To: San Joaquin Area Flood Control Agency

From: San Joaquin County Resource Conservation District

RE: Proposed Strategies to Address Concerns of Landowners and Reclamation Districts Downstream of the Paradise Cut Expansion and South Delta Restoration Project

Date: May 4, 2023

The proposed Paradise Cut Expansion and South Delta Restoration Project (Project) is a multi-benefit project proposed in the southern Sacramento-San Joaquin Delta (Delta) in the Central Valley, California. The goals of the Project are to reduce catastrophic flood risk to people and property in the South Delta; to restore riparian and other native habitats for Swainson's hawk, riparian brush rabbit, riparian songbirds, and other species; and to restore channel capacity (otherwise known as dredging) in portions of the South Delta downstream of Paradise Cut. The expanded flood bypass is estimated to reduce river flood stage by 0.7 – 3.0 feet along a 28-mile corridor of the San Joaquin River adjacent to Manteca, Lathrop, and Stockton.

PURPOSE OF MEMO

This memo describes potential impacts downstream of the Project and proposed strategies to address concerns with downstream impacts to landowners and reclamation districts located downstream of the proposed Project, including strategies to address concerns with hydraulic impacts downstream of the Project, which are above and beyond legal and permitting requirements. Landowners and reclamation districts located downstream of the Project provided feedback on the potential impacts and proposed strategies at a March 23, 2023, public meeting hosted by the San Joaquin County Resource Conservation District (RCD), which resulted in the *Paradise Cut Expansion and South Delta Restoration Project Avoidance, Mitigation, Monitoring and Maintenance Strategies Report* (Report) developed by ESA in April 2023 and included here as Attachment A.

The RCD, in partnership with American Rivers and the South Delta Water Agency (collectively referred to as "Partners"), led early planning efforts to develop the Project, and worked with reclamation districts to select the San Joaquin Area Flood Control Agency (SJAFCA) to lead the Project going forward in collaboration with Partners, local municipalities, and local reclamation districts. The Partners further completed a Preferred Conceptual Design for the Project in 2019. In 2021, the South Delta Water Agency also hired the consulting firm Anchor QEA to conduct an analysis of additional dredging, known as the Anchor report. The Preferred Conceptual Design already included significant dredging in response to concerns expressed by landowners downstream of the Project about potential impacts; the South Delta Water Agency commissioned the Anchor report to further address these concerns. SJAFCA will further evaluate the Preferred Conceptual Design and the Anchor report as part of a feasibility study beginning in 2023. From the RCD's perspective, the Project currently includes both the Preferred Conceptual Design and the additional dredging recommended in the Anchor report. The Project is currently only a concept, however, as there are no engineering drawings, restoration plans, formal project descriptions, or project specifications, so the SJAFCA-led feasibility study is likely to include Project updates.

Some of the proposed strategies to address downstream concerns with hydraulic impacts from the Project are included within the Preferred Conceptual Design, such as restoring channel depth (e.g., dredging). This memo outlines additional strategies SJAFCA may wish to consider adding to the Project, as well as proposed habitat enhancement projects to further increase the attractiveness of the Project to agencies interested in funding multi-benefit projects. Extensive descriptions of the following three strategy areas to address downstream impacts are included in this memo: 1) channel depth restoration and capacity expansion, 2) downstream flood risk reduction, and 3) habitat restoration. The RCD respectfully requests that SJAFCA consider including these strategies in the feasibility study for the Project.

This memo distinguishes between avoidance or mitigation strategies required by the California Environmental Quality Act, the National Environmental Policy Act, or other permitting processes and strategies to address landowner and reclamation district concerns with hydraulic impacts downstream of the Project, which expand beyond legal and permitting requirements.

At the March 23 workshop, the RCD received feedback on Environmental Science Associates' (ESA) analysis of potential impacts downstream of the Project and the three specific strategy areas to address concerns with impacts downstream of the Project including:

1. Channel depth restoration and capacity expansion
2. Downstream flood risk reduction
3. Habitat restoration

A more detailed description of ESA's analysis of impacts and strategies to address concern are described below.

The SJAFCA-led feasibility study (estimated to be completed 2025) will determine whether strategies to address concerns with downstream impacts the RCD recommends to SJAFCA as part of this process are ultimately included in the Project; there is no guarantee SJAFCA will construct any project generated through this process because of costs or other constraints.

PROJECT BACKGROUND

From the RCD's perspective, the Project currently includes both the Preferred Conceptual Design (**Figure 1**) and the additional dredging recommended in the 2021 Anchor report (**Figure 2**). The Project is only a concept and will change as SJAFCA analyzes the feasibility of project elements. The current Project includes:

- Up to 25 miles of dredging, in depths ranging from 6 to 8 feet, to restore several South Delta channels (Old River, Middle River, Fabian & Bell Canal, Tom Paine Slough and Paradise Cut) to their deepest historical elevations
- Installation of a new 1,000-foot weir on the left bank of the San Joaquin River approximately 3.1 river miles upstream of the existing rock weir
- Construction of about 7.8 miles of new setback levee, beginning about 1.3 miles away from the new weir at the southwest corner of the Deuel Vocational Facility, and including a 3.6-mile stretch of new setback levee on the right bank that was permitted and constructed by the ongoing River Islands Development project
- Potential setback of additional Paradise Cut levees for additional benefits as agreed to by local reclamation districts and landowners
- Modifications to rock embankments where two railroad lines, the eastern Union Pacific Railroad (a.k.a. the "eastern railroad") and the western Southern Pacific Railroad (a.k.a. the "western railroad"), and Interstate 5 cross Paradise Cut
- A 250-foot expansion of the eastern railroad undercrossing
- Installation of a new check valve structure on an existing conveyance structure that brings water into Tom Paine Slough to limit floodwaters from entering Tom Paine Slough at times of high flow
- Conversion of about 0.5 miles of breached existing levee to high-ground refuge habitat for small mammals and reptiles
- Purchase of new flood and conservation easements on agricultural land between the new weir and a point just downstream of the western railroad

- Retention of existing seasonal agriculture suitable for Swainson's hawk foraging habitat between the new weir and a point just downstream of the western railroad
- Restoration of riparian habitat within the existing Paradise Cut footprint from the eastern railroad track to the vicinity of the Old River confluence, about 6.1 miles of varying width
- Restoration of native grassland habitat within the channel between the existing rock weir and the eastern railroad, approximately 0.65 miles
- Restoration of shaded riverine aquatic habitat along the left bank of the mainstem San Joaquin River between the existing and proposed weirs, approximately 2.7 miles

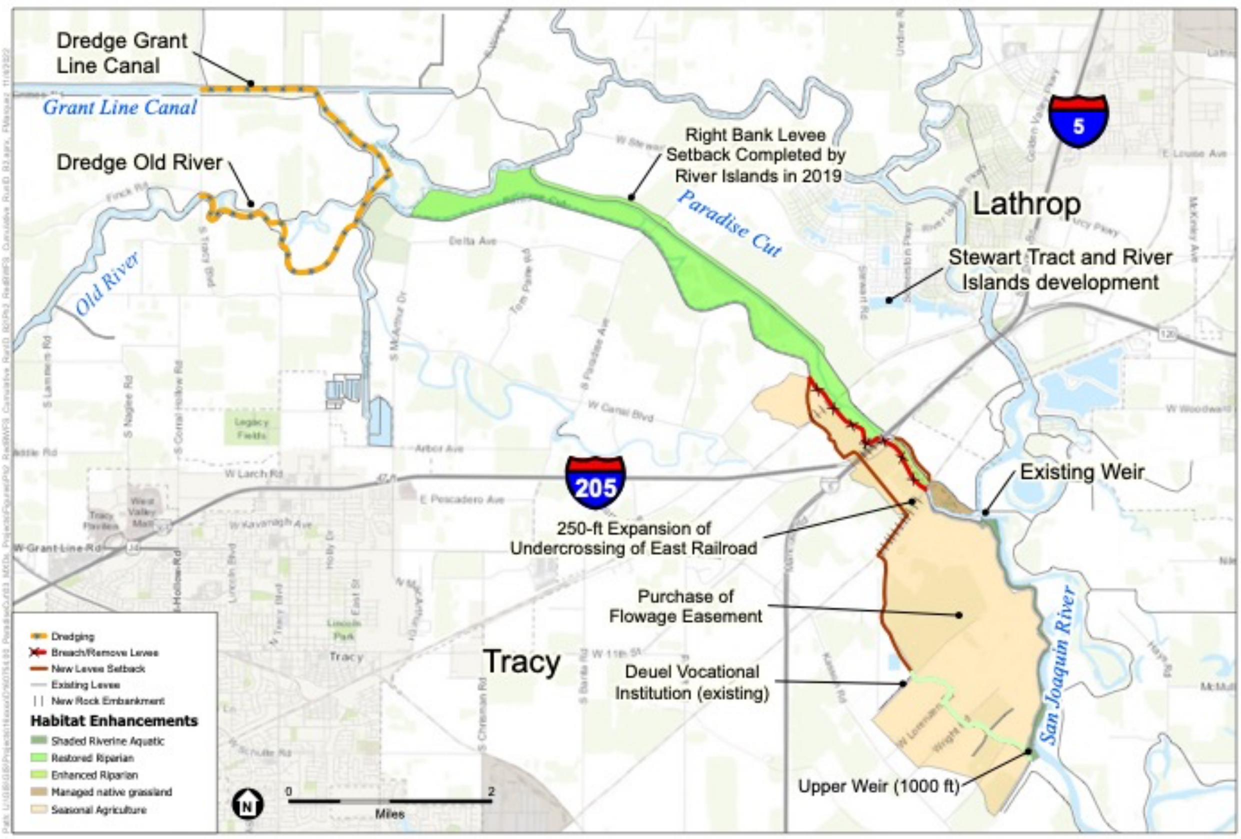

Figure 1. Paradise Cut Project in 2019 Preferred Conceptual Design.

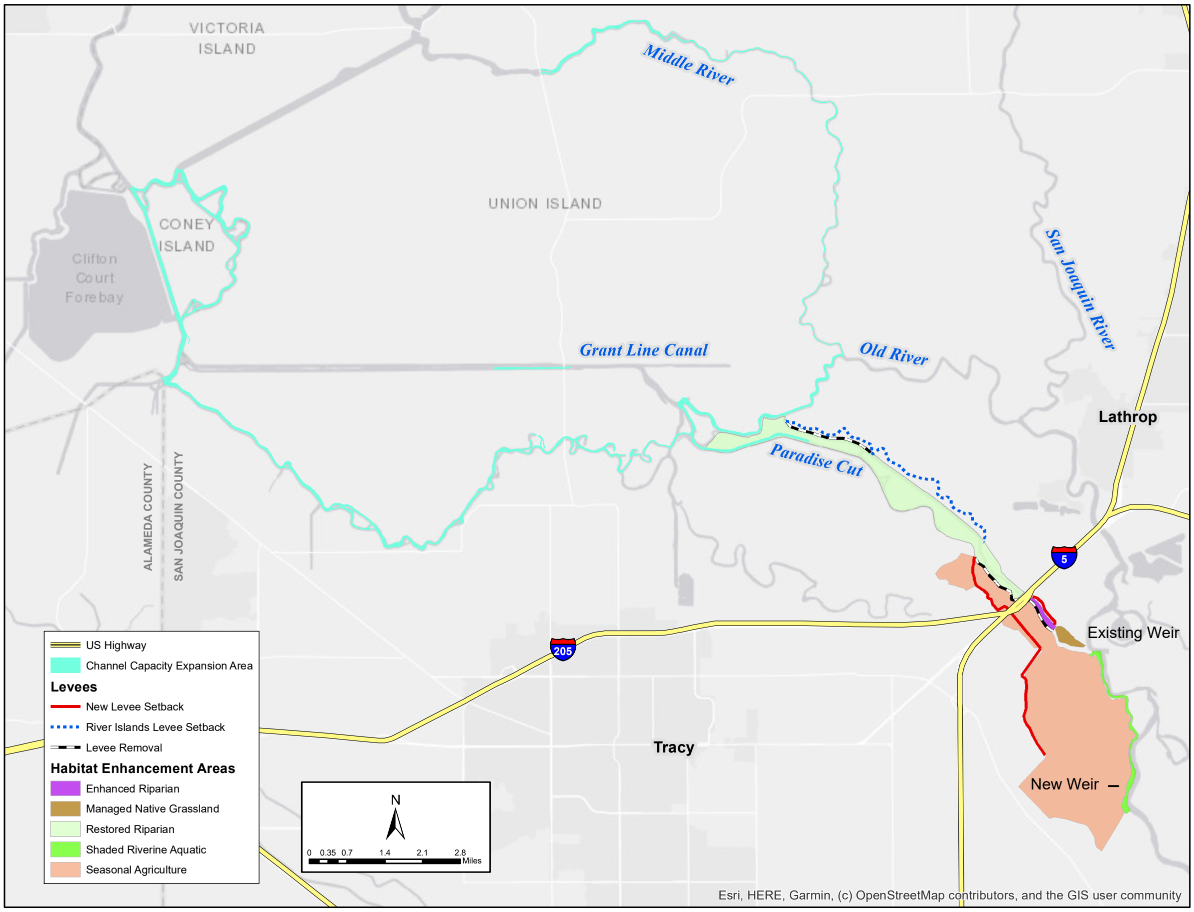

Figure 2. Paradise Cut Project with additional channel capacity expansion (dredging) recommended in the 2021 Anchor report.

ESA ANALYSIS OF DOWNSTREAM IMPACTS

On March 23, the RCD received feedback on ESA's evaluation of downstream impacts from the proposed Project, which is based on accuracy of five U.S. Army Corps of Engineers index points reflecting the condition of levees downstream of the Project that are intended to represent large lengths of leveed systems operated and maintained by several reclamation districts. The RCD is interested in whether these index points are accurate and if not, the studies or other work needed to ensure accuracy. These index points currently indicate potentially significant downstream hydraulic impacts from the proposed Project, although SJAFCA will conduct further analysis to verify the potential impacts. The RCD is also interested in other comments on ESA's analysis.

ESA's analysis is based upon hydraulic modeling results developed by MBK Engineers in 2019. Those results showed the water surface elevations and flow levels expected to result from the Preferred Conceptual Design, which included all of the Project features identified above except that it included five miles of dredging to two-foot depths, rather than the larger dredging program indicated above. The ESA analysis uses these hydraulic modeling results to assess the potential for increase in three categories of levee failure risk: seepage, erosion, and overtopping. These failure risks are assessed using levee performance curves developed for each of the three failure modes by the California Department of Water Resources at the five index points representing South Delta levees.

The ESA analysis indicates that there is potential risk of seepage- or erosion-induced levee failure in certain locations downstream of the Project under the current-day 100-year flood scenario. There would likely be escalation of the risk of through-seepage and under-seepage at the three index points near the western end of Stewart Tract, in particular. The risk of overtopping of downstream levees is minimal under the current-day 100-year flood scenario.

At this time, it is unknown to what degree levee inspections have been conducted and documented by the reclamation districts, the US Army Corps of Engineers, or others, but it is critical to solicit this information and identify areas where additional geotechnical assessments could improve understanding and confidence in levee performance. More refined hydraulic modeling, sediment modeling, and more detailed geotechnical investigations are all necessary for potential impacts and avoidance strategies to be better specified in future phases of planning and engineering design.

STRATEGY AREAS

At the March 23 public workshop, the RCD received feedback on the following three strategy areas to address concerns with downstream impacts from the Project: 1) channel depth restoration and capacity expansion, 2) downstream flood risk reduction, and 3) habitat restoration. The three strategy areas are described in more detail below:

1) Channel Depth Restoration and Capacity Expansion

The Preferred Conceptual Design for the Project includes a proposal to restore channel capacity along approximately five miles of Old River and Grant Line Canal, including dredging of about two feet in depth. The Anchor report further analyzes additional dredging opportunities for the restoration of channel capacity in approximately 25 miles of southern Delta channels, which includes the five miles of channels in the Preferred Conceptual Design.

The RCD received feedback on how this expanded dredging proposal in the Anchor report decreases hydraulic impacts from the Project, including the interest to conduct additional studies and modeling to determine the extent to which the expanded dredging will affect stage under high flow events and if additional dredging would further affect stage.

Increases in stage within Paradise Cut are an intended function of the Project, which moves floodwater off the mainstem San Joaquin River and into Paradise Cut in order to reduce flood risks to the urbanized areas of Lathrop, Manteca, and Stockton. The hydraulic model of the Preferred Conceptual Design's potential performance under the 1997 flood (similar to the current-day 100-year flood scenario) shows stage within Paradise Cut increasing by as much as two feet just upstream of the I-5 underpass, about six inches at the downstream end of Paradise Cut, and about six to eight inches in Old River and Grant Line Canal downstream of the Project.

These stage estimations already account for the effects of the dredging included in the Preferred Conceptual Design (five miles to two-foot depth) but not any additional dredging. The hydraulic analysis indicated that stage in Old River and Grant Line Canal would be about 1.5 – 2.0 inches higher if dredging had not been included in the Preferred Conceptual Design. While additional dredging may reduce stage further, there is not necessarily a direct or linear relationship between dredging quantity and stage under high flow scenarios due to 1) backwater conditions created by tides and downstream hydraulic constraints, and 2) the lower "relative roughness" of river and canal boundaries to the amount of water within them. Further detailed hydraulic modeling is required to assess the potential effects of additional dredging on stage under various scenarios, including those representing the much larger flood flows that will become more frequent under anticipated climate change.

Although the dredging identified in the Project does make some contribution to reducing peak flood stages downstream of Paradise Cut, its primary benefit to the Project is in the restoration of historic channel depths for the benefit of water supply and aquatic habitat. Additional dredging may not mitigate hydraulic impacts and levee failure risks to downstream landowners as effectively as other potential hydraulic impact mitigation strategies, so additional dredging in the Project should be considered and analyzed primarily in light of its channel restoration benefits rather than solely as a potential hydraulic impact mitigation measure.

2) Downstream Flood Risk Reduction

At the March 23 public workshop, the RCD and ESA received feedback on specific ideas to help address downstream impacts from the Project. ESA and Partners identified eight strategies, which are discussed in more detail below, including:

a) using dredge spoils to improve downstream levees
b) integrating ecological levee rehabilitation elements into levee improvements and maintenance
c) setting back levees to decrease flood risk
d) reconnecting and restoring floodplains to decrease sediment
e) decreasing levee erosion using vegetation
f) stabilizing levees with riprap
g) decreasing levee seepage with cutoff walls and seepage berms
h) monitoring and maintaining levees.

At this stage of the Project, it is uncertain whether the lead agency will need to include additional design measures in the Project to counter negative hydraulic impacts. Most risk reduction strategies are dependent upon the outcome of more detailed geotechnical and hydraulic analysis of the Project.

Local reclamation districts know their levees best, so the RCD sought proposed levee improvement projects and other strategies that specifically address concerns with downstream impacts from the Project, including the following:

a) Improving Downstream Levees with Dredging Spoils

According to the Anchor report, there isn't any evidence of sediment contamination that would rule out the potential use of dredge spoils for levee improvements. In addition, finding an efficient use of dredging spoils near the site of excavation could decrease projects costs since transport of soils is so expensive. The RCD received feedback on specific projects that would use dredging spoils to help address downstream impacts from the Project.

b) Using Ecological Levee Rehabilitation or "Green Levees" to Decrease Flood Risk

The RCD sought feedback on the potential for downstream reclamation districts to integrate ecological levee rehabilitation or "green levee" strategies, including setback levees, into either proposed levee improvements or ongoing levee maintenance efforts. The RCD received feedback from reclamation districts on opportunities to integrate green levees to help address downstream impacts from the Project. The integration of such features into the Project will increase the attractiveness of the Project to agencies interested in funding multi-benefit flood protection projects.

Green levee strategies may be similar to those developed by Reclamation District 1601 and KSN on [Twitchell Island](#) in the Central Delta (**Figure 3**), which involve:

1. Using dredge spoils (if geotechnically appropriate) to widen the levee cross section by creating toe berms and/or seepage berms behind existing levees to reduce the probability of failure, as well as to provide a foundation for constructing a new setback levee.
2. Building a new setback levee behind the existing levee with appropriate freeboard, slope, and geotechnical characteristics to avoid erosion, seepage, and overtopping hazards. The setback levee can be built as a traditional trapezoidal levee or as a terraced structure that could enable planting of trees and vegetation at the base of the waterside of the levee without reducing flood protection.
3. Planting of trees and other vegetation on at least one slope of the original levee.
4. Breaching of original levees in multiple locations to permit water to flow in and create aquatic habitat between the original levee and the setback levee. This backchannel in between the levees can be designed to be wet year-round or only at selected times of high flow, depending upon the ecosystem restoration objectives.
5. Maturing vegetation over time to create riparian and shaded riparian aquatic habitat within and alongside the backchannel.

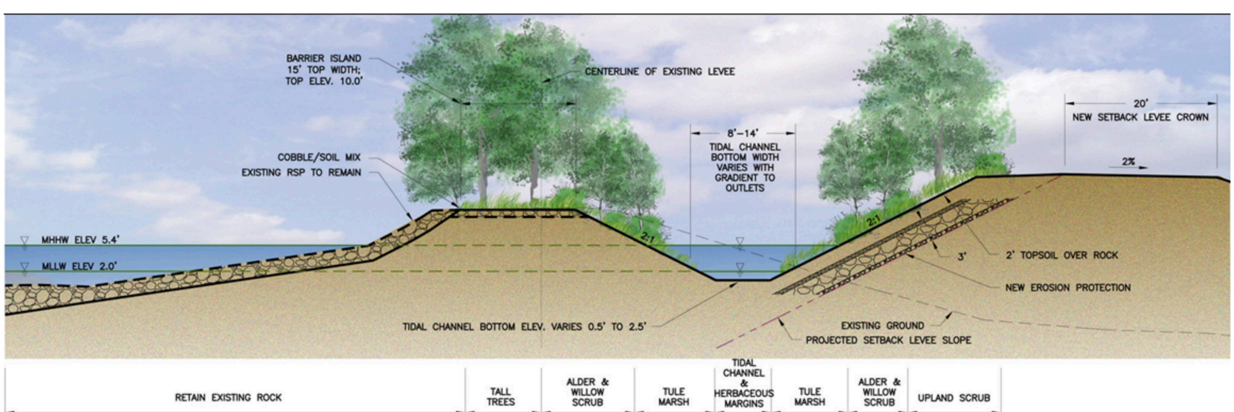

Figure 3. Example of ecological levee strategy with setback levee, wide islands, and

discontinuous back channels (KSN, Inc.).

These integrative green levee strategies offer a number of potential advantages, including creation of significant new habitat areas, expansion of overall channel capacity, and (depending upon design) protection against multiple modes of levee failure. If dredged spoils are found to be geotechnically suitable, this strategy would also provide an opportunity for placement and reuse of these spoils within the Project area, thereby avoiding the expense and environmental impact of off-site disposal. The types of habitat potentially created (especially shaded riparian aquatic) may also provide additional mitigation capacity for the impacts of other levee construction and rehabilitation projects elsewhere in the Lower San Joaquin River region.

Green levees would likely be most suitable in areas where significant channel widening and ecosystem restoration are feasible. Given the extensive earthmoving and vegetation planting involved, they are likely to be relatively expensive on a per-mile basis compared to other strategies, but also could bring multiple benefits (and avoided costs of dredge spoil disposal) that may partially or completely counterbalance the relatively high construction costs compared to other strategies.

Based on what is known at the present time, the green levee strategies may be best suited for consideration in the vicinity of the confluence of Paradise Cut and Old River (as represented by Index Points 30, 31 and 40 (**Figure 4**), due to the following general characteristics of this area:

- Relatively large increase in failure risk of existing levees from the hydraulic impacts of the Project
- Greater distance between ecosystem restoration areas and the State and Federal Water Project pumping facilities, compared to sites further west
- Slightly higher elevation above tidal zone, compared to sites further west

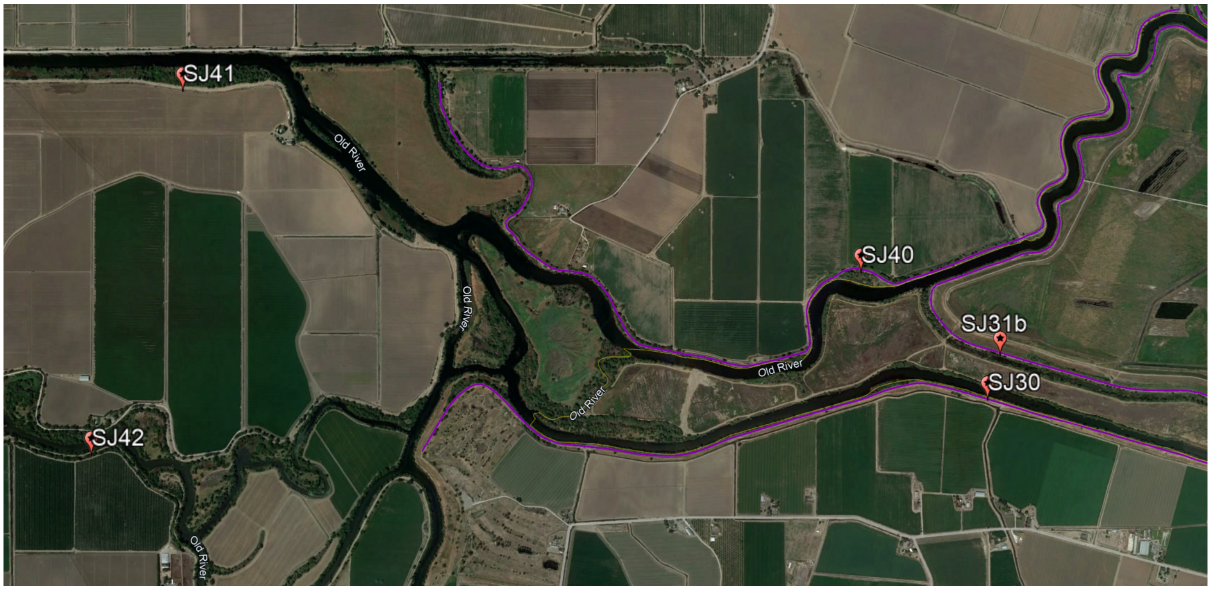

Figure 4. Index points on and downstream of Paradise Cut evaluated by the USACE for levee performance. Index points are intended to represent large lengths of leveed systems operated and maintained by several reclamation districts.

c) Setting Back Levees to Decrease Flood Risk

The green levee strategy identified above is a specialized case of the more general strategy of setback levees. Setting back levees can meet flood risk management objectives by expanding channel capacity while also restoring floodplain habitat and improving ecosystem processes. Setback levees may or may not involve complete removal of existing levees; often existing levees are breached, but not removed, in order to reduce earthmoving costs and to provide areas of high ground during high-flow events. At least two breaches are generally necessary in order to ensure proper passage of flows and to avoid fish stranding hazards. Setback levees can also incorporate side channels or other features specifically designed to enhance habitat quality.

