caps for Tops (20ft lenghts materail + labor) (7)		7	EA	$ 400	$ 2,800
	9	Anchor support system (pilings, cables, whales, etc) (8)		1	LS	$ 26,000	$ 26,000
	10	Dust control		1	LS	$ 40,000	$ 40,000
	11	U/S and D/S aprons Riprap		840	TN	$ 100	$ 84,000
		Subtotal					**$ 333,500**
		Notes:					
		1) Bulk channel earthwork is assumed to be completed in other costs					
		2) Cost for excavating 5' below sheet piles to allow for anchor tiebacks					
		3) Costs obtained from CMI					
		4) Delivery based on $5,000/truck and each truck can handle 40,000 lbs					
		5) Costs based on double material cost per CMI					
		6) Sheet pile installation based on double material cost per CMI					
		7) Cap material costs obtained from CMI					
		8) Anchor support system assumed to be same as material costs					
		–Estimate is for single structure					
		–CMI Info: www.cmisheetpiling.com					

QUANTITIES		PRICES	
BY John Yang	**CHECKED** Alexis Phillips-Dowell	**BY** Dag Fanta	**CHECKED** Vu Thai
DATE PREPARED October 27, 2016	**PEER REVIEW** Vu Thai	**DATE PREPARED** October 3, 2016	**PEER REVIEW** Alexis Phillips-Dowell

Table B-a.3a EBCS – 3 – Bypass Fishway, Cost Estimate Worksheet (Sheet 1 of 2)

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET __1__ OF __2__

FEATURE: Cost Estimate Fish Passage Task 3 Eastside Bypass Control Structure Alternative EBCS - 3 - Bypass Fishway September 2016	**PROJECT:** San Joaquin River Restoration Program
	WOID: SJRRP — **ESTIMATE LEVEL:** Conceptual
	REGION Pacific — **PRICE LEVEL:** 2016
	FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\ESBP CS\[Alt. 3 Bypass Channel update_f.xlsx]Total

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		3.2	AC	$ 3,750	$ 12,000
	2	Site Excavation and local haul for fill of fine material in ESM		2000	CY	$ 25	$ 50,000
	3	Site Excavation and disposal offsite		19500	CY	$ 35	$ 682,500
		Roughened Channel Fishway (see Sheet #2 for details)					
	6	Engineered Streambed Material (Boulders/Cobbles/Gravels/Fines)		1	EA	$ 940,000	$ 940,000
	7	Bankline Material (Boulders/Cobbles/Gravels/Fines)		1	EA	$ 184,000	$ 184,000
	8	Rockband Material (2'+ Boulders)		1	EA	$ 705,000	$ 705,000
	9	Geotextile Fabric		1	EA	$ 5,430	$ 5,430
		Culvert					
	10	20' x 20' Cast-In-Place Culverts and wingwalls (3 total)		970	CY	$ 1,000	$ 970,000
	11	Guardrails		1	LS	$ 30,000	$ 30,000
	12	Stoplog Gates, bottom sill plates, and stoplog slots		3	EA	$ 230,000	$ 690,000
	13	Foundation - AB		190	TON	$ 50	$ 9,500
		Subtotal					**$ 4,300,000**
		Other Construction Related Items					
	14	Dust Control		1		$ 10,000	$ 10,000
	15	SWPPP		1		$ 20,000	$ 20,000
	16	Permits		1		$ 10,000	$ 10,000
	17	Worker Protection		1		$ 10,000	$ 10,000
		Subtotal					**$ 50,000**
	18	Mobilization		5	PCT	LS	$ 220,000
	19	Design Contingency		15	PCT	LS	$ 651,570
		Contract Cost					**$ 5,200,000**
		Contingencies (25%)					$ 1,300,000
		Field Costs					**$ 6,500,000**
		Non-contract costs (35%)					$ 2,300,000
		Construction Cost					**$ 8,800,000**
		Project Total					**$ 8,800,000**

QUANTITIES		PRICES	
BY Amanda Peisch-Derby	**CHECKED** Josh Bannister	**BY** Anna Wu	**CHECKED** Vu Thai
DATE PREPARED September 1, 2016	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** September 9, 2016	**PEER REVIEW** Vu Thai

Table B-a.3b EBCS – 3 – Bypass Fishway, Cost Estimate Worksheet (Sheet 2 of 2)

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET__2__ OF __2__

FEATURE:

Cost Estimate
Fish Passage Task 3
Eastside Bypass Control Structure
Alternative EBCS - 3 - Bypass Fishway (Cont.)
September 2016

PROJECT:
San Joaquin River Restoration Program

WOID: SJRRP **ESTIMATE LEVEL:** Conceptual
REGION Pacific **PRICE LEVEL:** 2016

FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\ESBP CS\[Alt. 3 Bypass Channel update_f.xlsx]Total

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Roughened Channel Fishway Rock Mix for Fill					
	1	Engineered Streambed Material (Boulders/Cobbles/Gravels/Fines)					
	2	1/2 - 1 ton Rip-Rap (2'+ Rip-Rap)		1250	TN	$ 233	$ 291,250
	3	Light Rip-Rap		2700	TN	$ 110	$ 297,000
	4	Backing #2 RSP (6" Rip-Rap)		2700	TN	$ 110	$ 297,000
	5	Backing #3 RSP		640	TN	$ 75	$ 48,000
	6	Site Fill (native material placment)		640	TN	$ 10	$ 6,400
		Rock Band (2'+ Boulders)					
	7	2 ton Rip-Rap (3'+ Rip-Rap)		950	TN	$ 350	$ 332,500
	8	1 ton Rip-Rap (2'+ Rip-Rap)		1600	TN	$ 233	$ 372,800
		Bankline (Boulders/Cobbles/Gravels/Fines)					
	9	1/4 ton Rip-Rap		270	TN	$ 175	$ 47,250
	10	Facing RSP (10" - 16" Rip-Rap)		570	TN	$ 110	$ 62,700
	11	Backing #2 RSP (6" Rip-Rap)		570	TN	$ 110	$ 62,700
	12	Backing #3 RSP		135	TN	$ 75	$ 10,125
	13	Site Fill (native material placment)		135	TN	$ 10	$ 1,350
		Subtotal					**$ 1,850,000**

QUANTITIES		PRICES	
BY Amanda Peisch-Derby	**CHECKED** Josh Bannister	**BY** Anna Wu	**CHECKED** Vu Thai
DATE PREPARED September 1, 2016	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** September 9, 2016	**PEER REVIEW** Vu Thai

Table B-a.4 EBCS – 4 – Vertical-Slot Fishway, Cost Estimate Worksheet

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 1

FEATURE:

Cost Estimate
Fish Passage Task 3
Eastside Bypass Control Structure
Alternative EBCS - 4 - Vertical Slot Fishway
October 2016

PROJECT:

San Joaquin River Restoration Program

WOID:	SJRRP	**ESTIMATE LEVEL:**	Conceptual
REGION:	Pacific	**PRICE LEVEL:**	2016

FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Final Version\ESBP CS\[Alt. 4 Vertical Slot Fishway f.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		1.5	AC	$ 11,000	$ 16,500
	2	Demo stone slope protection and disposal offsite		640	TN	$ 28	$ 17,920
	3	Demo metal handrails on headwall and wingwall		2800	LB	$ 5	$ 14,000
	4	Site Excavation and stockpile to cover native fill		5900	CY	$ 32	$ 188,800
	5	Demo concrete headwall, wingwall, footings and part of sill		280	CY	$ 1,100	$ 308,000
	6	Construct concrete reinforced vertical slot fishway		290	CY	$ 1,100	$ 319,000
	7	Install metal trashracks		600	LB	$ 19	$ 11,400
	8	Install metal floor grating above fishway		4700	LB	$ 10	$ 47,000
	9	Install metal handrails above fishway		3600	LB	$ 10	$ 36,000
	10	Install sluice gates 8' x 10' at fishway entrance and exit with actuators		2	EA	$ 175,000	$ 350,000
	11	Construct concrete headwall, wingwall, footings and part of sill		260	CY	$ 1,100	$ 286,000
	12	Install metal handrails on headwall and wingwall		2800	LB	$ 10	$ 28,000
	13	Excavation for fishway exit slope, pool and disposal offsite		1600	CY	$ 65	$ 104,000
	14	Install cobble gabion matress on fishway exit slope		1000	TN	$ 209	$ 209,000
	15	Structure backfill (native material placement)		5900	CY	$ 25	$ 147,500
	16	Structure backfill (remainder to be imported)		340	CY	$ 75	$ 25,500
	17	Riprap replacement around control structure		290	CY	$ 151	$ 43,790
	18	Class 2 aggregate base for control structure maintenance road		57	TN	$ 90	$ 5,130
		Subtotal					**$ 2,200,000**
		Other Construction Related Items					
	19	Dust Control		1	LS	$ 40,000	$ 40,000
	20	SWPPP		1	LS	$ 20,000	$ 20,000
	21	Permits		1	LS	$ 10,000	$ 10,000
	22	Worker Protection		1	LS	$ 10,000	$ 10,000
		Subtotal					**$ 80,000**
	23	Mobilization		5	PCT	LS	$ 110,000
	24	Design Contingency		15	PCT	LS	$ 352,460
		Contract Cost					**$ 2,700,000**
		Contingencies (25%)					$ 700,000
		Field Costs					**$ 3,400,000**
		Non-contract costs (35%)					$ 1,200,000
		Construction Cost					**$ 4,600,000**
		Project Total					**$ 4,600,000**

QUANTITIES		PRICES	
BY John Yang	**CHECKED** Josh Bannister	**BY**	**CHECKED** Vu Thai
DATE PREPARED May 5, 2015	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** October 31, 2016	**PEER REVIEW** Alexis Phillips-Dowell

Appendix C. Alternative Design Package, Dan McNamara Road

Three design alternatives to provide fish passage at Dan McNamara Road were considered and are included in this design package. Each alternative aims to provide some type of access or alternate route for unimpeded fish passage. The conceptual designs considered include:

- Alternative DMR-1 – Modified Low Flow Crossing with 5-Barrel Box Culvert.
- Alternative DMR-2 – Crossing Removal.
- Alternative DMR-3 – Crossing Removal with Modified Detour.

1.0 Site Assessment

The following sections provide an overview of the site conditions at Dan McNamara Road, including the location and description, channel characteristics, flood operations, and the fish passage constraints.

1.1 Location and Description

Dan McNamara Road is a gravel-armored low flow crossing that is located within the Eastside Bypass that can be accessed from Sandy Mush Road (Figure C-1). The road crossing is downstream of the Merced National Wildlife Refuge and is located upstream of the Eastside and Mariposa Bypass Control structures. The low flow road crossing is a road within Merced County and is publicly accessible. In July 2010, the road was partially submerged (Photo C-1) at a flow of less than 25 cubic feet per second (cfs). The road crown is approximately 30 feet wide and it sits on a 60-foot county right of way (ROW). The properties located upstream and downstream of the county ROW are privately owned and access is restricted by barbed-wire fencing. The land use within the channel upstream (Photo C-2) and downstream of the road crossing (Photo C-3) is primarily cattle grazing. The U.S. Bureau of Reclamation (Reclamation) has acquired flowage easements for Restoration Flow from the adjacent property owners to mitigate the loss of access to Dan McNamara Road across the Eastside Bypass.

There are two culverts under the road crossing, one at the low-flow channel, and another within the floodplain. The one located within the center of the road is a single circular corrugated metal pipe culvert that is 50 feet long and 30 inches in diameter. The culvert does not include an apron. It protrudes approximately 10 feet on each side of the road. The culvert inlet and outlet are armored with cobble and concrete riprap with no flared end sections. There is an approximate 3-foot drop from the culvert outlet to an incised 175-foot-wide low-flow channel just downstream. The total bypass channel width is 1,500 feet, including the low-flow channel. The culvert capacity is estimated to be less than 20 cfs. Flows within the Eastside Bypass that exceed 25 cfs will begin to overtop the road. The second culvert that is within the floodplain is a circular reinforced concrete culvert that is 24 inches in diameter. This culvert is silted in partway, and does not appear to effectively convey flows (Photo C-4).

Deadman Creek runs parallel to and north of the bypass and collects the drainage between Sandy Mush Road and the Eastside Bypass Control Structure (EBCS). Drainage water from the creek can be diverted into the Eastside Bypass.

At the intersection of Dan McNamara Road and the Eastside Bypass, vehicle passage is limited because of the capacity of the culverts. When there is any flood flow in the bypass, which happens approximately 1 year out of every 4 to 5 years, the road is closed. This problem is alleviated by an existing detour which directs traffic onto the right bank (based on the view of a person looking downstream) levee of the Eastside Bypass from Sandy Mush Road or Dan McNamara Road. The detour consists of signs and gates to direct the traffic, as well as metal cattle guards to prevent livestock from straying (California Department of Water Resources 1969). From discussions with Reggie Hill, the General Manger for the Lower San Joaquin Levee District (LSJLD), the Merced County Road Department coordinates with LSJLD staff on the current detour operation for Dan McNamara Road.

Figure C-1 Dan McNamara Road Location Map

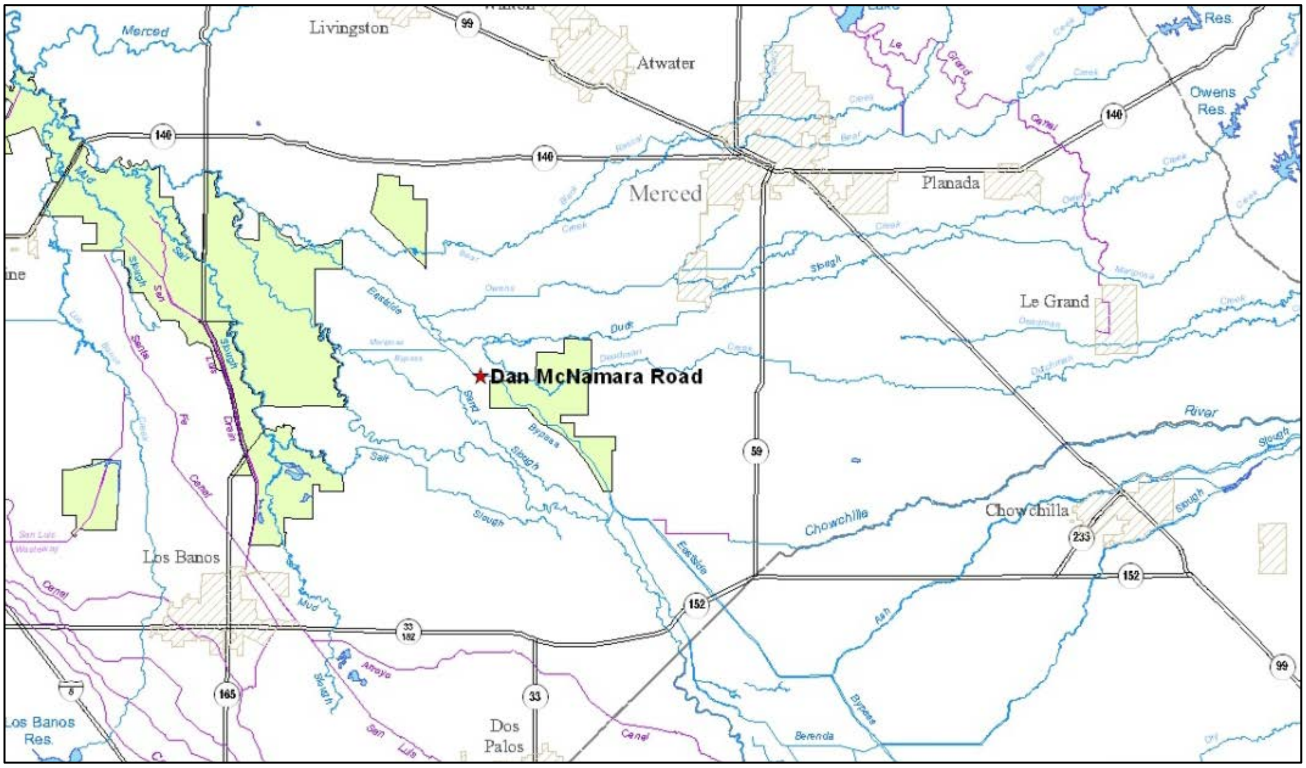


Photo C-1 **Dan McNamara Road when Partially Overtopped**

Photo C-2 **Looking Upstream in the Eastside Bypass Channel from the top of the Culvert Inlet**

Photo C-3 **Looking Downstream in the Eastside Bypass Channel from the top of the Culvert Inlet**

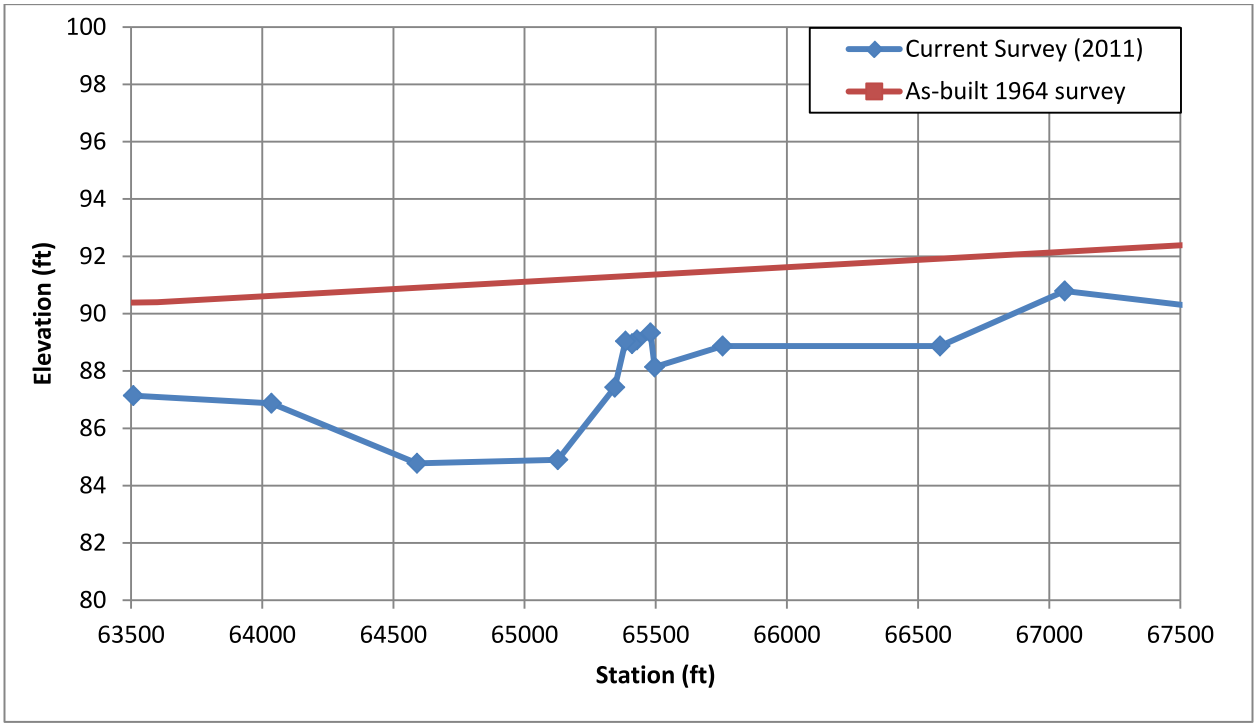
Photo C-4 **Culvert Inlet for the Overflow Channel (Historical Mariposa Slough channel)**

1.2 Channel Characteristics

There is a meandering low-flow channel upstream and downstream of the road crossing. Generally, the channel substrate in the bypass consists of loose sandy alluvium. The low-flow channel is pretty much void of any vegetation and the floodplain typically has low annual grasses. There are no large woody trees within this reach of the bypass. Grazing is allowed in the channel upstream and downstream of the road crossing.

The existing channel bed is raised at the road crossing with a drop of approximately 5 feet downstream, and approximately 3 feet upstream. Figure C-2 compares the estimated original design slope that was

Figure C-2 **Comparison of the Profile of the Existing Land Surface and the Original Bypass Design Slope**



taken from the Lower San Joaquin River Flood Control Project (LSJRFCP) as-built drawings (Spec 61-01, Sheet 53 for the Lower San Joaquin River Flood Control Project, Mouth of Bear Creek to Interchange Area, Eastside Bypass, June 2, 1964) for the bypass, with the existing ground slope based on a 2011 bathymetric and a 2008 LiDAR (Light Detection and Ranging) surveys.

1.2.1 Ground Subsidence

This section of the bypass where the crossing is located is subsiding; the estimated average subsidence ranges from 0.05 foot per year to 0.15 foot per year (California Department of Water Resources 2013). The channel is subsiding at a much greater rate upstream within the Upper Eastside Bypass (0.5 foot per year to almost 1 foot per year) compared to subsidence at the crossing, resulting in a flatter channel slope at the culverts instead of a much steeper slope of the channel upstream. This causes the potential for the upstream channel to erode more than it is now, which could result in an increase in sediment deposition near the road crossing.

1.3 Flood Capacity

Dan McNamara Road is within the Bypass channel that was constructed as a flood control facility with a flood design capacity from Sand Slough to the Mariposa Bypass of 16,500 cfs according to the *Lower San Joaquin River Flood Control Project Operation and Maintenance Manual* (Lower San Joaquin River Flood Control Project 1967 [Amended in 1978]).

1.4 Fish Passage Constraints

Dan McNamara Road crossing is a partial barrier for adult Chinook salmon because of insufficient depths over the road and high water velocity in the existing culvert. The crossing is not passable for fish until the road is overtopped and there is sufficient flow depth over the road to allow for passage. This occurs at flows more than 600 cfs (California Department of Water Resources 2012).

2.0 General Design Criteria

The design for each alternative must meet criteria for flow, fish passage, subsidence, and flood capacity. General design criteria applicable to all of the alternatives are discussed in this section. Additional design criteria for a specific fishway will be discussed within the alternative design description. The fish passage design criteria and guidelines are consistent with the California Department of Fish and Wildlife (DFW) and the National Marine Fisheries Service (NMFS). Specific criteria for the restoration fish passage projects were developed through a series of stakeholder workshops; but, they were never finalized by the SJRRP. The general criteria to guide the design for Task 3 are discussed here.

2.1 Flow

Flows through any passage facility at Dan McNamara Road will be designed to ensure unimpeded passage for flows between 85 cfs and 9,737 cfs. The *California Salmonid Stream Habitat Restoration Manual* specifies that the upper and lower design flows for adult Chinook salmon to pass unimpeded will be based on a flow exceedance analysis of 1 percent and 50 percent exceedance flows. At the high passage design flow for adult anadromous salmonids, defined as the 1 percent exceedance flow, the objective is to avoid excessive water velocities and turbulence. At the low passage design flow, defined as the 50 percent exceedance flow, the objective is to provide sufficient water depth (California Department of Fish and Game 2010). For Dan McNamara Road, exceedance flows were determined using flow duration curves that were based on hydrology developed for the SJRRP project alternatives.

2.2 Fish Passage

The fish passage design criteria for adult Chinook salmon (jump, depth, and velocity) is based on the criteria used for the SJRRP Reach 2B and Reach 4B site-specific projects and design criteria developed by the DFW, U. S. Army Corps of Engineers (USACE), NMFS, and Reclamation. Each design alternative must meet the required criteria shown in Table C-1. In addition to the fish passage criteria in Table C-1, additional criteria based on a specific type of fish passage structure will also be applied depending on the alternative. These criteria will be specified in the respective alternative.

Table C-1 Fish Passage Design Criteria for Adult Chinook Salmon

Minimum Depth of Flow (ft)	Maximum Recommended Hydraulic Drop (ft)	Recommended Design Velocity (fps)[a]
1	1.0	1.5-4.0

Notes

fps = feet per second, ft = feet

[a] Design velocity is based on the type of fish facility and could be greater for culverts (6 fps). If culverts are recommended follow the design velocities in Table 7-1 (National Marine Fisheries Service 2011).

A summary of how each of the above criteria will be applied to the culvert design in Alternative 1 is provided in the following paragraphs.

2.2.1 Minimum Depth of Flow

Depth within the culvert or over the road deck will need to meet a depth criterion of 1.0 foot.

2.2.2 Maximum Recommended Hydraulic Drop

The designs will ensure that any structures that will require an adult Chinook salmon to jump will have a maximum water surface difference over the structure of no more than 1.0 foot.

2.2.3 Recommended Design Velocity

For the culvert, the maximum average water velocity to ensure unimpeded passage is 6 fps based on the NMFS Table 7-1, which is required for a total culvert length of less than 60 feet from inlet to the outlet. The SJRRP fish passage design table recommends design velocities for fish facilities average between 1.5 fps and 4 fps. This range of velocities is essentially recommended to be at or below the cruising speed of 3.4 fps for an adult Chinook salmon. This limits the stress to the fish and preserves their energy to pass other obstacles and helps protect the overall health of the fish.

2.3 Ground Subsidence

The designs must account for ground subsidence consistent with the methodology and guidance provided in the preliminary draft *Technical Memorandum No. SUB-1 Subsidence Design Criteria* (U.S. Bureau of Reclamation 2013) for the SJRRP, except as noted. The technical memorandum estimated the total amount of subsidence assumed over the 25-year design life of the project at the road location is 1.25 feet. But, based on recent monitoring the total amount of subsidence during the next 25 years could be from 5 feet to 7 feet. The subsidence rates and lifespan may be modified as necessary as future data is collected and is subject to change based on ongoing monitoring efforts.

2.4 Flood Capacity

The design-flood capacity is 16,500 cfs and is based on the schematic of design flood capacity flows in the *Operations and Maintenance Manual for the Lower San Joaquin River Flood Control Project*. Design alternatives must ensure no adverse impact to the current flood control system. It must be demonstrated through hydraulic modeling that each alternative will produce less than a 0.1-foot rise in flood elevations at the design-flow capacity based on the Central Valley Flood Protection Board criterion.

3.0 Conceptual Designs

Three design alternatives were considered. Each alternative aims to provide some type of access or alternate route while providing unimpeded fish passage. The conceptual designs considered include:

- Alternative DMR-1 – Modified Low-Flow Crossing with 5-Barrel Box Culvert.
- Alternative DMR-2 – Crossing Removal.
- Alternative DMR-3 – Crossing Removal with Modified Detour.

3.1 Alternative DMR-1 – Modified Low Flow Crossing with 5-Barrel Culvert

This fish passage improvement design alternative for the Dan McNamara Road consists of replacing the existing road and culvert with five pre-cast concrete box culverts, each 12-feet wide and 12-feet tall (Figure C-3). Under existing conditions, when there is no Restoration Flow, traffic cannot cross approximately 25 percent of the time, which is at a flow of about 25 cfs. But, once Restoration Flows are present, flows will be as high as 1,150 cfs about 25 percent of the time. As a result, the new culverts are designed to allow traffic to cross the road at 1,150 cfs or at approximately the same flow frequency as they do now. This will allow vehicle access during most Restoration Flows, with the exception of the spring pulse, depending on the Restoration year-type. Flows more than 1,150 cfs, including flood flows, will pass over the road. The culverts and road crossing will then be overtopped, but will continue to meet velocity and depth criteria for flows up to 9,737 cfs. The flow through the culvert and over the road will need to meet fish passage design criteria for minimum depth and velocity.

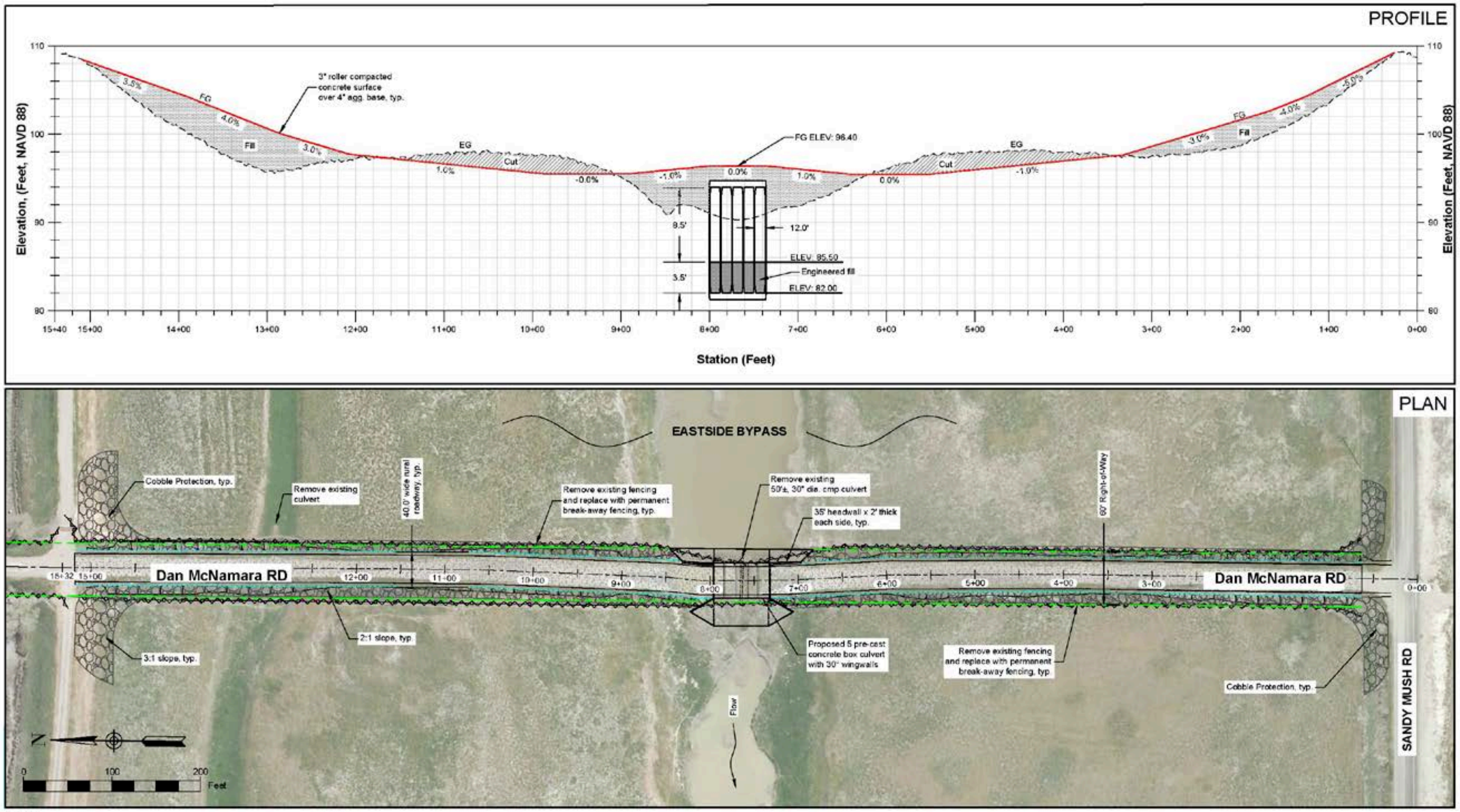
The culverts will be 40 feet long and the elevation of the top of the road will be at approximately 96.4 feet, which is approximately 4 feet above the existing road grade. To meet flood requirements and to improve the hydraulics through the culverts, 1,000 feet of the channel will be regraded, approximately 500 feet downstream to 500 feet upstream of the road crossing (Figure C-4). The majority of the grading will be to lower the overall channel culvert invert elevation, but additional grading within the floodplain areas may be needed. The existing channel slope is about 0.6 percent, which will be modified to approximately 0.3 percent. The grading will include excavating a low-flow channel that closely matches the existing low-flow channel geometry, but deeper and with a more gradual slope. It is estimated that there will be approximately 20,000 cubic yards of excavation needed to grade the main channel and road, and about 11,000 cubic yards of engineered road fill. Excess material may be stockpiled for other projects on-site or hauled off-site.

The culverts will be placed with a 0.25 percent slope and embedded with about 3.5 feet of engineered streambed material. This results in a culvert opening of approximately 8.5 feet. The culvert bed material will be composed of a mixture of coarse sand, clay, gravel, and cobble. The invert of the culvert will be at 82 feet (or 85.5 feet with the engineered fill). There will be a reinforced concrete headwall on the upstream end, with 30 percent flared wing walls on each side of the culverts downstream to improve the hydraulics through the structure and to protect against erosion.

A detailed geotechnical investigation into the soils and groundwater would be necessary to determine the size and structural components of the culvert foundation. That type of investigation is outside the scope of this design effort. As a result, for cost purposes of the conceptual design, an engineered streambed of fine granular base material with a thickness of 6 inches will be assumed as a base. A 2-foot deep concrete cast-in-place reinforced concrete cutoff wall will be assumed at the culvert inlet and outlet.

The road design will incorporate the Merced County Improvement Standards and Specifications (Merced County 2009) for a two-lane 60-foot wide rural roadway. Only the travel lanes and shoulders will be constructed. This results in a two-lane 40-foot wide road. An example of a road cross-section is shown in Figure C-5.

Figure C-3 **DMR-1 – Modified Low Flow Crossing with 5-Barrel Box Culvert, Profile and Plan Views of Culverts**



NOTES:

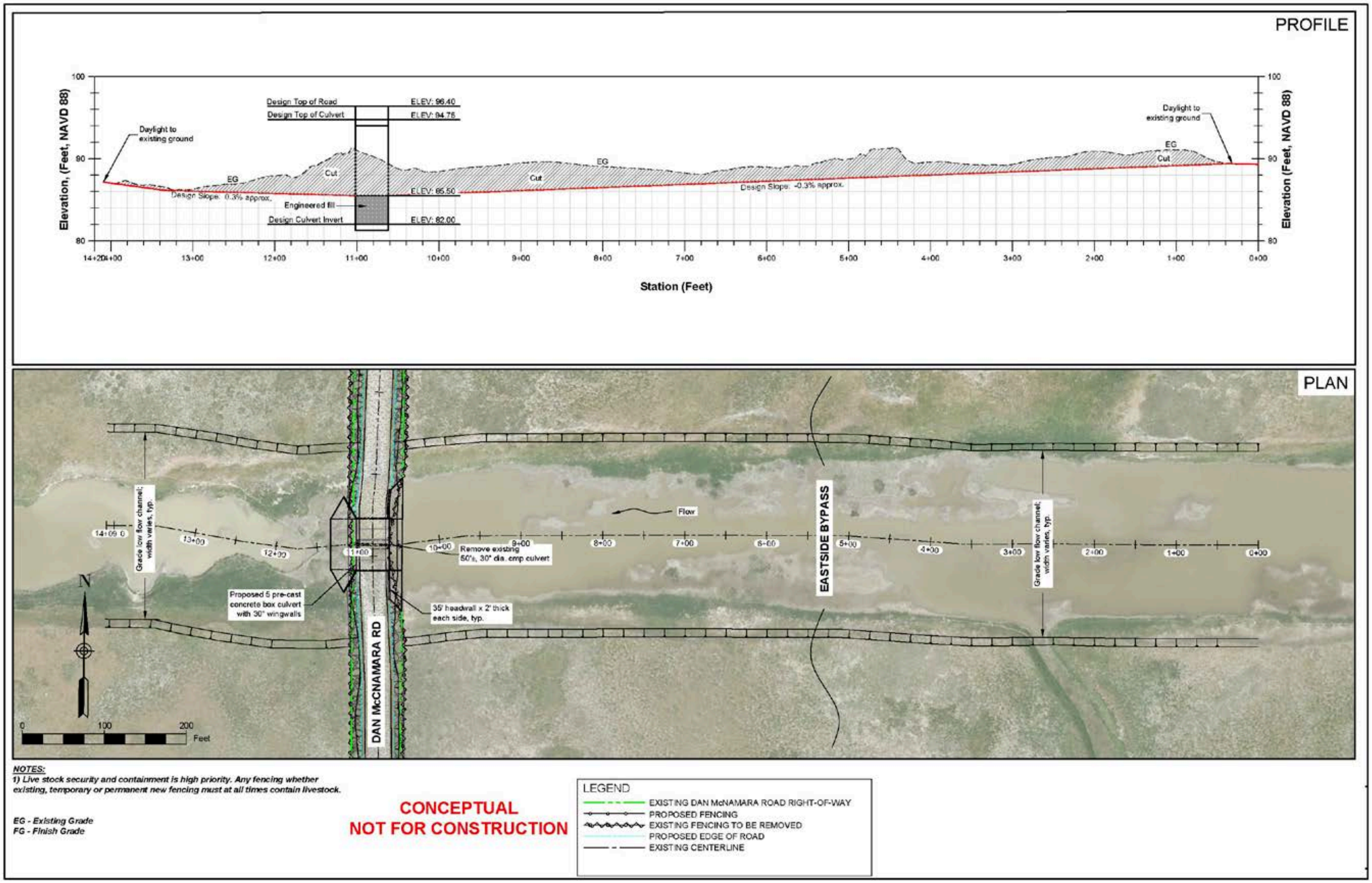
1) Live stock security and containment is high priority. Any fencing whether existing, temporary or permanent new fencing must at all times contain livestock.

EG - Existing Grade
FG - Finish Grade

CONCEPTUAL
NOT FOR CONSTRUCTION

LEGEND
- EXISTING DAN McNAMARA ROAD RIGHT-OF-WAY
- PROPOSED FENCING
- EXISTING FENCING TO BE REMOVED
- PROPOSED EDGE OF ROAD
- EXISTING CENTERLINE

Figure C-4 **DMR-1 – Modified Low Flow Crossing with 5-Barrel Box Culvert, Profile and Plan Views of Channel Grading**

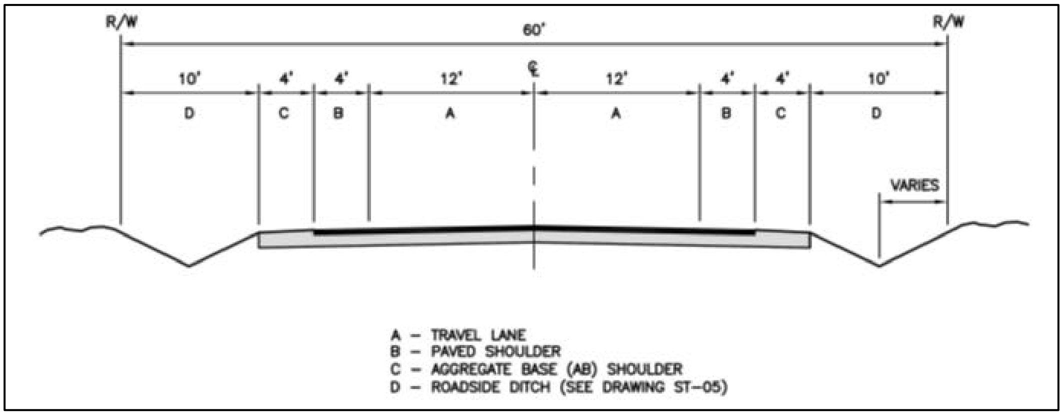


NOTES:

1) Live stock security and containment is high priority. Any fencing whether existing, temporary or permanent new fencing must at all times contain livestock.

EG - Existing Grade
FG - Finish Grade

Figure C-5 **Merced County Road Cross Section for Two-Lane Rural Roadway (Merced County, 2009)**



The travel lanes and shoulder for the road will be paved with 12 inches of rigid concrete pavement over a 6-inch aggregate road base. The road banks will have a 2:1 slope and will be armored with cobble, shotcrete, or gabion mattresses to prevent erosion. This should provide adequate drainage for the road, so it is assumed that a roadside ditch is unnecessary. The road is designed to meet line of sight requirements and not have a maximum grade of more than 5 percent, which is consistent with rural highway grade requirements (Figure C-4). Additional right-of-way may need to be acquired to allow for armoring of the new roadway.

Safety features, such as removable guard railing or a curb could be added to prevent vehicles from going off the road crossing. The road will be inundated at flows greater than 1,150 cfs, so gates would be placed at each end of the road to facilitate road closure and limit access when it is overtopped. Warning signs will also be added. To keep grazing cattle from crossing the road or from getting into the culverts, break away fencing (or some other exclusion cattle barrier) could be added approximately 10 feet upstream and downstream of the culvert openings and at the edge of the ROW. Additional measures to keep cattle out of the culvert include installing metal piping at the openings of the culvert or floating gates. But, fish passage must be a consideration with any choice.

3.1.1 Hydraulic Analysis

A one-dimensional model using Hydrologic Engineering Center's River Analysis System (HEC-RAS) was developed from a calibrated model to ensure that the conceptual alternative meets the criteria for flow, fish passage, flood capacity, and subsidence. The existing model was modified to include the proposed culverts, road crossing specifications, and channel grading. The conditions at the site also assume that the boards are in the EBCS, which has a minor impact on the hydraulic conditions at the crossing. The final design will need to consider the fish passage improvements at the EBCS. The road, once overtopped, was modeled as a weir. The model was used to simulate depth and velocity for a range of flows assuming a steady-flow condition.

3.1.1.1 Flow

The new culverts are designed to pass as much as 1,150 cfs of flow through the culverts. Flows more than 1,150 cfs, including flood flows, will pass over the road. The culverts and road crossing will then be overtopped, but would be able to provide unimpeded passage for the design flows of 85 cfs through 9,737 cfs.

3.1.1.2 Fish Passage

The hydraulic conditions for the alternative will need to meet the general criteria in Table C-1 for minimum flow depth and recommended structure jump height. The recommended velocity criterion for this alternative is summarized in Table C-2.

Table C-2 Fish Passage Design Criteria for the Alternative

Recommended Ramp Design Velocity (fps)	Recommended Design Culvert Velocity (fps) [a]
4.0	6.0

Notes:
fps = feet per second
[a] Table 7-1 (National Marine Fisheries Service 2011)

The flow depth criterion of 1.0 foot within the culvert is being met for the entire range of flows, as shown in Table C-3. The fish can continue to swim through the culverts until the flow over the road is greater than 1.0 foot, which is about 3,500 cfs, but will ultimately depend on the final road thickness. The velocity criterion of 6 fps for culverts is being met at all flows, as shown in Table C-4. Figures C-6 and C-7 show the water surface profiles and average velocities at the culvert.