Setback levees do not necessarily require the removal of agriculture from the floodplain. There are other locations in the lower San Joaquin Valley where agriculture occurs on the waterside of levees and is subject to periodic but infrequent flooding. Flowage easements, insurance, or other financial and legal strategies could be used to ensure the continued economic viability of floodplain agriculture in situations where existing agricultural lands were exposed to periodic but infrequent flow events.

Setback levees provide more channel capacity to convey flows and therefore generally reduce flood risks to adjacent lands. However, their ability to do so may also be limited by other constraints, such as flow bottlenecks, that ultimately determine how much water can pass through a given reach in a given amount of time. Conversely, the removal or relaxation of such bottlenecks may require expansion of downstream channel capacity to ensure continued safe passage of flows.

These considerations are important for Paradise Cut in light of the larger flood flows that are expected on the San Joaquin River under climate change scenarios. Existing hydraulic analyses assess the performance of the Preferred Conceptual Design under current hydrology, including the 1997 flood, which is similar to the 100-year flood under current hydrology. Safe conveyance of the substantially larger flows anticipated under climate change through Paradise Cut may require both the expansion of current bottlenecks (such as the railroad and freeway undercrossings) and the expansion of channel capacity through setback levees.

Projects that incorporate nature-based solutions such as setback levees are currently more competitive for grant funding. In addition, the increased flood risk under future climate scenarios may favor nature-based solutions like setback levees that may deliver multiple benefits in a more financially efficient manner in the long run. A comprehensive benefit-cost analysis is required to acknowledge and account for the multiple social, environmental, and economic benefits of setback levees.

d) Reconnecting and Restoring Floodplains to Decrease Sediment
Sedimentation in Paradise Cut and other South Delta channels is a complex phenomenon that may be related both to periodic San Joaquin River flows through Paradise Cut and to tidal and other hydraulic dynamics in the South Delta. There are no sediment transport models of the lower San Joaquin River, so little is known about the extent of deposition resulting from periodic flows from the San Joaquin River over the existing Paradise Cut weir, or about what levels of sedimentation could be expected from the Project and where deposition would occur in various flow scenarios.

If future investigations show that the Project would result in additional sedimentation of South Delta channels, there is potential for this to be addressed (at least partially) through the reconnection of floodplains where sediment can be deposited in high flow situations. Generally, sediment deposition occurs most readily in areas where the velocity of flow is slowing down. In areas where levee setbacks are possible, channels could be re-profiled and/or floodplains could be graded and replanted to promote more frequent floodplain inundation and overbank deposition of sediment. The area of flowage easements downstream of the new weir could also become a site of sediment deposition, depending upon flow dynamics. More analysis is required to determine if sedimentation issues exist, and if so, where changes in channel and floodplain geometry may prove helpful.

Floodplain restoration is considered a nature-based solution that could meet flood risk management objectives while improving geomorphic processes and providing ecological uplift. Projects that incorporate nature-based solutions are also more competitive for grant funding.

e) Decreasing Levee Erosion Using Vegetation

A variety of materials could be applied to channel banks or levee slopes to address erosion concerns. For the range of average velocities that are estimated under the 1997 flood scenario (7 ft/s or less on all drainages), numerous vegetation-based, rolled erosion control products, and/or soil bioengineering measures could apply (two options are illustrated in **Figures 5-6**). These types of measures could be selected over rock slope protection and hardscaping to promote vegetative growth and more suitable habitat conditions. In the past, the US Army Corps of Engineers (USACE) has generally not allowed the intentional planting of vegetation on levees that are part of federal flood control projects, which in this case includes the levees running along the left bank of Paradise Cut to the Old River confluence and along the right bank of Paradise Cut and then Old River until its confluence with Grant Line Canal. Any strategy to vegetate levees in this reach would have to be developed in close consultation with USACE. Levees further downstream of Paradise Cut (e.g., along Doughty Cut, Grant Line Canal, and Old River west of its confluence with the southern channel of Paradise Cut) are not subject to USACE rules in this regard.

Vegetated levees are considered a nature-based solution that could meet flood risk management objectives while improving geomorphic processes and providing ecological uplift. Projects that incorporate nature-based solutions are also more competitive for grant funding.

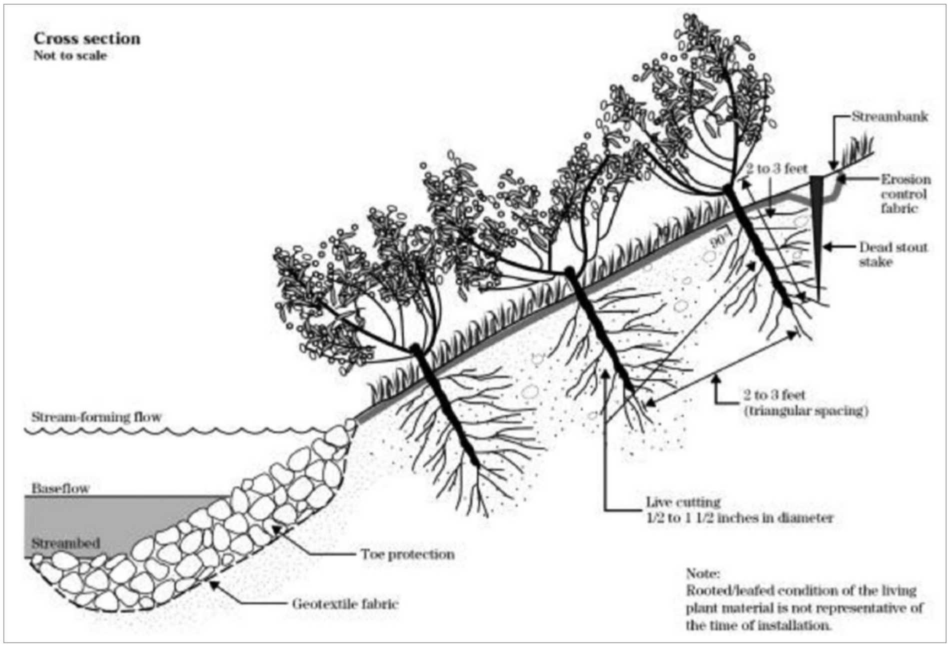

Figure 5. Decreasing erosion on levees using fabric cover over soil and live stake plantings.

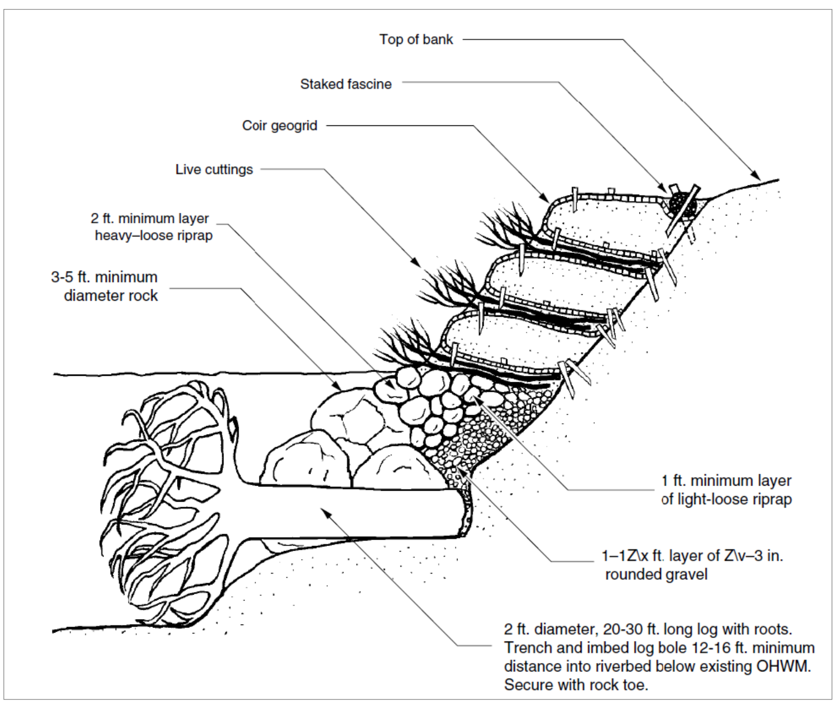

Figure 6. Decreasing erosion on levees using vegetated soil lifts (or geogrids)

f) Stabilizing Levees with Riprap

One strategy to stabilize levees is placing riprap (or quarry stone or rock slope protection) along the levee toe to stabilize the bank during a flood and prevent slipping and failure of the levee surface as water surface elevations recede. This is a common strategy for protection against erosion but has major ecological disadvantages, as it discourages the establishment of vegetation that provides riparian habitat and provides food sources and shade for fish and other aquatic organisms. Placement of new riprap where it has not previously existed will create environmental impacts that would likely require mitigation.

g) Decreasing Levee Seepage with Cutoff Walls and Seepage Berms

One anti-seepage strategy is cutoff walls, which create a physical barrier to seepage through the center of the levee down to competent, non-permeable materials below the levee foundation (**Figure 7**). Another strategy is the use of seepage berms along the landside toe of the levee, which helps to stabilize the levee toe and prevents upwelling of water and piping from under-seepage (**Figure 7**). Through-seepage and under-seepage are significant modes of failure for levees near the western end of Stewart Tract (SJ30, SJ31b, and SJ40 (**Figure 4**)).

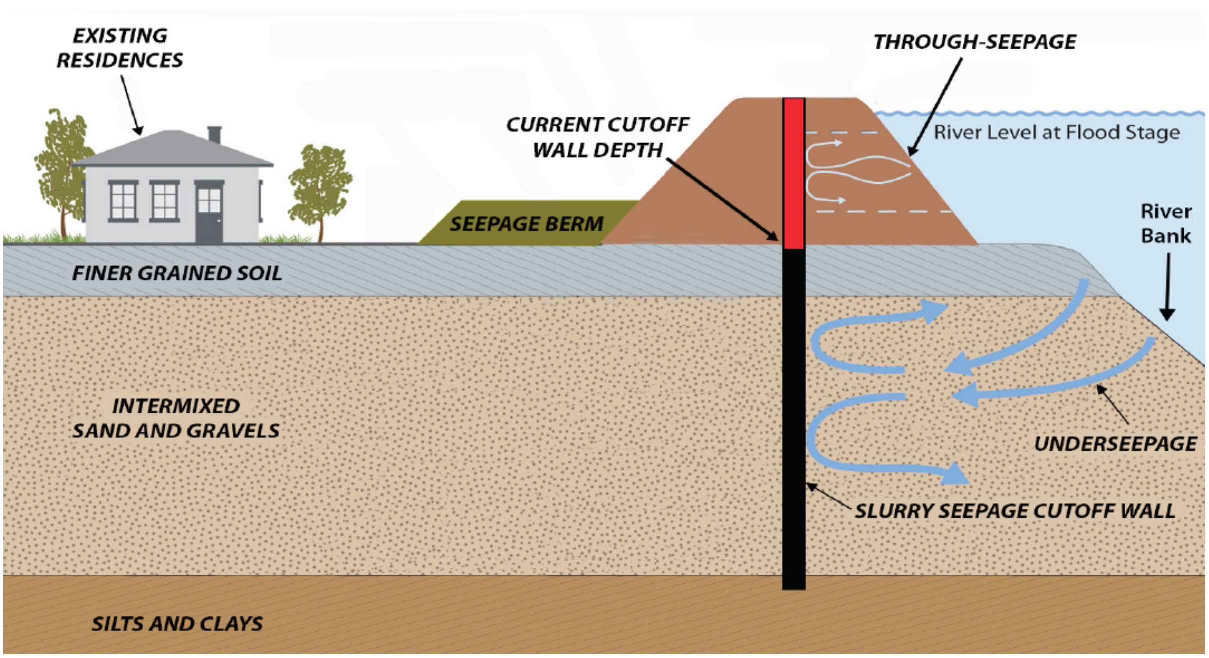

Figure 7. Diagram of cutoff walls and seepage berms to protect levees from through seepage and under seepage.

h) Monitoring and Maintaining Levees

Hydraulic impacts that result in a relatively minor increase in the probability of failure may not require additional physical design measures to address those impacts. In those instances, monitoring and maintenance measures to counteract those hydraulic impacts may prove more cost effective in the long run.

3) Habitat Restoration

The RCD has developed a list of conceptual "add on" habitat restoration projects which SJAFCA could consider including in the proposed Project. The Project currently includes significant habitat restoration by reestablishing many miles of shallow water habitat, so that these add-on projects would further increase the environmental benefits of the Project. On March 23, the RCD received feedback on the following habitat restoration projects in the Project:

(a) Hyacinth/Egeria Removal

The RCD recommends removing water hyacinth (*Eichhornia crassipes*) and curly leaf pondweed (*Egeria densa*), two invasive non-native aquatic plants that clog Delta waterways, as part of developing the Project. The dredging proposed as part of the Project will help increase channel capacity, increase shallow water habitat, and remove water hyacinth and *Egeria densa*. Increased channel depth may inhibit future growth of water hyacinth and *Egeria densa*.

(b) Salmon Slough Restoration

The RCD proposes to re-establish Salmon Slough as functioning waterway/habitat with a potential control structure to help improve water quality (**Figure 8**). Salmon Slough is currently choked with non-native vegetation, silt, and trash, which adversely affect channel habitat. The non-native vegetation and accumulated silt prevent any meaningful flow in the Slough except during times of high flow. Removing vegetation from Salmon Slough will allow for restoration of habitat and regular, increased flows from the tides. These increased flows also should improve local water quality.

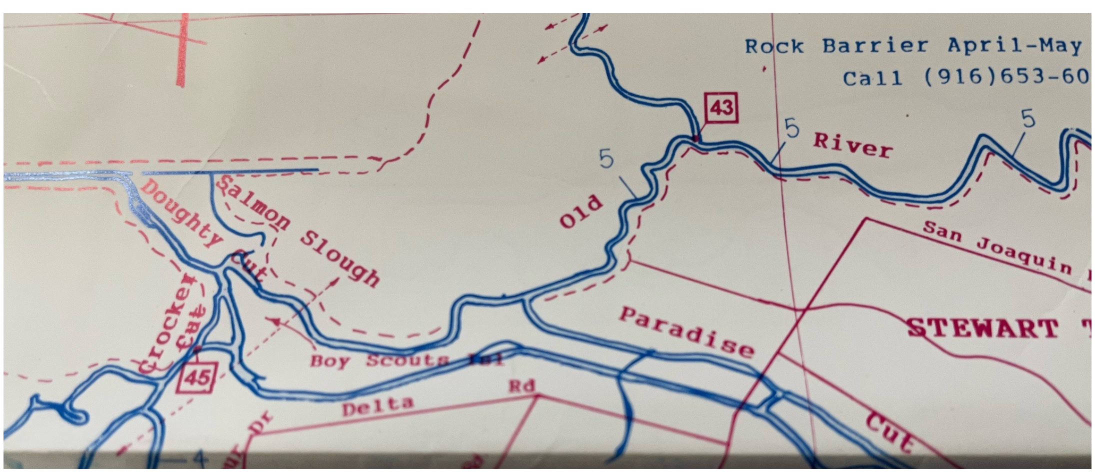

Figure 8. Salmon Slough at Doughty Cut downstream of Paradise Cut.

(c) 100-Acre Interior Channel Island Restoration

An interior channel island, of approximately 100 acres, located next to the Project is an ideal location to deposit dredging spoils and restore habitat for terrestrial and aquatic species. The RCD proposes that SJAFCA work with the wildlife agencies and the San Joaquin Council of Governments (SJCOG) to develop a habitat restoration project on the island as part of the San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP).

(d) Grant Line Canal Habitat Restoration

The RCD recommends exploring opportunities to improve habitat for native terrestrial and aquatic species along the southern border of Grant Line Canal from the Tracy Road Bridge to Doughty Cut, an area which does not currently benefit from tidal flows because of non-native vegetation and accumulated silt. The RCD proposes working with the wildlife agencies and the SJCOG to transform this area into valuable shallow water or other habitat with tidal flows as part of the SJMSCP. This project also would improve local water quality.

(e) Grant Line Canal/Fabian Bell Canal Channel Islands Preservation

The channel islands between Grant Line Canal and Fabian Bell Canal erode as a result of high flows. The RCD suggests exploring the use of dredging spoils or other means to enhance and protect the valuable habitat on these islands.

(f) Paradise Cut Habitat Enhancement

Paradise Cut is currently a dead-end slough unless the flows on the San Joaquin River reach approximately 17,000 cfs. The RCD recommends working with the wildlife agencies and the SJCOG to explore altering Paradise Cut to allow tidal and river flows to freely move through the channel to achieve the twin goals of improving habitat and local water quality and advancing the goals of the SJMSCP.

(g) Old River/Middle River Channel Island Preservation

Protect and, as possible, improve habitats on various channel islands in Old River and Middle River. Old River and, to a lesser extent, Middle River also contain many small channel islands, which are subject to erosion during high flow events. Many of these islands could be protected from such erosion and their habitat value improved and maintained.

(h) Tom Paine Slough Habitat Enhancement Project

The RCD recommends exploring opportunities to manage and maximize habitat associated with remnants of upper Tom Paine Slough. The upper reaches of Tom Paine Slough provide distinct and important habitats separate from those along and in the main Delta channels. The RCD recommends working with the wildlife agencies and the SJCOG to explore opportunities to protect and maintain this habitat as part of the Project and the SJMSCP, as well as provide additional flood protection for local farmers.

Final

PARADISE CUT EXPANSION AND SOUTH DELTA RESTORATION PROJECT

Avoidance, Mitigation, Monitoring and Maintenance Strategies Report

Prepared for
San Joaquin County Resource Conservation District
3294 N. Ad Art Road
Stockton, CA 95215

April 2023

ESA

Final

PARADISE CUT EXPANSION AND SOUTH DELTA RESTORATION PROJECT

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Prepared for

San Joaquin County Resource Conservation District
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PARADISE CUT EXPANSION AND SOUTH DELTA RESTORATION PROJECT

Avoidance, Mitigation, Monitoring and Maintenance Report

1. Executive Summary

This report identifies strategies to avoid, minimize, or mitigate impacts from the Paradise Cut Expansion and South Delta Restoration Project (Project) and identifies monitoring and maintenance strategies that may be necessary to ensure the long-term performance of both the Project and its impact mitigation strategies. The Project includes construction of a new weir, set back of existing levees, restoration of habitat, and restoration of channel capacities to reduce flood risks and enhance ecosystems in the lower San Joaquin Valley. The San Joaquin County Resource Conservation District, in partnership with American Rivers and the South Delta Water Agency, led early planning efforts to develop the Project and the San Joaquin Area Flood Control Agency (SJAFCA) will lead the Project in collaboration with local reclamation districts and project partners in the future.

SJAFCA will lead the design of the Project to divert flows off of the San Joaquin River and into Paradise Cut to reduce flood stages along the San Joaquin River, specifically in the urban areas of Lathrop, Manteca, and Stockton. As a result, the Project will also result in increased flows, stages and water velocities within and downstream of Paradise Cut, potentially creating hydraulic impacts to neighboring lands. This report assesses the approximate magnitude of these impacts, insofar as impacts can be determined with existing project descriptions and modeling information, and identifies strategies that could be deployed to minimize, avoid, and/or mitigate these impacts. While engineering designs, further hydraulic modeling, geotechnical investigation, and sedimentation analysis will all be required to more accurately assess impacts and identify avoidance and mitigation strategies, this report contains the following key findings based on currently available analysis:

- The current preliminary evaluation of engineering and design strategies was based on existing geotechnical assessments for five index points that are intended to represent large lengths of leveed systems operated and maintained by several reclamation districts. Additional information about the characteristics of downstream levees from local reclamation districts, property owners, the US Army Corps of Engineers, and geotechnical investigators is of critical importance to the refinement of these analyses and to the eventual engineering design and planning of the Project.

- Analysis based on the five index points indicates that there is potential risk of seepage- or erosion-induced levee failure in certain locations downstream of the Project under the approximate current-day 100-year flood scenario.
- The levee performance curves and hazard ratings for the five index points show that through-seepage and under-seepage are significant modes of failure for levees near the western end of Stewart Tract (SJ30, SJ31b, and SJ40).
- Generally, the risk of overtopping of downstream levees is minimal under the approximate current-day 100-year flood scenario.
- Nature-based solutions such as setback levees, channel and floodplain restoration, and soil bioengineering measures could meet flood risk management objectives while improving geomorphic processes and providing ecological uplift.
- Refined hydraulic modeling is recommended to estimate more precisely the velocities and shear stresses acting on the channel boundary.
- Additional investigation is needed to assess the potential for additional sedimentation of downstream channels as a result of the Project.
- Recent climate scenarios developed for the 2022 Update of the Central Valley Flood Protection Plan should be incorporated into all future analyses to account for potential changes to inland hydrology and sea levels and improve the long-term resilience of the Project.

The above findings incorporate the assumption of five miles of channel dredging in Old River and Grant Line Canal to a depth of two feet, which is a specified feature of the Project. The San Joaquin Area Flood Control Agency (SJAFCA) will be the project lead agency for the upcoming feasibility study and may consider adding more dredging to the project in the area analyzed in a report by Anchor QEA (2019) commissioned by the South Delta Water Agency. Although the dredging identified in the Project does make some contribution to reducing peak flood stages downstream of Paradise Cut, its primary benefit to the Project is in the restoration of historic channel depths for the benefit of water supply and aquatic habitat.

This report also assesses the potential environmental impacts of Project construction and identifies strategies that could be incorporated into the Project to minimize, avoid, or mitigate these impacts. With regard to habitat-related construction impacts, the report finds that the Project, as currently defined, is likely to be self-mitigating with respect to species and habitat impacts, with the possible exception of impacts to freshwater wetlands that may occur depending upon the precise alignment of future setback levees. A range of avoidance and mitigation strategies, identified in the report, will likely be needed to address potential impacts.

Finally, this report also identifies maintenance and monitoring strategies the Project may need to include to comply with pertinent regulations and sustain the Project's objectives over time, provides initial cost estimates for these activities where sufficient information exists, and outlines a conceptual plan for financing those costs. While many cost variables remain to be specified by forthcoming engineering and restoration designs, this report's preliminary estimate is that these costs will collectively amount to several million dollars per year during the construction phases, and likely over $1 million per year for at least the first three years after completion.

2. Introduction and Purpose

The Paradise Cut Expansion and South Delta Restoration Project (Project) is a multi-benefit flood project proposed in the southern Sacramento-San Joaquin Delta (Delta) consistent with the State of California's Central Valley Flood Protection Plan. The goals of the Project are to reduce catastrophic flood risk to people and property in the South Delta, restore riparian and other native habitat for Swainson's hawk, riparian brush rabbit, riparian songbirds and other species, and restore channel capacity in portions of the South Delta downstream of Paradise Cut. The San Joaquin County Resource Conservation District ("San Joaquin RCD"), in partnership with American Rivers and the South Delta Water Agency, led the first six years of planning efforts to develop this Project, starting with execution of a grant from the Sacramento-San Joaquin Delta Conservancy in 2016 and including development of this report.

The lead agency for the Project is the San Joaquin Area Flood Control Agency (SJAFCA), in collaboration with the California Department of Water Resources with a consortium of local reclamation districts, municipalities, environmental nonprofit organizations, and water agencies serving as advisors to the project.

The Project's "Preferred Conceptual Design" (as described in American Rivers 2019) proposes several components including weir construction, setback levee construction, levee removal, rock embankment modifications, channel dredging, and habitat enhancements. Identifying strategies to minimize negative hydraulic impacts and improve water quality and ecological outcomes within and downstream of the Project is necessary to advance project planning and permitting efforts.

The purpose of this report is to identify and evaluate strategies to avoid or mitigate impacts to interested parties located downstream from the Project and advance the goals of the Central Valley Flood Protection Plan, including improving ecosystem function. These strategies include ecologically beneficial levee rehabilitation, restoration of lost channel capacity and expansion of channel capacity (which includes dredging), flood risk reduction, and habitat enhancement. Many of these strategies are contained in the Preferred Conceptual Design, such as increasing channel capacity, but this report outlines further strategies SJAFCA may wish to consider exploring in the feasibility study SJAFCA will undertake in 2023 to further the Project. The report also identifies maintenance and monitoring recommendations consistent with these strategies, as well as provides a range of potential costs.

This report further distinguishes between avoidance or mitigation strategies required by the California Environmental Quality Act, the National Environmental Policy Act, or other permitting processes and new proposed avoidance and mitigation strategies, such as ecological levee rehabilitation potential, which expand beyond legal and permitting requirements.

The report includes the following sections:

1. Avoidance and mitigation strategies to address downstream impacts to interested parties from potential increases in flood stage or other hydraulic issues associated with the Project, including dredging, sediment management, and water quality improvements. This section includes a description of the strategies, a list of permits and other environmental review

requirements for each strategy, and a review of avoidance and mitigation measures from similar projects.

2. Avoidance and mitigation strategies for the environmental quality and habitat restoration components of the Project. This section includes a proposed ecological levee rehabilitation strategy and a discussion of the potential to use habitat enhancements included in the Project to mitigate for the project's impacts or potential future impacts associated with operation and maintenance of the project. This section further includes a description of the environmental costs and benefits of these mitigation strategies, a list of permits and other environmental review requirements for each strategy, and a review of avoidance and mitigation measures from similar projects.

3. Strategies needed to maintain and monitor habitat functions, channel conveyance, and flood protection levels associated with the Preferred Concept Design during and after Project construction. This includes a review of maintenance and monitoring activities undertaken by similar projects in the Delta and Central Valley.

4. Cost estimates and a conceptual finance strategy for the avoidance, mitigation, maintenance, and monitoring activities identified above.

This report is a companion to a separate report identifying the existing technical analyses pertinent to the Project as well as those still needed to further specify a preferred alternative and obtain needed permits and environmental approvals.[1]

3. Project Background

The San Joaquin RCD, in partnership with American Rivers and the South Delta Water Agency, developed the Preferred Conceptual Design for the Project in 2019 and is described in American Rivers (2019). Though this version of the Project is accepted as the current Preferred Conceptual Design and is treated as such in this document, SJAFCA will further evaluate the proposed project as part of a feasibility study beginning in 2023 (see below). There are no engineering drawings, restoration plans, formal project descriptions or project specifications (beyond those summarized below) at the time of this writing.

The current Preferred Conceptual Design includes:

- Installation of a new 1,000-foot weir on the left bank of the San Joaquin River approximately 3.1 river miles upstream of the existing rock weir
- Construction of about 7.8 miles of new setback levee, beginning about 1.3 miles away from the new weir at the southwest corner of the Deuel Vocational Facility, and including a 3.6-mile stretch of new setback levee on the right bank that was permitted, and constructed by the ongoing River Islands Development project.

[1] San Joaquin County Resource Conservation District. 2022. *Paradise Cut Expansion and South Delta Restoration Study Existing and Needed Technical Analyses*. Prepared by Environmental Science Associates.

- Removal of approximately 5.1 miles of existing levee, on the left bank of Paradise Cut between the eastern railroad to a point just downstream of the western railroad, and on the right bank from approximately the latter point to the western tip of Stewart Tract.
- Modifications to rock embankments where two railroad lines, the eastern Union Pacific Railroad (a.k.a. the “eastern railroad”), and the western Southern Pacific Railroad (a.k.a. the “western railroad”) and Interstate 5 cross Paradise Cut
- A 250 ft. expansion of the eastern railroad undercrossing
- Channel depth restoration, including dredging of about 2 feet in depth, along approximately 5 miles of Old River and Grant Line Canal
- Installation of a new check valve structure on an existing conveyance structure that brings water into Tom Paine Slough, to limit floodwaters from entering Tom Paine Slough at times of high flow
- Conversion of about 0.5 miles of breached existing levee to high-ground refuge habitat for small mammals and reptiles
- Purchase of new flood and conservation easements on agricultural land between the new weir and a point just downstream of the western railroad
- Retention of existing seasonal agriculture suitable for Swainson’s hawk foraging habitat between the new weir and a point just downstream of the western railroad
- Restoration of riparian habitat within the existing Paradise Cut footprint from the eastern railroad track to the vicinity of the Old River confluence, a distance of about 6.1 miles of varying width
- Restoration of native grassland habitat within the channel between the existing rock weir and the eastern railroad, a distance of approximately 0.65 miles
- Restoration of shaded riverine aquatic habitat along the left bank of the mainstem San Joaquin River between the existing and proposed weirs, a distance of approximately 2.7 miles

In December 2021, the SJAFCA Board of Directors passed two motions affirming SJAFCA will serve as the Project Lead for the Project, and SJAFCA will enter into a funding agreement with the California Department of Water Resources (DWR) to perform a feasibility study and other work to identify a preferred project alternative and advance project planning.

The feasibility study will assess the likely performance of potential project alternatives under both existing and anticipated future conditions, including the new estimations of potential future flood flows on the lower San Joaquin River produced by DWR in the 2022 Update to the Central Valley Flood Protection Plan. Specification of a preferred alternative will enable additional fundraising from state and federal sources, development of engineering and restoration designs, and, once those designs have reached a sufficient level of refinement, commencement of the California Environmental Quality Act (CEQA) process and other permitting processes.

The preferred project alternative identified by the feasibility study may differ from the Preferred Conceptual Design described above. The estimations of project impacts, avoidance and mitigation measures, maintenance and monitoring requirements, and preliminary cost estimates outlined in this document may therefore all be subject to change because of the feasibility study's findings and subsequent project design and permitting activities.

4. Input from Interested Parties

Interested parties and local engagement teams have provided input into development of the Project in previous phases of project conceptualization. Issues raised during these discussions include:

- The potential for increased diversion of flood water down Paradise Cut to result in increased sedimentation, erosion, and levee failure risk within and downstream of Paradise Cut
- The potential for degradation of water quality, including increased turbidity, within and downstream of Paradise Cut
- The potential for alteration of flow regimes
- The potential need to re-use or dispose of accumulated dredge spoils
- The ability to maintain desired channel depths following dredging activities
- The potential cost to maintain openings under the highway and railways
- The potential for contaminated dredged materials to pose a re-use/disposal challenge

On March 23, 2023, the San Joaquin RCD hosted a public outreach meeting about the Project at the Roberts-Union Farm Center in the South Delta. Key findings from this report were shared with attendees, along with additional information produced by the RCD. Comments received from audience members in that meeting were subsequently incorporated into this report.

5. Avoidance and Mitigation Strategies to Address Negative Hydraulic Impacts

Several concerns of interested parties focus on the potential for negative hydraulic impacts on downstream landowners and reclamation districts. Potential hydraulic impacts may include changes in erosion and sedimentation patterns, loss of channel capacity, and increased flood risk. This section outlines how potential hydraulic impacts are being evaluated and offers an array of strategies to address those impacts through pre-construction engineering and design. Based on the estimated change in flood risk, some hydraulic impacts may be best reserved for post-construction maintenance and monitoring.

5.1 Summary of With-Project Hydraulic Modeling Results

American Rivers, a partner of the San Joaquin County RCD and SJAFCA, hired MBK Engineers to evaluate and address hydraulic impacts of the Project through the use of numerical modeling applications of with-project conditions. American Rivers (2019) discusses the baseline hydrology and the array of with-project alternatives evaluated. MBK Engineers developed a one-dimensional HEC-RAS model to compare and contrast the alternatives through changes in flow regimes and water surface elevations, in addition to velocity and shear stress, which are the key parameters to evaluate erosion and sedimentation concerns.

The negative hydraulic impacts described in this memorandum are based on a conceptual design with no engineering drawings or specifications to precisely inform hydraulic model terrains or parameters. As such, numerous modeling assumptions have been made and it is anticipated hydraulic modeling results and impact evaluations will change as formal engineering and design of the project is conducted.

The conceptual design memo outlines three river discharge and levee breach assumptions that were used to model hydraulics within the area of interest (**Table 1**). The "1997 flood" scenario, which assumes 110,000 cfs at Vernalis and levee breaches and relief cuts where the levee system has not been improved, is viewed as the most realistic of the three hydrologic scenarios. Changes in flow regimes, water surface elevations, and velocity will be tied to the 1997 flood scenario, which is roughly comparable to the present-day 100-year flood on the San Joaquin River. Shear stress was not documented or evaluated in the conceptual design memo.

TABLE 1
HYDROLOGY AND LEVEE BREACH ASSUMPTIONS. SOURCE: AMERICAN RIVERS 2019

Hydrologic Scenario	Discharge at Vernalis (cfs)	Levee Breach Assumptions
Design Flood	52,000	No levee breaches
1997 Flood*	110,000	Levee breaches and relief cuts same as 1997 event except where levees have been significantly improved (i.e. super levees) or are assumed to be improved as part of the project.
100-Year (1% AEP) plus climate change**	235,000	Levees overtop but do not breach.

*76,000 cfs estimate at Vernalis gauge plus estimated 35,000 cfs that bypassed gauge.

** 116,000 cfs in the river and 120,000 cfs on the floodplain.

5.1.1 Flow Regimes

As intended, the Project (or MVP, short for "Minimum Viable Project," on the figures below) increases flow into the Paradise Cut bypass and significantly reduces peak flows along several miles of the San Joaquin River and the upstream portions of Old River and Middle River, distributaries of the San Joaquin River.

In this context, hydraulic impact concerns center around downstream impacts of increased flows delivered from Paradise Cut into Old River and Grant Line Canal. **Figure 1** shows that peak flows in Old River and Grant Line Canal increase between 8-11%, depending on the precise location, downstream of Stewart Tract. Increases in peak flows can translate into increases in flood stage, velocity, and shear stress, all of which can pose increased risks to the channels and levee systems (discussed further below).

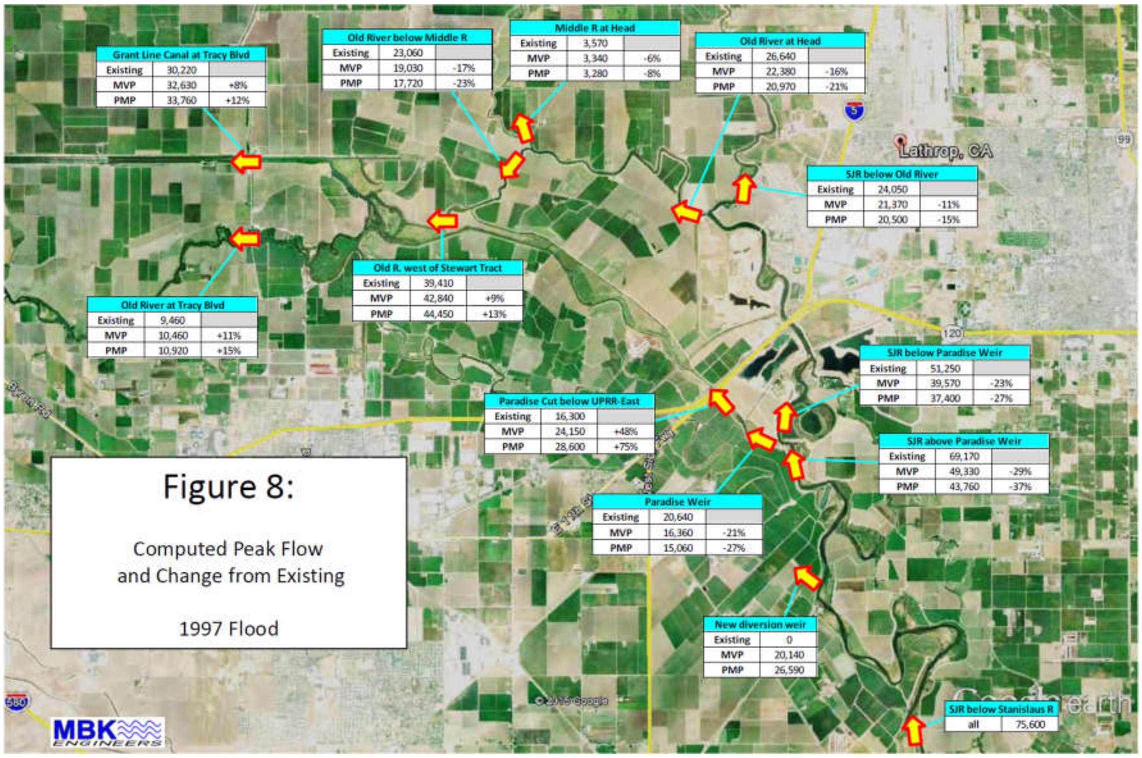


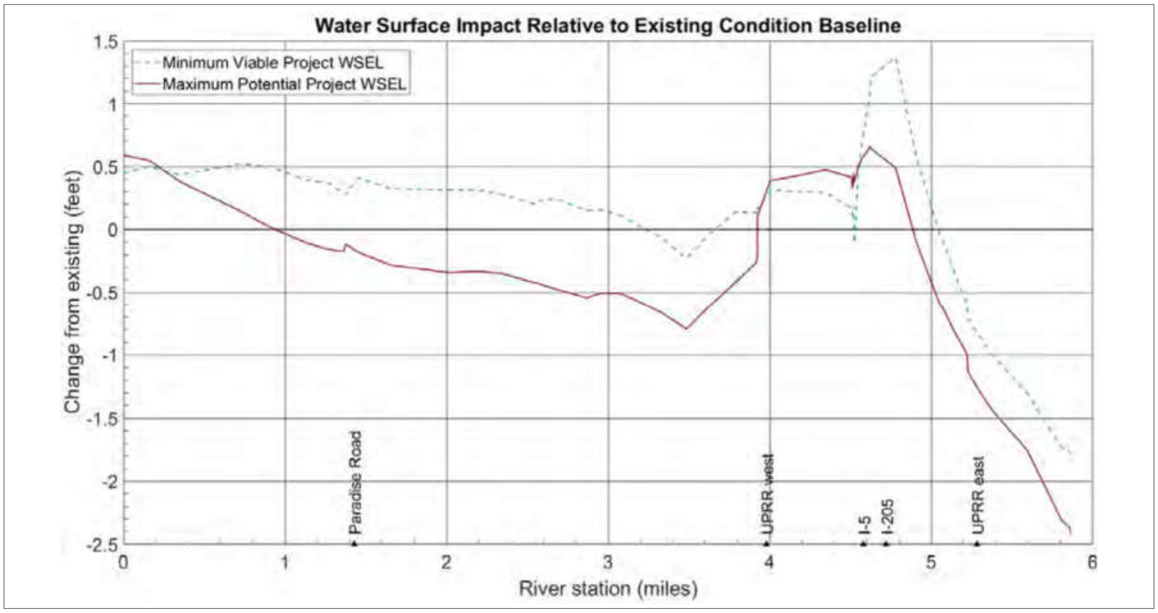
Figure 1
Estimated Changes in Flow Regimes within the Project Area under the 1997 Flood Scenario

5.1.2 Water Surface Elevations

Noteworthy increases in water surface elevations (or "stage") were isolated to three locations within the project area:

- Paradise Cut downstream of the Union Pacific Railroad tracks east of I-205 (UPRR east)
- Old River downstream of Stewart Tract
- Grant Line Canal downstream of Stewart Tract

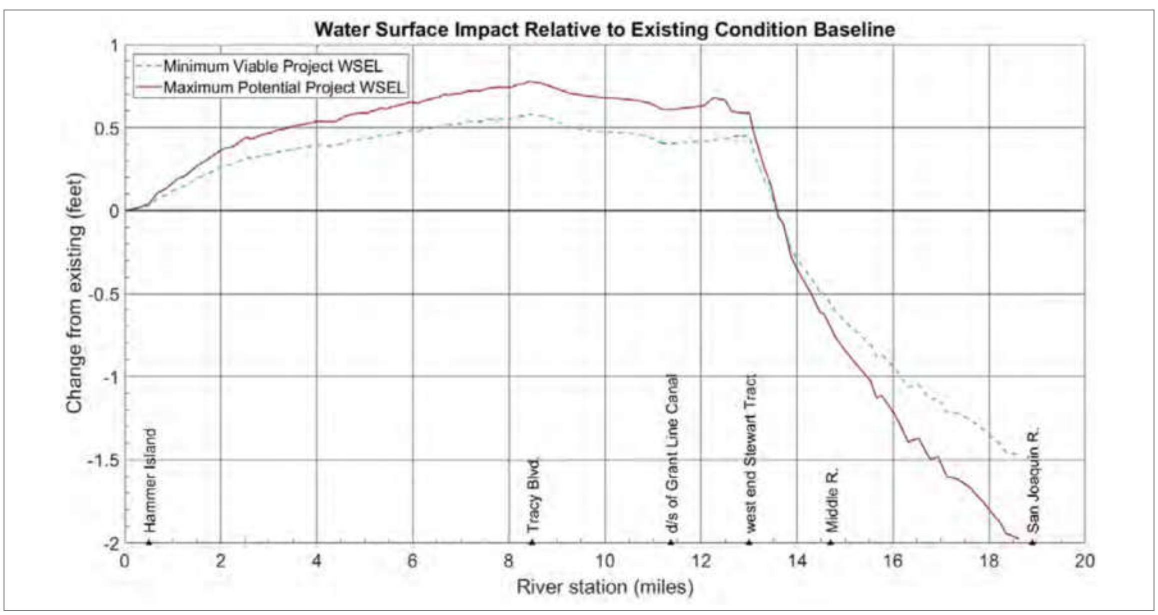
Stage increases within Paradise Cut are part of the intended function of the project: moving water from the San Joaquin River through Paradise Cut to reduce flood risks to the urbanized areas of Lathrop, Manteca, and Stockton. The maximum stage increase with Paradise Cut occurs near the I-205 underpass (**Figure 2**). Conveyance within Paradise Cut improves significantly for a mile downstream of I-5, but then stage increases steadily to a maximum of 0.5 feet above existing conditions at the west end of Stewart Tract.



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 2
Changes in Water Surface Elevations within Paradise Cut under the 1997 Flood Scenario

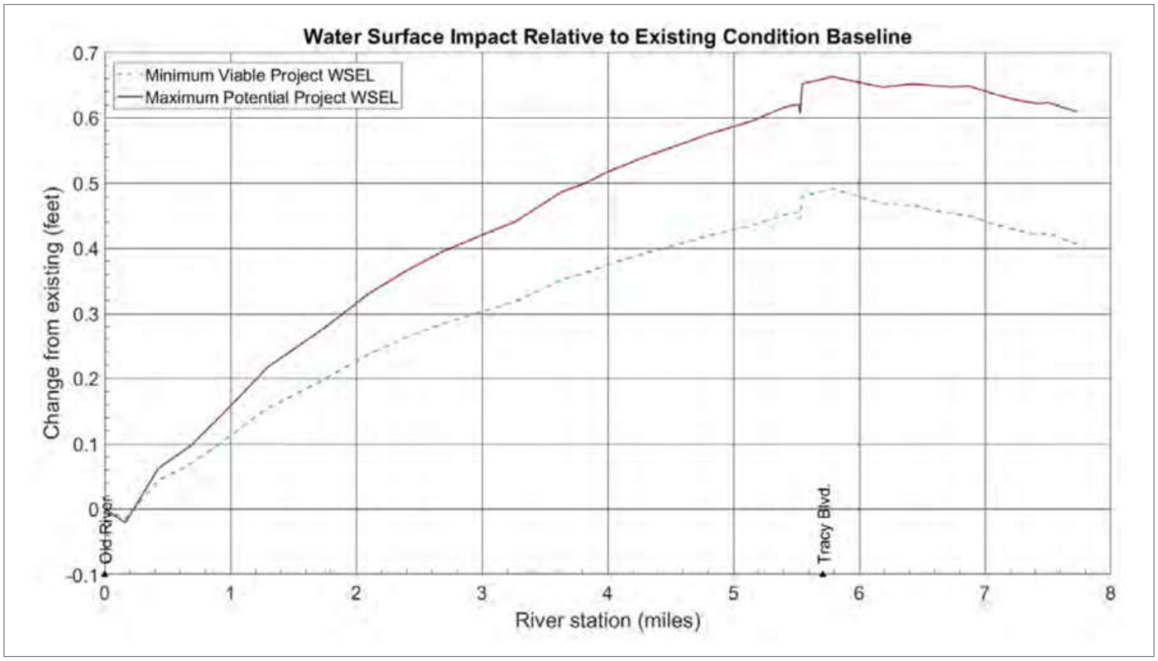
Stage increases at the west end of Stewart Tract continue downstream of the confluence with Old River peaking at ~0.6 ft above existing conditions at the flow constriction under Tracy Blvd then declining steadily to zero as Old River approaches Hammer Island (**Figure 3**). Significant stage reductions are observed between the upstream split with the San Joaquin River through Paradise Cut adjacent to Stewart Tract.



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 3
Changes in Water Surface Elevations within Old River under the 1997 Flood Scenario

Stage increases are similar within Grant Line Canal though peak water surface elevations are slightly less at 0.5 feet above existing condition at flow construction under Tracy Blvd. As with Old River, stage increases decline steadily to zero as Grant Line Canal approaches the confluence with Old River (**Figure 4**).



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 4
Changes in Water Surface Elevations within Grant Line Canal under the 1997 Flood Scenario

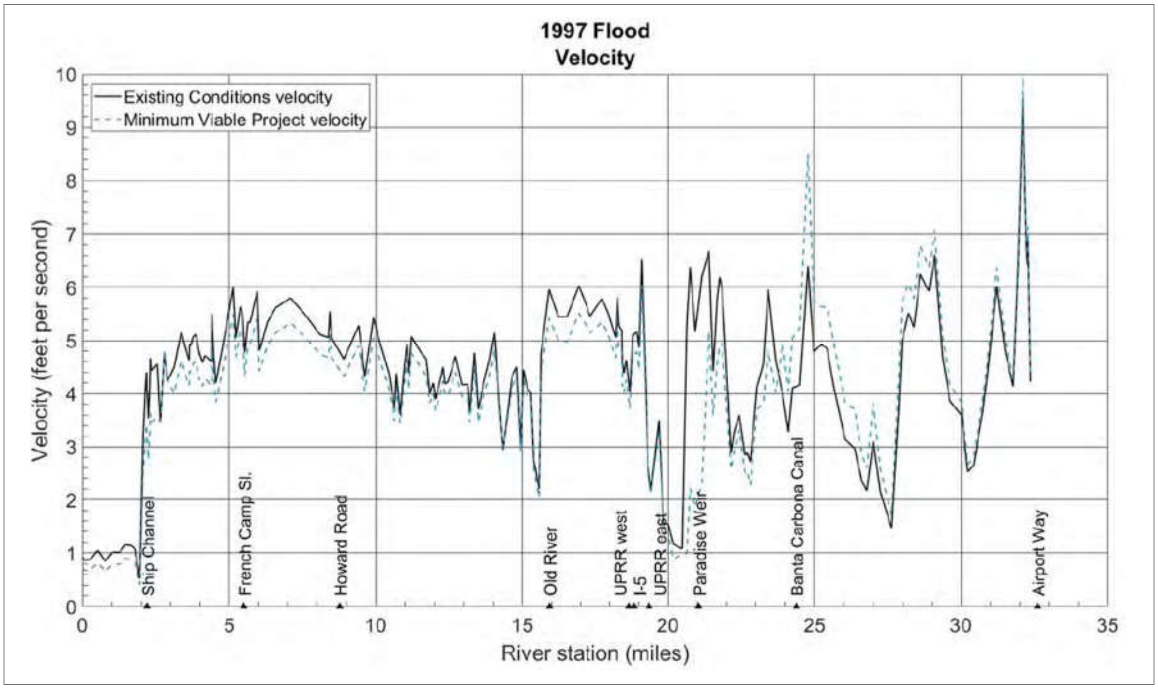
5.1.3 Average Velocities

Increases in velocity were observed at several isolated locations within the project area:

- The San Joaquin River at the Banta-Carbona Canal (adjacent to the proposed new weir)
- Paradise Cut downstream of underpasses with I-205, UPPR west, and Paradise Road
- Grant Line Canal downstream of Tracy Blvd.

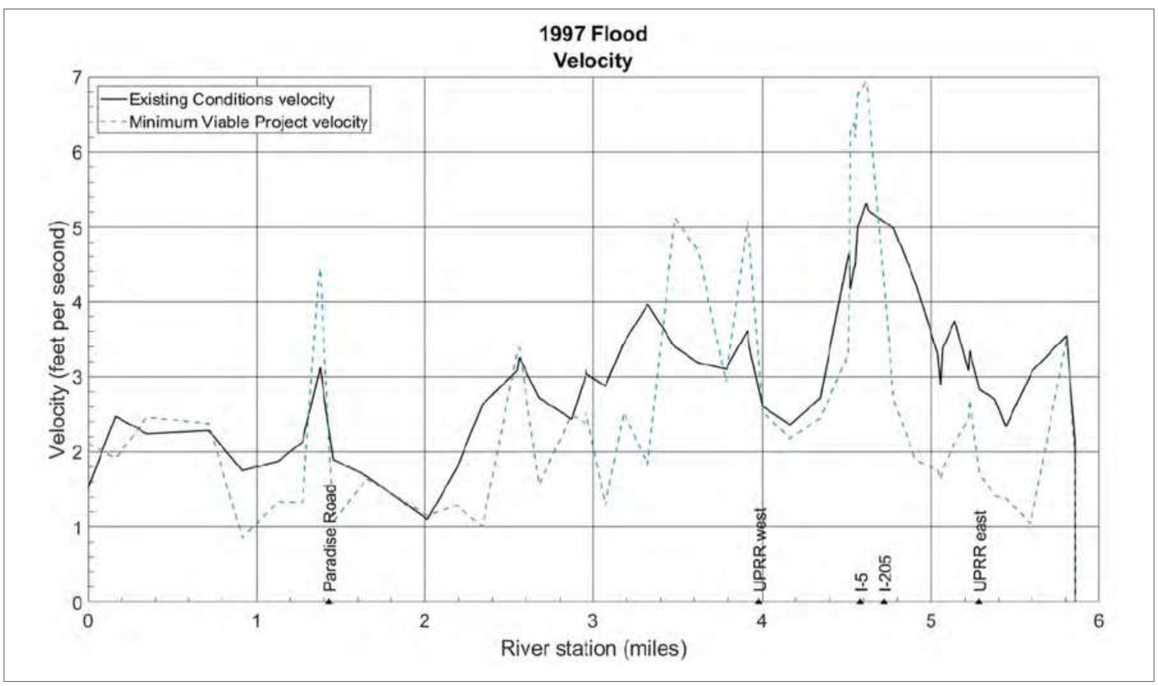
Under the 1997 flood scenario, velocity upstream of Banta Carbona Canal increases from approximately 6.5 ft/s to 8.5 ft/s (**Figure 5**).