Table C-3 Summary of Flow Depth

Flow Profile (cfs)	Flow Depth in the Culvert (ft)	Flow Depth over the Road (ft)
85	4.9	--
1,250	8.2	--
2,000	8.5	--[a]
4,500	8.5	1.9
9,737	8.5	4.6

Notes:
cfs = cubic feet per second, ft = feet
[a] Water elevation is at bridge deck and flow is submerged in culvert

Table C-4 Summary of Velocities

Flow Profile (cfs)	Velocity within the Culvert (fps)	Velocity over the Road (fps)
85	0.3	--
1,150	2.4	--
2,000	3.9	--
4,500	2.7	2.9
9,737	2.2	2.3

Notes:
cfs = cubic feet per second, fps = feet per second

Figure C-6 Water Surface Profiles of Design Conditions

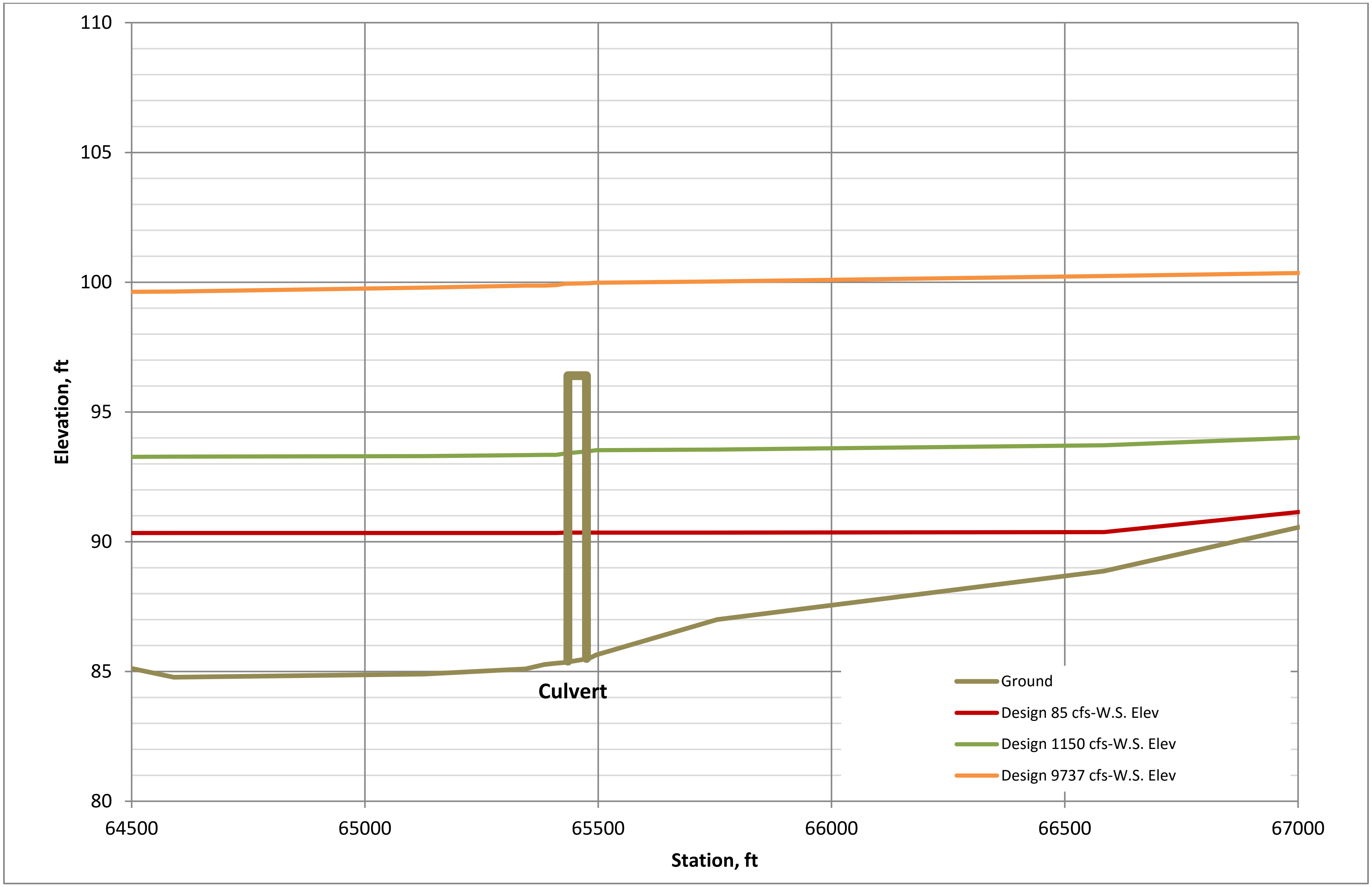
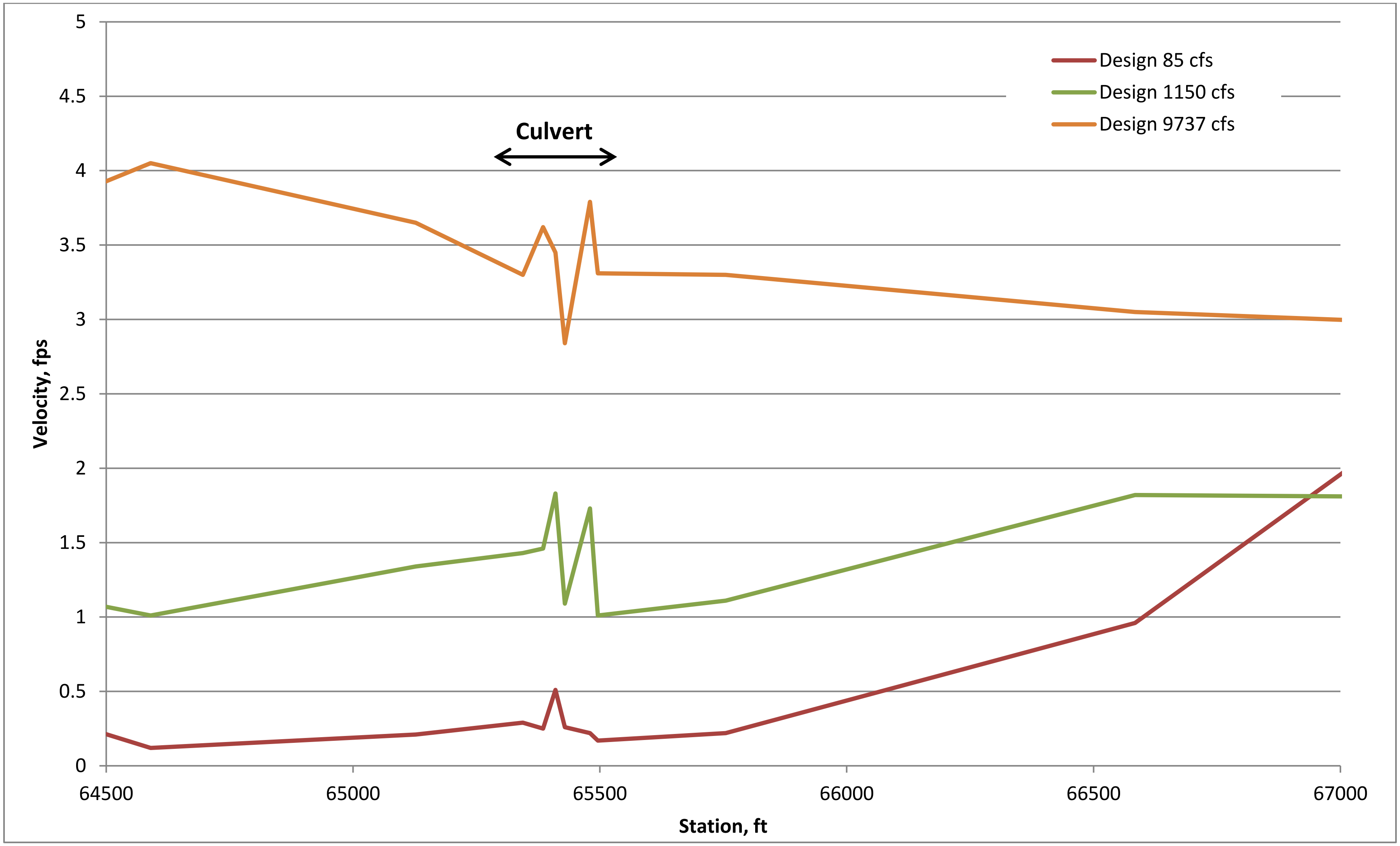


Figure C-7 Main Channel Average Velocity Profiles for the Design Condition



3.1.1.3 Flood Capacity

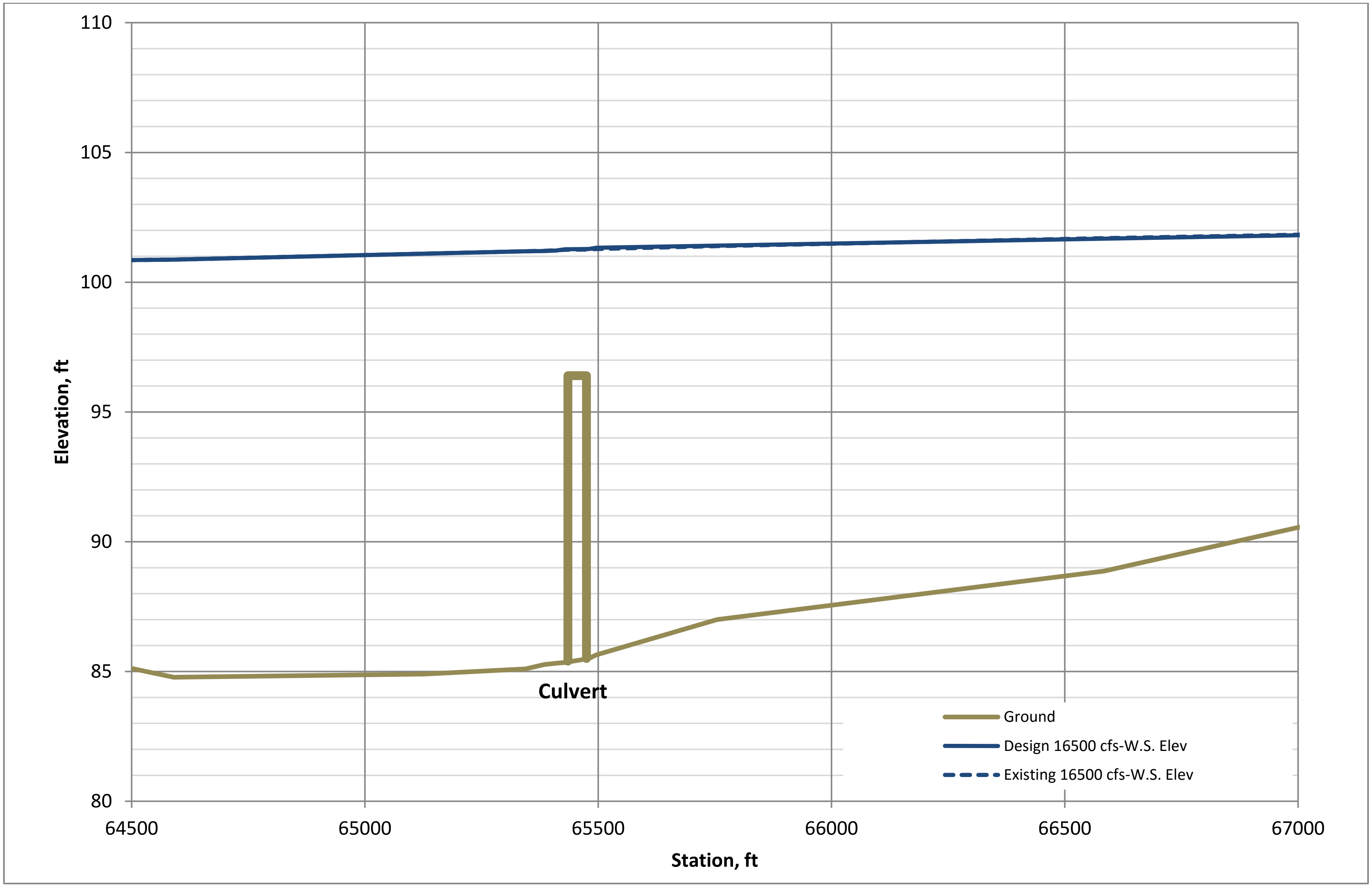
The water surface profiles generated from the hydraulic models for the existing condition and the design alternative were compared to ensure that there is less than 0.1-foot rise in water surface elevation at the design flow of 9,737 cfs (Figure C-8 and Table C-5).

Table C-5 Summary of Difference in Water Surface Elevation at Flood Capacity

Cross Section	Feet from Culvert	Design Flood Water Surface Elevation (ft)	Existing Conditions Flood Water Surface Elevation (ft)	Difference (ft)
Upstream	1155	101.7	101.7	0.0
Upstream	326	101.4	101.4	0.0
Upstream	67	101.3	101.3	0.0
Upstream	51	101.3	101.3	0.0
Culvert	0	101.3	101.3	0.0
Downstream	19	101.2	101.2	0.0
Downstream	44	101.2	101.2	0.0

Note:
ft = feet

Figure C-8 Water Surface Profile for Flood Condition



3.1.2 Ground Subsidence

Currently, the culverts include about 0.5 foot of freeboard at 1,150 cfs before the water hits the top of the culverts. Subsidence over time may reduce the capacity of the culverts because of increased water depths. The embedded material could be removed or could erode over time and create additional flow capacity. Additional modeling will be necessary to confirm this finding and determine if additional culverts are needed to provide future flow capacity.

3.1.3 Operations and Maintenance

Dan McNamara Road is within the road ROW of Merced County. This alternative assumes that the county is the owner of the crossing and accepts the operations and maintenance of the road crossing. But, whether this continues in the future needs to be determined.

Major operations for this alternative would require the closure of the road when flows overtop. That would include removal of guard railing, if installed, when flows more than 1,150 cfs are forecasted. This is similar to current flood operations.

Maintenance of the culverts and road would be needed on an annual basis. Debris and trash removal from the culverts and entrance would likely occur by hand after major floods or Restoration Flows. Initially, monitoring of the structure during salmonids migration may be needed to ensure that the culverts remain clear to provide unimpeded fish passage.

The roadway embankments would need to be inspected for possible signs of erosion or scour that may undermine the structure. Sediment may need to be removed from the road to keep it clear, and may also need to be removed from the low-flow channels and culverts to maintain capacity. During certain low-flow events outside of fish migration, board guides could be added to some of the culverts to allow the flushing of sediment through the culverts to maintain overall capacity.

3.1.4 Cost Estimate

The estimated construction costs for the series of box culverts and roadway is approximately $6.5 million. The cost estimate worksheets are included in Attachment A. Generally, the cost estimate includes:

- Clearing and grubbing the site.
- Excavation of the channel and existing road.
- Demolition of the existing culverts.
- Construction of the new culverts and roadway.
- Replace of fencing and gates.
- Acquire additional right-of-way.

The cost estimate assumes approximately 18,000 cubic yards will be excavated from the low-flow channel to regrade the channel back to its original slope. An additional 2,500 cubic yards of material will be excavated to remove the existing road embankment. Additional costs were considered for the removal of the existing culverts in both the low-flow channel and within the floodplain.

The five barrel-box culverts will be constructed of structural concrete on top of a 1-foot aggregate base foundation. Approximately 390 cubic yards of fill will be embedded into the culverts to allow for a natural bottom as well as erosion and sediment deposition. Grouted riprap will be added upstream and around the structure for erosion protection.

The road itself will require approximately 11,000 cubic yards of engineered fill, assuming a 25 percent compaction, with a 6-inch aggregate base, and topped with 12 inches of Portland Cement Concrete rigid pavement. The entire road will be armored with 1-foot thick gabion mattresses. Costs were also included to extend the existing right-of-way by 14 feet on either side of the road to allow for the road embankments.

Additional costs were added for fencing and cattle grades within the channel.

Contingencies for design, field costs, and contract costs are included in the cost estimate, and total approximately 50 percent of the overall cost of the alternative.

3.1.5 Benefits and Consequences

The primary benefit of this alternative is that it continues to provide a crossing through the bypass at the same location and allows vehicle access during most Restoration Flows.

The culverts still would not allow vehicles to cross during the spring pulses during the wettest years. General maintenance of the culverts and road could be high after significant flow events. The culverts are designed to meet fish passage design criteria; but, the channel in this area will be constricted and could potentially cause future erosion and road stabilization issues if not designed properly.

3.1.6 Future Design Considerations

If this alternative is preferred, the following additional design considerations include:

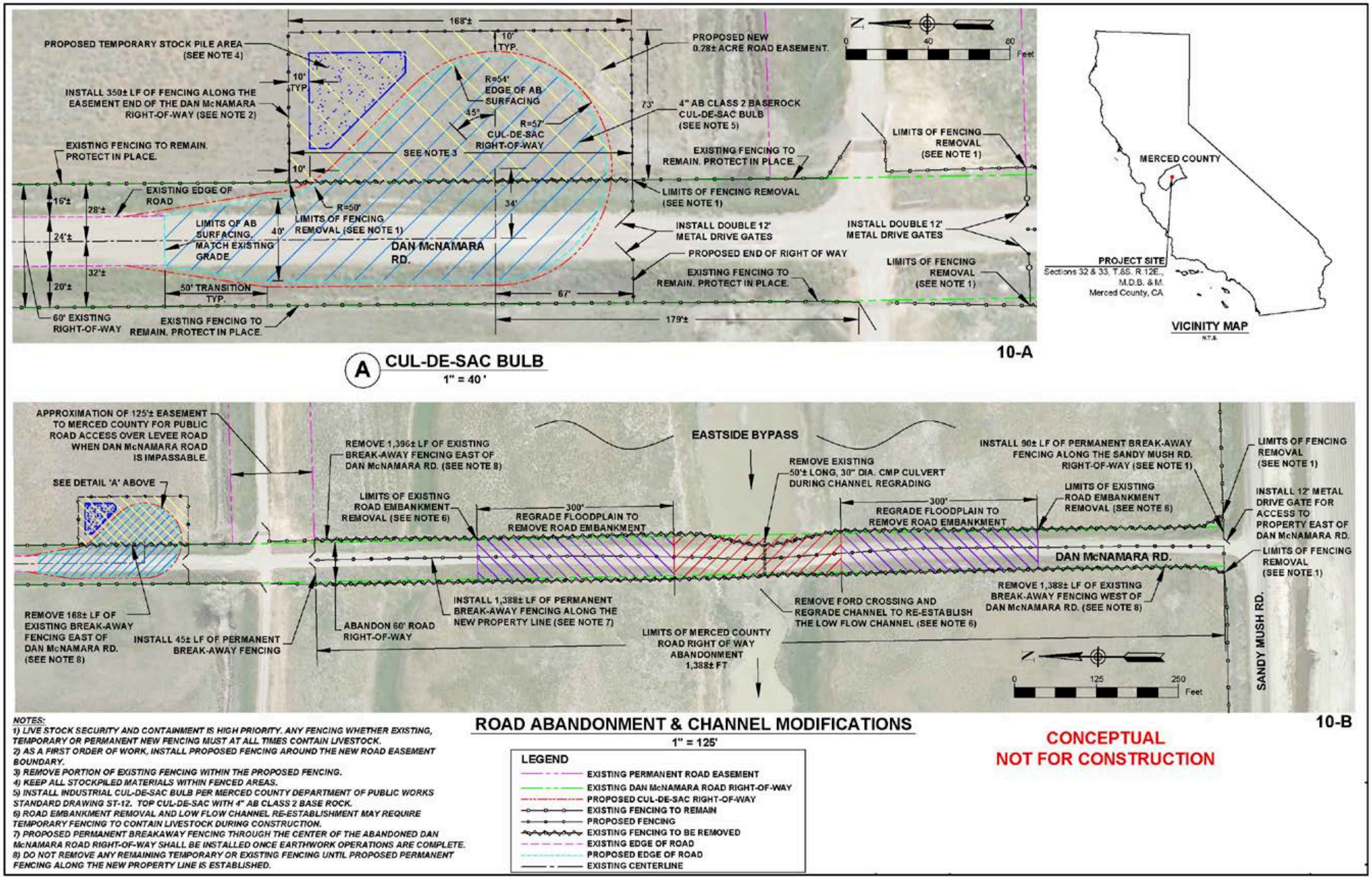
- The frequency and flow at which the road can be overtopped.
- The final channel slope.
- The ability to find a guard rail that meets State standards and are removable during high-flow events, as the guard rail may impact the hydraulics or become damaged.

3.2 Alternative DMR-2 – Crossing Removal

This fish passage improvement design alternative consists of completely removing and abandoning Dan McNamara Road from the Eastside Bypass. The Restoration Flow easement for the Eastside Bypass at the existing Dan McNamara Road has already been acquired by Reclamation. Abandoning the crossing includes the removal of the existing culverts and roadway embankment, as well as constructing a cul-de-sac (Figure C-9). Removal of the road would require incoming traffic to be routed. Options available to the County include routing traffic onto other public roads to access Dan McNamara to the north of the Eastside Bypass, or to use the Merced County Road ROW for Dan McNamara Road across the Eastside Bypass. Figure C-10 shows a potential traffic reroute of approximately 25 miles.

Once the road is removed, channel excavation is needed to restore the original bypass channel slope. The amount of grading needed to return the channel to natural grade is approximately 30,000 cubic yards, the same volume as Alternative DMR-1. The overall channel work and slope is similar to the design for Alternative DMR-1.

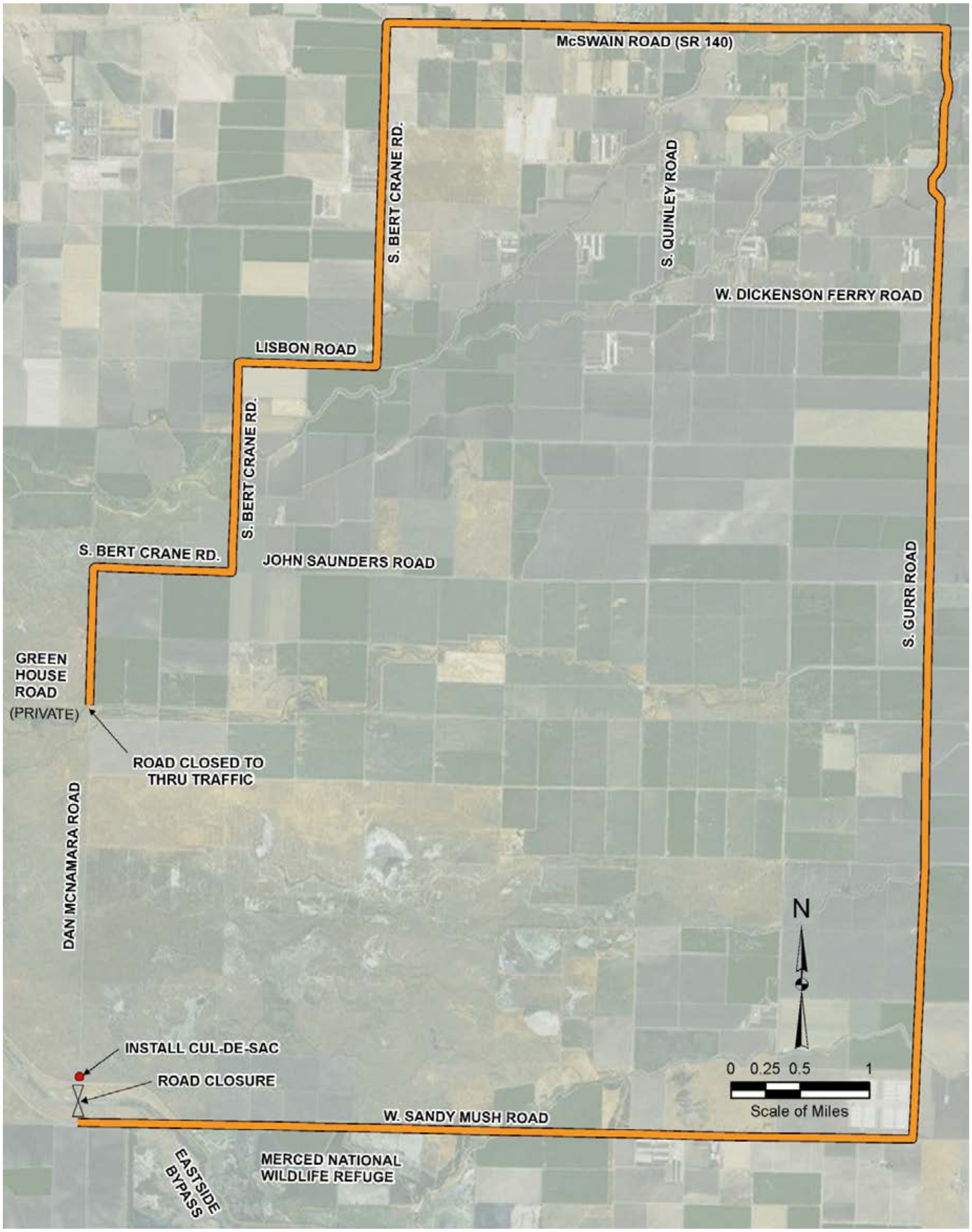
Figure C-9 **Alternative DMR-2: Crossing Removal, Plan View**



NOTES:

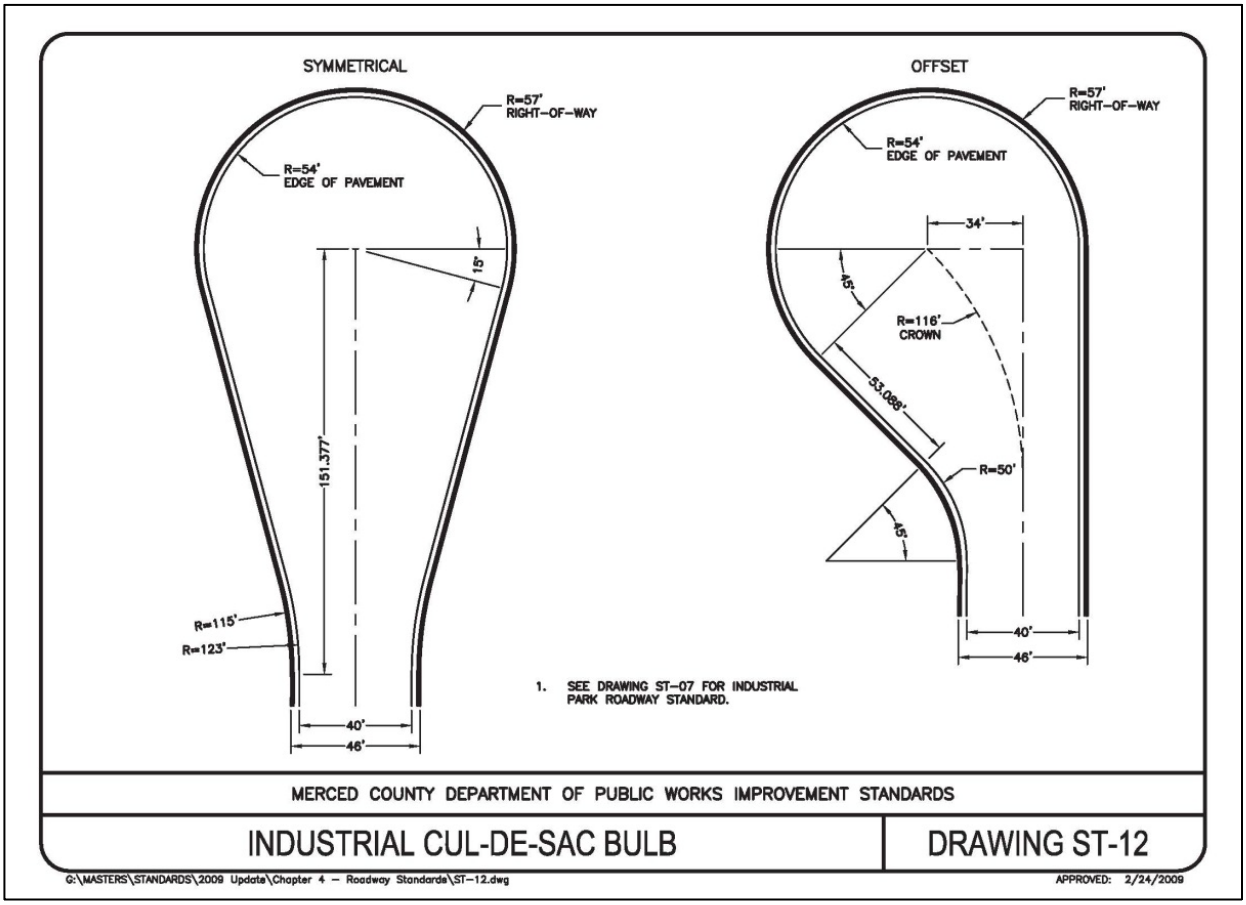
1) *LIVE STOCK SECURITY AND CONTAINMENT IS HIGH PRIORITY. ANY FENCING WHETHER EXISTING, TEMPORARY OR PERMANENT NEW FENCING MUST AT ALL TIMES CONTAIN LIVESTOCK.*
2) *AS A FIRST ORDER OF WORK, INSTALL PROPOSED FENCING AROUND THE NEW ROAD EASEMENT BOUNDARY.*
3) *REMOVE PORTION OF EXISTING FENCING WITHIN THE PROPOSED FENCING.*
4) *KEEP ALL STOCKPILED MATERIALS WITHIN FENCED AREAS.*
5) *INSTALL INDUSTRIAL CUL-DE-SAC BULB PER MERCED COUNTY DEPARTMENT OF PUBLIC WORKS STANDARD DRAWING ST-12. TOP CUL-DE-SAC WITH 4" AB CLASS 2 BASE ROCK.*
6) *ROAD EMBANKMENT REMOVAL AND LOW FLOW CHANNEL RE-ESTABLISHMENT MAY REQUIRE TEMPORARY FENCING TO CONTAIN LIVESTOCK DURING CONSTRUCTION.*
7) *PROPOSED PERMANENT BREAKAWAY FENCING THROUGH THE CENTER OF THE ABANDONED DAN McNAMARA ROAD RIGHT-OF-WAY SHALL BE INSTALLED ONCE EARTHWORK OPERATIONS ARE COMPLETE.*
8) *DO NOT REMOVE ANY REMAINING TEMPORARY OR EXISTING FENCING UNTIL PROPOSED PERMANENT FENCING ALONG THE NEW PROPERTY LINE IS ESTABLISHED.*

Figure C-10 **Alternative DMR-2: Proposed Traffic Route for Dan McNamara Road Closure**



A cul-de-sac will be constructed to allow the public and the Merced County Department of Public Works access to equipment such as a motor grader to turn around on Dan McNamara Road north of the Eastside Bypass. The preliminary design for the cul-de-sac references the Merced County Department of Public Works Improvement Standards Drawing ST-12, Industrial Cul-de-sac Bulb, shown in Figure C-11 (Merced County 2009). This provides for a 54-foot radius for the turnaround within the cul-de-sac. Dan McNamara Road north of the Eastside Bypass is a one-lane rural roadway that remains unpaved. The soil from the channel grading could be used to construct the cul-de-sac. The cul-de-sac may require additional ROW acquisition, as the current ROW for Dan McNamara Road is 60 feet wide. Because the cul-de-sac exceeds the current ROW, a land acquisition of 0.25 acre may be required.

Figure C-11 Merced Count Industrial Cul-de-sac Bulb



There are two property owners that would potentially be impacted by this alternative, as the centerline of Dan McNamara Road is the property line between two parcels. To prevent public access to private lands, locked gates would be added. In addition, the ROW access across the bypass would be vacated. This would be accomplished through the approval of a ROW vacation through the Merced County Department of Public Works.

To ensure segregation of livestock, a cattle exclusion barrier will continue to be required across the Eastside Bypass channel. The optimum location of the replacement fencing would be the centerline of the existing 60-foot wide ROW, which is the west section line of Section 33 (T.8S, R.12 E., MDB&M). This cattle barrier will need to be designed to withstand the Restoration and flood flows without collecting debris that would impact the fish passage and exacerbate flooding, and would need to be collapsible or floating. A gate could be installed within the fencing to pass flows with minimal damage and help protect the livestock security. The gate could be placed at the low-flow point in the channel and would be opened for Restoration Flows.

3.2.1 Hydraulic Analysis

A one-dimensional model using HEC-RAS was developed to simulate the depth and velocity for a range of flows assuming a steady-flow condition. The model was modified by removing the existing crossing and grading the channel to remove the road and culvert.

3.2.1.1 Flow

Because this alternative involves the removal of the existing culverts and crossing, the channel will provide unimpeded passage for the design flows of 85 cfs through 9,737 cfs.

3.2.1.2 Fish Passage

This alternative provides for unimpeded fish passage with the removal of the road and culverts.

3.2.1.3 Flood Capacity

The design-flood capacity flow at Dan McNamara Road of 16,500 cfs was simulated in the HEC-RAS model and the water surface for the existing condition. With the removal of the structure, the hydraulic results show that this alternative produces no increase in flood water surface elevations at the design-flood capacity. The flood water surface elevation is reduced at the crossing and improves the flow conveyance because the elevated road crossing material is removed from the bypass.

3.2.2 Ground Subsidence

No additional design measures were considered for channel grading, except that the channel will be designed as close to the original slope as possible.

3.2.3 Operations and Maintenance

It is assumed that the bypass channel will need minimal maintenance, but could include periodic removal of debris within the cul-de-sac. The landowner’s access gates within the channel will need to be operated, and the cattle exclusion barrier will need to be cleared of debris to ensure unimpeded fish passage.

3.2.4 Cost Estimate

The estimated construction costs to remove the crossing and construct a cul-de-sac are approximately $1.9 million. The cost estimate worksheets are included in Attachment A. Generally, the cost estimate includes:

- Clearing and grubbing the site.
- Excavation of the channel.
- Demolition of the existing culverts.
- Construction of the cul-de-sac.
- Replacement of cattle fencing and gates.
- Acquire additional road easements.

Similar to Alternative DMR-1, the cost estimate assumes approximately 18,000 cubic yards will be excavated from the low-flow channel to regrade the channel to its original slope, and requires that the existing culverts would be demolished.

The cul-de-sac would be constructed of 4 inches of aggregate base on top of approximately 2,600 cubic yards of engineered fill. Additional easements around the cul-de-sac may be required and are included in the cost estimates. The cost estimates also include fencing and gates within the bypass and around the cul-de-sac to prevent public access to the bypass and to keep cattle within the respective land owner properties.

Contingencies for design, field costs, and contract costs are included in the cost estimate and total approximately 50 percent of the overall cost of the alternative

3.2.5 Benefits and Consequences

The major benefits of this alternative are the minimal cost for the demolition and improvements, as well as the amount saved in the cost of the maintenance and operations of the existing crossing. This alternative could eliminate the costs to the LSJLD and Merced County to close Dan McNamara Road and for traffic control.

3.2.6 Future Design Considerations

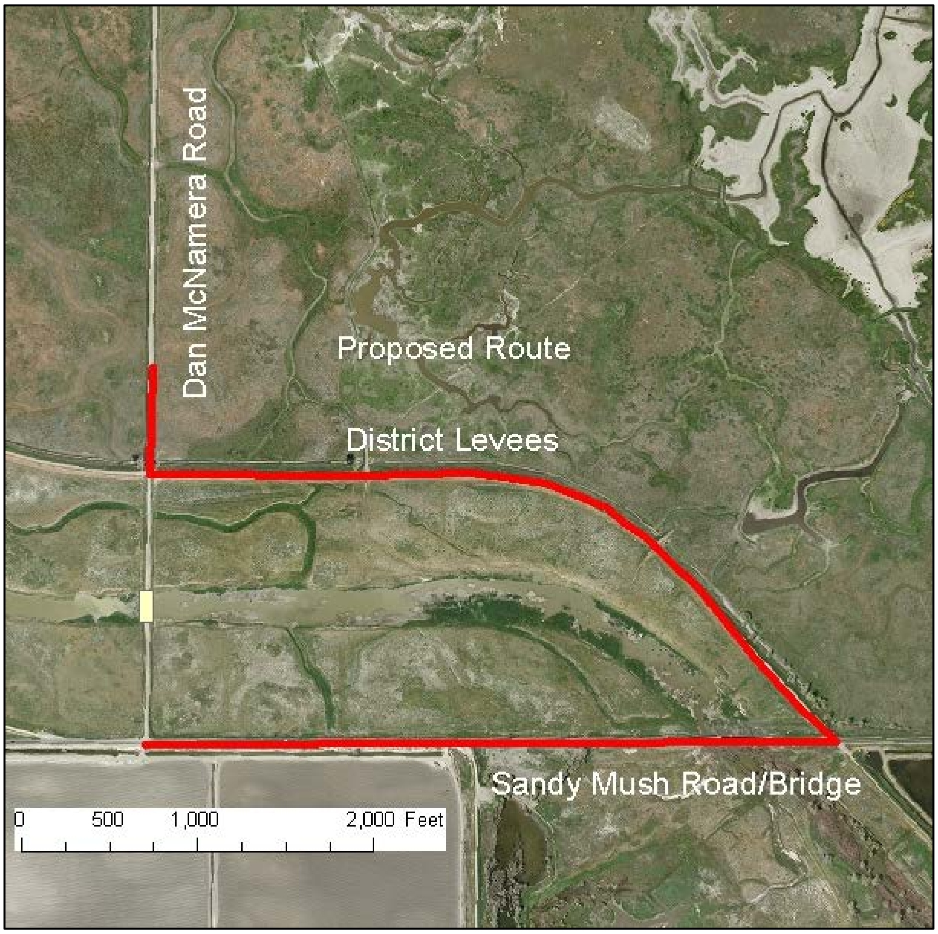
The road vacation, and the specific location or need for a cul-de-sac should be discussed early in the process to solidify the project. The new traffic route that will result from this alternative will have some cost to the public using vehicles if accessing the crossing from the south. The vacation would have to be approved by the Merced County Board of Supervisors.

Transverse livestock fencing with four or five strands of barbed wire fencing is allowed in the Eastside Bypass operation and maintenance documents and will need to be designed to allow for unimpeded fish passage.

3.3 Alternative DMR-3 – Crossing Removal with Modified Detour

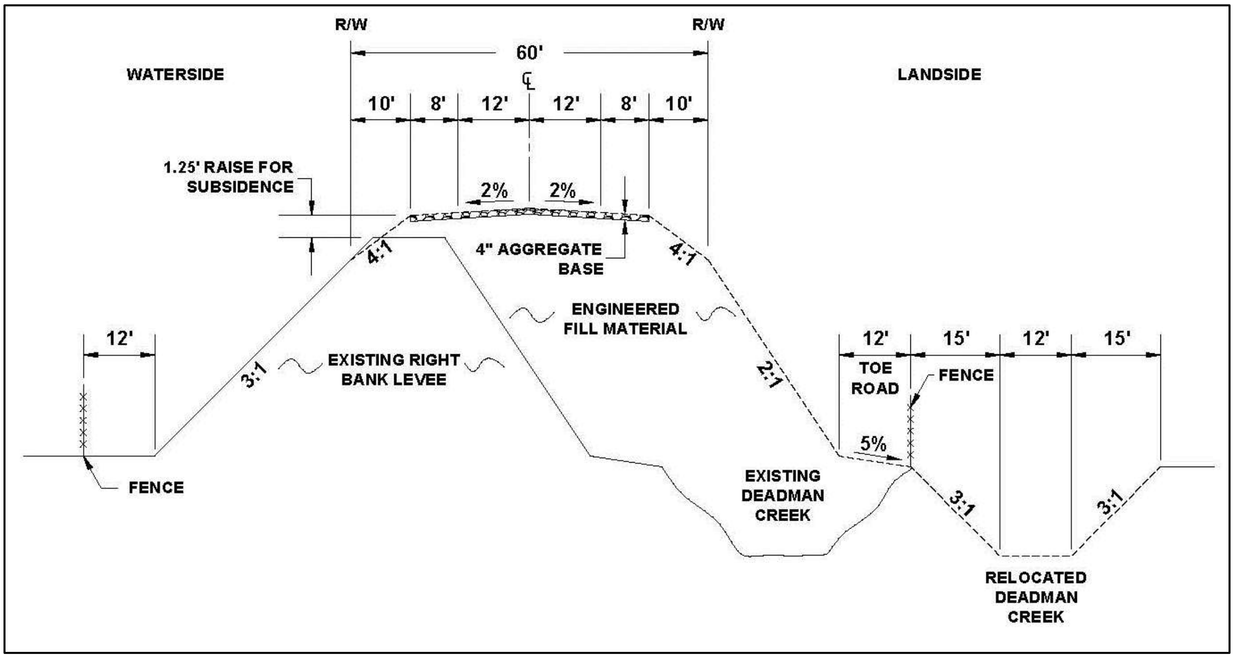
Similar to Alternative DMR-2, this fish passage improvement design includes removing the existing culvert crossing. But, instead of routing traffic onto existing public roads, this alternative improves the existing detour for Dan McNamara Road (Figure C-12). The levee will be expanded to provide for a 60-foot rural roadway, which is wider than the existing Dan McNamara Road, north of the Eastside Bypass. The existing detour easement varies in width from 135 feet to 175 feet. The current detour easement that was dedicated to Merced County for public access for use of the levee road, when Dan McNamara Road is impassable, is given by a “meets and bounds” description without a relationship to the existing levee embankment. As a result, additional ROW may be needed. According to discussions with LSJLD staff and Merced County Department of Public Works staff, Dan McNamara Road north of the levee is inundated during flood events and is not passable. This detour will be primarily used when Restoration Flows are present.

Figure C-12 **Dan McNamara Road Detour via Sandy Mush Road and the Eastside Bypass Levee**



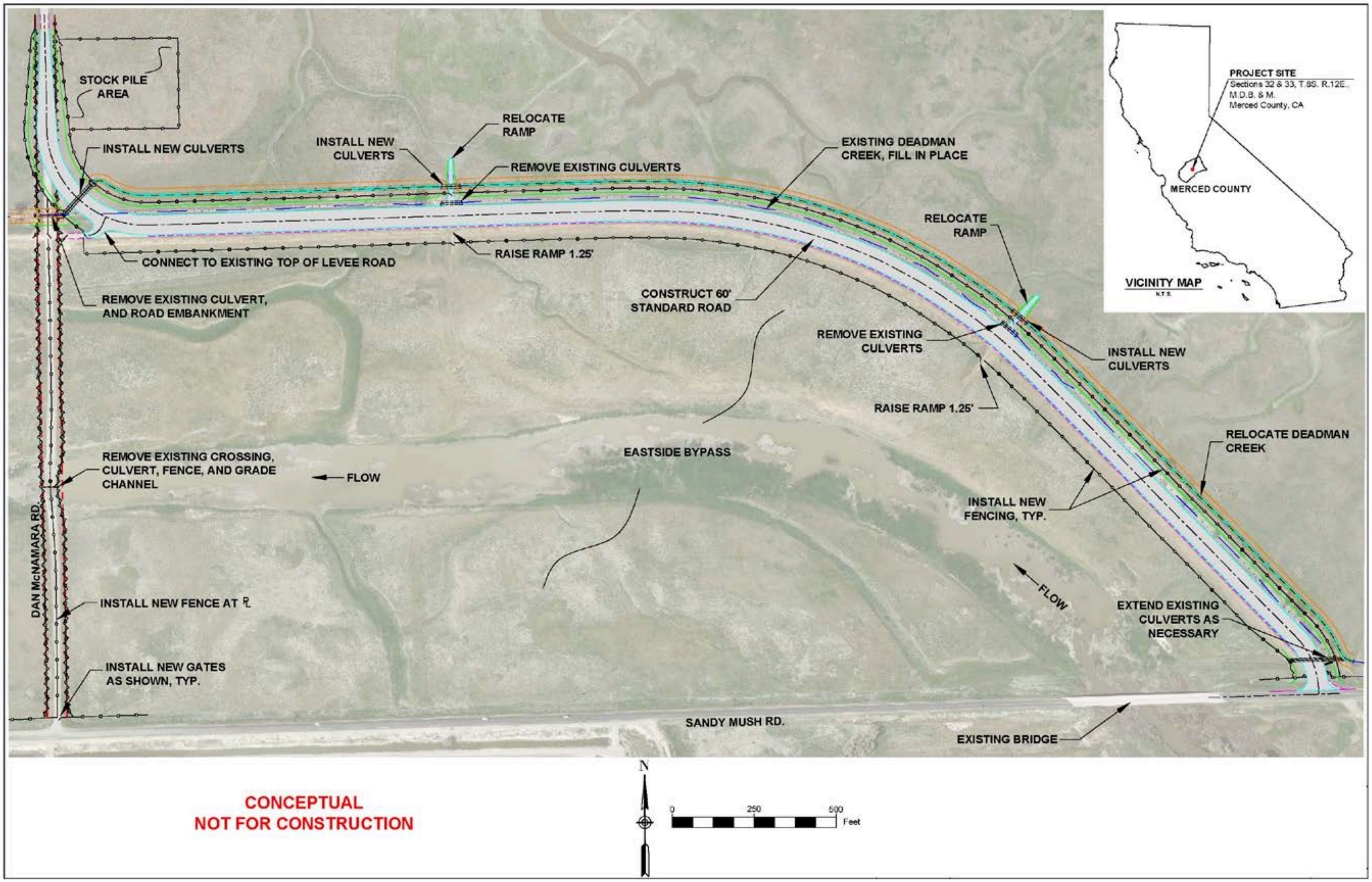
The goal of this detour would be to provide levee access that is equal to, or better than, current conditions on Dan McNamara Road to Sandy Mush Road. This means that the levee crown would be widened approximately 40 feet. This is intended to provide a 60-foot rural roadway that will provide two-way traffic and should not require guardrails. Currently, the levee crown between Dan McNamara and Sandy Mush Road varies in width from 15 feet to 24 feet. The levee crown is armored with gravel for heavy equipment and vehicle traffic. Improvements to the bypass levee that will allow for a wider road will need to meet USACE levee standards. The road will need to meet Merced County standards. The new levee and road will widen the right bank levee to the north. This will require that segments of the adjacent Deadman Creek be relocated (Figure C-13).

Figure C-13 **Profile of Levee Road and Deadman Creek Relocation**



The detour levee improvement work (Figure C-14) will start on the existing Dan McNamara Road, approximately 240 feet north of the landside toe of the levee.

Figure C-14 Alternative DMR-3 – Crossing Removal with Modified Detour, Plan View



Embankment will be constructed so that the road will ramp up to the top of the levee. The Deadman Creek channel will need to be relocated at this road ramp to continue the drainage in the pair of 54-inch diameter reinforced concrete culverts with concrete headwalls. The headwalls will be designed to minimize the embankment footprint by retaining the embankment. There are also two earthen ramps that give the property owner access from landside of the levee to the channel side in this stretch of the levee system. These ramps will be reconstructed to continue to provide access. The right levee will be raised to account for subsidence and material will be filled into the wider levee (Figure C-13). The placement of the fill will fill the existing channel, and the replacement channel will be excavated at a minimum of 12 feet from the toe.

3.3.1 Hydraulic Analysis

The hydraulic analyses completed for this alternative is the same as Alternative DMR-2. The existing model was modified by removing the crossing, and grading the channel to simulate the removal of the low-flow crossing and culvert. The hydraulic results for flow, fish passage, and flood capacity are identical to Alternative DMR-2.

3.3.2 Ground Subsidence

To address ground subsidence with this alternative, the levee height will be raised by at least 1.25 feet. Additional hydraulic modeling will be necessary to determine ultimately how much the levees will need to be raised.

3.3.3 Operations and Maintenance

The maintenance of the detour road will be very similar to the current operations for Dan McNamara Road. Crews from the Merced County Department of Public Works will need to fill pot holes with gravel and run the motor graders to keep the road in a uniform grade. There should not be any restrictions on the type of herbicide that is used for weed abatement. The ramp up from the existing Dan McNamara Road to the top of the levee may need an increased amount of maintenance because of the steep, super-elevated curve of the gravel road.