The maximum velocity observed along Paradise Cut occurs below the I-5 and 1-205 overpasses where velocity climbs from approximately 5.3 ft/s up to 7 ft/s (**Figure 6**). Downstream of UPRR west and Paradise Road, maximum values range between 4.5 and 5 ft/s.



NOTE: Right end of graph is upstream and water flows from right to left along graph.

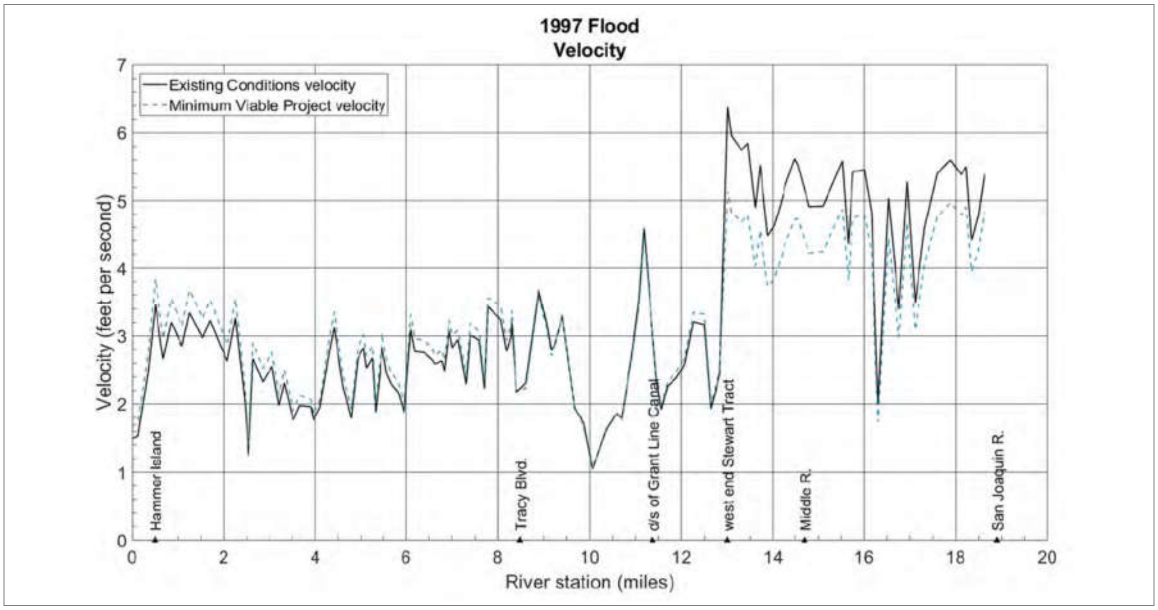
Figure 5
Velocity Profiles Along the San Joaquin River under the 1997 Flood Scenario



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 6
Velocity Profiles within Paradise Cut under the 1997 Flood Scenario

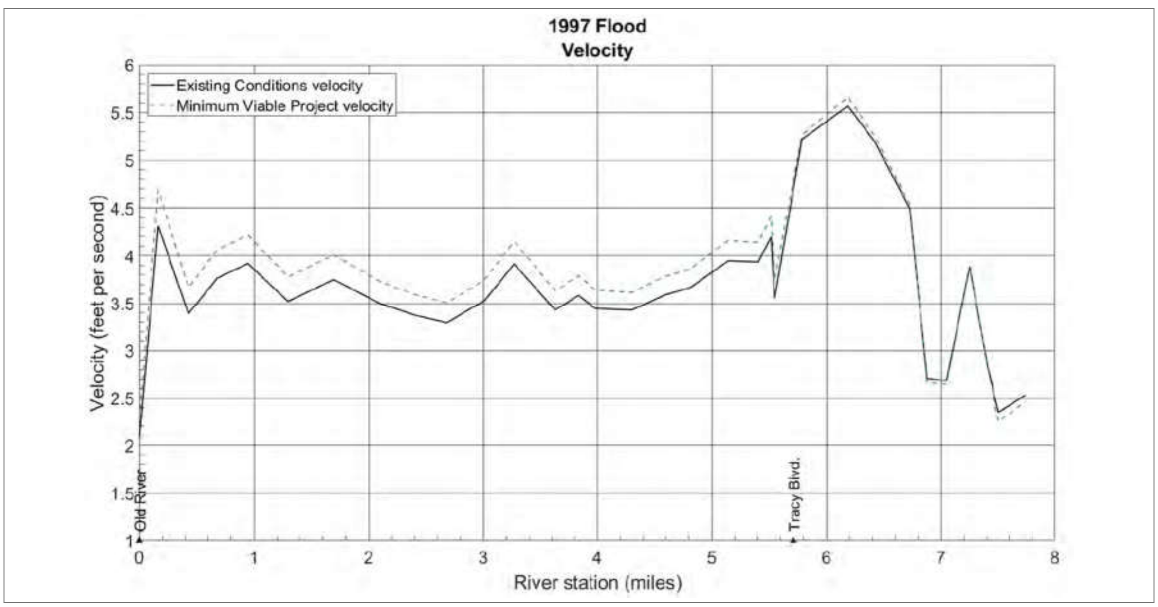
Very small velocity increases are observed in Old River downstream of Tracy Blvd. (**Figure 7**). The greatest increase occurs upstream of Hammer Island where velocity goes from 3.4 ft/s to 3.8 ft/s.



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 7
Velocity Profiles Along Old River under the 1997 Flood Scenario

Similar to Old River, very small velocity increases are observed in Grant Line Canal downstream of Tracy Blvd. (**Figure 8**) where estimated velocity increases average 0.3 ft/s.



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 8
Velocity Profiles Along Grant Line Canal under the 1997 Flood Scenario

5.2 Potential Negative Hydraulic Impacts

Changes in hydraulic conditions have the potential to impact the performance of the channels (rivers and canals) and structures (levees, weirs, etc.) that comprise the flood management system. Changes in hydraulic condition of channels may result in excess erosion of the bed and banks, which can in turn result in localized sedimentation elsewhere in the system. The beginning of this section will discuss the potential impacts of erosive forces based on the velocity profiles presented in the previous section. The discussion will then follow with an overview of the potential impacts of increased stage on the leveed system.

5.2.1 Erosion of the Channel Boundary

Channel boundaries are typically comprised of a variety of materials including sediments, bedrock, vegetation, debris, and hydraulic structures. Each of these materials can withstand a range of hydraulic forces before the material is compromised. Much work has been done to define the "permissible" velocities of channel materials and Fischenich (2001) includes a highly regarded compilation of this work.

Soils that comprise the boundary of the San Joaquin River and distributaries are readily mobilized by significant floods such as the 1997 event. Bank vegetation and various revetments (e.g. rock slope protection) that cover and integrate with the soil can prevent erosion of the banks and levees. **Table 2** shows the maximum velocity that various materials can withstand before becoming unstable and eroding.

American Rivers (2019) documents velocity values from a one-dimensional (1D) model that can only present velocity in terms of cross-sectional averages. In reality, peak velocities typically occur along the thalweg of a river where most of the river current is funneled or along the outside of a tight meander bend where helical flow patterns concentrate hydraulic forces. Regardless, the average velocities reported under with-project conditions can be managed with numerous vegetative or biotechnical measures or placement of riprap. Measures will vary based on the setting and risks to be managed. A two-dimensional hydraulic model of project area would allow for more precise (and potentially higher) velocity estimates.

5.2.2 Sedimentation within the Channel

Sedimentation occurs when the amount of sediment transported from upstream exceeds the transport capacity of the channel it enters. In this context, sediment mobilized through upstream erosion can result in downstream sedimentation. In addition, changes in flow regimes or channel geometry under with-project conditions (e.g., widening) can reduce velocities and cause sediment or other mobilized materials to deposit. Though erosion and sedimentation are natural processes for rivers, excess sedimentation can result in a loss of channel capacity, localized erosion of adjacent riverbanks, and increased flood stages.

Sedimentation patterns are more difficult to assess and typically require a sediment transport model that can evaluate changes in sediment transport capacity over space and time. A sediment transport model has not been developed for the project area at this time. Local landowners and the

South Delta Water Agency have observed sedimentation in South Delta channels which has reduced channel capacity in several locations. There are multiple important questions related to this sedimentation which will require further investigation in future phases of Project planning:

- The extent of sedimentation in key locations and channels
- The extent to which this sedimentation is a project of flow dynamics in Paradise Cut (as opposed to the larger hydrodynamics of the South Delta as a whole
- The extent to which the Project may be expected to change sedimentation patterns in the selected locations

TABLE 2
PERMISSIBLE SHEAR AND VELOCITY FOR SELECTED LINING MATERIALS

Boundary Category	Boundary Type	Permissible Shear Stress (lb/sq ft)	Permissible Velocity (ft/sec)	Citation(s)
Soils	Fine colloidal sand	0.02 - 0.03	1.5	A
	Sandy loam (noncolloidal)	0.03 - 0.04	1.75	A
	Alluvial silt (noncolloidal)	0.045 - 0.05	2	A
	Silty loam (noncolloidal)	0.045 - 0.05	1.75 – 2.25	A
	Firm loam	0.075	2.5	A
	Fine gravels	0.075	2.5	A
	Stiff clay	0.26	3 – 4.5	A, F
	Alluvial silt (colloidal)	0.26	3.75	A
	Graded loam to cobbles	0.38	3.75	A
	Graded silts to cobbles	0.43	4	A
	Shales and hardpan	0.67	6	A
Gravel/Cobble	1-in.	0.33	2.5 – 5	A
	2-in.	0.67	3 – 6	A
	6-in.	2.0	4 – 7.5	A
	12-in.	4.0	5.5 – 12	A
Vegetation	Class A turf	3.7	6 – 8	E, N
	Class B turf	2.1	4 - 7	E, N
	Class C turf	1.0	3.5	E, N
	Long native grasses	1.2 – 1.7	4 – 6	G, H, L, N
	Short native and bunch grass	0.7 - 0.95	3 – 4	G, H, L, N
	Reed plantings	0.1-0.6	N/A	E, N
	Hardwood tree plantings	0.41-2.5	N/A	E, N
Temporary Degradable RECPs	Jute net	0.45	1 – 2.5	E, H, M
	Straw with net	1.5 – 1.65	1 – 3	E, H, M
	Coconut fiber with net	2.25	3 – 4	E, M
	Fiberglass roving	2.00	2.5 – 7	E, H, M
Non-Degradable RECPs	Unvegetated	3.00	5 – 7	E, G, M
	Partially established	4.0-6.0	7.5 – 15	E, G, M
	Fully vegetated	8.00	8 – 21	F, L, M
Riprap	6 – in. d_{50}	2.5	5 – 10	H
	9 – in. d_{50}	3.8	7 – 11	H
	12 – in. d_{50}	5.1	10 – 13	H
	18 – in. d_{50}	7.6	12 – 16	H
	24 – in. d_{50}	10.1	14 – 18	E
Soil Bioengineering	Wattles	0.2 – 1.0	3	C, I, J, N
	Reed fascine	0.6-1.25	5	E
	Coir roll	3 - 5	8	E, M, N
	Vegetated coir mat	4 - 8	9.5	E, M, N
	Live brush mattress (initial)	0.4 – 4.1	4	B, E, I
	Live brush mattress (grown)	3.90-8.2	12	B, C, E, I, N
	Brush layering (initial/grown)	0.4 – 6.25	12	E, I, N
	Live fascine	1.25-3.10	6 – 8	C, E, I, J
	Live willow stakes	2.10-3.10	3 – 10	E, N, O
Hard Surfacing	Gabions	10	14 – 19	D
	Concrete	12.5	>18	H

[1] Ranges of values generally reflect multiple sources of data or different testing conditions.

A. Chang, H.H. (1988).
B. Florineth. (1982)
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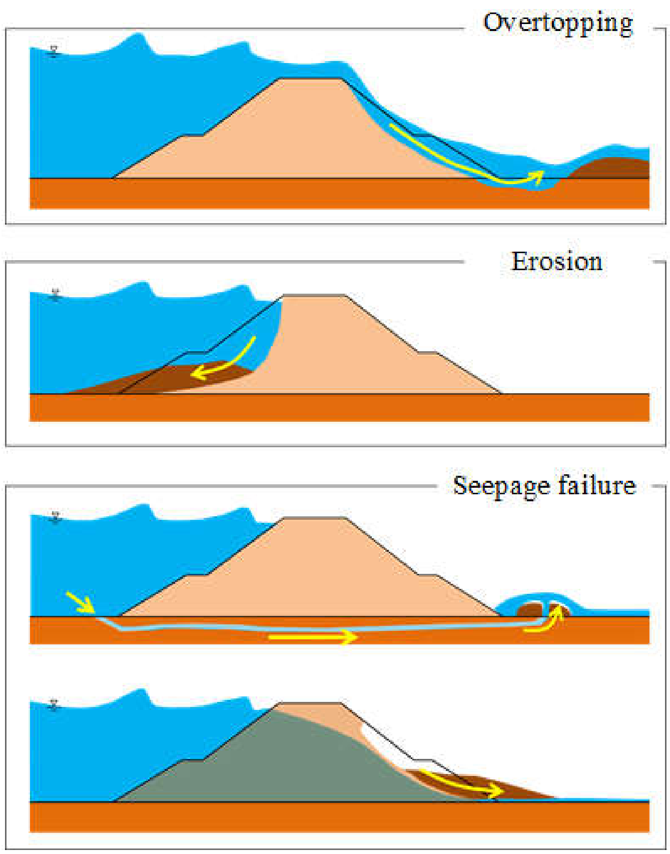
K. Sprague, C.J. (1999).
L. Temple, D.M. (1980).
M. TXDOT (1999)
N. Data from Author (2001)
O. USACE (1997).

SOURCE: Fischenich 2001

5.2.3 Modes of Levee Failure

Leveed systems are subject to increased hydraulic forces during flood events. As discussed, increased velocities can result in erosion of the levee foundation (the floodplain or riverbank) or embankment (the levee itself). Increases in flood stage can also exert additional pressure on the levee and result in increased seepage of water through the levee or underneath the levee (**Figure 9**). Additional water within the soils of the levee can increase the specific weight of materials, create geotechnical instabilities, and result in failures of the levee slope. Seepage through the levee or foundation can create preferential flow paths and piping of the soils, which can also lead to internal erosion and geotechnical failure. Finally, increases in flood stage that exceed the levee crest can result in overtopping of the levee, erosion (or jetting) of the landside levee face, and breaching of the levee.

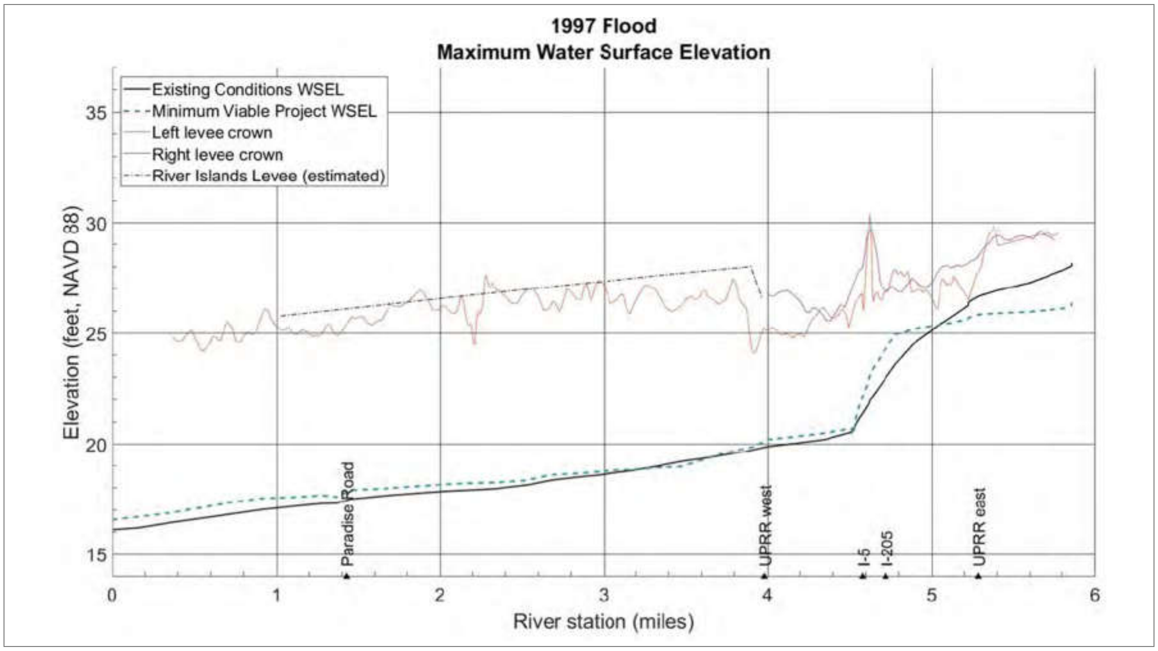


SOURCE: PWRI Web Magazine.

Figure 9
Schematic Illustration of Modes of Levee Failure

Overtopping Evaluation

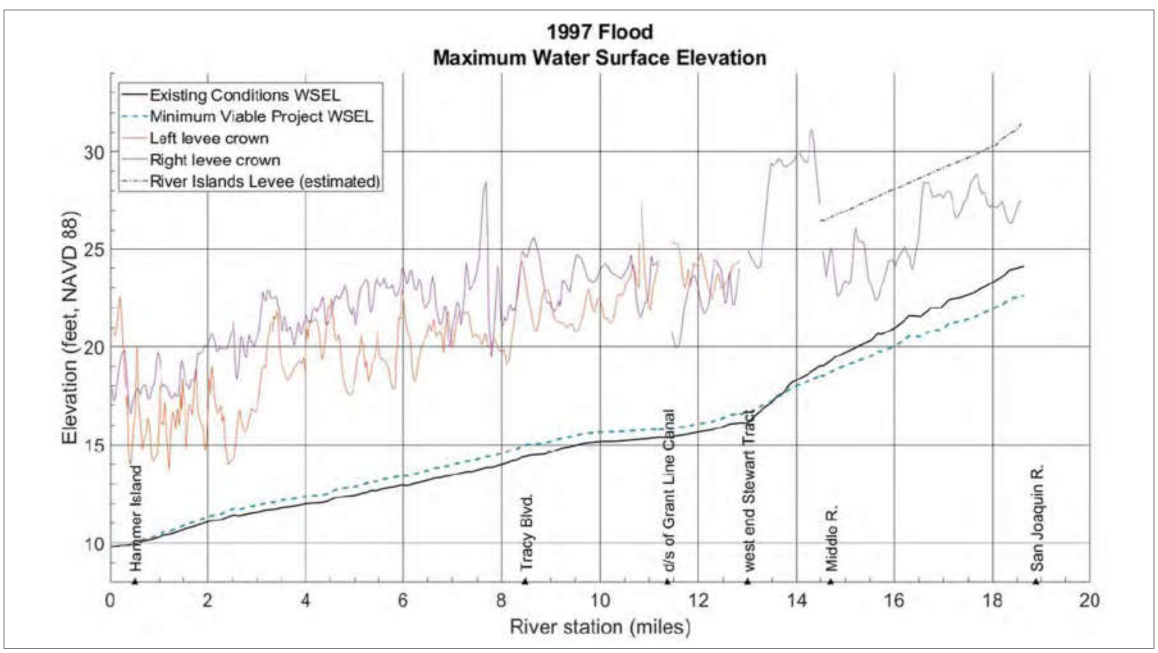
A preliminary evaluation of overtopping potential under the 1997 flood scenario was conducted as part of American Rivers (2019). It was found that all increases in stage under the with-project condition are well within the existing freeboard of the leveed system and therefore do not pose any overtopping hazard. Stage increases in Paradise Cut are within two feet of the right levee crown near I-205.



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 10
Comparison of Top-of-Levee Profiles and Water Surface Elevations within Paradise Cut under the 1997 Flood Scenario

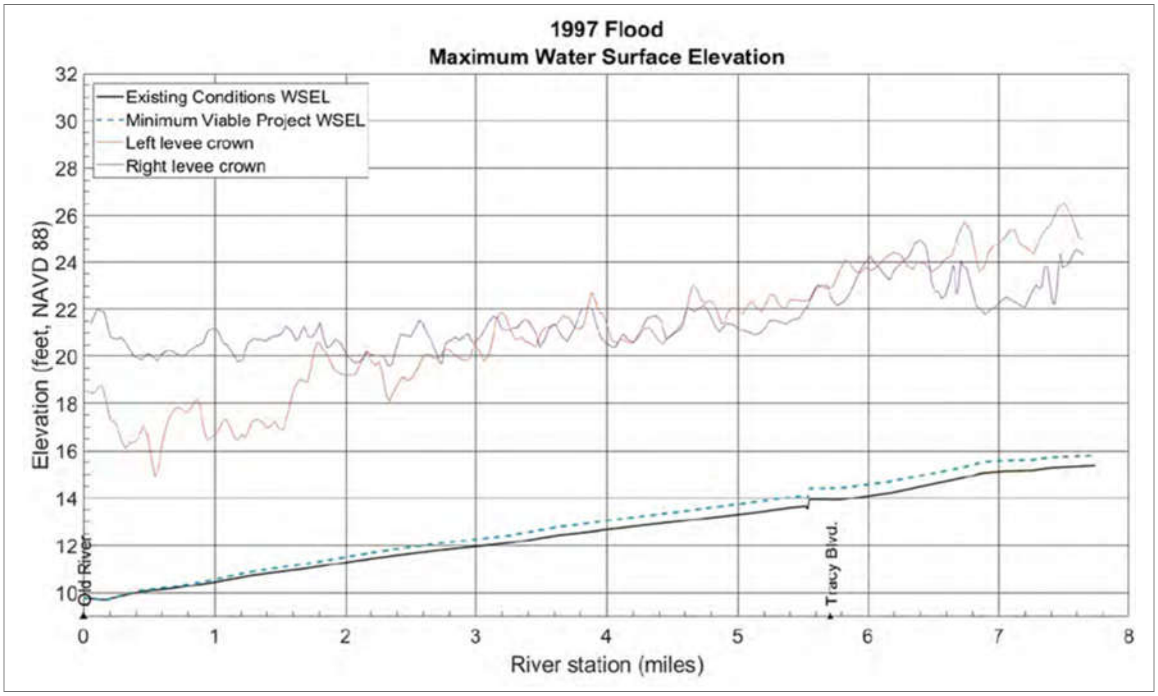
Minor increases in flood stage west of Stewart Tract in Old River are far below the top of levee and significant freeboard remains (**Figure 11**). Freeboard is reduced to approximately three feet along the left levee crown a couple miles upstream of Hammer Island.



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 11
Comparison of Top of Levee Profiles and Water Surface Elevations within Old River under the 1997 Flood Scenario

Grant Line Canal has significant capacity relative to Old River and moderate increases in flood stage under the with-project scenario remain several feet below either levee crest. The most constrained freeboard occurs approximately 0.5 miles upstream of the confluence with Old River, where freeboard is five feet above the water surface elevation of the 1997 flood scenario; however at this location, there is practically no difference between existing conditions and with-project conditions (a 0.05-foot stage increase).



NOTE: Right end of graph is upstream and water flows from right to left along graph.

Figure 12
Top of Levee Profiles and Water Surface Elevations within Grant Line Canal under the 1997 Flood Scenario

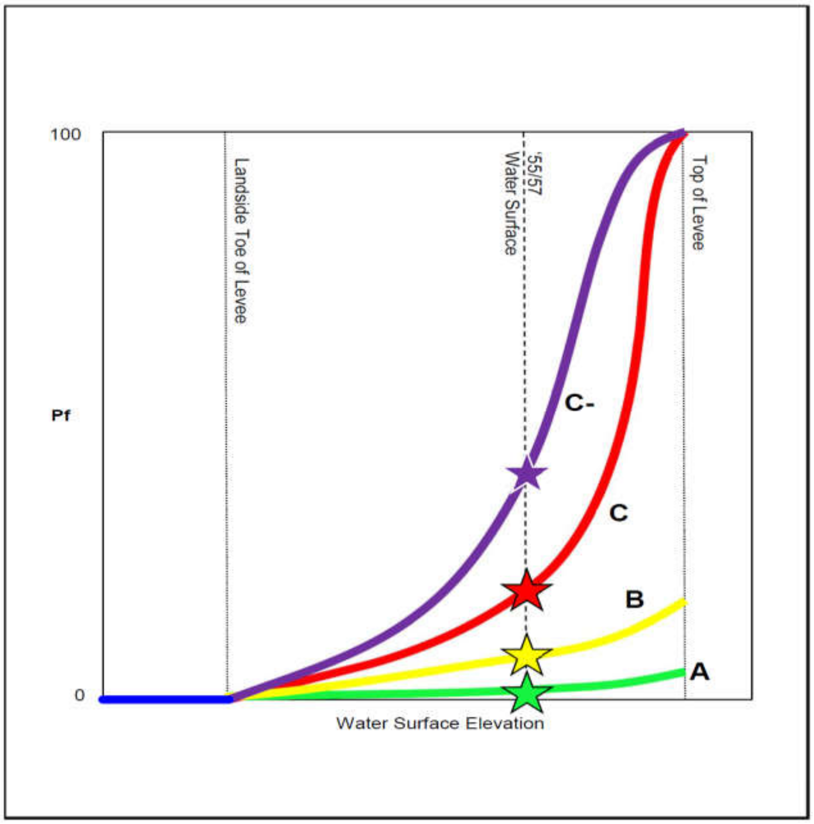
Though overtopping is not anticipated to occur anywhere under the 1997 flood scenario, increases in flood stage and incremental loss of freeboard should be further evaluated using risk and uncertainty methods (e.g. HEC-FDA) to assess any increase in annual overtopping probability (AOP) over the total range of potential flood events.

Levee Performance Curves and Hazard Ratings

As part of the 2017 update to the Central Valley Flood Protection Plan (CVFPP), DWR developed a series of levee performance curves to support the economic modeling of planned flood risk reduction measures (URS 2015). Levee performance curves were developed for each mode of levee failure (e.g. through-seepage etc.) at a series of index points. The mode-specific performance curves were compiled into a cumulative curve at each index point to understand the overall probability of levee failure with increasing water surface elevations (**Figure 13**).

Levee performance curves are based on two parameters: the elevation of water against the levee relative to the landside toe of the levee and the probability of failure (Pf). As water surface elevations increase so does the probability of failure as more forces act on the levee. Levees built to modern design standards are less sensitive to an increase in water surface elevations. In other words, as water surface elevations rise there is a minor increase in the probability of failure. In contrast, levees with poor performance characteristics are more sensitive to increases in water surface elevations, which can result in a significant increase in the probability of failure.

For the CVFPP economic modeling effort, levees were graded on their historic or perceived future performance. Highly resilient levees were given an “A” rating, while the worst performing levees were given a “C-”. Figure 13 illustrates the range of performance curves and associated “hazard” ratings.



NOTE: Pf indicates the probability of levee failure. Steep performance curves (those with C and C- ratings) are more sensitive to changes in water surface elevations.

Figure 13
An Example of Levee Performance Curves and Associated Hazard Ratings (A through C-)

Index points are horizontal coordinates used to represent portions of levee systems evaluated as part of the CVFPP. Each index point was assigned a cumulative levee performance curve and hazard ratings for each of the four primary modes of levee failure. Five index points are located at the western end or downstream of Stewart Tract (**Figure 14**). Two of the index points are within Paradise Cut (SJ30 and SJ31b), two are associated with Old River (SJ40 and SJ42), and one is along the southern levee of Grant Line Canal (SJ41).

Figure 14
Index Points Located Downstream of Paradise Cut

The quality of levee performance data varies between the index points. Index points near Paradise Cut (SJ30, SJ31, and SJ40) have poor performance ratings for erosion and seepage-based modes of failure (**Figures 15-17**). As such, those performance curves are steeper and more sensitive to increases in water surface elevation. Performance curves further downstream on Grant Line Canal (SJ41) and Old River (SJ42) are less sensitive to increases in water surface elevations, but the individual hazard ratings and performance curves are based on limited data (LD) sources (**Figures 18-19**).

Although the 1997 flood scenario is considered the most realistic of the three hydrologic scenarios, the levee performance data were developed using water surface elevations associated with the original levee system design that dates back to 1955 or 1957 (the "Design" hydrologic scenario; see Table 1). Although the data have not been presented in this document, the maximum increase in the design water surface elevation (DWSE) under with-project conditions is approximately 0.3 feet at the specified areas of interest: Paradise Cut, Grant Line Canal, and Old River (American Rivers 2019). Using a common (unit) increase in water surface elevations allows for direct comparisons of sensitivity between levee performance curves and will help to identify areas that may require additional design measures to counteract negative hydraulic impacts.

The levee performance curves for the western end of Paradise Cut (SJ30 and SJ31b) are steep due to poor hazard ratings for erosion, through-seepage, and under-seepage modes of levee failure (**Figures 15 and 16**). At SJ30, a unit increase in the design water surface elevation increases the probability of levee failure by 19%. Similarly, a unit increase in water surface elevations at SJ31b (the levee opposite of SJ30) increases the probability of levee failure by 30%. Index point SJ40 is located on the right levee of Old River approximately 0.4 miles downstream of SJ30 and SJ31b. The SJ40 levee performance curve is very steep due to the very poor hazard ratings (C-) for erosion, through-seepage, and under-seepage. At this location, a unit increase in water surface elevations results in a 14% increase in the probability of failure.

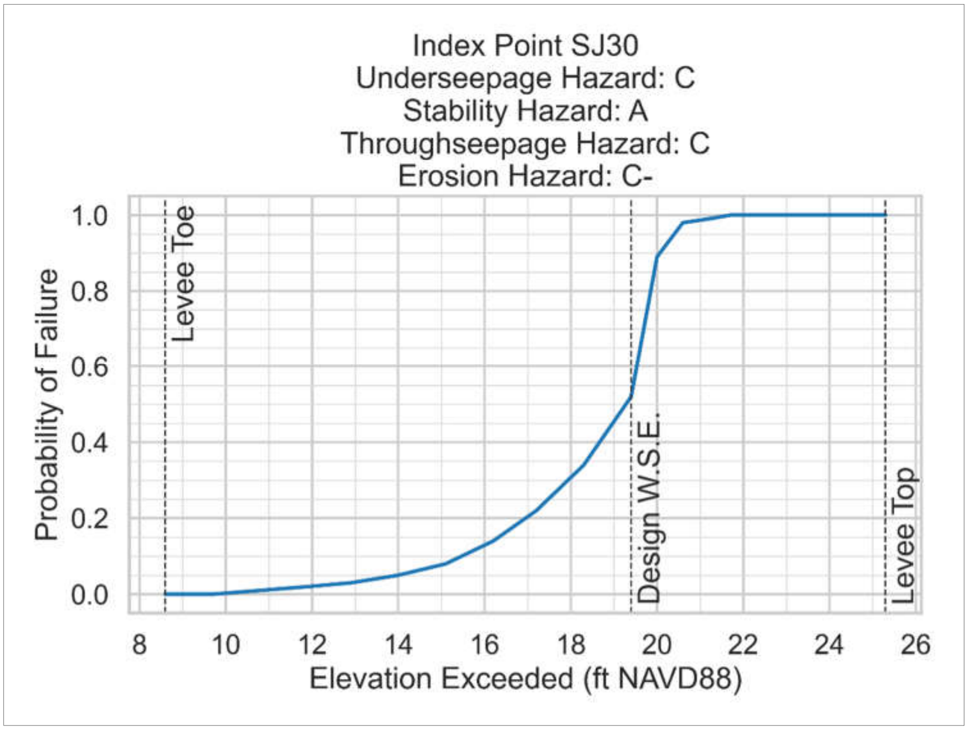


Figure 15
Levee Performance Curve for Index Point SJ30 Located on the Left Levee at the Western End of Paradise Cut

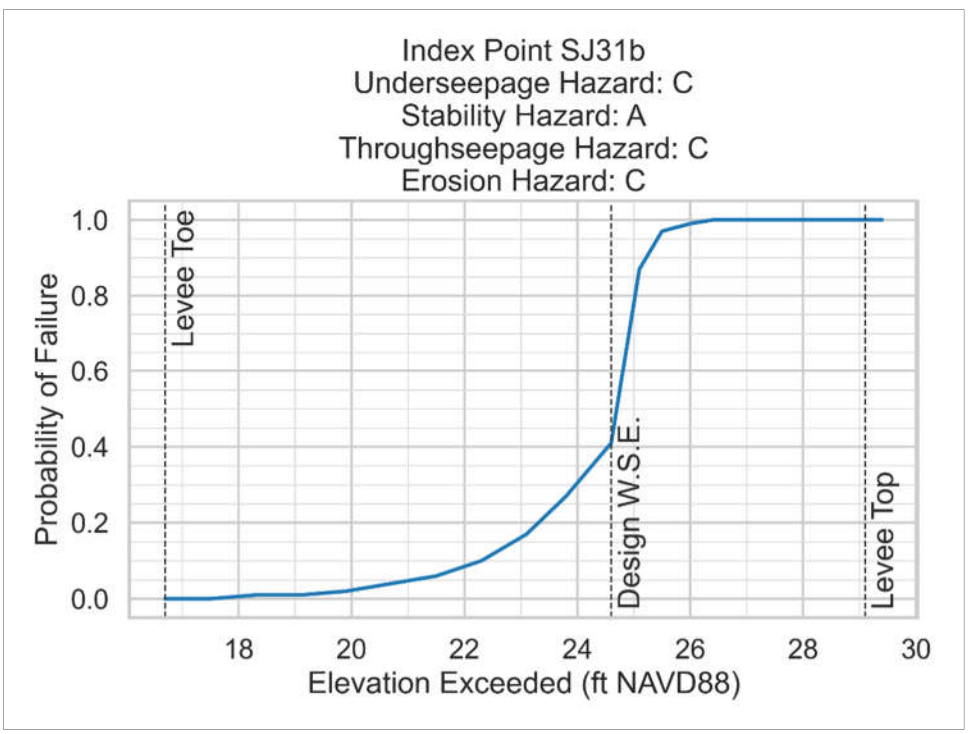


Figure 16
Levee Performance Curve for Index Point SJ31b Located on the Right Levee at the Western End of Paradise Cut

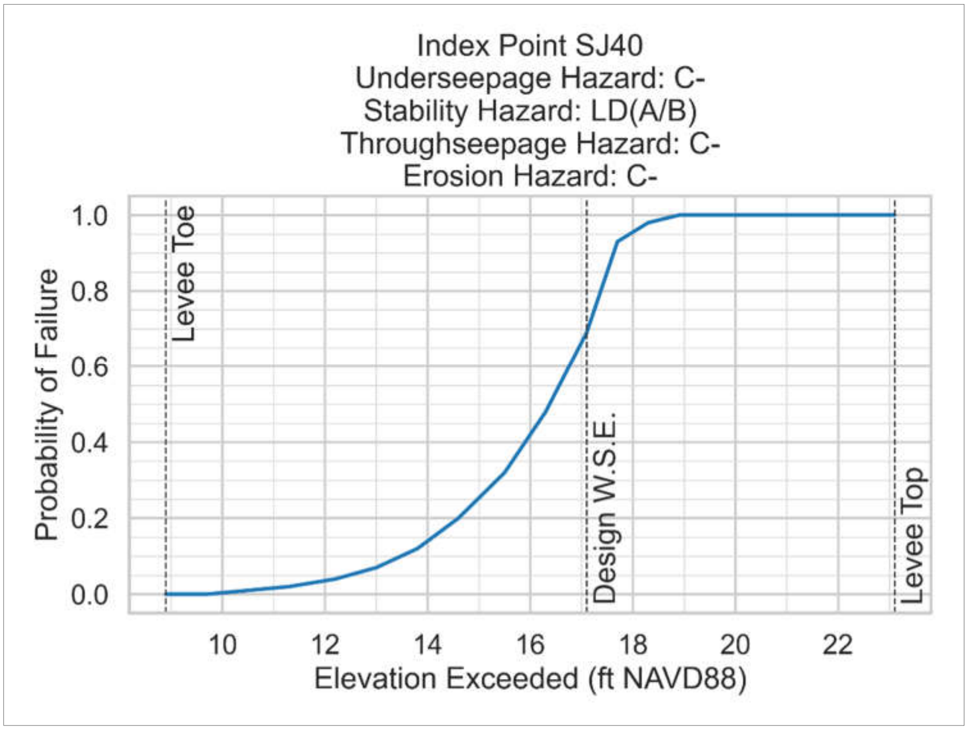


Figure 17
Levee Performance Curve for Index Point SJ40 Located on the Right Levee of Old River Just Downstream of the Paradise Cut

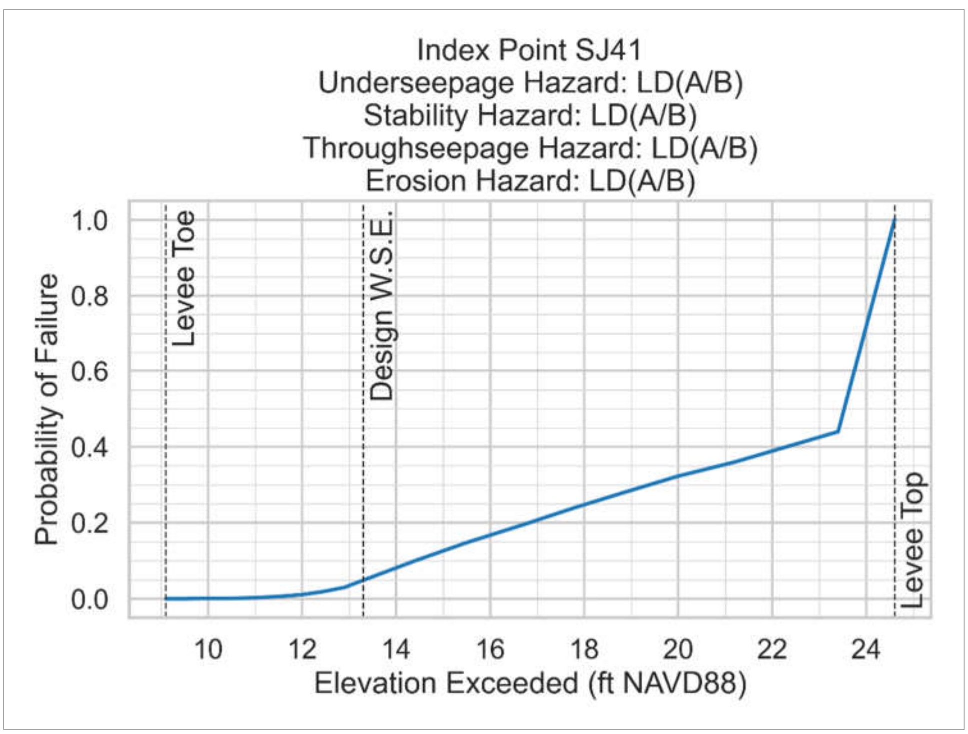


Figure 18
Levee Performance Curve for Index Point SJ41 Located on the Left Levee of Grant Line Canal

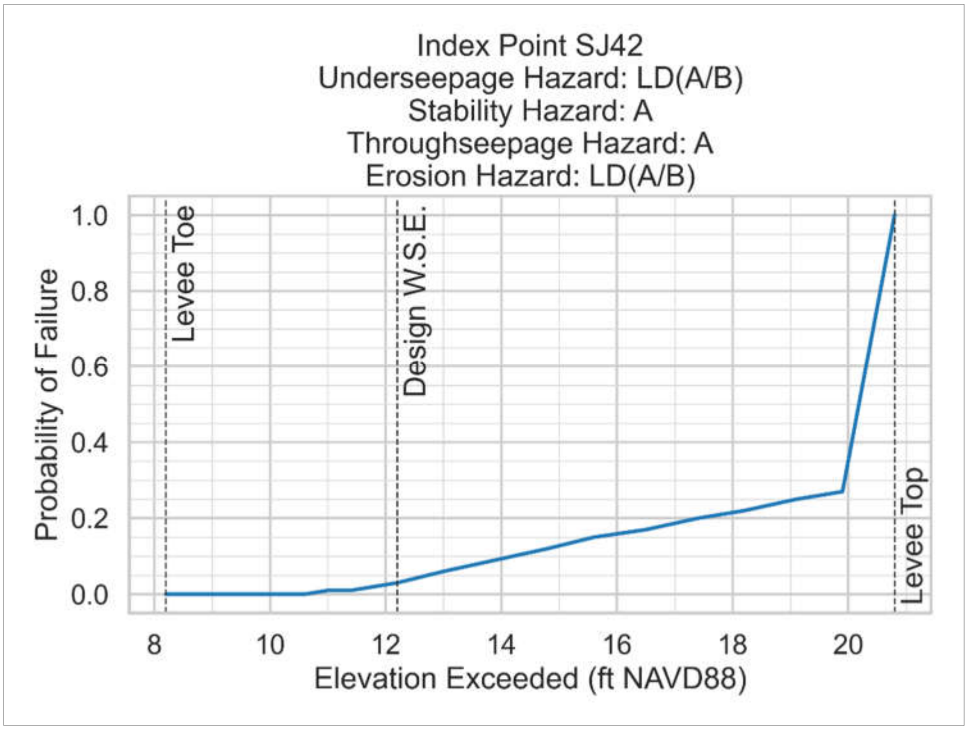


Figure 19
Levee Performance Curve for Index Point SJ42 Located on the Left Levee of Old River

The levee performance curves downstream of the Old River and Grant Line Canal split are poorly developed due to a lack of data but appear to be relatively insensitive to moderate changes in water surface elevations. The levee performance curve at SJ41 (**Figure 18**) is less steep due to good ratings across all modes of levee failure (A/B). Due to the lack of data, these ratings are based on the professional judgement of an expert panel (URS 2015). The levee performance curve at SJ42 (**Figure 19**) is less steep than SJ41 due to the excellent ratings (A) for stability and through-seepage and good ratings (A/B) for erosion and under-seepage. A unit increase in water surface elevations at SJ41 or SJ42 results in a 2% increase in the probability of failure.

A summary of levee hazard ratings for each of the five index points and changes in the probability of failure due to a unit increase of 0.3 ft in water surface elevations during the design flood scenario are provided in **Table 3** below. The data show that the probability of failure for three of the leveed systems (SJ30, SJ31b, and SJ40) increases from 14-30% under with-project conditions. Two other leveed systems (SJ41 and SJ42) show a two percent increase in probability of failure, but also have hazard ratings based on limited geotechnical data. At this time, the five index points that have been discussed are not associated with significant stability hazards (all have an A or A/B rating). Stability hazard ratings for SJ40 and SJ41 are based on limited data and professional judgement.

TABLE 3
HAZARD RATINGS AND POTENTIAL CHANGES IN THE PROBABILITY OF FAILURE AT FIVE INDEX POINTS

Index Point	River	Design WSE*	Hazard Rating[1]				Probability of Failure (Pf)		
			Erosion	Stability	Through-seepage	Under-seepage	DWSE	DWSE + 0.3 ft	Change in Pf
SJ30	Paradise Cut	19.3	C-	A	C	C	51%	70%	19%
SJ31b	Paradise Cut	24.6	C	A	C	C	40%	70%	30%
SJ40	Old River	17.1	C-	LD (A/B)	C-	C-	69%	83%	14%
SJ41	Grant Line	13.2	LD (A/B)	LD (A/B)	LD (A/B)	LD (A/B)	5%	7%	2%
SJ42	Old River	12.2	LD (A/B)	A	A	LD (A/B)	3%	5%	2%

NOTES:
* ft NAVD88
1 LD signifies "lacking data"

5.2.4 Other Potential Issues

In the public meeting hosted by the San Joaquin County RCD on April 23, audience members identified additional potential issues related to the hydraulics and potential impacts of the Project that should be considered in future engineering and restoration design efforts:

- Ensuring that dredging or any other Project action does not change the flow split between Old River and Grant Line Canal
- Ensuring that the effect of State Water Project and Central Valley Project export pumps, which periodically cause flows to reverse in some South Delta channels and can pull in fish, are considered in both the engineering and restoration designs of the Project
- Assessing locations where levees no longer conform to their original design specifications, particularly with regard to waterside slopes, which have become too steep in some locations
- Assessing potential benefits of additional flows in Tom Paine Slough
- Assessing potential benefits of dredging upper portion of Paradise Cut
- Assessing potential impacts of channel dredging on irrigation water access, particularly in cases where lowering the bed of the channel could increase pumping requirements
- Ensuring that the Project retains access to all pumps and pipelines to ensure that they can be maintained properly in perpetuity

- Assessing the potential opportunities presented by River Islands' plans to degrade the federal project levee along Paradise Cut and Old River, which if approved and implemented would result in a large high-ground bench on the waterside of new levees along those reaches

- Ensuring that robust data collection on river elevations and levee conditions is used to inform all models and designs

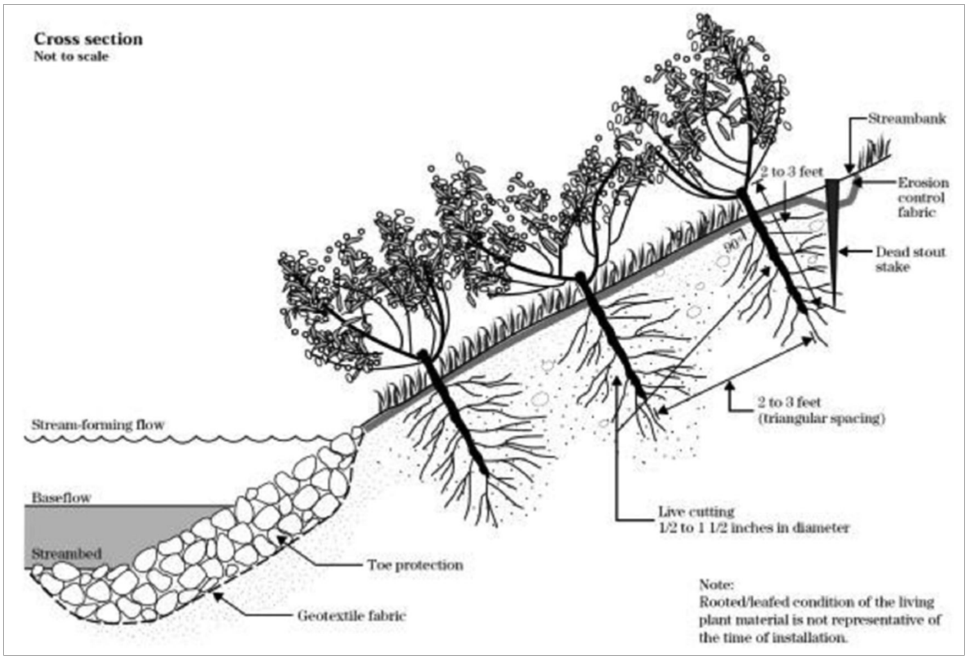
- Assessing the long-term fiscal impact on Reclamation District 2095, which is where most new flowage easements would need to be obtained under the current Project design

5.3 Hydraulic Impact Avoidance and Mitigation Strategies and Potential Design Measures

Hydraulic impacts that result in a relatively minor increase in the probability of failure may not require additional physical design measures to address those impacts. In those instances, monitoring and maintenance measures may prove more cost effective in the long run. By contrast, hydraulic impacts that could result in a significant decrease in levee performance could require design measures tailored to the prominent modes of levee failure and site-specific channel conditions. The following sections describe the types of measures that could be included in future design iterations to address areas with a significant reduction in levee performance under the with-project conditions outlined in the conceptual design memo.

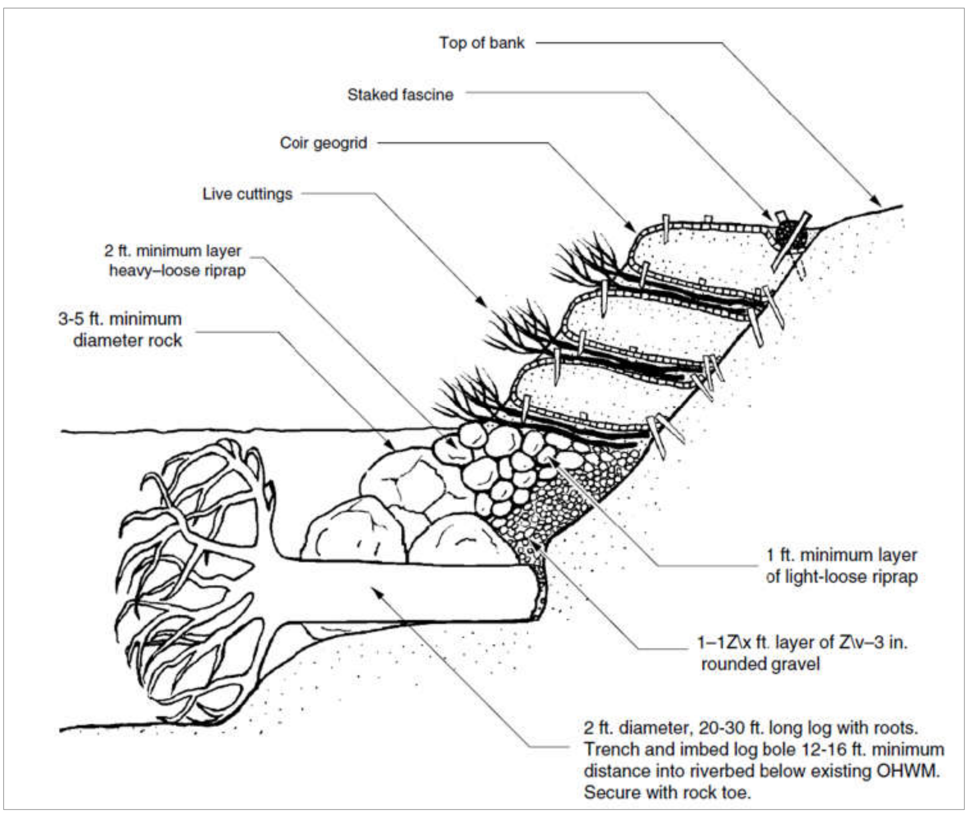
5.3.1 Erosion Countermeasures

As discussed in Section 4.2.1, a variety of materials could be applied to channel banks or levee slopes to address erosion concerns. For the range of average velocities that are estimated under the 1997 flood scenario (7 ft/s or less on all drainages), numerous vegetation-based, rolled erosion control products (RECPs), and/or soil bioengineering measures could apply (two options are illustrated in **Figures 20-22**). These types of measures could be selected over rock slope protection and hardscaping to promote vegetative growth and generally more suitable habitat conditions. In the past, the US Army Corps of Engineers (USACE) has generally not allowed the intentional planting of vegetation on levees that are part of federal flood control projects, which in this case includes the levees running along the left bank of Paradise Cut to the Old River confluence and along the right bank of Paradise Cut and then Old River until its confluence with Grant Line Canal. Any strategy to vegetate levees in this reach would have to be developed in close consultation with USACE. Levees further downstream of Paradise Cut (e.g. along Doughty Cut, Grant Line Canal, and Old River west of its confluence with the southern channel of Paradise Cut) are not subject to USACE rules in this regard. Vegetated levees are considered a nature-based solution that could meet flood risk management objectives while improving geomorphic processes and providing ecological uplift. Projects that incorporate nature-based solutions are also more competitive for grant funding.