3.3.4 Cost Estimate

The estimated construction cost to remove the crossing and improve the existing detour is $17 million. The cost estimate worksheets are included in Attachment A. Generally, the cost estimate includes the following:

- Clearing and grubbing the site.
- Excavation of the bypass channel and Deadman Creek.
- Demolition of the existing culverts.
- Replace or extend existing culverts and other infrastructure along Deadman Creek.
- Improve levees and road.
- Add or replace fencing, gates, and road easements.

The cost estimate considers excavation of 43,000 cubic yards from the low-flow channel to regrade the bypass channel back to its original slope, and also from Deadman's Creek to allow for its relocation, as well as the construction of the newly improved levee. Approximately 165,000 cubic yards of engineered compacted fill will be used to improve the existing levees. The costs also assume that the material for the levees will be imported. The top of the levees will be protected with 4 inches of aggregate base and the levee slopes will be stabilized with hydroseed.

Three existing culverts, and other infrastructure associated the relocation of the Deadman's Creek, will need to be relocated to allow for the wider and taller levees. The cost estimates include fencing and gates within the bypass to prevent public access to the bypass and to keep cattle within the respective land owner properties.

Contingencies for design, field costs, and contract costs are included in the cost estimate, and total approximately 50 percent of the overall cost of the alternative

3.3.5 Benefits and Consequences

Relocating Deadman Creek will impact wetland habitat, which will be challenging to mitigate. This will extend the project construction schedule and construction cost.

The proposed levee cross section design may meet the USACE standard geometry, and may help reduce underseepage. The wider crown road will be a benefit during flood flights, as there will be enough room for two-way traffic and room for stock piling flood fight materials if needed. There currently does not appear to be a maintenance road at the toe of the levee, but this design will provide a maintenance road at the levee toe for use by LSJLD.

3.3.6 Future Design Considerations

If this alternate is preferred, detailed flow calculations will be needed for the culverts on Deadman Creek. This will require more detailed topographic data of the channel from Sandy Mush Road downstream to the EBCS at the proposed intersection with Sandy Mush Road and the detour road, and will require determination of where the ROW will be adjusted, and the ultimate levee width.

4.0 References

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Attachment A – Cost Estimates

Table C-a.1 Alternative DMR-1 – Modified Low Flow Crossing with 5-Barrel Box Culvert, Cost Estimate Worksheet

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET__1__ OF __1__

FEATURE: Cost Estimate Fish Passage Task 3 Dan McNamara Road Crossing Alternative DMR-1 - Modified Low Flow Xing with 5-Barrel Box Culvert October 2016	**PROJECT:** San Joaquin River Restoration Program **WOID:** SJRRB **REGION:** Pacific **ESTIMATE LEVEL:** Conceptual **PRICE LEVEL:** 2016 **FILE:** P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\[Alt. 2 Crossing Removal - Cul-de-Sac_f.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		15	AC	$ 3,000	$ 45,000
	2	Permanent ROW widening (aprx.14 ft ea. side of ex. 60' ROW)		2	AC	$ 10,000	$ 20,000
	3	Remove existing barbed wire fencing		2900	LF	$ 5	$ 14,500
	4	Demo existing CMP culverts		2	EA	$ 1,000	$ 2,000
	5	Site excavation and disposal offsite (low flow channel)		18000	CY	$ 35	$ 630,000
	6	Site excavation and disposal offsite (road embankment)		2500	CY	$ 35	$ 87,500
	7	Engineered, compacted fill with offsite material (road)		11000	CY	$ 35	$ 385,000
	8	Construct 5 barrel (12ft x 12 ft) concrete box culvert		470	CY	$ 1,000	$ 470,000
	9	Class 2 aggregate base foundation (1 ft thick)		18	TN	$ 45	$ 810
	10	Engineered, compacted fill with offsite material (embedded)		390	CY	$ 35	$ 13,650
	11	Grouted Riprap Light Class (around box culvert structure)		2700	CY	$ 165	$ 445,500
	12	Armor road embankment/levees w/1 ft thick gabion mattresses		94000	SF	$ 6	$ 564,000
	13	Class 2 aggregate base (6" granular road base)		2000	TN	$ 45	$ 90,000
	14	PCC Rigid Pavement (12" thick)		2200	CY	$ 140	$ 308,000
	15	Install 5-strand barbed wire breakaway fencing		3000	LF	$ 10	$ 30,000
	16	Install new cattle grade double swing gates		2	EA	$ 4,000	$ 8,000
		Subtotal					**$ 3,100,000**
		Other Construction Related Items					
	17	Dust Control		1	EA	$ 10,000	$ 10,000
	18	SWPPP		1	EA	$ 20,000	$ 20,000
	19	Permits		1	EA	$ 10,000	$ 10,000
	20	Worker Protection		1	EA	$ 10,000	$ 10,000
	21	Traffic Control		1	EA	$ 20,000	$ 20,000
		Subtotal					**$ 70,000**
	22	Mobilization		5	PCT	LS	$ 160,000
	23	Design Contingency		15	PCT	LS	$ 456,040
		Contract Cost					**$ 3,800,000**
		Contingencies (25%)					$ 1,000,000
		Field Costs					**$ 4,800,000**
		Non-contract costs (35%)					$ 1,700,000
		Construction Cost					**$ 6,500,000**
		Project Total					**$ 6,500,000**

QUANTITIES		**PRICES**	
BY Alexis Phillips-Dowell	**CHECKED** Josh Bannister	**BY** Josh Bannister	**CHECKED** Alexis Phillips-Dowell
DATE PREPARED April 29, 2015	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** June 29, 2015	**PEER REVIEW** Amanda Peisch-Derby

Table C-a.2 Alternative DMR-2 – Crossing Removal, Cost Estimate Worksheet

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 1

FEATURE:

Cost Estimate
Fish Passage Task 3
Dan McNamara Road Crossing
Alternative DMR-2 - Crossing Removal - Cul-de-Sac
October 2016

PROJECT:
San Joaquin River Restoration Program

WOID: SJRRB
ESTIMATE LEVEL: Conceptual
REGION: Pacific
PRICE LEVEL: 2016
FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\[Alt. 2 Crossing Removal - Cul-de-Sac_f.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		12	AC	$ 1,500	$ 18,000
	2	New road easement around Cul-de-Sac		1	AC	$ 10,000	$ 10,000
	3	Remove existing barbed wire fencing and gates		3000	LF	$ 5	$ 15,000
	4	Demo existing culvert (30" dia. CMP x +/-50 ft. long)		2	EA	$ 1,000	$ 2,000
	5	Site excavation and disposal offsite (cul-de-sac)		350	CY	$ 35	$ 12,250
	6	Site excavation and disposal offsite (low flow channel)		18000	CY	$ 35	$ 630,000
	7	Engineered, compacted fill with offsite material		2600	CY	$ 35	$ 91,000
	8	Class 2 aggregate base for cul-de-sac top (4")		320	TN	$ 45	$ 14,400
	9	Install 5-strand barbed wire breakaway fencing		1800	LF	$ 10	$ 18,000
	10	Install new cattle grade swing gates		5	EA	$ 4,000	$ 20,000
		Subtotal					**$ 830,000**
		Other Construction Related Items					
	11	Dust Control		1	CY	$ 10,000	$ 10,000
	12	SWPPP		1	CY	$ 20,000	$ 20,000
	13	Permits		1	CY	$ 10,000	$ 10,000
	14	Worker Protection		1	CY	$ 10,000	$ 10,000
	15	Traffic Control		1	CY	$ 10,000	$ 10,000
		Subtotal					**$ 60,000**
	16	Mobilization		5	PCT	LS	$ 45,000
	17	Design Contingency		15	PCT	LS	$ 164,350
		Contract Cost					**$ 1,100,000**
		Contingencies (25%)					$ 300,000
		Field Costs					**$ 1,400,000**
		Non-contract costs (35%)					$ 500,000
		Construction Cost					**$ 1,900,000**
		Project Total					**$ 1,900,000**

QUANTITIES		PRICES	
BY S. Greg Farley	**CHECKED** Josh Bannister	**BY** Josh Bannister	**CHECKED** Alexis Phillips-Dowell
DATE PREPARED April 20, 2015	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** October 21, 2016	**PEER REVIEW** Amanda Peisch-Derby

Table C-a.3 Alternative DMR-3 –Crossing Removal with Modified Detour, Cost Estimate Worksheet

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET__1__ OF __1__

FEATURE: **Cost Estimate** **Fish Passage Task 3** **Dan McNamara Road Crossing** **Alternative DMR-3 - Xing Removal with Modified Permanent Detour** October 2016	**PROJECT:** **San Joaquin River Restoration Program**
	WOID: SJRRB / **ESTIMATE LEVEL:** Conceptual
	REGION: Pacific / **PRICE LEVEL:** 2016
	FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\[Alt. 3 Xing removal with permanent detour_f.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		30	AC	$ 3,000	$ 90,000
	2	Permanent ROW along widened right bank levee top		6	AC	$ 10,000	$ 60,000
	3	Temporary Construction Easement		6.6	AC	$ 5,000	$ 33,000
	4	Demo existing 48" Dia. RCP culverts		6	EA	$ 1,000	$ 6,000
	5	Demo 12" cobbles at Deadman Creek's 3 culvert inlets/outlets		620	CY	$ 8	$ 4,960
	6	Demo stair case at drainage structure near Sandy Mush Rd		1	EA	$ 1,000	$ 1,000
	7	Site excavation and disposal offsite (channel, creek, rd. emb)		43000	CY	$ 35	$ 1,505,000
	8	Remove existing barbed wire fencing, gates, and cattle gaurds		4200	LF	$ 5	$ 21,000
	9	Temporary chain link fencing for stockpile area		970	LF	$ 10	$ 9,700
	10	Construct double 54" Dia. RCP culverts at 3 locations		490	LF	$ 220	$ 107,800
	11	Extend double 48" Dia. CMP culverts near Sandy Mush Rd		135	LF	$ 195	$ 26,325
	12	Construct concrete headwalls/endwalls at 3 locations		47	CY	$ 1,000	$ 47,000
	13	Engineered, compacted fill with offsite material		165000	CY	$ 35	$ 5,775,000
	14	Install 12" cobbles at 3 culvert inlet/outlet locations and 1 bend		170	TN	$ 65	$ 11,050
	15	Construct stair case at drainage structure near Sandy Mush Rd		1	LS	$ 1,000	$ 1,000
	16	Class 2 aggregate base roadway top (4")		4700	TN	$ 45	$ 211,500
	17	Install 5-strand barbed wire breakaway fencing		11500	LF	$ 10	$ 115,000
	18	Install new cattle grade double swing gates		10	EA	$ 4,000	$ 40,000
	19	Hydroseeding		15	AC	$ 4,500	$ 67,500
		Subtotal					**$ 8,100,000**
		Other Construction Related Items					
	20	Dust Control		1	EA	$ 10,000	$ 10,000
	21	SWPPP		1	EA	$ 20,000	$ 20,000
	22	Permits		1	EA	$ 10,000	$ 10,000
	23	Worker Protection		1	EA	$ 10,000	$ 10,000
	24	Traffic Control		1	EA	$ 20,000	$ 20,000
		Subtotal					**$ 70,000**
	25	Mobilization		5	PCT	LS	$ 410,000
	26	Design Contingency		15	PCT	LS	$ 1,287,165
		Contract Cost					**$ 9,900,000**
		Contingencies (25%)					$ 2,600,000
		Field Costs					**$ 12,500,000**
		Non-contract costs (35%)					$ 4,500,000
		Construction Cost					**$ 17,000,000**
		Project Total					**$ 17,000,000**

QUANTITIES		**PRICES**	
BY S. Greg Farley	**CHECKED** Josh Bannister	**BY** Josh Bannister	**CHECKED** Alexis Phillips-Dowell
DATE PREPARED May 12, 2015	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** October 21, 2016	**PEER REVIEW** Amanda Peisch-Derby

Appendix D. Alternative Design Package, Merced Refuge Weirs

Three design alternatives to provide fish passage at two weirs in the Merced National Wildlife Refuge (MNWR) were considered and are included in this design package. Each alternative aims to provide water supplies to the MNWR equivalent to those currently supplied using the existing weirs while providing unimpeded fish passage. The conceptual designs considered include:

- Alternative MNWR-1 – Direct Pumping from East Wetlands to West Wetlands.
- Alternative MNWR-2 – Screened Pump Intake in the West Wetlands.
- Alternative MNWR-3 – Rock/Boulder Weir.

1.0 Site Assessment

The following sections provide an overview of the site conditions at the MNWR weirs, including the location and description, channel characteristics, flood operations and the fish passage constraints.

1.1 Location and Description

There are two weirs in the Eastside Bypass within the MNWR as shown in Figure D-1. The MNWR includes a series of wetlands divided into units, as shown in Figure D-2. The weirs were constructed to divert Bypass water into the units for the MNWR's irrigation use and are operated by the U. S. Fisheries and Wildlife Service.

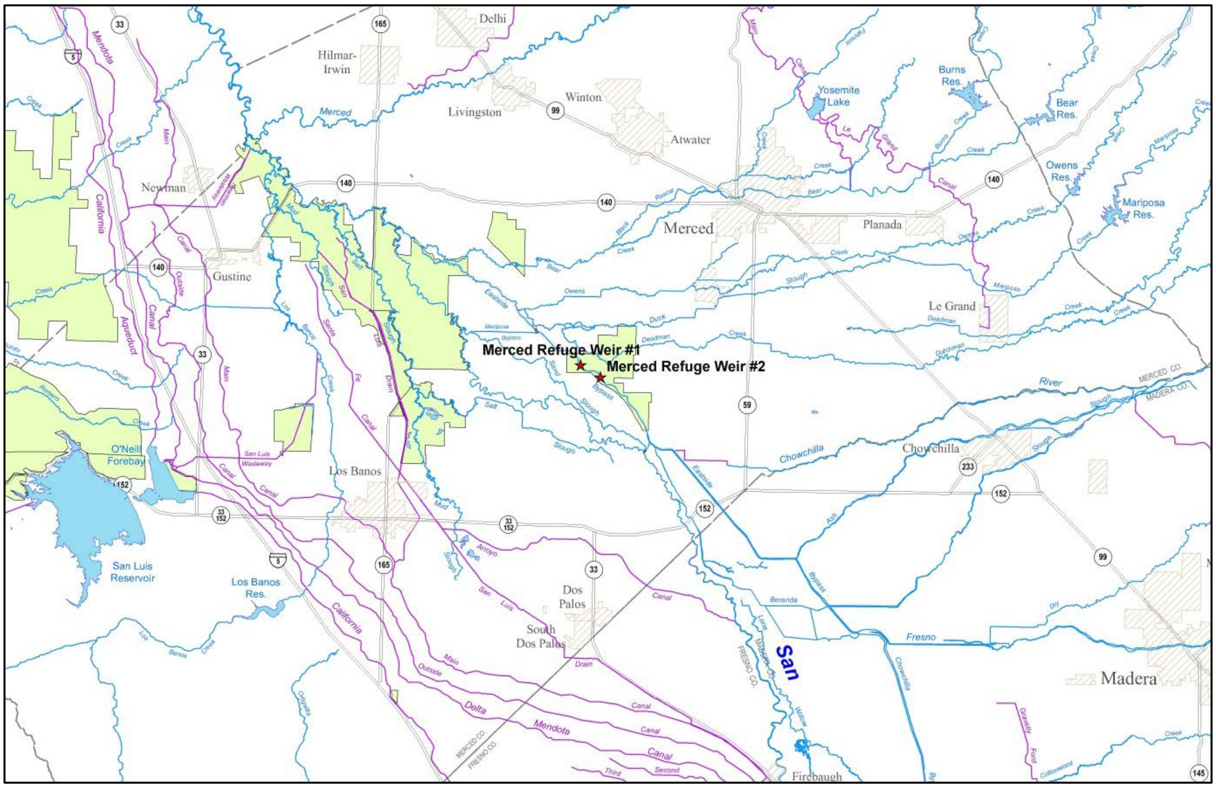
The Lower Merced Weir #1 (lower weir) is less than 1 mile south of the West Sandy Mush Road and approximately 1.4 river miles downstream of the Upper Merced Weir #2 (upper weir). Of the two weirs, the lower weir is larger and acts as a partial fish passage barrier in the bypass. In addition, the weir acts as the hydraulic control within this section of the bypass by causing the upper weir to be submerged when the boards are in.

The lower weir (Photos D-1 through D-4) is used to divert flows from the bypass into MNWR wetlands located within the bypass levees on the left overbank. This area is known as the West Wetlands. The flows are diverted into the wetlands by installing wooden boards to raise the water surface elevations in the pool upstream of the weir. The boards are inserted during periods of low flow which typically occur from September through March. The upper weir (Photos D-5 and D-6) prevents the water from flowing upstream, thereby creating a small lake between the two weirs.

The length of the lower weir, from the right bank (based on the view of a person looking downstream) toward the left bank, is approximately 62 feet and the total height is approximately 6.5 feet. The weir has a 3-foot wide metal grate on top for pedestrian access to the metal I-beams designed to accommodate the boards shown in Photo D-2.

The weir has 14 bays that average a width of 4.5 feet. There is a concrete apron at the bottom of the weir structure that extends approximately 6 feet downstream. There are also two concrete sills on the apron. The most downstream is a 1-foot tall by 10-inch wide sill. This small concrete sill is typically

Figure D-1 **Merced Refuge Weirs Location Map**



submerged at all flows. The second sill is approximately 2 feet higher than the concrete apron and is located where the boards are placed.

The structure has concrete abutments on the right bank and cobble armoring on the left bank (Photo D-3). The cobble bank, on the west toward the left overbank, is overtopped before the weir is overtopped when the boards are inserted to the elevation of the metal grate.

No repairs are known to have been performed on the weir since it was constructed. It is assumed that periodic maintenance is performed to remove sticks and other debris that have accumulated at the weir. But, site visits conducted over the summer showed major debris in places that had not been cleared (Photo D-4).

The length of the upper weir is approximately 59 feet and the height is approximately 6 feet. It is capped by wooden planks for access while installing the wooden boards as shown in Photos D-5 and D-6. The weir has 12 bays that average a width of 4 feet. There is a concrete apron for a distance of approximately 4 feet, but more could be buried under sediment. The weir has concrete abutments that tie into the banks of the channel.

Figure D-2 **Merced National Wildlife Refuge Wetlands and Irrigation Facilities (shown within the orange border)**

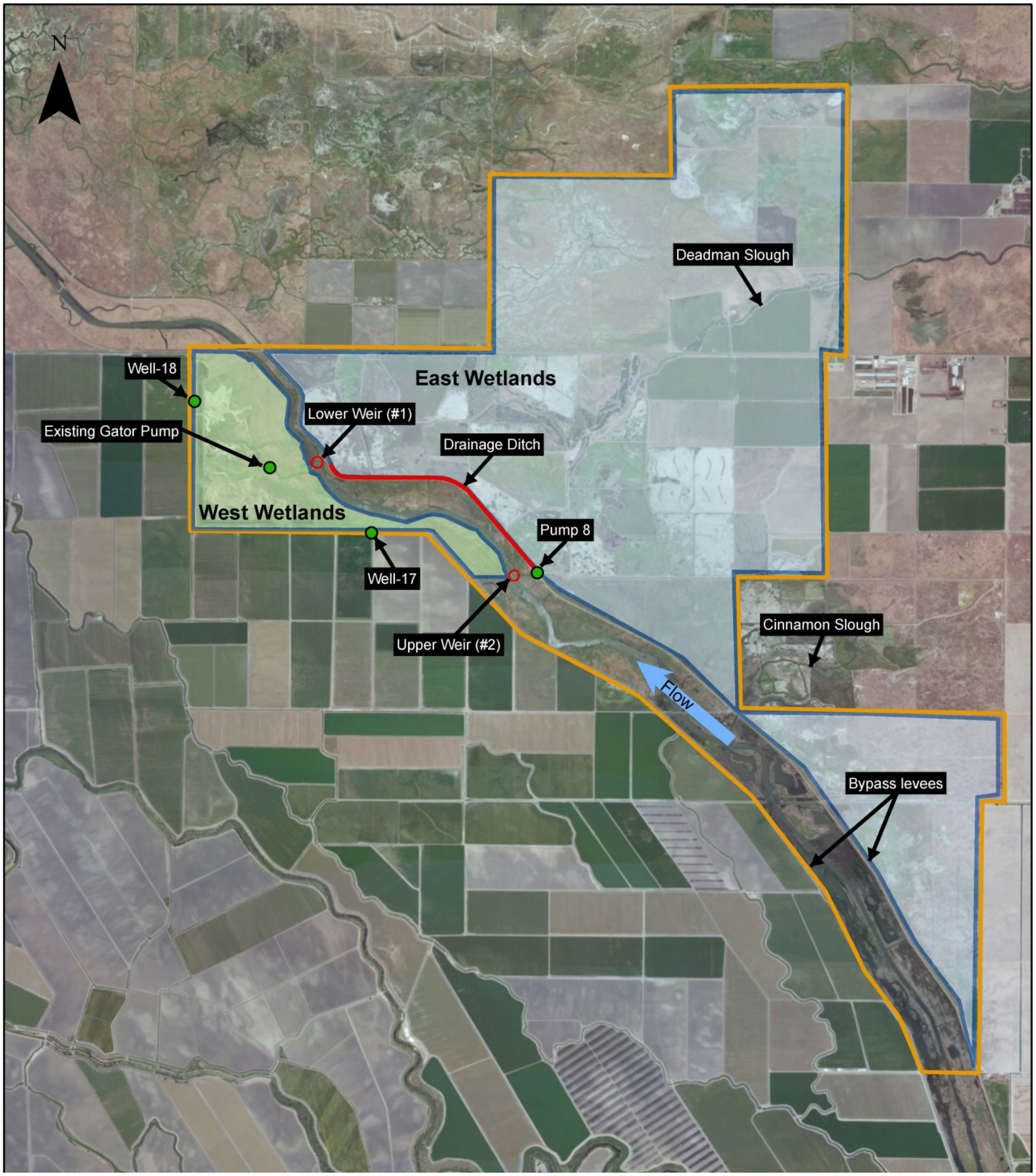


Photo D-1 Lower Merced Weir Looking Downstream Toward the West (Left) Bank

Photo D-2 Lower Merced Weir Metal Grate with Wooden Boards

Photo D-3 Lower Merced Weir Upstream Looking Downstream from Cobble Bank

Photo D-4 Lower Merced Weir Showing Debris Accumulation Upstream of Weir

Photo D-5 Upper Merced Weir Looking East at the Right Bank

Photo D-6 Upper Merced Weir Looking Downstream

1.2 Water Supply and MNWR Operations

The following sections summarize the general operations of the MNWR wetland pond units which are shown in Figure D-2. The MNWR is dependent on the available water sources from three supplies, the Merced Irrigation District, the bypass, and groundwater. These water supply sources and the operations are described in the following paragraphs.