SOURCE: Lyn and Newton 2015

Figure 20
Fabric Cover Over Soil and Live Stake Plantings



SOURCE: USBR 2015

Figure 21
Vegetated Soil Lifts (or geogrids)

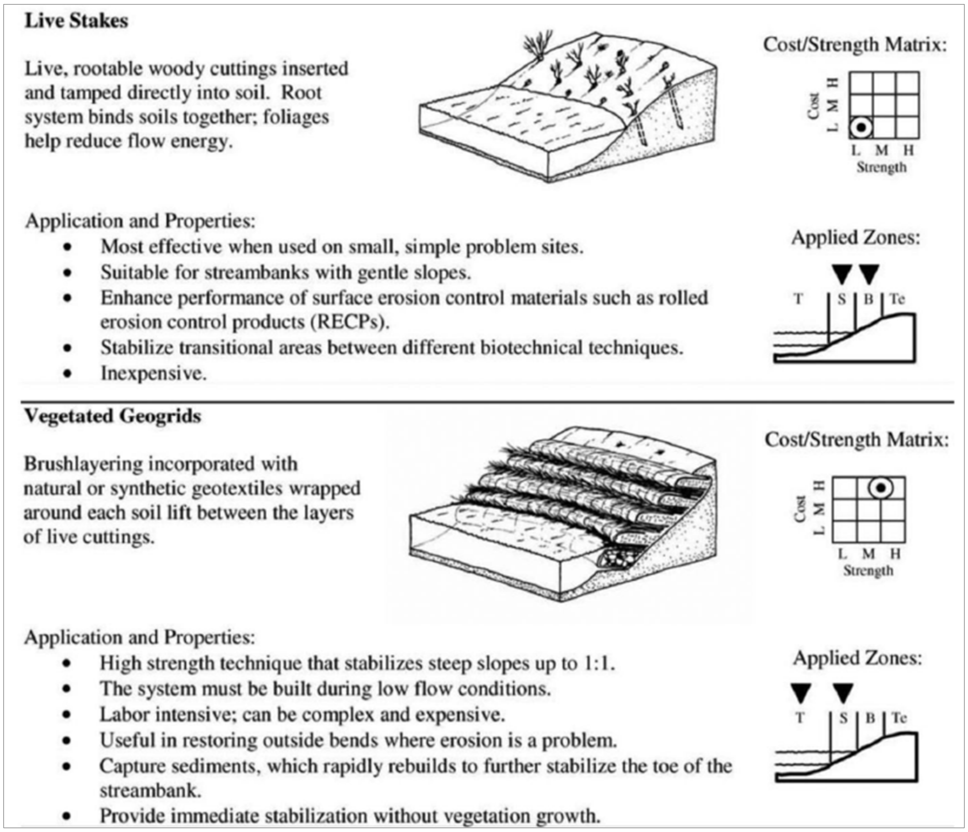


Figure 22
A Cost and Strength Comparison for Two Soil Bioengineering Methods that Could Be Used to Address Erosion Concerns

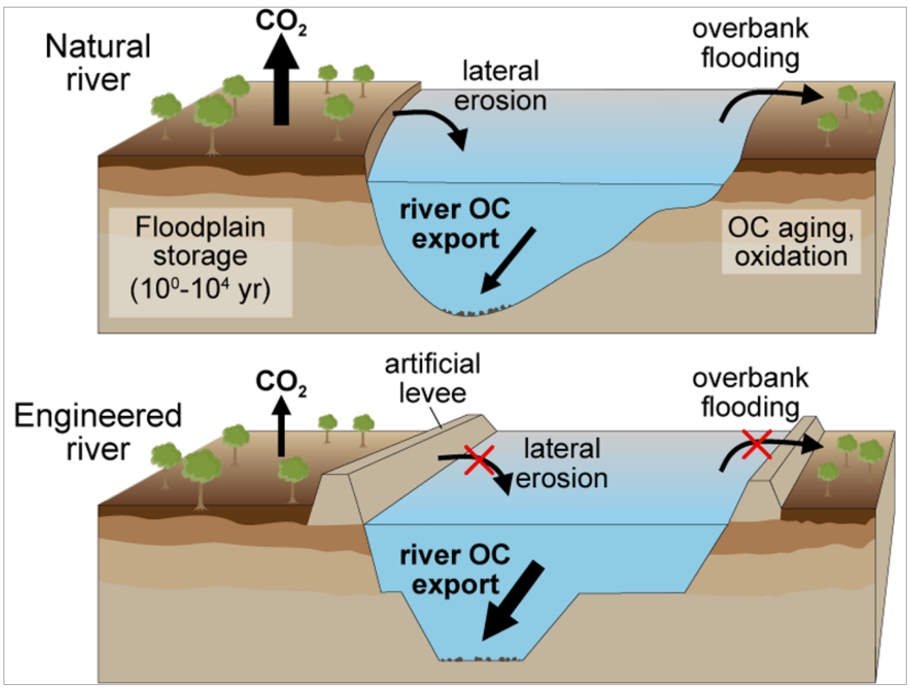
5.3.2 Sedimentation Countermeasures

Localized sedimentation concerns (though not identified at this time) could be addressed through changes in channel geometry or channel-to-floodplain connectivity. Changes in channel geometry are limited within the study area because the levees that border each drainage and the need to maintain levee freeboard. In areas with less physical constraints or where levee setbacks are possible, channels could be re-profiled and/or floodplains could be graded and replanted to promote more frequent floodplain inundation and overbank deposition of sediment (**Figure 23**). More analysis is required to determine if sedimentation issues exist, and if so, where changes in channel and floodplain geometry may prove helpful.

Sedimentation in Paradise Cut and other South Delta channels is a complex phenomenon that may be related both to periodic San Joaquin River flows through Paradise Cut and to tidal and other hydraulic dynamics in the South Delta. There are no sediment transport models of the lower San Joaquin River, so little is known about the extent of deposition resulting from periodic flows from the San Joaquin River over the existing Paradise Cut weir, or about what levels of sedimentation could be expected from the Project and where deposition would occur in various flow scenarios.

If future investigations show that the Project would result in additional sedimentation of South Delta channels, there is potential for this to be addressed (at least partially) through the reconnection of floodplains where sediment can be deposited in high flow situations. Generally speaking, sediment deposition occurs most readily in areas where the velocity of flow is slowing down. In areas where levee setbacks are possible, channels could be re-profiled and/or floodplains could be graded and replanted to promote more frequent floodplain inundation and overbank deposition of sediment. The area of flowage easements downstream of the new weir could also become a site of sediment deposition, depending upon flow dynamics. More analysis is required to determine if sedimentation issues exist, and if so, where changes in channel and floodplain geometry may prove helpful.

Floodplain restoration is considered a nature-based solution that could meet flood risk management objectives while improving geomorphic processes and providing ecological uplift. Projects that incorporate nature-based solutions are also more competitive for grant funding.



NOTE: Natural rivers with channel-to-floodplain connectivity allow for overbank flooding and sediment deposition which allows for oxidation and storage of carbon in the floodplain.

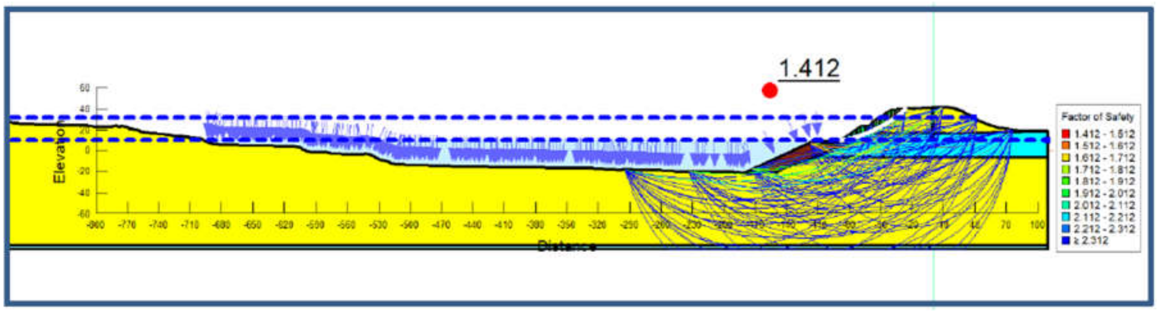
SOURCE: Repasch 2021.

Figure 23
Erosion, Sedimentation, and Carbon Cycling Processes for Natural and Engineered Rivers

5.3.3 Stability Measures

At this time, the five index points that have been discussed are not associated with significant stability hazards (all have an A or A/B rating). Stability hazard ratings for SJ40 and SJ41 are based on limited data and professional judgement. If future geotechnical assessments or conversations with interested parties identify areas of instability, a common countermeasure is the placement of riprap (or quarry stone) along the levee toe to stabilize the bank during a flood and prevent slipping and failure of the levee surface as water surface elevations recede (**Figure 24**). This is a common strategy for protection against erosion but has major ecological disadvantages, as it discourages the establishment of vegetation that provides riparian habitat and provides food sources and shade for fish and other aquatic organisms. Placement of new riprap where it has not previously existed will create environmental impacts that would likely require mitigation.

22-foot Rapid Drawdown



NOTE: In this example, placement of riprap at the levee toe meets an agreed upon factor of safety of 1.2 for bank stability.

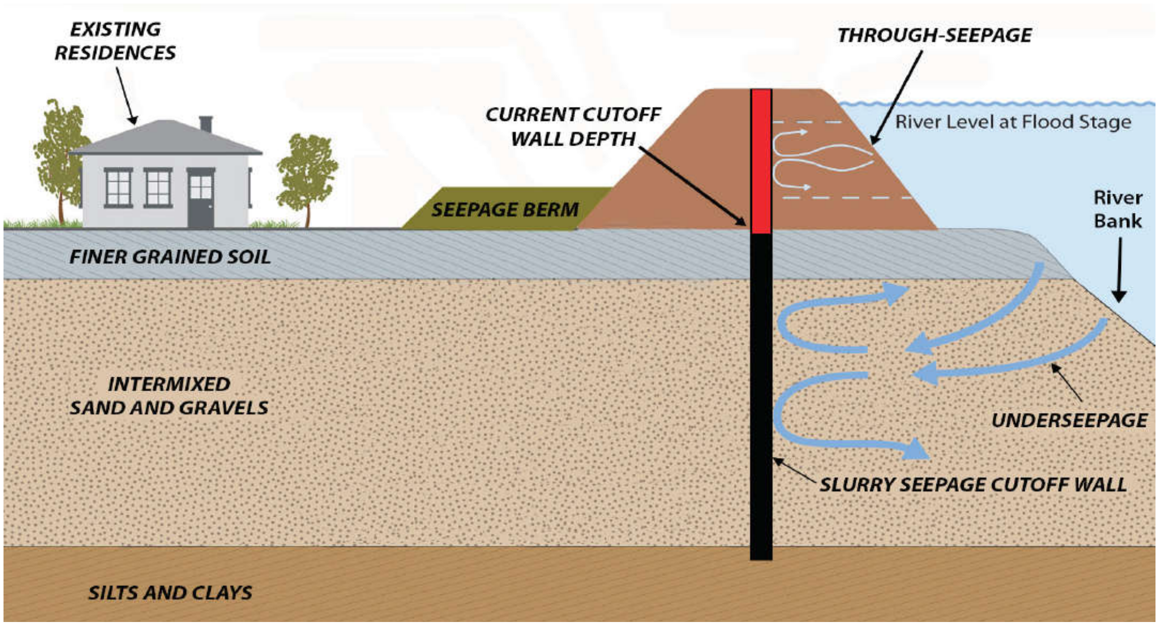
Figure 24
An Example of a Geotechnical Analysis Used to Test Slope Stability Measures

5.3.4 Seepage Countermeasures

The levee performance curves and hazard ratings for the five index points show that through-seepage and under-seepage are significant modes of failure for levees near the western end of Stewart Tract (SJ30, SJ31b, and SJ40). The San Joaquin River Restoration Program has explored numerous designs to address seepage, including cutoff walls, drainage ditches, interceptor lines, shallow groundwater pumps, build-up of low lying areas, channel conveyance improvements, and habitat improvements (SMP Appendix I, Draft Sept 214). Seepage can also be addressed through real estate actions including land acquisition, seepage easements, and license agreements.

One common seepage countermeasure is cutoff walls, which create a physical barrier to seepage through the center of the levee down to competent, non-permeable materials below the levee foundation (**Figure 25**). Another common countermeasure is the use of seepage berms along the landside toe of the levee which helps to stabilize the levee toe and prevents upwelling of water and piping from under-seepage.

Construction of seepage berms may be a prime opportunity for the re-use of dredging spoils, as long as further analysis shows those spoils to be geotechnically suitable and sufficiently free of contamination to be safely re-used for this purpose. As noted elsewhere, analysis to date (Anchor 2021) has found no evidence of contamination that would rule out the potential use of dredge spoils for seepage berms or other levee enhancements. Re-use of dredge spoils in this manner would avoid substantial costs associated with transport of spoils for disposal elsewhere.



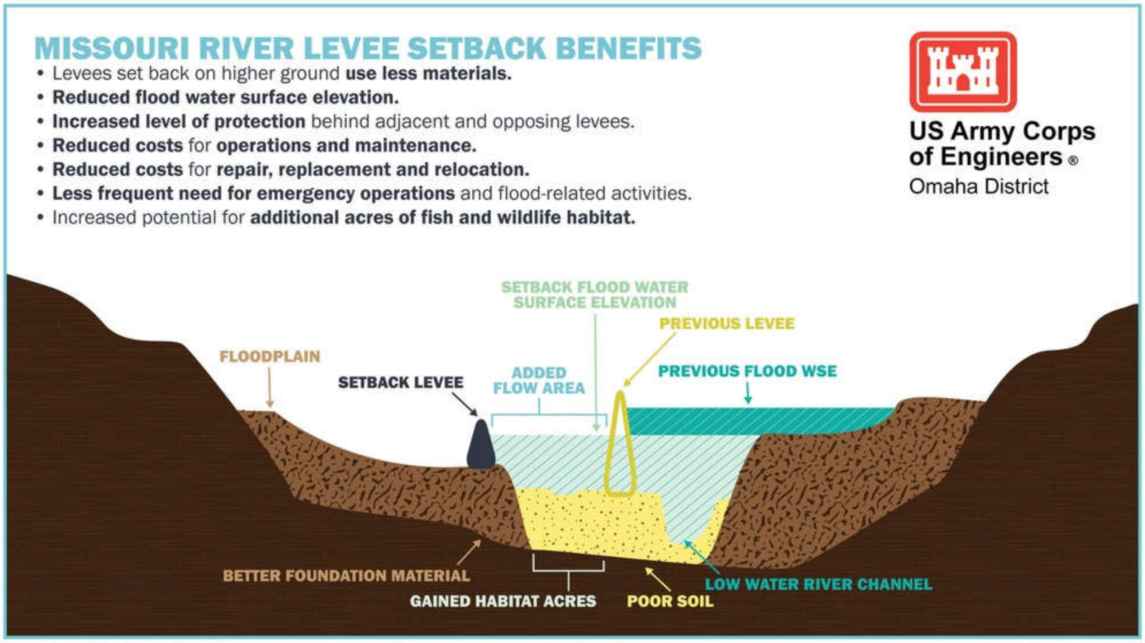
SOURCE: Image courtesy of Hans Carota (USACE 2020).

Figure 25
An Exhibit Showing Seepage Pathways and Cutoff Wall and Seepage Berm Countermeasures

5.3.5 Overtopping Countermeasures

Although an increase in overtopping is not expected under the 1997 flood scenario, increases in water surface elevations across a broader range of hydrologic scenarios may result in an incremental increase in AOP. As discussed, a hydrologic risk and uncertainty analysis is required to assess the incremental risk. Generally, two options existing to address overtopping concerns: 1) raise the crest of the levee or 2) setback levees to create transient flood storage and reduce water surface elevations (**Figure 26**). Either option may require a complete rebuild of the levee if the existing levee is deficient and poses a significant flood risk through other modes of levee failure. Raising the crest of the levee will almost always require widening of the base of the levee to maintain appropriate slopes on the levee faces, and may be another opportunity for re-use of dredge spoils if they are proven to be geotechnically suitable. Input from local landowners has also pointed out that some levees in the south Delta may already have overly steep slopes, a condition that may need to be addressed as part of a broader strategy to avoid unwanted hydraulic effects of the Project.

Setback levees also allow for reconnection of channels and floodplains, partial restoration of geomorphic processes, and opportunities for habitat restoration. Setting back levees can expand channel capacity while also restoring floodplain habitat and improving ecosystems. Setbacck levees may or may not involve complete removal of existing levees. Often existing levees are breached, but not removed, in order to reduce earthmoving costs and to provide areas of high ground during high-flow events. At least two breaches are generally necessary to ensure proper passage of flows and avoid fish stranding hazards. Setback levees can also incorporate side channels or other features specifically designed to enhance habitat quality.



SOURCE: USACE 2013.

Figure 26
An Exhibit Outlining the Multiple Benefits of Setback Levees in Flood Risk Management

Setback levees do not necessarily require the removal of agriculture from the floodplain. There are other locations in the lower San Joaquin Valley where agriculture occurs on the waterside of levees and is subject to periodice but infrequent flooding. Flowage easements, insurance, or other financial and legal strategies could be used to ensure the continued economic viability of floodplain agriculture in situations where existing agricultural lands were exposed to periodic but infrequent flow events.

Setback levees provide more channel capacity to convey flows and therefore generally reduce flood risks to adjacent lands. However, their ability to do so may also be limited by other constraints, such as flow bottlenecks, that ultimately determine how much water can pass through a given reach in a given amount of time. Conversely, the removal or relaxation of such bottlenecks may require expansion of downstream channel capacity to ensure continued safe passage of flows.

These considerations are important for Paradise Cut in light of the larger flood flows that are expected on the San Joaquin River under climate change scenarios. Existing hydraulic analyses assess the performance of the Preferred Conceptual Design under current hydrology, including the 1997 flood, which is similar to the 100-year flood under current hydrology. Safe conveyance of the substantially larger flows anticipated under climate change through Paradise Cut may require both the expansion of current bottlenecks (such as the railroad and freeway undercrossings) and the expansion of channel capacity through setback levees.

Projects that incorporate nature-based solutions such as setback levees are currently more competitive for grant funding. In addition, the increased flood risk under future climate scenarios may favor nature-based solutions like setback levees that may deliver multiple benefits in a more financially efficient manner in the long run. A comprehensive benefit-cost analysis is required to acknowledge and account for the multiple social, environmental, and economic benefits of setback levees.

5.3.6 Integrated Strategies

Integrated strategies that combine multiple countermeasures should be considered as part of the design process for the Project. For example, ecological levee rehabilitation, or "green levee," strategies have potential to address erosion, stability and seepage concerns simultaneously. An example has been developed by Reclamation District 1601 on Twitchell Island in the central Delta which involves:

1. Using dredge spoils (if geotechnically appropriate) to widen the levee cross section by creating toe berms and/or seepage berms behind existing levees to reduce the probability of failure, as well as to provide a foundation for constructing a new setback levee.

2. Building a new setback levee behind the existing levee with appropriate freeboard, slope, and geotechnical characteristics to avoid erosion, seepage, and overtopping hazards. The setback levee can be built as a traditional trapezoidal levee or as a terraced structure that could enable planting of trees and vegetation at the base of the waterside of the levee without reducing flood protection.

3. Planting of trees and other vegetation on at least one slope of the original levee.

4. Breaching of original levees in multiple locations to permit water to flow in and create aquatic habitat between the original levee and the setback levee. This backchannel in between the levees can be designed to be wet year-round or only at selected times of high flow, depending upon the ecosystem restoration objectives.

5. Maturing vegetation over time to create riparian and shaded riparian aquatic habitat within and alongside the backchannel.

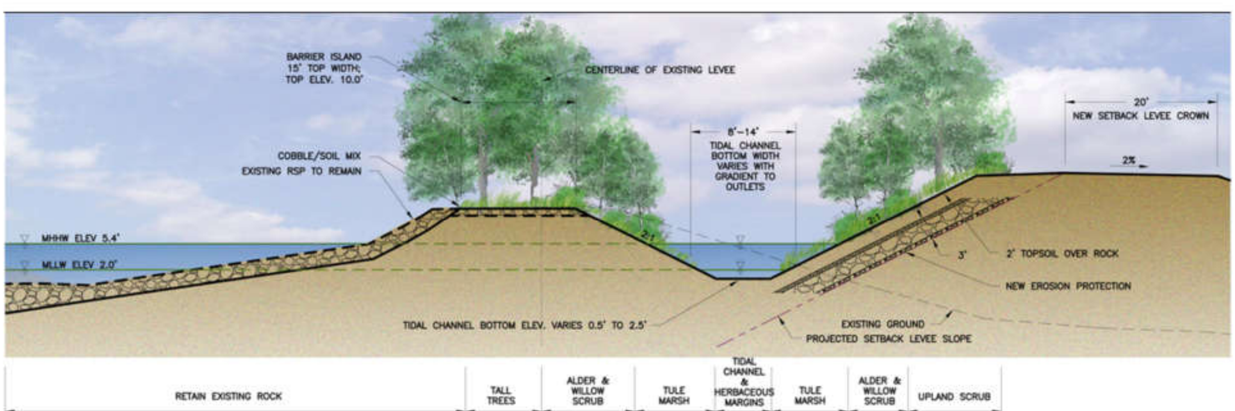


Figure 27
Example of Ecological Levee Strategy with Setback Levee, Wide Islands and Discontinuous Back Channels

(courtesy of KSN, Inc.)

These integrative green levee strategies offer a number of potential advantages, including creation of significant new habitat areas, expansion of overall channel capacity, and (depending upon design) protection against multiple modes of levee failure. If dredged spoils are found to be geotechnically suitable, this strategy would also provide an opportunity for placement and reuse of these spoils within the project area, thereby avoiding the expense and environmental impact of off-site disposal. The types of habitat potentially created (especially shaded riparian aquatic) may also provide additional mitigation capacity for the impacts of other levee construction and rehabilitation projects elsewhere in the Lower San Joaquin River region.

Green levees would likely be most suitable in areas where significant channel widening and ecosystem restoration are feasible. Given the extensive earthmoving and vegetation planting involved, they are likely to be relatively expensive on a per-mile basis compared to other strategies, but also could bring multiple benefits (and avoided costs of dredge spoil disposal) that may partially or completely counterbalance the relatively high construction costs compared to other strategies.

Based on what is known at the present time, the green levee strategies may be best suited for consideration in the vicinity of the confluence of Paradise Cut and Old River (as represented by Index Points 30, 31 and 40, due to the following general characteristics of this area:

- Relatively large increase in failure risk of existing levees from the hydraulic impacts of the Project (as shown in Appendix A)
- Greater distance between ecosystem restoration areas and the State and Federal Water Project pumping facilities, compared to sites further west
- Slightly higher elevation above tidal zone, compared to sites further west

5.4 Recommendations

At this early stage of the project, it is uncertain whether SJAFCA will need to include additional design measures in the project to counter negative hydraulic impacts. Previous hydraulic impact analyses (American Rivers 2019; DWR 2019) considered erosion countermeasures like rock slope protection but did not consider or evaluate countermeasures for seepage hazards or other modes of levee failure. In addition, the current preliminary evaluation of engineering and design strategies was based on existing geotechnical assessments for index points that are intended to represent large lengths of leveed systems operated and maintained by several reclamation districts (RDs). At this time, it's unknown to what degree levee inspections have been conducted and documented by RDs, the US Army Corps of Engineers, or others, but it's critical to solicit this information and identify areas where additional geotechnical assessments could improve understanding and confidence in levee performance.

As the next phase of feasibility planning begins, refined hydraulic modeling is recommended to more precisely estimate velocities and shear stresses acting on the channel boundary and levees. A two-dimensional hydraulic model would allow for depth-averaged velocity and shear stress values for the entire study area and help to isolate areas of concern with regards to erosion and sedimentation. Some level of sediment transport modeling may be required to analyze sedimentation patterns in areas of concern. In turn, refined modeling could be used to evaluate and select potential erosion countermeasures or changes in channel and/or floodplain geometry that may alleviate in-channel sedimentation concerns.

Nature-based solutions like setback levees, channel and floodplain restoration, and soil bioengineering measures could meet flood risk management objectives while improving geomorphic processes and providing ecological uplift. Areas where floods have particularly high consequences may require traditional hardscaping measures like riprap or concrete to protect infrastructure. Incorporation of nature-based features into the design will be an ongoing discussion with the project partners and other interested parties. Multi-benefit projects are also more competitive for grant funding.

Existing levee performance data indicate that several levee segments are sensitive to increases in water surface elevations and that hazard-specific countermeasures may be required to address the potential increase in flood risk. Consequences of levee failure have not been evaluated at this time, but those will undoubtedly drive the inclusion of design measures that target specific modes of levee failure. It appears that countermeasures may be required to address seepage concerns near Stewart Tract, such as setback levees, cutoff walls, seepage berms, or other countermeasures.

Downstream of Stewart Tract, water surface elevations appear to be influenced by hydraulic controls imposed by the bridge crossing along Tracy Blvd. Additional study is required to assess hydraulic impact strategies at these crossings. Given the small increase in flood risk along Old River and Grant Line Canal levees, increasing and enhancing monitoring and maintenance of those levees may be sufficient to address hydraulic impacts in some locations.

Finally, recent climate scenarios from the 2022 Update of CVFPP should be incorporated into the planning study to 1) account for potential changes to inland hydrology and sea levels and 2) design for the long-term resilience of the project. It is possible under future climate scenarios that overtopping becomes a more concerning mode of levee failure (especially at the eastern end of Paradise Cut) and that existing seepage concerns are exacerbated. The increased flood risk under future climate scenarios may favor nature-based solutions like setback levees that may deliver multiple benefits in a more financially efficient manner in the long run. A comprehensive benefit cost analysis (BCA) is required to acknowledge and account for multiple social, environmental, and economic benefits.

6. Avoidance and Mitigation Strategies to Address Environmental Impacts of Construction and Channel Restoration

Implementation of the Project would involve a variety of construction activities that could result in direct or indirect physical changes to the environment. These activities may include site clearing; placement of structures or other materials; building or assembling of infrastructure; relocation or demolition existing facilities; landscaping; or any mobilization activity that would move construction-related equipment and/or materials onto a site that may result either directly or indirectly in physical changes to the environment.

Construction activities associated with the Project may include:

- Mobilization of equipment and materials,
- Preparation of staging areas,
- Establishment of designated access and haul routes,
- Staging and storage of equipment and materials,
- Preparation of the Project site,
- Preparation/use of borrow sites,
- Site restoration and/or site demobilization,
- Disposal of excess materials, and,
- Dewatering, excavation, fill, and placement of materials in water.

Typical impact mechanisms resulting from these construction activities may include:

- Movement and placement of large amounts of soil/materials during construction of Project components,
- Physical disturbance of vegetation and/or habitat during construction of Project components,
- Release and exposure of sediments and turbidity in water,
- Noise, motion, and vibration from construction,
- Alteration of the visual landscape,
- Release and exposure of construction-related contaminants or emissions,
- Removal/replacement of recreational structures, and,
- Dredging of the existing channel.

6.1 Avoidance and Mitigation Strategies

California Code of Regulations, Title 14 (a.k.a. the "CEQA Guidelines"), Section 15370 defines mitigation as:

- Avoiding the impact altogether;
- Minimizing the impact by limiting its degree or magnitude;
- Rectifying the impact by repairing, rehabilitating, or restoring the impacted environmental resource;
- Reducing or eliminating the impact over time, through actions that preserve or maintain the resource; and,
- Compensating for the impact by replacing or providing substitute resources or environmental conditions, including through permanent protection of such resources in the form of conservation easements.

Table 4 identifies the avoidance and mitigation strategies relevant to addressing potential impacts associated with flood risk reduction components identified in Section 5 (i.e., hydrology and hydraulics, dredging, sediment management, and water quality pertinent to the Project), as well as environmental quality and habitat enhancement components of the Project.

TABLE 4
RECOMMENDED AVOIDANCE MITIGATION STRATEGIES FOR POTENTIAL PROJECT ISSUES

Project Components	Potential Issue	Avoidance and Mitigation Category
Flood Risk Reduction (Hydrology and Hydraulics, Dredging, Sediment Management, and Water Quality)	Potential methods to increase channel capacity	In-water Work Measures
	Potential mitigation requirements for dredging activities	Dredging Operations Measures
	Potential methods to reduce or maintain current levels of flood risk, or mitigate for increased risk if necessary	*Refer to Maintenance and Monitoring Strategies*
	Potential mitigation requirements for water quality impacts	Water Quality and Hazardous Materials Measures
Environmental Quality and Habitat Enhancement	Potential use of habitat enhancements to mitigate the project's impacts or future impacts associated with operation and maintenance of the project	Habitat Enhancement and Species Protection Measures

The individual avoidance and mitigation strategies are described in greater detail below. These strategies were identified through a review of projects with similar components in the Delta and Central Valley regions (refer to Appendix A). General protection measures are those that apply to all components of the Project; measures related to specific avoidance and mitigation categories are grouped together into individual sub-sections below.

6.1.1 General Protection Measures

- **GPM-1 Receipt and Copies of All Permits and Authorizations** –The Project proponent shall ensure that a readily available copy of all applicable permits and authorizations is maintained by the construction foreman/manager on the Project site for the duration of project activities. Work shall not begin until all necessary permits and authorizations have been received.

- **GPM-2 Construction Work Windows and Hours –** The Project proponent shall establish construction work windows to avoid impacts to aquatic resources and associated beneficial uses during the wet season. Construction activities may be limited to daylight hours to the extent feasible.

- **GPM-3 Environmental Awareness Training** – For projects occurring in aquatics resources (e.g., wetlands, riparian areas, etc.), prior to engaging existing or new personnel in construction activities, the Project proponent shall develop and implement a training program. Topics covered should include a review of procedures and any permit training requirements to educate construction personnel on the applicable environmental rules and regulations, the types of sensitive resources in the project area, and the measures required to avoid and minimize effects on these resources.

- **GPM-4 Construction Best Management Practices (BMPs) and Monitoring** – The Project proponent shall identify standard practices and measures that will be implemented prior to, during, and after construction to avoid or minimize effects of construction activities on sensitive resources (e.g., species, habitat), and monitoring protocols for verifying the protection. The Project proponent shall consult the permits to determine whether an approved biologist or resource specialist should conduct inspections and/or prepare a monitoring log of construction site conditions and observations.

- **GPM-5 Work Areas** – Construction work and materials staging shall be restricted to designated work areas, routes, staging areas, temporary interior roads, or limits of the existing roadways. Prior to initiating construction or grading activities, brightly colored fencing or flagging or other practical means shall be erected to demarcate the limits of the project activities, including the boundaries of designated staging areas; ingress and egress corridors; stockpile areas for spoils disposal, soil, and materials; and equipment exclusion zones. Flagging or fencing shall be maintained in good repair for the duration of project activities.

- **GPM-6 Environmentally Sensitive Areas** – A combination of monitoring, flagging and/or fencing shall be used to minimize disturbance to environmentally sensitive areas (e.g., water and wetlands).

- **GPM-7 Prevent Spread of Invasive Species** – The spread or introduction of invasive exotic plant species by arriving vehicles, equipment, imported gravel, and other materials, shall be avoided to the maximum extent possible.

- **GPM-8 Equipment Maintenance and Materials Storage** – Vehicle traffic shall be confined to existing roads and the proposed access route(s). Staging areas for equipment storage, maintenance, construction materials, fuels, lubricants, solvents, and other possible contaminants shall be established in coordination with resource agencies.

- **GPM-9 Hazardous Material Management** - Develop and implement site-specific plans that will provide detailed information on the types of hazardous materials used or stored at all sites associated with facilities and required emergency-response procedures in case of a spill. Before construction activities begin, establish a specific protocol for the proper handling and disposal of hazardous materials.

- **GPM-10 Material Disposal and Trash Removal** - All refuse, debris, unused materials, and supplies that cannot reasonably be secured shall be removed daily from the project work area and deposited at an appropriate disposal or storage site. All construction debris shall be removed from the project work area immediately upon project completion. All trash will be properly contained within sealed containers, removed from the work site, and disposed of daily.

- **GPM-11 Noise Abatement** - Develop and implement a plan to avoid or reduce the potential in-air noise impacts related to construction, maintenance, and operations.

- **GPM-12 Fugitive Dust Control** – The Project proponent shall implement basic and enhanced control measures at all construction and staging areas to reduce construction-related fugitive dust and ensure the project commitments are appropriately implemented before and during construction, and that proper documentation procedures are followed.

- **GPM-13 Design Standards** – The Project proponent shall ensure that the standards, guidelines, and codes, which establish minimum design criteria and construction requirements for project features, are followed.

- **GPM-14 Revegetate Disturbed Areas** – All temporarily disturbed areas shall be de-compacted and seeded/planted with an assemblage of native riparian, wetland, and/or upland plant species suitable for the area. The project proponent shall develop a revegetation plan, including (as applicable) a schedule; plans for grading of disturbed areas to pre-project contours; planting palette with plant species native to the project area; invasive species management; performance standards; and maintenance requirements (e.g., watering, weeding, and replanting).

- **GPM-15 Lighting –** During construction and operation, any lights needed to illuminate construction areas, staging areas, parking lots etc. shall be directed away from any adjacent sensitive wildlife habitat for sensitive wildlife. With the exception of public safety, lighting shall not occur in the vicinity of the wildlife corridor, to the extent possible.

6.1.2 In-water Work Measures

- **IWW-1 General In-water Work Measures** - Once the scope of in-water work is determined, ensure appropriate in-water materials and vehicles are used, and that there is proper placement of materials, structures, and operations of equipment. The Project proponent shall refer to relevant permit approvals for additional measures.

- **IWW-2 Notification of Activities in Waterways** – Before in-water construction or maintenance activities begin, appropriate agency representatives shall be notified when these activities could affect water quality or aquatic species.

- **IWW-3 Dewatering/Diversion Plan** – Should dewatering or diversion be necessary, the project proponent shall ensure the area to be dewatered encompasses the minimum area necessary to perform construction activities. The project proponent shall provide a dewatering plan with a description of the proposed dewatering structures, and appropriate types of BMPs for the installation, operation, maintenance, and removal of those structures. The period of dewatering/diversion shall extend only for the minimum amount of time needed to perform the restoration activity and to allow special-status species time to leave on their own before final clearance surveys and construction can begin.

6.1.3 Dredging Operations Measures

- **IWW-4 Dredging Operations and Dredging Materials Reuse Plan –**The project proponent shall develop and implement a dredging operation and dredging materials management plan to minimize the effects that could occur during dredging operations and material reuse and disposal. The plan shall describe a sampling program for conducting physical and chemical analyses of sediments before disturbance. It shall also describe BMPs to be implemented during dredging operations (e.g., using less intrusive dredging procedures, properly containing dredging spoils and water, using silt curtains, methods to minimize turbidity, and timing dredging activity to coincide with low flows). The plan also shall describe methods to evaluate the suitability of dredged material for reuse and disposal.

- **HMM-3 Remediation Plan** – For anticipated contamination of dredged materials, the project proponent shall review detailed information about the past and current uses, records of known contamination and hazardous materials usage for the areas proposed for dredging. Contaminants found in soil and/or groundwater that would constitute remediation include the full range of industrial and agricultural chemicals, including VOCs, petroleum hydrocarbons, chlorinated solvents, pesticides, metals, gross alpha and beta radiation and other industrial compounds.

6.1.4 Water Quality and Hazardous Materials Measures

- **WQM-1 Staging Area and Stockpiling of Materials and Equipment –** Staging, storage, and stockpile areas must be outside of waters of the state. To the extent feasible, staging shall occur on access roads or other previously disturbed upland areas, such as developed areas, paved areas, parking lots, areas with bare ground or gravel, and areas clear of vegetation, to avoid aquatic habitats and limit disturbance to surrounding habitats. Similarly, all maintenance equipment and materials (e.g., road rock and project spoil) shall be restricted to the existing service roads, paved roads, or other determined designated staging areas.

- **WQM-2 Stormwater Pollution Prevention Plan –** A stormwater pollution prevention plan, or SWPPP, shall be developed that includes measures to be implemented to minimize pollutants in stormwater discharges during and after construction to prevent water quality degradation related to project area runoff to receiving waters.

- **WQM-3 Erosion and Sediment Control Plan –** An erosion and sediment control plan shall be developed that includes measures to be implemented for ground-disturbing activities to control short-term and long-term erosion and sedimentation effects and to restore soils and vegetation in areas affected by construction activities. Measures may be incorporated into other plans developed and implemented as part of the National Pollutant Discharge Elimination System permitting process for covered activities.

- **HMM-1 Spill Prevention, Containment and Countermeasure Plan –** A spill prevention, containment and countermeasure plan or SPCCP, shall be developed that includes measures to prevent and respond to spills of hazardous material that could affect navigable waters, as well as emergency notification procedures.

- **HMM-2 Methylmercury Management –** Design and construction of tidal wetland restoration and mitigation sites shall minimize ecological risks of methylmercury production.

6.1.5 Habitat Enhancement and Species Protection Measures

- **HEM-1 Avoidance of Vegetation Disturbance –** During Project construction, the project proponent shall minimize, to the greatest extent feasible, the amount of soil, terrestrial vegetation, emergent native vegetation, and submerged vegetation disturbed.

- **SPM-1 Preconstruction Survey –** If special-status plants are present and/or special-status terrestrial animal species habitat is present (e.g., stationary habitat such as burrows, bird nests, cavities for bats, etc.), where appropriate, based on project-specific requirements, a qualified, agency-approved biologist with experience on the identification of all applicable life stages of the special-status species shall conduct reconnaissance-level preconstruction surveys and implement additional measures, as appropriate, to protect the species from construction-related disturbance before work begins. The intent of the survey is to assess current species habitat and use locations in the project area immediately prior to construction. Special-status plant species surveys shall be conducted in the appropriate blooming period, as applicable, prior to the start of construction for proper plant identification. If construction activities cease for more than five consecutive days, and there is potential for special-status species to re-occupy the site, the agency-approved biologist shall re-survey the project area and implement measures, as appropriate.

- **SPM-2 Fish Rescue and Salvage Plan** – Pending permit requirements, a fish rescue and salvage plan may be developed that includes measures that detail procedures for fish rescue and salvage to avoid and minimize the number of listed species of fish stranded during construction activities, especially during the placement and removal of any enclosures (e.g., cofferdams or exclusion netting) at construction sites.

- **SPM-3 Underwater Sound Control and Abatement Plan –** Pending permit requirements, an underwater sound control and abatement plan may be developed that includes measures to minimize the effects of underwater construction noise on fish, particularly from any required impact pile driving activities. Potential effects of pile driving will be minimized by restricting work to the least sensitive period of the year and by controlling or abating underwater noise generated during pile driving.

6.1.6 Special-Status Species Measures

Special-Status Plants

- **VEG-1:** Areas of the project site deemed to present potentially suitable habitat for special-status plants will be surveyed by a qualified botanist following the "Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities" (CDFW 2018). This protocol, which is intended to maximize detectability, includes the identification of reference populations to facilitate the likelihood of field investigations occurring during the appropriate floristic period.

- **VEG-2:** Special-status plant species will be avoided whenever possible by delineating and observing a no-disturbance buffer of at least 50 feet from the outer edge of the plant population(s) or specific habitat type(s) required by special-status plant species. If buffers cannot be maintained, then consultation with CDFW may be warranted to determine appropriate minimization and mitigation measures for impacts to special-status plant species.

- **VEG-3:** If a State-listed plant species is identified during botanical surveys, consultation with CDFW is warranted to determine if the Project can avoid take. If take cannot be avoided, take authorization is warranted. Take authorization would occur through issuance of an ITP, pursuant to Fish and Game Code section 2081, subdivision (b).

Giant Garter Snake

- **GGS-1:** To the extent feasible, will limit project construction and maintenance activities to the active season for GGS, May 1 to October 1. The contractor may also conduct work between October 2 and November 1 or between April 1 and April 30 if ambient air temperatures exceed 75ºF during the work and maximum daily air temperatures have exceeded approximately 75ºF for at least 3 consecutive days immediately preceding the work.

- **GGS-2:** A designated biologist will present a worker education and awareness program to all on-site construction personnel before materials staging or ground-disturbing activities begin. The program will describe how best to avoid impacts on GGS and will address the topics of species descriptions and identification, life history, and habitat requirements during various life stages. This education program can include handouts, illustrations, photographs, and project maps showing areas of minimization and avoidance measures. All construction personnel will sign a sign-in sheet documenting that they received the training.

- **GGS-3:** The RCD will ensure that a designated biologist surveys the project footprint for burrows, soil cracks, crevices, and other features potentially suitable for use by GGS within terrestrial habitat located within 200 feet of suitable aquatic habitat. Surveys will be completed no more than 3 days before construction or maintenance activities in terrestrial habitat that could support GGS. Any identified burrows, soil cracks, crevices, or other habitat features will be flagged by the designated biologist or otherwise identified as biologically sensitive areas. The RCD will avoid these biologically sensitive areas during construction and subsequent maintenance. If activities temporarily stop for more than 7 days, the designated biologist will repeat the surveys for soil cracks and similar features, as described above, before construction work resumes.

- If feasible and accepted by CDFW and USFWS, the RCD may also use other survey techniques (e.g., scent-detection dogs) as an alternative or supplement to surveys conducted by the designated biologist. Such surveys will identify cracks and burrows to help determine occupancy by GGS, and these burrows will be flagged as biologically sensitive areas to be avoided during subsequent work as described above.

- **GGS-4:** GGS exclusion fencing will be installed consistent with USFWS and CDFW guidance to divert moving snakes from the active construction zone during periods when GGS are active. This exclusion fencing will be installed adjacent to irrigation canals and drainage ditches. The RCD will also install and regularly maintain exclusion fencing around to redirect any GGS away from the active construction zone. The exclusion fencing will be installed before the start of construction. The RCD will maintain the exclusion fencing for the duration of the Proposed Project's construction activities. A designated biologist will inspect the exclusion fence daily to verify the condition and function of the fence and to verify that snakes are not becoming trapped in the excluded areas.

- **GGS-5:** If a GGS individual is observed within the project footprint, the RCD will stop work and notify a designated biologist immediately. The snake will be allowed to leave on its own, and the designated biologist will remain in the area for the remainder of the workday to ensure that the snake is not harmed. Alternatively, with prior approval by CDFW and USFWS, the designated biologist may capture the snake and relocate it unharmed to suitable habitat at least 200 feet from the project area. The RCD will notify CDFW and USFWS by telephone or email within 24 hours of a GGS observation during project activities. If the snake does not voluntarily leave the project area and cannot be captured and relocated unharmed, project activities will remain halted to prevent harm to the snake, and CDFW and USFWS will be consulted to identify next steps. The RCD will implement the measures recommended by CDFW and USFWS before resuming project work in the area.

Western Pond Turtle

- **WPT-1:** A designated biologist will present a worker education and awareness program to all on-site personnel before materials staging or ground-disturbing activities begin. The biologist will explain to construction workers how best to avoid impacts on western pond turtle and will address the topics of species descriptions and identification, life history, and habitat requirements during various life stages. This education program can include handouts, illustrations, photographs, and project mapping showing areas of minimization and avoidance measures. The crew members will sign a sign-in sheet documenting that they received the training.

- **WPT-2:** A designated biologist will conduct a preconstruction survey within 7 days before the establishment of staging areas and the start of construction and maintenance activities.

- **WPT-3:** Should a western pond turtle be observed during the preconstruction survey, the biologist will identify the location using GPS coordinates. The RCD will revisit these locations within 8 hours of ground disturbance. A designated biologist may relocate the turtle found within the construction footprint to suitable habitat away from the construction zone.

- **WPT-4:** If a western pond turtle is observed on land within the active construction zone, specifically in areas of ground disturbance, access routes, stockpile areas, or staging areas, the RCD will immediately stop work within approximately 200 feet of the turtle and notify a designated biologist. If possible, the turtle will be allowed to leave on its own, and the designated biologist will remain in the area for the remainder of the workday to ensure that the turtle is not harmed. Alternatively, with prior CDFW approval, the designated biologist may capture the turtle and relocate it unharmed to suitable habitat at least 200 feet from the project area. If the turtle does not voluntarily leave the project area and cannot be captured and relocated unharmed, construction activities within approximately 200 feet of the turtle will stop to prevent harm to the turtle, and CDFW will be consulted to identify next steps. The RCD will implement the measures recommended by CDFW before resuming project activities in the area.

General Nesting Birds

- **NEST-1:** If vegetation removal is to begin during the nesting season (February 15 to August 31), a designated biologist will conduct a preconstruction nesting survey before the vegetation is removed. The preconstruction survey will be conducted within 14 days before the start of ground-disturbing activities. If the survey shows no evidence of active nests, no additional measures are recommended. If construction does not begin within 14 days of the preconstruction survey, or if it halts for more than 14 days, an additional preconstruction survey is recommended.

- **NEST-2:** If any active nests are located in the project area, the construction contractor will establish an appropriate buffer zone around the nests, as determined by a designated biologist (typical buffer zones are 100 feet for migratory bird nests, 250 feet for raptor nests, and 500 feet for western yellow-billed cuckoo, unless a qualified avian biologist determines that smaller buffers would be sufficient to avoid impacts). Factors to be considered for determining buffer size will include the presence of natural buffers provided by vegetation or topography; nest height; locations of foraging territory; and baseline levels of noise and human activity. Buffers will be maintained until a qualified biologist has determined that the young have fledged and are no longer reliant upon parental care for survival. The designated biologist will monitor nests daily during construction to evaluate whether construction activities have the potential to disturb nesting.

Yellow-Billed Cuckoo/Least Bell's Vireo

- **YBC-1:** If active yellow-billed cuckoo or least Bell's vireo nests are identified within 500 feet of noise-generating construction or maintenance activities and noise is in excess of 60 dBA (decibel A weighted) hourly Leq (equivalent continuous noise level), or if noise is in excess of ambient noise levels if ambient noise levels exceed 60 dBA hourly Leq, measures will be implemented to reduce noise levels to 60 dBA hourly Leq or to ambient noise levels if ambient noise levels exceed 60 dBA hourly Leq at the nest location. Noise monitoring will occur daily during maintenance activities that are occurring during the breeding season and will be reported weekly. No construction or maintenance activities, including tree removal, will occur in the buffer zone until the young have fledged or the nest is no longer active, as confirmed by an avian biologist. If measures cannot be identified, implemented, and demonstrated to be effective to avoid adverse effects on these species, then construction in the area round the active yellow-billed cuckoo or least Bell's vireo nests will stop and the wildlife agencies re-consulted.

Swainson's Hawk

- **SWHA-1:** If vegetation removal is to begin during the nesting season for Swainson's hawk (between March 1 and September 15), a designated biologist will conduct a minimum of one protocol-level preconstruction survey. The survey(s) will occur during the recommended survey periods for the nesting season that coincides with the start of construction activities, in accordance with the Recommended Timing and Methodology for Swainson's Hawk Nesting Surveys in California's Central Valley (Swainson's Hawk Technical Advisory Committee, 2000). Where legally permitted, the designated biologist will conduct surveys for nesting Swainson's hawk within 0.25 mile of the project area.

- **SWHA-2:** If active Swainson's hawk nests are found within 0.25 mile of construction or maintenance activities, the findings will be reported to CDFW following the preconstruction survey. For purposes of this avoidance and minimization requirement, "construction activities" are defined to include the operation of heavy equipment during construction or other project-related activities that could cause nest abandonment or forced fledging within 0.25 mile of a nest site between February 1 and September 15. Should an active nest be present within 0.25 mile of a construction area, the RCD will consult with CDFW to establish appropriate avoidance measures; determine whether high-visibility construction fencing will be erected around the buffer zone; and implement a monitoring and reporting program before any construction activities occur within 0.25 mile of the nest. Should the designated biologist determine that the construction activities are disturbing the nest, the biologist will halt construction activities until RCD consults with CDFW. The construction activities will not resume until CDFW determines that they will not result in abandonment of the nest site. Should the designated biologist determine that construction activities within the buffer zone have not disturbed the nest, the RCD will report to CDFW summarizing the survey results within 30 days after the final monitoring event, and no further avoidance and minimization measures for nesting habitat are recommended.

Burrowing Owl

- **BUOW-1:** Where suitable habitat is present on or in the vicinity of the Project area, an assessment of the presence or absence of burrowing owl will be conducted by having a qualified biologist conduct surveys following the California Burrowing Owl Consortium (1993) "Burrowing Owl Survey Protocol and Mitigation Guidelines" and the CDFG (2012) "Staff Report on Burrowing Owl Mitigation". Specifically, these documents suggest three or more surveillance surveys conducted during daylight, with each visit occurring at least three weeks apart during the peak breeding season of April 15 to July 15, when burrowing owl are most detectable.

- **BUOW-2:** If burrowing owl presence is detected, to the extent possible, the RCD will implement no-disturbance buffers, as outlined by CDFG (2012), be implemented prior to and during any ground-disturbing activities, and specifically that impacts to occupied burrows be avoided in accordance with the following table unless a qualified biologist approved by CDFW verifies through non-invasive methods that either: 1) the birds have not begun egg laying and incubation; or 2) that juveniles from the occupied burrows are foraging independently and are capable of independent survival.

Location	Time of Year	Level of Disturbance		
		Low	Med	High
Nesting sites	Apr 1-Aug 15	200m	500m	500m
Nesting sites	Aug 16-Oct 15	200m	200m	500m
Nesting sites	Oct 16-Mar 31	50m	100m	500m

- **BUOW-3:** If burrowing owls are found within these recommended buffers and avoidance is not possible, the RCD will evict the birds from burrows if necessary for Project implementation. The burrow exclusion will be conducted by qualified biologists and only during the non-breeding season, before breeding behavior is exhibited and after the burrow is confirmed empty through non-invasive methods, such as surveillance. CDFW recommends mitigation in the form of replacement of occupied burrows with artificial burrows at a minimum ratio of one burrow collapsed to one artificial burrow constructed (1:1) to mitigate for evicting burrowing owls and the loss of burrows.

Roosting Bats

- **BAT-1:** If removal of trees with suitable roost cavities and/or dense cover must occur during the bat pupping season (April 1 through July 31), surveys for active maternity roosts in trees designated for removal shall be conducted by a qualified biologist. The surveys shall be conducted from dusk until dark.

- **BAT-2:** If a special-status bat maternity roost is located, appropriate buffers around the roost sites shall be determined by a qualified biologist and implemented to avoid destruction or abandonment of the roost resulting from tree removal or other project activities. The size of the buffer shall depend on the species, roost location, and specific construction activities to be performed in the vicinity. No project activity shall commence within the buffer areas until the end of the pupping season (August 1) or until a qualified biologist confirms the maternity roost is no longer active.

- **BAT-3:** Vegetation removal, particularly tree removal, shall be conducted between September 16 and January 31, to the extent feasible, to minimize potential loss of bat maternity roosts.

Valley Elderberry Longhorn Beetle

- **VELB-1:** The RCD will retain a qualified biologist to conduct a focused survey in areas where elderberry shrubs could occur within 100 feet of project construction areas. The survey will follow the USFWS conservation guidelines for the valley elderberry longhorn beetle (USFWS 2017). If elderberry shrubs are found, the RCD will implement avoidance measures that are consistent with the USFWS conservation guidelines for this species (USFWS 2017).

- **VELB-2:** All elderberry shrubs located adjacent to construction areas, but can be avoided, will be temporarily fenced and designated as environmentally sensitive areas by the RCD.