1.2.1 Merced Irrigation District

The Merced Irrigation District supplies water from Deadman Slough for irrigating the northern part of the MNWR, which is referred to as the East Wetlands of the MNWR. Water then drains from the East Wetlands to a drainage ditch that runs parallel to the bypass levees. From there, the ditch water can be pumped into other parts of the MNWR or the bypass. For instance, one of the pumps (Pump 8), shown in Figure D-2, pumps water into the Cinnamon Slough in the summer and into the bypass in the winter. Cinnamon Slough drains into the bypass via a culvert with a gauge and outlet control structure. There are also other outlets that drain water into the bypass via culverts and outlet control structures that are not shown in Figure D-2.

1.2.2 Bypass

Water use from the bypass is generally opportunistic because the water is only used when available; it generally consists of rainfall runoff and drainage water from the East Wetlands. Wooden boards are inserted into all of the slots at the lower weir to impound the water up to an elevation of approximately 100 feet. The boards are used when the water level in the bypass is low, generally from September through March. To prevent the impounded water from flowing upstream and leaving the MNWR, boards are placed in the slots of the upper weir. This allows the water in the bypass to flow into an unlined channel on the left overbank within the West Wetlands. A mobile gator pump is located at the end of the channel (Figure D-2). The suction end of the pump is located in the channel and it has a screen to prevent debris from entering the pump. The pump is rated at 4,500 gallons per minute (10 cubic feet per second [cfs]). The suction diameter is 12 inches; the discharge diameter is 16 inches. The water is pumped into a pipeline that has a "Y" configuration. The top ends of the "Y" pipeline terminate in two standpipes with valves that discharge into the two major units of the West Wetlands.

1.2.3 Groundwater

The MNWR has two deep wells (Well 17 and Well 18) located in the West Wetlands(Figure D-2) that can be used during the winter, if the bypass water is unavailable. The MNWR staff suggests that the wells are expensive to operate and that the water quality is not always as good as the bypass water. The wells are generally used in January. They are on timers and are scheduled to run for a day and are turned off the next day.

1.3 Channel Characteristics

The overall bypass main-channel width upstream of the lower weir is approximately 200 feet, which is constricted by the weir to approximately 80 feet wide downstream of the weir. The channel downstream of the lower weir appears stable.

Because the weirs and MNWR wetlands are within the bypass, the area near the edge of the bypass channel has thick vegetation made up of heavy brush and trees. The overbank is sparsely vegetated with mostly low annual grasses.

The bypass is experiencing regional subsidence that varies along the bypass and surrounding areas. The rate of ground subsidence at the MNWR is approximately 0.05 foot to 0.3 foot per year (California Department of Water Resources 2013). But, the channel is subsiding at a much greater rate upstream within the Upper Eastside Bypass (0.5 foot per year to almost 1 foot per year). This is resulting in a flatter channel slope within the MNWR compared to a much steeper slope of the channel upstream. Given that subsidence is occurring at a greater rate upstream, when compared to the MNWR, water depths at the weir locations will be greater in the future.

1.4 Flooding

The West Wetlands and weirs are located within the Lower San Joaquin River Flood Control Project levees. Currently, flooding within the bypass occurs about 1 year in every 4 or 5 years. When flood flows do occur, the boards are removed from both weirs, and the weirs and West Wetlands becomes inundated.

1.5 Existing Fish Passage Constraints

The lower and upper weirs currently impede the upstream migration of adult Chinook salmon for varying flows depending on whether the boards are installed (California Department of Water Resources 2012). Because the weirs work together to create a pool/lake, the lower weir is the primary barrier and controls the water surface elevation at the upper weir.

When the boards are in at the lower and upper weirs, unimpeded passage is possible when the lower weir is overtopped at flows more than 3,000 cfs. The upper weir is completely submerged when the boards are in at the lower weir, so passage at the upper weir is unimpeded.

If the boards are removed at the upper and lower weirs then passage at the lower weir is impeded only for flows less than 100 cfs, assuming that fish can jump over the downstream sill. There is a risk of injury to the fish during jumping because of the overhead metal grate and the many I-beams for the wooden boards at the lower weir. If the upper weir boards remain installed when the lower weir boards are removed, then the upper weir impedes fish passage until it is overtopped when flows exceed 700 cfs. Clogging with debris at low flows could exacerbate the impedance of fish at both weirs.

2.0 General Design Criteria

The design for each alternative must meet criteria for flow, fish passage, subsidence, and flood capacity. General design criteria applicable to all of the alternatives are discussed in this section. Additional design criteria for a specific fishway will be discussed within the alternative design description. The fish passage design criteria and guidelines are consistent with the California Department of Fish and Wildlife (DFW) and the National Marine Fisheries Service (NMFS). Specific criteria for the restoration fish passage projects were developed through a series of stakeholder workshops; but, they were never finalized by the San Joaquin River Restoration Program (SJRRP). It is recommended that DWR meet with the regulatory agencies to finalize the criteria at this structure. For the purposes of the report, the general criteria to guide the design of the project components are discussed here.

2.1 Flow

Flows through any passage facility for the MNWR weirs will be designed to ensure unimpeded passage for flows between 85 cfs and 9,737 cfs. These flows were determined in accordance with the *California Salmonid Stream Habitat Restoration Manual*, which specifies that the upper and lower design flows for adult Chinook salmon to pass unimpeded be based on a flow exceedance analysis of 1 percent and 50 percent exceedance flows. At the high passage design flow for adult anadromous salmonids, defined as the 1 percent exceedance flow, the objective is to avoid excessive water velocities and turbulence. At the low passage design flow, defined as the 50 percent exceedance flow, the objective is to provide sufficient water depth (California Department of Fish and Game 2010). For the MNWR weirs, exceedance flows were determined using flow duration curves that were based on hydrographs of expected flow releases for the SJRRP through the bypass.

2.2 Fish Passage

The fish passage design criteria for adult Chinook salmon (jump, depth, and velocity) is based on the criteria used for the SJRRP Reach 2B and Reach 4B site-specific projects, and design criteria developed by DFW, the U. S. Army Corps of Engineers (USACE), NMFS, and the U.S. Bureau of Reclamation. Each design alternative must meet the required criteria shown in Table D-1. In addition to the fish passage criteria in Table D-1, additional criteria based on a specific type of fish passage structure will also be applied, depending on the alternative. These criteria will be specified in the respective alternative.

Table D-1 Fish Passage Design Criteria for Adult Chinook Salmon

Minimum Depth of Flow (ft)	Maximum Recommended Hydraulic Drop (ft)	Recommended Design Velocity (fps)[a]
1	1.0	1.5-4.0

Notes:
fps = feet per second, ft = feet
[a]Design velocity is based on the type of fish facility and could be greater for culverts (6 fps). If culverts are recommended follow the design velocities in Table 7-1 (National Marine Fisheries Service 2011).

The following paragraphs provide a summary of how each of the criteria will be applied.

2.2.1 Minimum Depth of Flow

Depth within the fishway will need to meet a depth criterion of 1.0 foot.

2.2.2 Maximum Recommended Hydraulic Drop

The designs will ensure that any structures that will require an adult Chinook salmon to jump will have a maximum water surface difference over the structure of no more than 1.0 foot.

2.2.3 Recommended Design Velocity

The SJRRP fish passage design table recommends design velocities for fish facilities average between 1.5 feet per second (fps) and 4 fps. This range of velocities is essentially recommended to be at or below the cruising speed of 3.4 fps for an adult Chinook salmon. This limits the stress to the fish and helps preserve their energy to pass other obstacles and to protect the overall health of the fish.

2.3 Ground Subsidence

The designs must account for ground subsidence consistent with the methodology and guidance provided in the preliminary draft *Technical Memorandum No. SUB-1 Subsidence Design Criteria* (U.S. Bureau of Reclamation 2013) for the SJRRP except as noted. The technical memorandum estimated the total amount of subsidence assumed during the 25-year design life of the project at the weir locations is 1.25 feet. But, based on recent monitoring, the total amount of subsidence during the next 25 years could be between 6 feet and 8 feet. The subsidence rates and lifespan may be modified as necessary as future data are collected. The data are subject to change based on ongoing monitoring efforts.

2.4 Flood Capacity

The design flood capacity is 16,500 cfs and is based on the schematic of design flood capacity flows in the *Operations and Maintenance Manual for the Lower San Joaquin River Flood Control Project* (Lower San Joaquin River Levee District 1967 [Amended in 1978]). Design alternatives must ensure no adverse impact to the current flood control system. It must be demonstrated through hydraulic modeling that each alternative will produce less than a 0.1-foot rise in flood elevations at the design flow capacity based on the Central Valley Flood Protection Board criterion.

3.0 Conceptual Designs

Conceptual design alternatives were developed to provide unimpeded fish passage at the upper and lower MNWR weirs. Each alternative is aimed at providing water supplies to those currently supplied by the existing weirs to the MNWR, while providing unimpeded fish passage that satisfies the design criteria described in the previous section. One of the alternatives analyzed was a modification of the operations of the lower weir. This alternative would allow fish passage by removing the boards from some of the bays while maintaining the current water deliveries for irrigation of the MNWR West Wetlands during the five months that fish passage coincide with the weir boards in. The initial hydraulic and fish passage analyses, as well as the additional operational effort required from the MNWR staff, showed that this alternative is likely not feasible. As a result, this alternative was discarded and will not be discussed any further.

The feasible conceptual designs considered include:

- MNWR-1 – Direct Pumping from East Wetlands to West Wetlands.
- MNWR-2 – Screened Pump Intake in the West Wetlands.
- MNWR-3 – Rock/Boulder Weir.

3.1 Alternative MNWR-1 – Direct Pumping from East Wetlands to West Wetlands

Under this alternative, the lower and upper weirs would be removed from the bypass channel and the channel regraded at the weir locations to remove accumulated debris. Water deliveries for irrigation of the West Wetlands would be conveyed by directly pumping drainage water from the East Wetlands using the MNWR's existing pipeline network and pump system (Figure D-3). The pump system would provide equivalent water supply to replace the existing gator pump. Drainage water will no longer be pumped by Pump 8 into the bypass or allowed to flow from the Cinnamon Slough into the bypass.

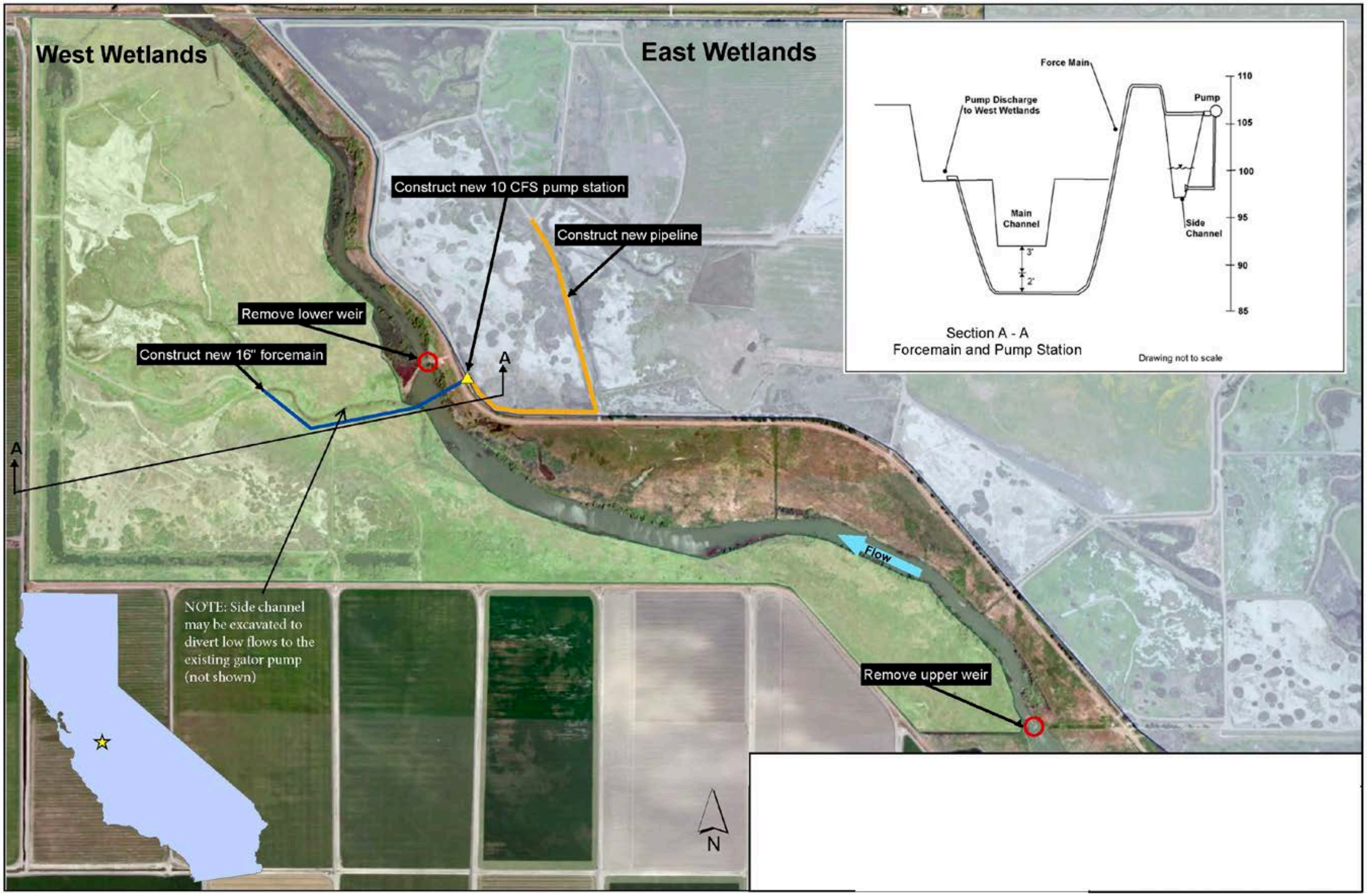
The new water conveyance structure would consist of new pipelines to be connected to the existing MNWR pipeline network, a new pump station, and a force main. The new pipeline to connect to the existing MNWR pipeline network will be approximately 3,300 feet long and 12 inches in diameter. This new pipeline will discharge into a sump that is 35 feet wide at the top, 4 feet deep, and 10 feet long.

A permanent pump would be located by the existing drainage ditch, in the vicinity of the lower weir, to pump the drainage water from the East Wetlands. The pump would discharge into a force main which would pass on top of the existing bypass levee, down the waterward levee slope, and continue underground approximately 5 feet below the invert of the bypass channel. The suction pipeline would be a minimum of 12 inches in diameter, and the discharge pipeline would be 16 inches in diameter and approximately 2,500 feet long. It is assumed that this new pump would, at a minimum, replace the capacity of the existing gator pump which is approximately 10 cfs. The pump will need to have a pumping head of approximately 25 feet. The discharge velocity would be approximately 7 fps. A schematic of the pump station layout is shown in Figure D-3.

The bypass channel will be regraded to remove any sediment deposition that has accumulated behind the weirs to restore the bypass channel slope. Regrading will likely be minimal and require no more than 100 cubic yards of excavation.

In order for the MNWR to still have access to the opportunistic flows within the bypass, the existing feeder channel that serves the mobile gator pump will be excavated to match the invert of the bypass low flow channel. The regraded channel will allow water to flow by gravity to the gator pump without the need for the lower weir.

Figure D-3 **MNWR-1 – Direct Pumping from East Wetlands to West Wetlands, Plan and Profile Views**



3.1.1 Hydraulic Analysis

A one-dimensional model using Hydrologic Engineering Center's River Analysis System (HEC-RAS) was developed from a calibrated model to evaluate the flow, flood capacity, and fish passage design criteria for the conceptual alternative. The existing model was modified by removing the lower and upper weirs, and regrading to remove the accumulated sediment behind the weirs. The model was used to simulate depth and velocity for a range of flows assuming a steady-flow condition.

3.1.1.1 Flow

Because this alternative involves the removal of the existing weirs with the channel returned to a condition that would no longer impede fish passage, the channel will now provide unimpeded fish passage for design flows of 85 cfs through 9,737 cfs.

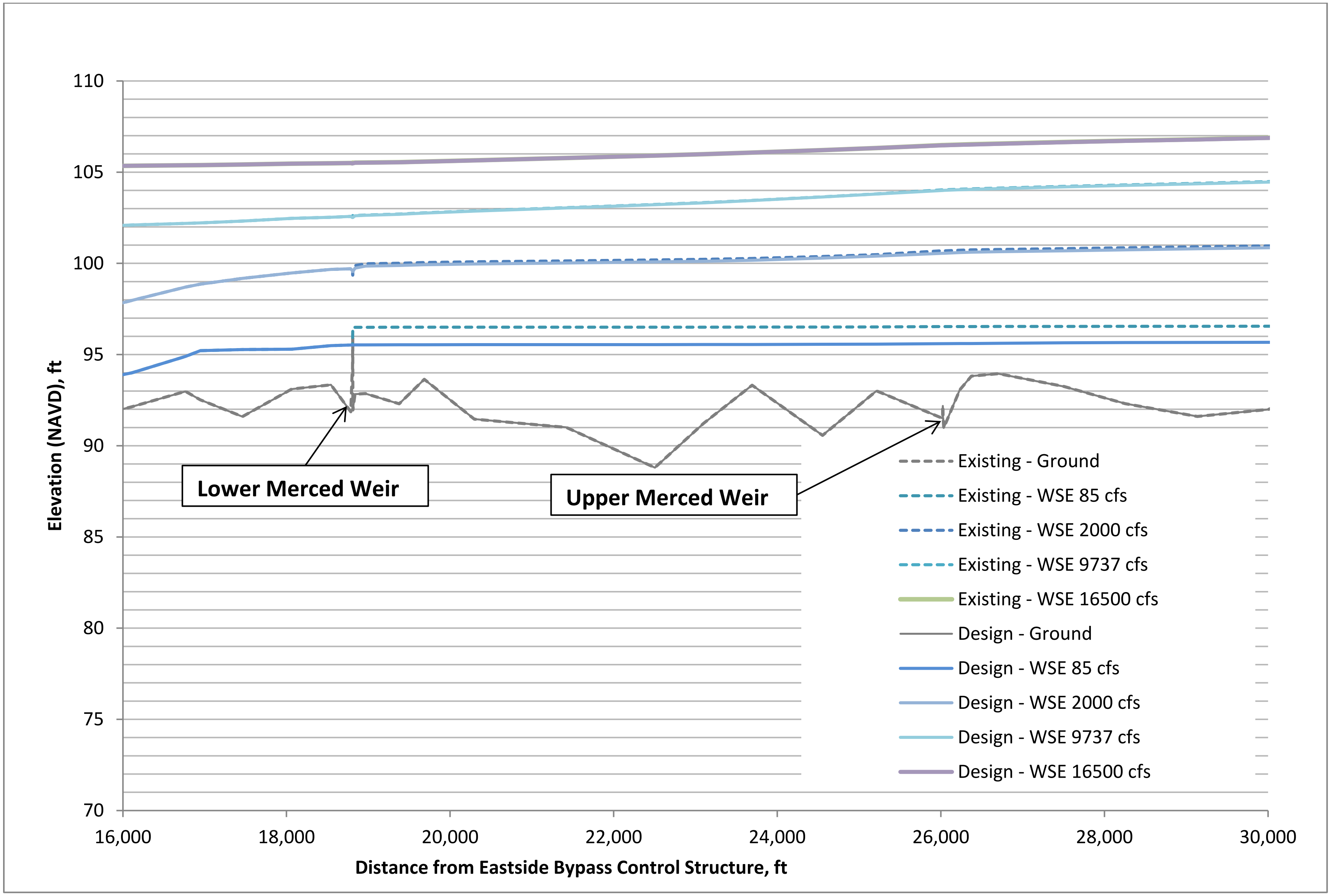
3.1.1.2 Fish Passage

This alternative provides for unimpeded fish passage through the removal of the weirs.

3.1.1.3 Flood Capacity

The water surface profiles generated from the hydraulic models for the existing condition and the design alternative were compared for selected flows ranging from the lower design flow of 85 cfs to the flood capacity flow of 16,500 cfs (Figure D-4). This alternative will improve flood capacity at the lower design flow of 85 cfs by lowering the design water surface elevation by approximately 1 foot. Flows more than 2,000 cfs do not show any significant water surface elevation change.

Figure D-4 **Bypass Channel Hydraulics**



3.1.2 Ground Subsidence

The design for subsidence will include burying the discharge pipeline an additional 2 feet lower than the minimum 3 feet cover below the bypass so that potential scouring of the bypass channel bed and ground subsidence does not cause it to be exposed in the bypass channel in the future.

3.1.3 Operations and Maintenance

Once the weirs are removed, it is assumed that the bypass channel will need minimal maintenance, such as the periodic removal of debris and sediment. The operation and maintenance of the pump station is assumed to be the responsibility of the MNWR staff. The pump station will be operated on a schedule similar to the existing mobile gator pump, from September through March, and as needed. The life expectancy of the pump is assumed to be 10 years. It is recommended that the operations follow the pump manufacturer’s operations manual. In addition, the pump station’s physical, mechanical, and electrical maintenance should be performed. A good preventative maintenance program will minimize unscheduled or “breakdown” maintenance. The feeder channel leading to the gator pump will have to be cleared of sediment periodically to maintain its good working condition.

3.1.4 Cost Estimate

The estimated construction cost for the direct pumping from East Wetlands to West Wetlands alternative is approximately $3.9 million. The costs were developed based on similar construction projects in the Central San Joaquin Valley. Details of the cost estimate are contained in Attachment A and include site preparation and construction, and removal of the lower and upper weirs.

The pump station costs include a 4,500 gpm skid-mounted pump, foundation work, concrete slab, and all accessories necessary for a fully functioning pump station. The pump station will have a 10-foot by 12-foot by 12-foot enclosure to protect it from the weather elements. The cost estimates include bringing power to the pump station through overhead power lines. No provision has been made for a standby generator. Costs for the discharge force main include jacking and boring under the bypass channel. The costs also include excavation of the feeder channel leading to the existing gator pump.

The removal of the existing upper and lower weirs include the demolishing and removal of the concrete foundation and apron, as well as the removal of metal grating and other miscellaneous metal work, regrading, and dewatering.

An additional cost equivalent to 50 percent of the estimated total capital cost has been included to cover other project-related costs such as design changes, permitting, regulatory compliance, environmental compliance (such as the California Environmental Quality Act [CEQA]), construction management, program implementation, and construction contingency.

3.1.5 Benefits and Consequences

The major benefit of this alternative is that the existing weirs would be removed and the channel returned to a condition which satisfies the design criteria for fish passage. This would enable unimpeded fish passage where there is currently partially impeded passage at the weirs. It would also improve the conveyance of flood flows within the bypass. The construction of a fixed pump station would enable the MNWR to maintain the same level of service for the pumping of water into the West Wetlands.

A disadvantage of this alternative is that the MNWR would not be able to capture opportunistic flows within the bypass. This could be mitigated by allowing the MNWR to use the existing mobile gator pump to pump from the bypass. If the MNWR uses the existing gator pump, a fish screen may need to be added to reduce the potential risks to fish because of unscreened pumping.

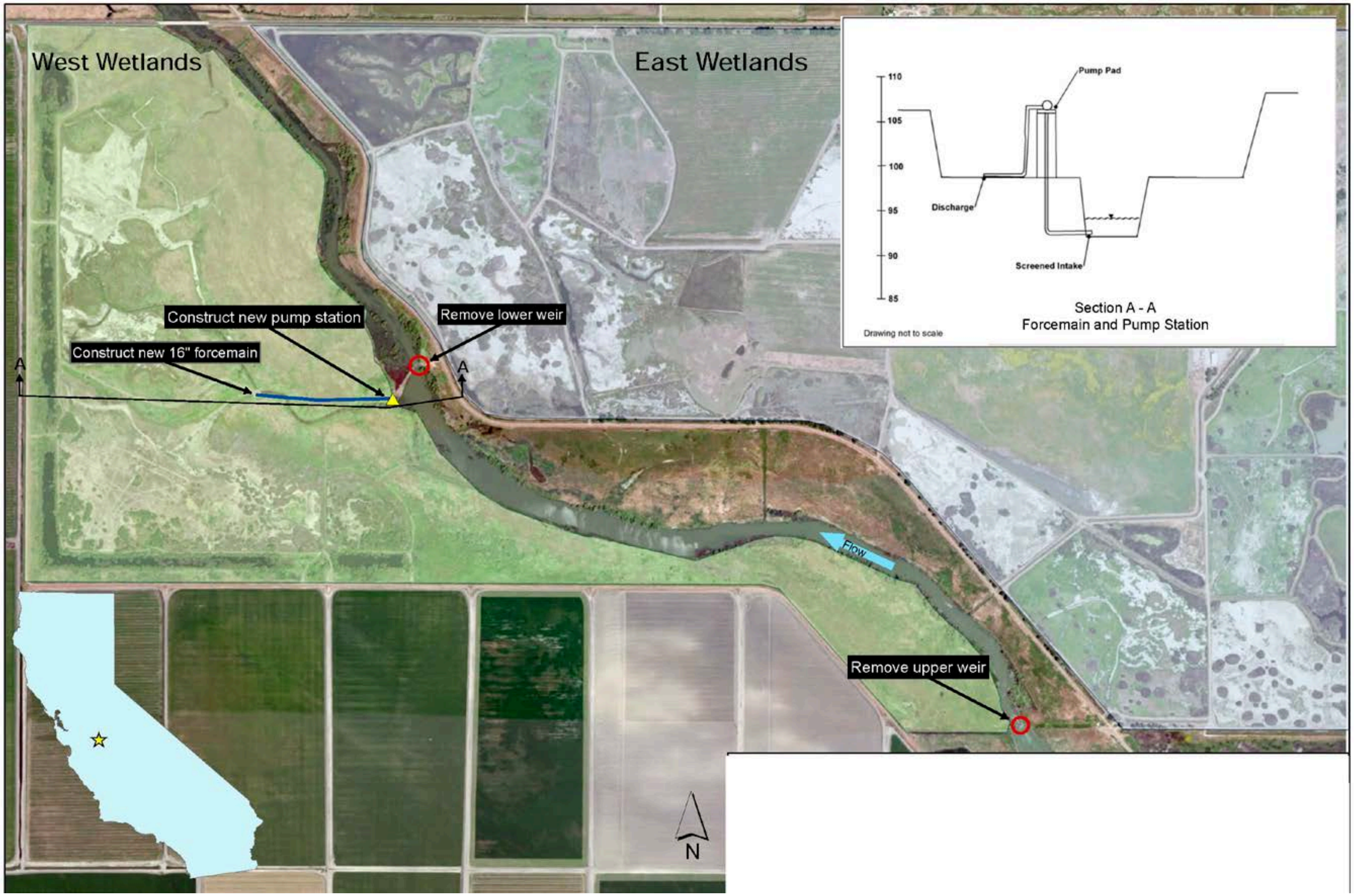
3.2 Alternative MNWR-2 – Screened Pump Intake in the West Wetlands

Under this alternative, similar to Alternative MNWR-1, both weirs would be removed and the channel would be regraded at the locations of the two weirs. A fixed-screened intake and pump station would be constructed to provide water equivalent to the existing gator pump for the MNWR's water needs at the West Wetlands. This alternative would provide for unimpeded fish passage through the removal of both weirs. The screened intake would be located in the bypass near the current location of the lower weir as shown in Figure D-5, where it would be submerged over the entire range of design flows in the bypass. An alternative location of the pump can be selected to minimize sedimentation of the pump sump. This screened intake would be connected via a buried pipe that is controlled by a permanent pump station located on the left overbank on the MNWR property.

This alternative would not require any substantial excavation of the wetlands apart from the structural work needed to construct the pumping/lift plant and site piping. The pumping/lift plant would be a permanent facility located near the screened inlet location to minimize construction disturbance to the wetlands. This facility would contain one pump rated to lift 10 cfs over a head of approximately 20 feet. This pump would provide the equivalent amount of water supplied by the existing mobile gator pump.

It is anticipated that the screened inlet would be located at the bypass invert elevation of approximately 92 feet to allow adequate capture of the lowest flows in the bypass to pump. The screened inlet will be NFMS approved, meaning a separate fish screen is not necessary. The minimum depth of water at the sump was calculated at approximately 2.8 feet. To achieve the associated minimum water surface elevation requires a minimum flow of 20 cfs in the bypass channel. The pump station pad would be located at a higher elevation to prevent higher river stages and flood flows from flooding the facility. The pad elevation is assumed to be located above the flood capacity elevation of approximately 105.5 feet. The existing wetlands have water surfaces that vary from elevation approximately 96 feet to 99 feet. A schematic of the pump station is shown in Figure D-5.

Figure D-5 **Alternative MNWR-2 Screened Pump Intake in the West Westlands, Plan and Profile Views**



3.2.1 Hydraulic Analysis

A one-dimensional model using HEC-RAS was developed from a calibrated model to evaluate the flow, flood capacity, and fish passage design criteria. Similar to Alternative MNWR-1, the existing model was modified by removing the lower and upper weirs, and regrading to remove the accumulated sediment behind the weirs. The model was used to simulate depth and velocity for a range of flows assuming a steady-flow condition.

3.2.1.1 Flow

Similar to Alternative MNWR-1, this alternative involves the removal of the existing weirs, with the channel returned to a condition that would no longer impede fish passage.

3.2.1.2 Fish Passage

Similar to Alternative MNWR-1, the hydraulic simulations show that this alternative would provide for unimpeded fish passage through the removal of the weirs for design flows of 85 cfs to 9,737 cfs. In addition, the fish screen for the pump screen intake would meet the screen criteria specified by NMFS guidelines. The screen material must be corrosion resistant and sufficiently durable to maintain a smooth uniform surface with long term use. Approach velocity must not exceed 0.2 fps for passive screens, or 0.4 fps for active screens. The sweeping velocity must be greater than twice the approach velocity and ideally between 0.8 fps to 3 fps. The next phase of design will include a more detailed design analysis of the fish screen for the intake pump, including an assessment showing that the screen will meet the fish passage criteria.

3.2.1.3 Flood Capacity

Similar to Alternative MNWR-1, the removal of the weirs and regrading shows no rise in water surface elevation between the water surface profiles generated from the hydraulic models for the existing condition and the design alternative. Because this alternative includes the removal of both weirs, flood capacity is improved at the lower design flow.

3.2.2 Ground Subsidence

Subsidence will affect the overall channel capacity and the screened intake elevation. But, because the intake is not a large structure, it is assumed that both the screened intake and the low-flow channel will subside at the same rate. If there are changes in water surface elevations from ground subsidence, remedial actions such as lowering the intake may need to be taken to ensure that the pump continues to function as designed.

3.2.3 Operations and Maintenance

The operations and maintenance of the bypass channel for this alternative is the same as Alternative MNWR-1. But, because of the pump being located in the channel, sediment in the sump will have to be removed periodically to ensure the proper functioning of the pump station.

3.2.4 Cost Estimate

The estimated construction cost for the screened pump intake alternative is approximately $1.4 million. The costs were developed based on similar construction projects in the Central San Joaquin Valley.

Details of the cost estimate are contained in Attachment A and include site preparation and construction, and removal of the lower and upper weirs.

The cost estimate for the intake works includes a concrete intake structure and the construction of an NMFS approved fish screen located on the suction side of the pump. The pump station costs include a 4,500 gpm skid-mounted pump, foundation work, concrete slab, and all accessories necessary for a fully functioning pump station. The pump station will have a 10-foot by 12-foot by 12-foot enclosure to protect it from the weather elements. The cost estimates include bringing power to the pump station through overhead power lines. No estimates have been provided for a standby generator. Costs for the discharge force main do not include jacking and boring.

The removal of the existing upper and lower weirs include the demolishing and removal of the concrete foundation and apron, as well as the removal of metal grating and other miscellaneous metal work, regrading, and dewatering.

An additional cost, equivalent to 50 percent of the estimated total capital cost, has been included to cover other project-related costs such as design changes, permitting, regulatory compliance, environmental compliance (such as CEQA), construction management, program implementation, and construction contingency.

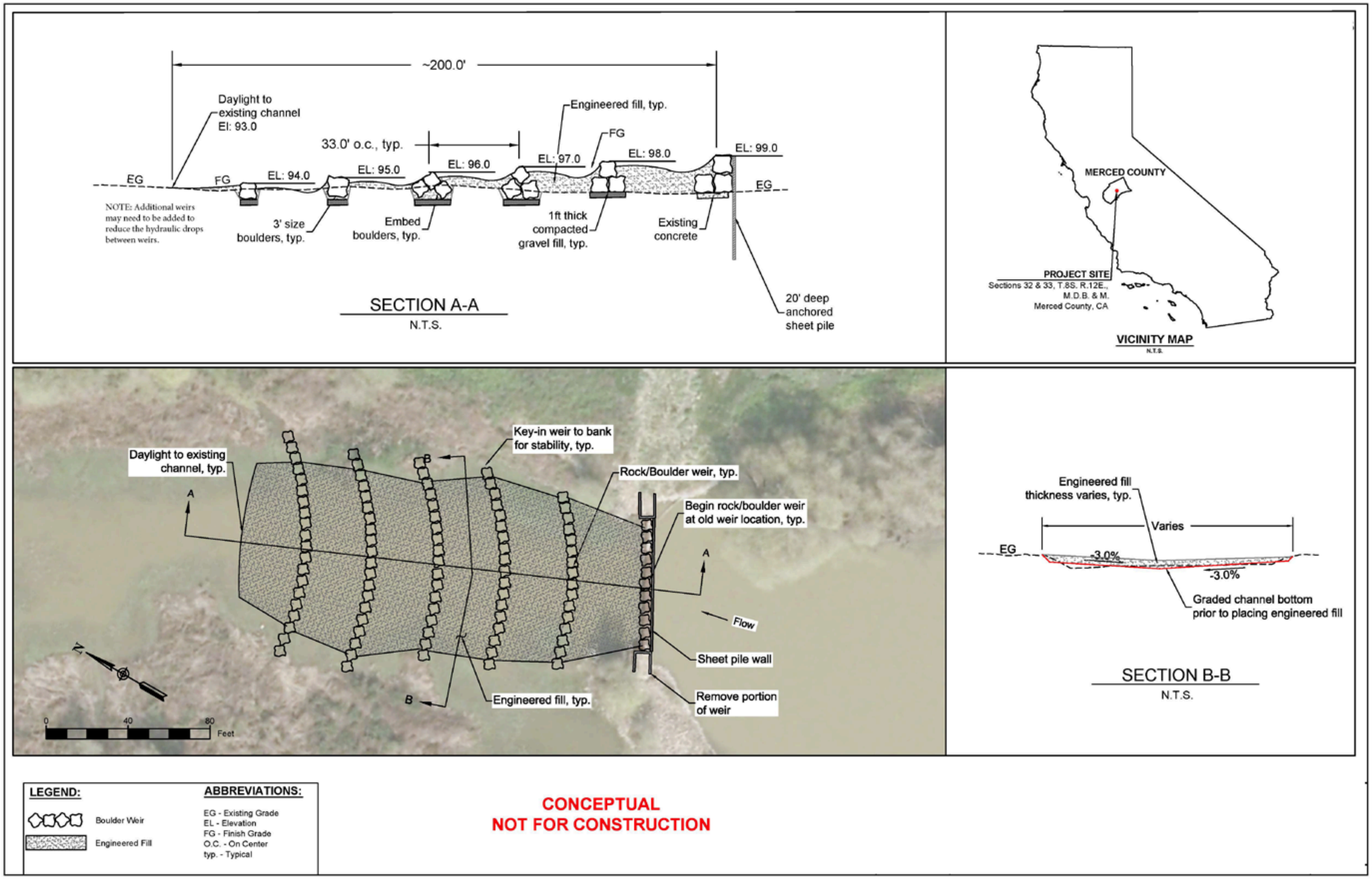
3.2.5 Benefits and Consequences

The benefits of this alternative are that it will maintain the existing wetlands and operations of the MNWR, as well as provide for unimpeded fish passage in the bypass at the MNWR. Additionally, it will increase the pumping efficiency, and reduce overall pumping costs compared to the trailer-mounted gator pump that is currently used by the MNWR. This alternative will also free the gator pump to be used elsewhere in the refuge, as needed. A disadvantage of this alternative is the potential silting of the intake works. This may be mitigated by locating the pump in a different portion of the channel, incorporating a silting basin, or doing other measures to minimize silting at the intake. Another disadvantage of this alternative is that the MNWR would not be able to capture opportunistic flows less than 20 cfs. But, because Restoration Flows are likely to be more than 20 cfs, this should not be a problem when Restoration Flows are being released.

3.3 Alternative MNWR-3 – Rock/Boulder Weir

Under this alternative, portions of the existing weir, such as the metal grating and miscellaneous structural steel, would be removed and replaced with a series of rock weirs to allow passage as shown in Figure D-6. The boards in the existing head elevation of approximately 99 feet would be maintained at the new weir to allow the MNWR gator pump to continue operation as it is now. The existing pool elevation will be maintained by the first rock weir that will replace the existing weir. The first rock weir will have a 20-foot deep anchored sheet pile for stability. It will also have an upstream berm sloped at 3H:1V for additional stability.

Figure D-6 **Alternative MNWR- 3 Rock Boulder Weir, Plan and Profile Views**



The elevation drop across the channel is approximately 6 feet because the weir crests starts from 99 feet and daylights at 93 feet. The hydraulic drop between crests of the successive rock weirs will be 1 foot resulting in six stepped-rock weirs and six pools. The resulting slope from the weir crest to the downstream weir where it daylights will be 3 percent. In between successive weirs will be engineered pools for resting, approximately 2 feet deep, but may be greater, if needed. The length of the first rock weir is 62 feet and the rest of the rock weirs average 138 feet in length and should be keyed into the bank for stability. The distance between adjacent weirs will be approximately 33 feet for a total distance of 198 feet.

The weirs will be in the planform of an arch or chevron with the apex pointing upstream. The apex of the weir will have an angle of 120 degrees. To avoid excessive upstream backwater effects and downstream scour the side slope of the weir will not exceed 5H:1V. The side slopes will come together to form a v-notch in each weir to allow flow depths sufficient to provide passage at low flows.

The median rock size needed for the boulder weir design was determined to estimate how large the stone needs to be to form an erosion resistant layer that will remain stable throughout the flow profile of the channel. The USACE (U.S. Army Corps of Engineers 1994) dimensionless relationship for determining rock diameter was used to size the rocks needed for the weir. This equation is applicable for riprap on beds with slopes ranging from 2 percent to 20 percent. It was used to size rocks that will be stable under the design flow. Based on this formula and the design flow of 9,737 cfs (the flood capacity of 16,500 cfs was not used because it would result in less flow per unit length), the median diameter (D50) of the rock to be used to construct the weir will be approximately 2.2 feet. The largest rock size (D100) to be used for construction as determined from the rock sizing analysis will be approximately 4.4 feet. The minimum rock size will be approximately 1.7 feet. As a cross check, U.S. Department of Agriculture Fish Passage and Screening Design Equation TS14N-22 (Natural Resources Conservation Service 2007) was used to calculate the minimum rock diameter required. The minimum rock diameter of 1.4 feet compares favorably with that adopted for this design using the USACE equation.

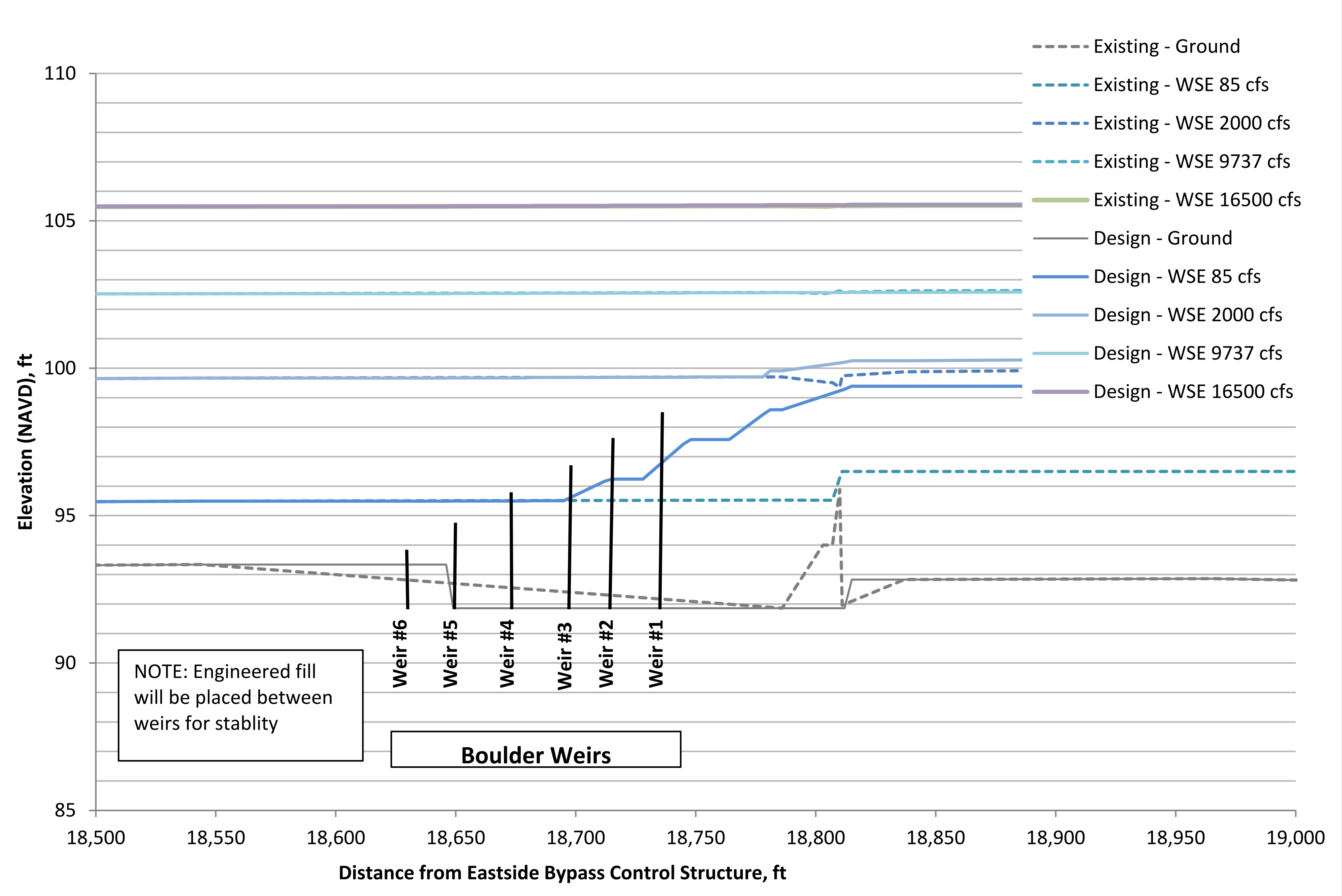
3.3.1 Hydraulic Analysis

A one-dimensional model using HEC-RAS was developed from a calibrated model to ensure that the conceptual alternative meets the criteria for flow, fish passage, flood capacity, and subsidence. The existing model was modified by removing the blocked obstructions that represented the existing weir and inserting six inline weirs to represent the boulder weirs (Figure D-7). The model was used to simulate depth and velocity for a range of flows assuming a steady-flow condition.

3.3.1.1 Flow

The rock weirs are designed to pass fish unimpeded through the range of the design flows from 85 cfs to 9,737 cfs.

Figure D-7 Existing and Post Design Hydraulics for Boulder Weir



3.3.1.2 Fish Passage

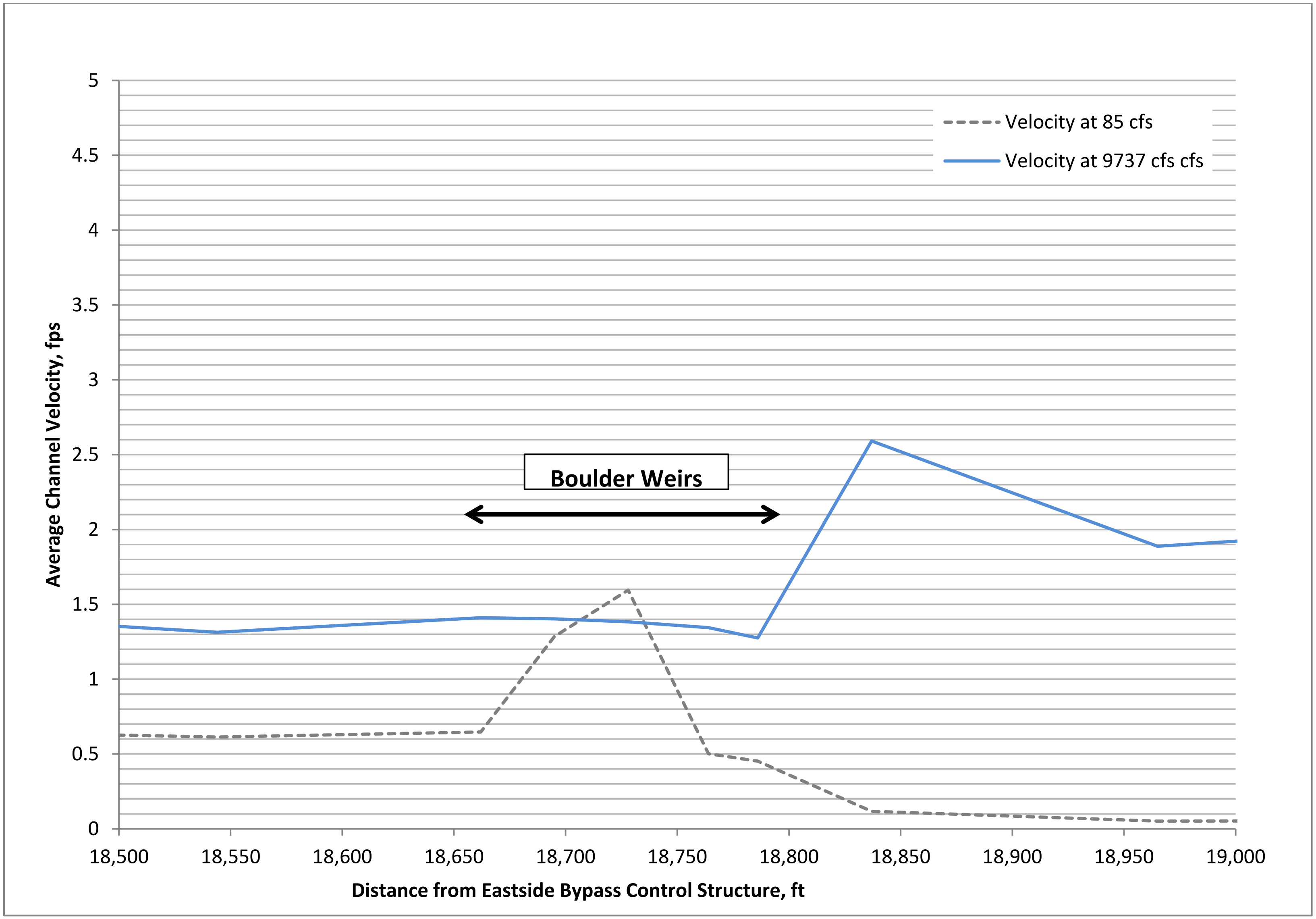
The USACE design guidelines recommend that a structure, such as a rock weir, have a slope from 2 percent to 20 percent, and recommend a maximum elevation drop across the channel of 8 feet. A channel slope of 3 percent has been used for this alternative and the total elevation drop is 6 feet. The drop between successive rock weir crests is 1 foot which will create hydraulic drops of approximately 1.0 foot (Table D-2). Additional weirs may be needed to reduce the hydraulic to less than 1.0 foot in between Weir #3 and Weir #4. The pool channel bottom between successive rock weirs will also be deepened to create engineered resting pools approximately 2 feet deep. Figure D-8 shows the velocity profile for each simulated flow. As shown in Figure D-8, the velocities over the rock weirs are within the velocity criterion of 1.5 fps to 4.0 fps.

Table D-2 Boulder Weir Hydraulics for 85 cfs

Weir Number	Spacing Between Weirs (ft)	Weir Height (ft)	Hydraulic Drop at 85 cfs (ft)
Weir #1 (upstream end)	-	6.5	0.0
Weir #2	34	6.0	0.8
Weir #3	33	5.0	1.0
Weir #4[a]	33	3.0	1.3
Weir #5	33	2.3	0.7
Weir #6 (downstream end)	33	1.3	0.0

Notes:
cfs = cubic feet per second, ft = feet
[a] An additional weir may be required to reduce the maximum hydraulic drop between the Weir #3 and Weir #4

Figure D-8 **Velocity Profile at Design Conditions**



3.3.1.3 Flood Capacity

The design flood capacity of 16,500 cfs was simulated in the HEC-RAS model. The alternative model water surface profiles (Figure D-7) for 16,500 cfs shows a water surface elevation of no significant rise (less than 0.1 foot) over the existing condition water surface elevation for the design flood. As a result, this meets the design criterion.

3.3.2 Ground Subsidence

This alternative assumes that both the channel and the rock weirs will subside at the same rate. But, if the water surface profile should change and it is necessary to raise the weir height, this can be done by adding more rocks or additional weirs downstream.

3.3.3 Operations and Maintenance

It is recommended that maintenance be done to keep the weirs in good operation. This may include the removal of debris that may obstruct the fish passageway. Unlike the previous weirs that allowed the boards to be removed and sediment to be flushed through the weirs, this alternative includes a permanent upstream structure that will likely accumulate sediment. Because the weir structure is permanent, removal of accumulated sediment upstream of the weirs may also be required to reduce impacts to flood conveyance and fish passage. Furthermore, the stability and integrity of the weirs should be checked periodically and any defects corrected to enable the structure to continue performing as designed.

3.3.4 Cost Estimate

The construction cost estimate for the boulder weir alternative is approximately $2.4 million. The costs were developed based on similar construction projects in the Central San Joaquin Valley. Details of the cost estimate are contained in Attachment A and include:

- Site preparation.
- Removal of the entire upper weir.
- Removal of only the concrete middle walls and metals of the lower weir.
- Construction of the boulder weirs.

Site preparation costs include clearing and grubbing at the lower weir site. They also include channel site excavation and disposal offsite of any waste generated.

The removal of the existing upper weir includes the demolishing and removal of the concrete foundation and apron, as well as the removal of metal grating and other miscellaneous metal work, regrading, and dewatering. It is assumed that only the concrete walls, metal walkway, and structural steel will be removed at the lower weir. The foundation of the lower weir, as well as the abutting concrete, will be incorporated into the boulder weir.

The cost estimate for the rock/boulder weirs include graded boulders, engineered streambed material, anchoring, and all other materials necessary to create a fully functioning and stable weir system. It will include a single-wall, anchored sheet pile for stability.

An additional cost equivalent to 50 percent of the estimated total capital cost has been included to cover other project-related costs such as design changes, permitting, regulatory compliance, environmental compliance (such as CEQA), construction management, program implementation, and project construction contingency.

3.3.5 Benefits and Consequences

Weirs constructed of rock are preferable to rigid weirs constructed of sheet pile or concrete because of inherent irregularities in the surface of rock structures. They generally provide increased hydraulic diversity and better passage performance in comparison to rigid weirs. They can also be easily adjusted by moving individual rocks by hand or with small equipment. The height can also be increased by adding more rocks. The only disadvantage is that the weir height would be permanently fixed because it cannot be lowered similar to the existing weir using stop logs. Additional long-term maintenance after large flow events may be required to repair the weirs and restore fish passage.

4.0 References

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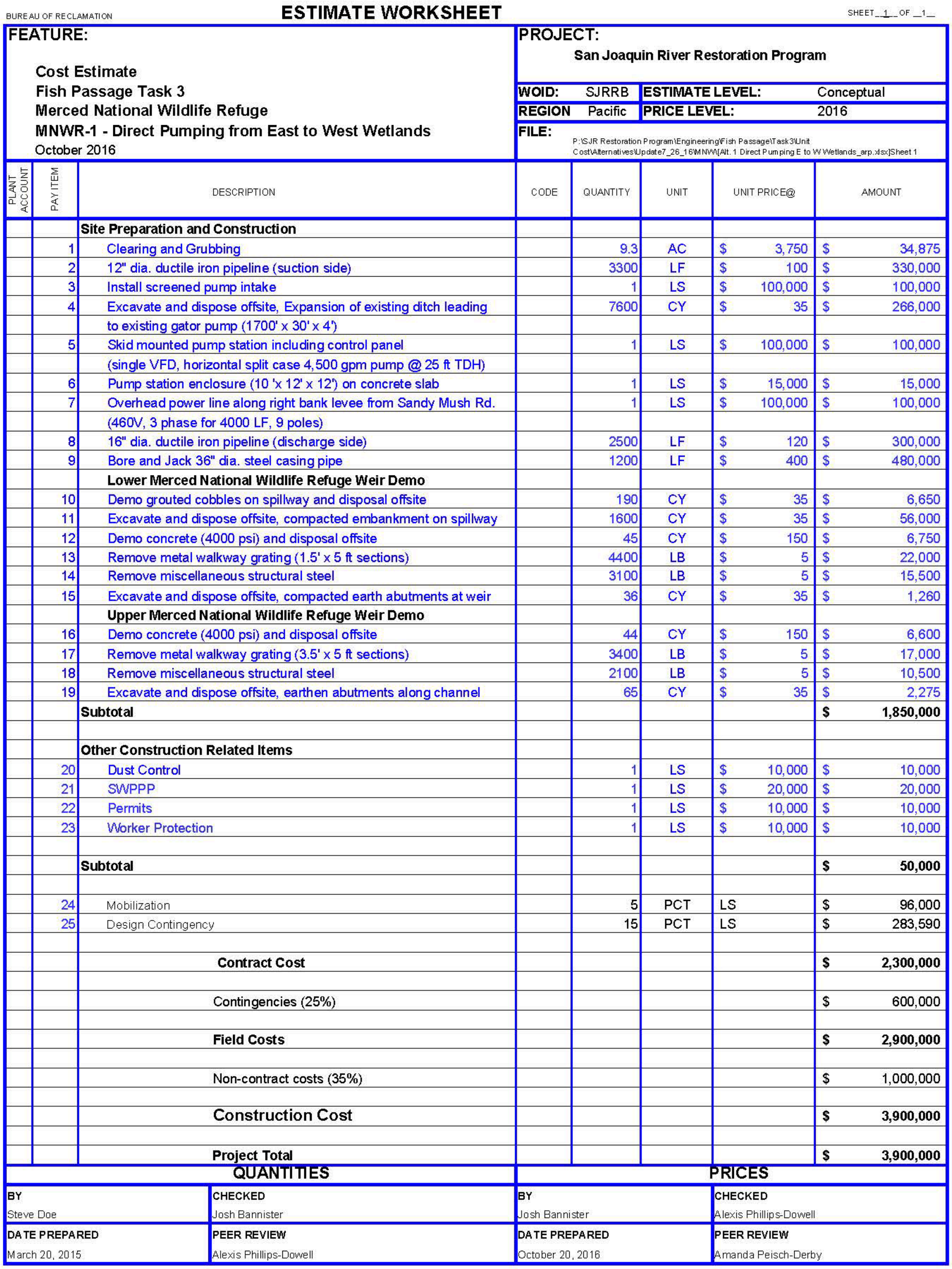
U.S. Bureau of Reclamation 2012. DRAFT Hydraulic and Sediment Studies for Reach 4B1. Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project Appendix A – Initial Alternatives Evaluation. USBR.

___________. 2013. Technical Memorandum No. SUB-1. Subsidence Design Criteria for the San Joaquin River Restoration. USBR Mid-Pacific Region.

Attachment A – Cost Estimates

Table D-a.1 Alternative MNWR-1 – Direct Pumping from East Wetlands to West Wetlands, Cost Estimate Worksheet



BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 1

FEATURE:

Cost Estimate
Fish Passage Task 3
Merced National Wildlife Refuge
MNWR-1 - Direct Pumping from East to West Wetlands
October 2016

PROJECT: San Joaquin River Restoration Program

WOID: SJRRB **ESTIMATE LEVEL:** Conceptual

REGION Pacific **PRICE LEVEL:** 2016

FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\MNW\[Alt. 1 Direct Pumping E to W Wetlands_arp.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		9.3	AC	$ 3,750	$ 34,875
	2	12" dia. ductile iron pipeline (suction side)		3300	LF	$ 100	$ 330,000
	3	Install screened pump intake		1	LS	$ 100,000	$ 100,000
	4	Excavate and dispose offsite, Expansion of existing ditch leading to existing gator pump (1700' x 30' x 4')		7600	CY	$ 35	$ 266,000
	5	Skid mounted pump station including control panel (single VFD, horizontal split case 4,500 gpm pump @ 25 ft TDH)		1	LS	$ 100,000	$ 100,000
	6	Pump station enclosure (10 'x 12' x 12') on concrete slab		1	LS	$ 15,000	$ 15,000
	7	Overhead power line along right bank levee from Sandy Mush Rd. (460V, 3 phase for 4000 LF, 9 poles)		1	LS	$ 100,000	$ 100,000
	8	16" dia. ductile iron pipeline (discharge side)		2500	LF	$ 120	$ 300,000
	9	Bore and Jack 36" dia. steel casing pipe		1200	LF	$ 400	$ 480,000
		Lower Merced National Wildlife Refuge Weir Demo					
	10	Demo grouted cobbles on spillway and disposal offsite		190	CY	$ 35	$ 6,650
	11	Excavate and dispose offsite, compacted embankment on spillway		1600	CY	$ 35	$ 56,000
	12	Demo concrete (4000 psi) and disposal offsite		45	CY	$ 150	$ 6,750
	13	Remove metal walkway grating (1.5' x 5 ft sections)		4400	LB	$ 5	$ 22,000
	14	Remove miscellaneous structural steel		3100	LB	$ 5	$ 15,500
	15	Excavate and dispose offsite, compacted earth abutments at weir		36	CY	$ 35	$ 1,260
		Upper Merced National Wildlife Refuge Weir Demo					
	16	Demo concrete (4000 psi) and disposal offsite		44	CY	$ 150	$ 6,600
	17	Remove metal walkway grating (3.5' x 5 ft sections)		3400	LB	$ 5	$ 17,000
	18	Remove miscellaneous structural steel		2100	LB	$ 5	$ 10,500
	19	Excavate and dispose offsite, earthen abutments along channel		65	CY	$ 35	$ 2,275
		Subtotal					**$ 1,850,000**
		Other Construction Related Items					
	20	Dust Control		1	LS	$ 10,000	$ 10,000
	21	SWPPP		1	LS	$ 20,000	$ 20,000
	22	Permits		1	LS	$ 10,000	$ 10,000
	23	Worker Protection		1	LS	$ 10,000	$ 10,000
		Subtotal					**$ 50,000**
	24	Mobilization		5	PCT	LS	$ 96,000
	25	Design Contingency		15	PCT	LS	$ 283,590
		Contract Cost					**$ 2,300,000**
		Contingencies (25%)					$ 600,000
		Field Costs					**$ 2,900,000**
		Non-contract costs (35%)					$ 1,000,000
		Construction Cost					**$ 3,900,000**
		Project Total					**$ 3,900,000**

QUANTITIES		PRICES	
BY Steve Doe	**CHECKED** Josh Bannister	**BY** Josh Bannister	**CHECKED** Alexis Phillips-Dowell
DATE PREPARED March 20, 2015	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** October 20, 2016	**PEER REVIEW** Amanda Peisch-Derby

Table D-a.2 Alternative MNWR-2 – Screened Pump Intake in the West Wetlands, Cost Estimate Worksheet

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 1

FEATURE: Cost Estimate Fish Passage Task 3 Merced National Wildlife Refuge MNWR-2- Screened Pump Intake in West Wetlands October 2016	**PROJECT:** San Joaquin River Restoration Program
	WOID: SJRRB **ESTIMATE LEVEL:** Conceptual
	REGION Pacific **PRICE LEVEL:** 2016
	FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Update7_26_16\MNW\[Alt. 2 Screened Pump intake in W Wetlands_arp.xlsx]without fish screen

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		3	AC	$ 3,800	$ 11,400
	2	Construct concrete sump box 5 ft x 5 ft x 10 ft		4.2	CY	$ 850	$ 3,570
	3	12" dia. ductile iron pipeline (suction side)		20	LF	$ 100	$ 2,000
	4	Install screened pump intake		1	LS	$ 100,000	$ 100,000
	5	Skid mounted pump station including control panel		1	LS	$ 100,000	$ 100,000
		(single VFD, horizontal split case 4,500 gpm pump @ 20 ft TDH)					
	6	Pump station enclosure (10 'x 12' x 12') on concrete slab		1	LS	$ 15,000	$ 15,000
	7	Overhead power line along right bank levee from Sandy Mush Rd.		1	LS	$ 100,000	$ 100,000
		(460V, 3 phase for 4000 LF, 9 poles)					
	8	16" dia. ductile iron pipeline (discharge side)		1500	LF	$ 120	$ 180,000
		Lower Merced National Wildlife Refuge Weir Demo					
	9	Demo grouted cobbles on spillway and disposal offsite		190	CY	$ 35	$ 6,650
	10	Excavate and dispose offsite, compacted embankment on spillway		1600	CY	$ 35	$ 56,000
	11	Demo concrete (4000 psi) and disposal offsite		45	CY	$ 150	$ 6,750
	12	Remove metal walkway grating (1.5' x 5 ft sections)		4400	LB	$ 5	$ 22,000
	13	Remove miscellaneous structural steel		3100	LB	$ 5	$ 15,500
	14	Excavate and dispose offsite, compacted earth abutments at weir		36	CY	$ 35	$ 1,260
		Upper Merced National Wildlife Refuge Weir Demo					
	15	Demo concrete (4000 psi) and disposal offsite		44	CY	$ 150	$ 6,600
	16	Remove metal walkway grating (1.5' x 5 ft sections)		3400	LB	$ 5	$ 17,000
	17	Remove miscellaneous structural steel		2100	LB	$ 5	$ 10,500
	18	Excavate and dispose offsite, earthen abutments along channel		65	CY	$ 35	$ 2,275
		Subtotal					**$ 660,000**
		Other Construction Related Items					
	19	Dust Control		1	LS	$ 10,000	$ 10,000
	20	SWPPP		1	LS	$ 20,000	$ 20,000
	21	Permits		1	LS	$ 10,000	$ 10,000
	22	Worker Protection		1	LS	$ 10,000	$ 10,000
		Subtotal					**$ 50,000**
	23	Mobilization		5	PCT	LS	$ 35,000
	24	Design Contingency		15	PCT	LS	$ 108,495
		Contract Cost					**$ 850,000**
		Contingencies (25%)					$ 200,000
		Field Costs					**$ 1,050,000**
		Non-contract costs (35%)					$ 350,000
		Construction Cost					**$ 1,400,000**
		Project Total					**$ 1,400,000**

QUANTITIES		PRICES	
BY Steve Doe	CHECKED Josh Bannister	BY Josh Bannister	CHECKED Alexis Phillips-Dowell
DATE PREPARED March 20, 2015	PEER REVIEW Alexis Phillips-Dowell	DATE PREPARED October 20, 2016	PEER REVIEW Amanda Peisch-Derby

Table D-a.3 Alternative MNWR-3 – Rock/Boulder Weir, Cost Estimate Worksheet

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 1

FEATURE: Cost Estimate Fish Passage Task 3 Merced National Wildlife Refuge MNWR-3- Rock/Boulder Weir October 2016	**PROJECT:** **San Joaquin River Restoration Program**
	WOID: SJRRB — **ESTIMATE LEVEL:** Conceptual
	REGION Pacific — **PRICE LEVEL:** 2016
	FILE: P:\SJR Restoration Program\Engineering\Fish Passage\Task3\Unit Cost\Alternatives\Final Version\MNW\[Alt. 3 Rock-Boulder Weir_arp.xlsx]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE@	AMOUNT
		Site Preparation and Construction					
	1	Clearing and Grubbing		3	AC	$ 3,750	$ 11,250
	2	Channel preparation site excavation and disposal offsite		105	CY	$ 25	$ 2,625
	3	Channel preparation site fill (engineered, compacted)		240	CY	$ 35	$ 8,400
	4	Class 2 aggregate base (1' thick pads beneath 5 of the rock weirs)		210	TN	$ 90	$ 18,900
	5	Construct 6 boulder weirs (2+' boulders)		1100	TN	$ 151	$ 166,100
	6	Single-wall, anchored, sheet pile wall		1	EA	$ 110,000	$ 110,000
	7	Engineered, compacted fill (between weirs) with offsite material		1900	CY	$ 35	$ 66,500
	8	Engineered Streambed Material (Boulders/Cobbles/Gravels/Fines)		2900	TN	$ 233	$ 675,700
		Lower Merced National Wildlife Refuge Weir Partial Demo					
	9	Remove metal walkway (1.5' x 5 ft sections) and concrete middle walls		4400	LB	$ 5	$ 22,000
	10	Remove miscellaneous structural steel		3100	LB	$ 5	$ 15,500
	11	Excavate and dispose offsite sill, sediment and debris at weir site		36	CY	$ 35	$ 1,260
		Upper Merced National Wildlife Refuge Weir Demo					
	12	Demo concrete (4000 psi) and disposal offsite		44	CY	$ 150	$ 6,600
	13	Remove metal walkway grating (1.5' x 5 ft sections)		3400	LB	$ 5	$ 17,000
	14	Remove miscellaneous structural steel		2100	LB	$ 5	$ 10,500
	15	Excavate and dispose offsite, earthen abutments along channel		65	CY	$ 35	$ 2,275
		Subtotal					**$ 1,150,000**
		Other Construction Related Items					
	16	Dust Control		1	LS	$ 10,000	$ 10,000
	17	SWPPP		1	LS	$ 20,000	$ 20,000
	18	Permits		1	LS	$ 10,000	$ 10,000
	19	Worker Protection		1	LS	$ 10,000	$ 10,000
		Subtotal					**$ 50,000**
	20	Mobilization		5	PCT	LS	$ 59,000
	21	Design Contingency		15	PCT	LS	$ 206,390
		Contract Cost					**$ 1,450,000**
		Contingencies (25%)					$ 350,000
		Field Costs					**$ 1,800,000**
		Non-contract costs (35%)					$ 600,000
		Construction Cost					**$ 2,400,000**
		Project Total					**$ 2,400,000**

QUANTITIES		**PRICES**	
BY Steve Doe	**CHECKED** Josh Bannister	**BY** Josh Bannister	**CHECKED** Alexis Phillips-Dowell
DATE PREPARED March 20, 2015	**PEER REVIEW** Alexis Phillips-Dowell	**DATE PREPARED** October 20, 2016	**PEER REVIEW** Amanda Peisch-Derby

DEPARTMENT OF WATER RESOURCES • STATE OF CALIFORNIA •