These areas will be avoided by all construction personnel. Where feasible, effects will be avoided by establishing and maintaining a 100- foot-wide buffer around elderberry plants. Where a 100-foot buffer is not feasible, effects may be minimized by providing a minimum setback, with a buffer around elderberry plants measuring at least 20 feet wide.

- **VELB-3:** No insecticides, herbicides, or other chemicals that might harm the beetle or its host plant will be used by the RCD within established buffers (20 feet) around elderberry shrubs.

- **VELB-4:** Elderberry shrubs that cannot be avoided and require removal will be transplanted by the RCD. If none of the areas of suitable habitat to be created as part of the project would be available before the impact would occur, alternative transplant locations will be identified. Transplant activities will be conducted in accordance with USFWS guidelines (USFWS 2017). If ground-disturbing activities are to occur within 20 feet of the dripline of an elderberry shrub, minimization and compensation measures consistent with the USFWS conservation guidelines (USFWS 2017) will be implemented. These measures include transplanting elderberry shrubs to the riparian habitat creation areas and planting compensatory elderberry seedlings and associated native plantings.

  The RCD will develop a mitigation plan that will specify how to manage the elderberry transplant area to ensure that the appropriate habitat conditions are provided. At a minimum, the plan will specify the number of replacement elderberry shrubs and associated native plants to be established and associated success criteria; specify remedial measures to be undertaken if survival success criteria are not met; and describe short- and long-term maintenance and management.

Crotch Bumble Bee

- **CBB-1:** In accordance with CDFW recommendations, all small mammal burrows and thatched/bunch grasses will be surveyed for Crotch bumble bee during the optimal flight period of April 1through July 31 during the peak blooming period of preferred plant species prior to Project implementation. Avoidance of detected queens or workers is encouraged to allow Crotch bumble bees to volitionally leave the Project site. Avoidance and protection of detected nests prior to or during Project implementation will be implemented with delineation and observance of a 50-foot no-disturbance buffer.

Anadromous Fish

- **FISH-1:** The potential exists for fish, including migratory juvenile fish, to become trapped in scour holes and other depressions that may form on Paradise Cut bypass during operations as floodwaters recede. The RCD will monitor Paradise Cut following flood events that inundate significant portions of the created floodplains to identify areas that may have scoured and that have resulted in fish stranding. If monitoring indicates that fish stranding has occurred, the RCD will use appropriate methods (e.g., seining, electrofishing), as authorized, as soon as possible following isolation of the water body to remove stranded fish. Rescued fish will be released to the nearest main channel area. Qualified fish biologists will conduct monitoring and fish rescue operations. To reduce the potential for further fish stranding at locations where scour pools have formed following floodplain inundation, the RCD will then use appropriate methods (e.g., grading, rock placement) to fill in new scour holes to reduce their potential to strand fish in the future. Scour areas and depressions that are identified to be potential stranding sites will be filled that year before the beginning of the next winter season.

- **FISH-2:** The RCD shall visually monitor the waterway adjacent to the dredge area (i.e., within 300 feet) during all dredging operations for any affected fish including, but not limited to, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS of North American green sturgeon. Observation of one or more affected fish will be reported to NMFS within 24 hours of the incident. Dredging operations shall be halted immediately until NMFS is consulted to determine the cause of the incident and whether any additional protective measures are necessary to protect listed salmonids and green sturgeon. Any protective measures that are determined necessary to protect listed salmonids and sturgeon shall be implemented as soon as practicable within 72 hours of the incident.

  Affected fish are defined as:

  1. Dead or moribund fish at the water surface;
  2. Showing signs of erratic swimming behavior or other obvious signs of distress;
  3. Gasping at the water surface; or
  4. Showing signs of other unusual behavior.

Table 5 identifies the potential work window limitations that may be required to reduce potential impacts on special-status species based on their life history requirements.

6.2 Habitat Impact Calculations

The preliminary evaluation of habitat impacts was based on the four major activities projected to occur under the project:

1. Dredging of portions of Grant Line Canal and Old River
2. Degradation and/or removal of existing levees
3. Construction of new setback levees, including the 250-ft expansion of the east railroad undercrossing
4. Construction of a new weir structure along the mainstem San Joaquin River

6.2.1 Dredging

Approximately five miles of dredging within portions of Grant Line Canal and Old River were identified to potentially affect open water habitat for special-status fish species. Assuming that the entire width of the channels within these reaches of Grant Line Canal and Old River are projected to be dredged, it is estimated that approximately 141 acres of riverine channel would be affected. The dredging activities are assumed to be conducted via barge-mounted equipment, thereby avoiding impacts to shoreline habitat that would be expected if heavy machinery, such as long-arm reach excavators, were to be staged along the banks of Grant Line Canal or Old River.

Stockpiling of dredge spoils can also affect habitat if placed in sensitive areas. Placement of dredge spoils in uplands may result in conversion of habitat as well as inadvertent entombing of wildlife that may be present, particularly those utilizing burrows. For example, giant garter snakes are often found in burrows close to aquatic habitat during the cold period of the year when they are less active, and are thus potentially vulnerable to sidecasting of dredge spoils along levee slopes. For the purposes of this analysis, it is assumed that any dredged spoils will be either placed on a barge and disposed of at an off-site location, or the dredge materials will be placed in an uplands area with generally lower sensitivity with respect to biological resources impacts (e.g., an agricultural field).

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TABLE 5
ANTICIPATED CONSTRUCTION WORK WINDOWS

Species		Types of Activity Affected	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anadromous Fish (Salmon, Steelhead, Sturgeon)	Survey Period	Dredging	Presence Assumed in Riverine Channels											
	Potential Work Window		No dredging in Delta channels							Dredging Window for Old River/Grant line Canal (August through October)			No dredging in Delta channels	
Non-raptor Nesting Birds	Survey Period	Vegetation removal (primarily); also any work occurring within nest buffer	Outside Nesting Season	Nesting bird survey (February through August)							Outside Nesting Season			
	Potential Work Window		Preferred Period for Vegetation Removal	Nesting Bird Season: may need to avoid work within active nest buffers until juveniles fledged (February through August)							Preferred Period for Vegetation Removal (outside nesting season)			
Burrowing Owl	Survey Period	Any work type	Non-Breeding Season Survey (less preferred)	Breeding Season Survey (CDFW-preferred timing)							Non-Breeding Season Survey (less preferred)			
	Potential Work Window		May need to avoid burrows for year-around residents	Work Needs to Avoid Buffers for Occupied Burrows during breeding season, if present (exclusion and passive relocation of burrowing owls a potential option)							May need to avoid burrows for year-around residents			
Swainson's hawk	Survey Period	Vegetation removal (primarily); also any work occurring within nest buffer	Outside Nesting Season	Swainson's hawk survey (February through August)							Outside Nesting Season			
	Potential Work Window		Vegetation removal	Nesting Bird Season: may need to avoid work within active nest buffers until juveniles fledged (February through August)							Preferred Period for Vegetation Removal (outside nesting season)			
Giant garter snake	Survey Period		Pre-construction survey for giant garter snake expected to be conducted in days immediately preceding ground-disturbing activities. Survey area includes non-riparian uplands within 200 feet of suitable aquatic habitat for the species.											
	Potential Work Window (uplands)	Earthwork primarily, but also any access of heavy equipment					Initial ground disturbance in uplands (Active Season: May 1 to October 1)							
	Potential Work Window (aquatic habitat)	Sediment removal channel dewatering, fill of aquatic habitat,	Sediment Removal (non-Active season)									Sediment Removal (non-Active season)		
Western pond turtle	Survey Period		Pre-construction survey for western pond turtle expected to be conducted in days immediately preceding ground-disturbing activities Survey area includes non-riparian uplands within 200 feet of suitable aquatic habitat for the species.											
	Potential Work Window (uplands)	Any construction work in vicinity of suitable turtle nests areas					Minimal restrictions except to avoid any areas of potential turtle nests during breeding period (May 1 to November 1)							
	Potential Work Window (aquatic habitat)	Any in-water work areas suitable for western pond turtle					Window for working in suitable aquatic habitat for western pond turtle (i.e., when turtles are most active and able to avoid work).							
Roosting bats	Survey Period	Vegetation removal (primarily); also any work occurring within roost buffer				Bat roosting survey (April through July)								
	Potential Work Window		Preferred Period for Vegetation Removal			Work Needs to Avoid Maternity Roosts, if present, until end of pupping season (July 31)					Preferred Period for Vegetation Removal (September to January)			
Valley elderberry longhorn beetle	Survey Period	Vegetation removal (primarily); any work occurring within roost buffer	Year-around											
	Potential Work Window		Transplant Period: when shrubs are dormant (November to February 14).	Avoidance Buffer Around Elderberry Shrub During VELB Flight Season (if working within 165 feet of elderberry shrub)									Transplant Period: when shrubs are dormant (November to February 14).	

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6.2.2 Degradation/Removal of Existing Levees

Removal of the existing levees may contribute to direct or indirect impacts to existing wetland and riverine features present within the project site. For example, there is a potential for construction work to result in fill of seasonal wetland features in the immediate vicinity of existing levees as levees targeted for removal or degradation are graded and excavated. The preliminary analysis of potential impacts tabulated below assumes that any aquatic resources within 50 feet of the levees within the project site targeted for removal or degradation would be potentially affected by construction. The analysis projects that approximately five to six acres of freshwater wetland habitat could be affected and a minimal area (<0.5 acre) of riverine habitat would be affected (**Table 6**). This estimate is expected to be highly conservative (i.e., an overestimate) given the fact that in many circumstances, direct impacts to aquatic resources can be minimized or entirely avoided through project design, and indirect impact impacts can be minimized through implementation of BMPs such as those identified in Section 6.1 above.

TABLE 6
PRELIMINARY ESTIMATES IMPACTS TO EXISTING LANDCOVERS THROUGH DEGRADATION/REMOVAL OF EXISTING LEVEES

Landcover Type[a]	Impacts (Acres)[b]
Riparian	~5
Grassland	~10
Agricultural Land	~7
Wetlands/Other Waters	~4-5

NOTES:
[a] Estimates on landcover type are based on VegCAMP data and National Wetland Inventory.
[b] Estimates are highly preliminary and are expected to change substantially once a final alternative and design are established. They are only presented herein for planning purposes and to provide context for the general scale of habitat impacts that may ultimately arise.

6.2.3 Construction of New Setback Levees

Construction of the new setback levees is expected to result in conversion of existing landcovers. The setback levee expansion is also tied to work associated with expansion of the Union Pacific Railroad undercrossing. These impacts include clearing and grubbing of areas for placement of the new setback levee prism itself, plus an expectation of some over-excavation to ensure that the soil structure beneath the new setback levee is geotechnically stable. The levee geometry is assumed to be the same as the existing levees that will be degraded and/or removed once the new setback levees are constructed. The preliminary analysis of potential impacts (**Table 7**) assumes that any aquatic resources within 50 feet of the new setback levee alignment would be potentially affected by construction.

TABLE 7
PRELIMINARY ESTIMATES IMPACTS TO EXISTING LANDCOVERS THROUGH CONSTRUCTION OF NEW SETBACK LEVEES

Landcover Type[a]	Impacts (Acres)[b]
Riparian	~6
Grassland	~16
Agricultural Land	~30
Developed	~1
Wetlands/Other Waters	~2-4

NOTES:
[a] Estimates on landcover type are based on VegCAMP data and National Wetland Inventory.
[b] Estimates are highly preliminary and are expected to change substantially once a final alternative and design are established. They are only presented herein for planning purposes and to provide context for the general scale of habitat impacts that may ultimately arise.

6.2.4 Construction of New Weir Structure

Construction of the new weir structure approximately 3.1 river miles upstream of the existing Paradise Cut weir is expected to involve installation of a concrete weir structure sited immediately landward of the existing levee located along the left bank of the mainstem San Joaquin River. It is anticipated that the area behind the landward toe of the San Joaquin River levee would need to be substantially excavated to ensure there is a geotechnically stable base for placement of a new concrete weir structure. It will also likely be necessary to accommodate a concrete apron on the downstream end of the weir to dissipate some of the energy of water flowing over the weir structure and to prevent it from creating a scour hole that undermines the foundation of the weir itself. Finally, installation of the new weir will require modifying the geometry of the existing levee on the left bank of the San Joaquin River to lower the elevation of the crown of the levees, thereby facilitating the diversion of water into the expanded Paradise Cut bypass.

It is anticipated that the new weir construction will permanently impact approximately 1.4 acres of riparian habitat, principally associated with the modifications to the existing San Joaquin River levee geometry (**Table 8**). It is not expected that the levee modifications will need to extend down to the waterline on the waterside slope of the levee, thereby preventing any direct permanent impacts to the riverine habitat present within the San Joaquin River and minimizing the potential to affect riparian vegetation overhanging the channel (i.e., shaded riverine aquatic habitat), which is particularly important for native salmonid fishes.

Additionally, the project is expected to affect approximately seven acres of open space habitat. Of these seven acres, 4.7 acres have been mapped by VegCAMP as annual or perennial grasslands, and approximately 2.3 acres have been mapped as agricultural land, although based on aerial imagery, it appears that most of this “open space” located behind the landside slope of the existing San Joaquin River Project levee is cropland. An additional 1.42 acres of agricultural land is expected to be temporarily affected to facilitate construction staging, stockpiling and staging.

TABLE 8
PRELIMINARY ESTIMATES OF PERMANENT AND TEMPORARY IMPACTS TO EXISTING LANDCOVERS THROUGH CONSTRUCTION OF NEW WEIR STRUCTURE

Landcover Type[a]	Permanent Impacts (Acres)[b]	Temporary Impacts (Acres)[b]
Riparian	~1-2	-
Grassland	~5	-
Agricultural Land	~2-4	~2
Freshwater Wetlands	<0.01	-

NOTES:
[a] Estimates on landcover type are based on VegCAMP data and National Wetland Inventory.
[b] Estimates are highly preliminary and are expected to change substantially once a final alternative and design are established. They are only presented herein for planning purposes and to provide context for the general scale of habitat impacts that may ultimately arise.

6.3 Compensatory Mitigation Projections

The Project will restore and enhance a significant amount of habitat, introducing the possibility that it may be able to “self-mitigate” for habitat- and species-related impacts. The sub-sections below estimate the spatial extent of potential project impacts to each habitat type and compares those estimates to the areas of habitat that will be restored or enhanced by the project, in order to assess the project’s capacity for self-mitigation.

6.3.1 Riverine

Channel dredging will impact riverine habitat, which is assumed to occur to an average of two feet in depth across a total of five miles of Old River and Grant Line Canal. The impact calculations assume that SJAFCA will dredge the entire width of these channels, including naturally shallow areas along the banks of these features. Doing so conservatively estimates (i.e., overestimates) the likely realized extent of dredging footprint, since SJAFCA will likely focus dredging activities only on certain portions of the channel cross-section.

Under these assumptions, the project would result in up to 141 acres of impacts to riverine habitat associated with dredging (**Table 9**). Since the effect of the dredging is only temporary and will not result in permanent loss of any riverine habitat, the regulatory agencies (e.g., National Marine Fisheries Service, California Department of Fish and Wildlife, Central Valley Regional Water Quality Control Board) are unlikely to require in-kind compensatory mitigation of riverine/channel habitat. The fish agencies may express concerns regarding potential impacts to shallow, shoreline habitat that are considered particularly important to juvenile salmonid species, even if these impacts are ultimately temporary in duration or not actually realized (e.g., if dredging is limited to the deeper portions of the channel). The planned 3.5 miles of shaded riverine aquatic (SRA) restoration and enhancement planned as part of the Paradise Cut project is expected to be sufficient to adequately address the fish agencies concerns about temporal losses to fish habitat conditions.

TABLE 9
COMPENSATORY MITIGATION ESTIMATION

Landcover Type[a]	Impact Duration	Potential Impacts[b]	Proposed On-Site Compensation	Ratio
Riverine	Permanent		~3.5 linear miles of SRA	NA/ [c]
	Temporary	~141		
Riparian	Permanent	~5	810 ac restored; 29 ac enhanced	>100:1
	Temporary	-		
Grassland	Permanent	~31	41 acres	> 1: 1
	Temporary	-		
Agricultural Land	Permanent	~41	2,750 acres of cropland	>50:1
	Temporary	~2		
Freshwater Wetlands	Permanent	~9	TBD[d]	TBD
	Temporary	-		

NOTES:
[a] Estimates on landcover type are based on VegCAMP data and National Wetland Inventory.
[b] Estimates are highly preliminary and are expected to change substantially once a final alternative and design are established. They are only presented herein for planning purposes and to provide context for the general scale of habitat impacts that may ultimately arise.
[c] Based on prior consultations for dredging project, the project team assumes that NMFS/CDFW/Central Valley Regional Board will not require any riverine habitat mitigation for temporary effects to Grant Line Canal and Old River associated with dredging. The planned restoration and enhancement of shaded riverine aquatic (SRA) habitat for the Paradise Cut project can be presented as approach to mitigate the temporary impacts to fisheries habitat from dredging.
[d] The Project currently does not include any plans for on-site wetland or other aquatic resource restoration or establishment. While the preliminary analysis does include potential impacts to aquatic resources, it is expected that the weir and levee work can be sited and designed in a manner to either entirely avoid or substantially reduce the net impacts to aquatic resources associated with construction work.

6.3.2 Riparian

Levee degradation, setback levee construction, and weir construction (Table 7) will potentially impact limited amounts of riparian habitat (roughly five acres). Riparian habitat is important for a wide array of species, including many special-status bird species. Loss of riparian habitat will be an important consideration for a CDFW Lake or Streambed Alteration Agreement. Given that extensive riparian habitat restoration or enhancement of hundreds of acres is planned as part of the Project (Table 7), SJAFCA is likely to easily achieve compensatory mitigation for loss of riparian habitat..

6.3.3 Grassland

Levee removal/degradation, setback levee construction, and weir construction are all expected to collectively contribute to a loss of grassland habitat of approximately 30 acres (**Table 9**). Grassland habitat is considered foraging habitat for Swainson’s hawk. Grassland habitat is important for other sensitive species, such as northern harrier, which use grasslands for nesting. The Project will include a projected 41 acres of grassland restoration, which means that the potential temporary or permanent loss of grasslands associated with project construction will be compensated for on-site at a greater than 1:1 ratio.

6.3.4 Agricultural Land

Construction effects are expected to result in an estimated conversion of approximately 40 acres of existing agricultural land. Certain agricultural lands are utilized by Swainson's hawk for foraging, depending on crop types. For example, orchards and vineyard are not considered suitable for use by Swainson's hawk for foraging while crops such as alfalfa provide excellent foraging habitat. Since crop types on a given plot of land are subject to change, determination of whether certain agricultural land represents suitable foraging habitat for Swainson's hawk depends on current cropping patterns. For the purposes of this analysis, it is assumed that all ~40 acres of agricultural land could be potential Swainson's hawk foraging habitat. Additionally, CEQA calls for consideration and potential mitigation for conversion of certain types of farmland, particularly high quality farmland (i.e., Important Farmland). Given that the project will involve preservation of over 2,500 acres of farmland, the loss of agricultural land tied to construction of the project is expected to be considered fully mitigated.

6.3.5 Freshwater Wetlands/Other Waters

Construction work could result in fill of seasonal wetlands and other aquatic features, particularly with respect to construction of the new setback levees and weir structure. Though careful pre-project planning could likely avoid a sizable portion of these impacts, it is nonetheless reasonable to assume that some aquatic resources impacts could remain.

Based on the current conceptual understanding of where construction footprints would generally be located, it is preliminarily estimated that as many as approximately nine acres of seasonal wetlands or other waters could be permanently affected. Currently, no on-site wetland restoration is specifically planned for the Project. The regulatory agencies (the U.S. Army Corps of Engineers, the Central Valley Regional Water Quality Control Board, and the California Department of Fish and Wildlife) would likely require no net loss of habitat, whether from on-site compensatory mitigation or through purchase of off-site third-party mitigation bank credits. For small amounts of aquatic habitat losses, it is often most practical to purchase the bank credits from an already-established bank entity. However, purchase of such bank credits for several acres of wetlands can quickly become costly (on the order of many hundreds of thousands or millions of dollars). In such a situation, on-site restoration of wetlands or other waters within the Paradise Cut project area to serve as compensatory mitigation for losses associated with construction may emerge as a more preferred approach over use of a third-party bank.

6.4 Recommendations

Based on this analysis, the following recommendations are offered to avoid and mitigate the environmental impacts of the Project:

1. Incorporate the mitigation measures described in Section 6.1 into the Project. These avoidance and mitigation strategies have been identified based upon what is known (or reasonably assumed) about the physical configuration of the Project. If that changes substantially as a result of the SJAFCA feasibility study that is scheduled to begin in 2023, it may be necessary to review the list of measures to ensure the completeness and appropriateness of these measures in light of the eventual preferred alternative.

2. Seek to avoid, to the maximum feasible extent, the siting of setback levees or associated construction and staging areas in areas with freshwater wetlands or other aquatic habitat resources. Should such siting prove unavoidable, assess the potential to incorporate a commensurate area of similar habitat into the Project design to mitigate for these impacts, or, alternatively, budget for the acquisition of needed credits from an off-site mitigation bank. The relative desirability of these alternatives will likely depend primarily on the areal extent of impacts and required mitigation.

3. Consult with regulatory agencies early in the design process to ascertain, to the extent possible, their prospective conclusions about the adequacy of intended restoration actions to mitigate for project impacts. The preliminary conclusion drawn here for the current project description is that, with the possible exception of potential impacts to freshwater wetlands, the Project is self-mitigating with respect to habitat-related impacts. Even if the project description does not change substantially because of the SJAFCA feasibility study, additional dialogue with the regulatory agencies should be conducted to confirm this conclusion to the extent possible.

7. Maintenance and Monitoring Strategies

A number of maintenance and monitoring strategies, described below, may be required to ensure that Project meets and sustains its objectives. Engineering and restoration designs will be required to achieve greater specification of these strategies.

7.1 Operations and Maintenance

There are two main operations and maintenance strategies for design measures that address negative hydraulic impacts. The first strategy is for countermeasures that are included in the project design and constructed at the same time as bypass expansion and restoration measures – for example, the inclusion of seepage berms along the levee represented by index point SJ30. For measures that are part of the implemented project, standard O&M practices would apply: ensure the levee is operated within an explicit range of conditions, inspect the levee and document deficiencies, maintain the levee to meet performance objectives, and repair or replace levee components as needed. Project measures and specific O&M requirements would be included in an update of the existing O&M manuals or supplements.

A second strategy is for hydraulic impacts that do not exceed a yet-to-be-defined acceptable risk threshold. As discussed in Section 5, increases in water surface elevations can result in widely different increases in the probability of failure depending on levee hazard ratings and the shape of the resultant cumulative performance curve. For levees that may experience a small increase in the probability of failure that's below the risk threshold, an adaptive management approach may apply.

In this instance, the levees of interest may be subject to a more frequent inspection schedule to monitor levee condition and performance during and after flood events. If poor performance is observed, adaptive management would occur to resolve the deficiency. Contingency measures may vary from placement of rock slope protection to installation of a cutoff wall. This strategy attempts to avoid excess design measures that inflate the project budget and recognizes that monitoring and adaptive management may result in lower long-term costs if the observed levee performance is acceptable. Such a strategy may be more appropriate for leveed systems with relatively low consequences of failure. Additional discussions with reclamation districts and interested parties are required to define acceptable risk, levee performance, and adaptive management thresholds.

Maintenance is also necessary for areas of restored vegetation, primarily to ensure successful plant establishment. Maintenance of restored habitats involves three major components:

- **Irrigation:** For newly planted vegetation, whether begun from seeds, propagules, or seedlings, irrigation is generally required for a period of up to three years after planting to ensure proper vigor and growth.
- **Weed suppression:** Cultivation or mowing is also necessary, usually also for a period of up to three years, to prevent undesirable vegetation from out-competing the restoration plantings.
- **Replanting of failed plant starts:** It is prudent to assume that approximately 15% of new plant starts will need to be replanted each year for at least the first three years to compensate for routine seedling mortality. This is particularly important for any vegetated areas that are being used for compliance with regulatory requirements for mitigation, as mitigation agreements generally contain quantified success criteria pertaining to survival and persistence of desired vegetation.

Given the large size of the restoration areas in the Project (e.g., over 800 acres of riparian forest, plus additional restoration areas) it is assumed SJAFCA will carry out these tasks by mechanized means. Weed control would primarily be conducted through mowing, and irrigation through sprinklers. Weed control activities are assumed to be concentrated in the spring months (March through May), irrigation in the summer months (June through September), and replanting in the fall (October). Approximate costs associated with these activities are presented in section 8.2.

7.2 Monitoring and Adaptive Management

Maintenance and monitoring strategies are actions intended to ensure the goals of the project are met over time. These include both day-to-day activities as well as long-term commitments to monitor changes in environmental conditions. Additionally, implementation of adaptive management is a requirement for any ecosystem restoration and/or water management actions that are considered covered actions under the Delta Stewardship Council's Delta Plan. Policy G P1(b)(4) (Cal. Code Regs., tit. 23, § 5002(b)(4)) of the Delta Plan requires that there are adequate provisions for continued implementation of adaptive management appropriate to the scope of the action and that the requirements are satisfied through the development of an adaptive management plan that is consistent with the 9-step, 3-phase framework described in Appendix 1B of the Delta Plan. Such adaptive management plans are expected to include a discussion of project goals and measurable objectives, definition of specific metrics to track performance towards those goals and objectives, and a description of a plan for strategies that could be used if the performance measure targets are not met.

Tables 10 and **11** summarize the expected monitoring activities that will be implemented as part of a compliance program pursuant to anticipated permit requirements by regulatory agencies. **Table 12** presents the expected monitoring actions that will be implemented as part of the implementation of the adaptive management program for the project. Specifically, recommendations were gathered from review of maintenance and monitoring activities undertaken by sufficiently similar projects in the Delta or Central Valley (refer to Appendix A). Additional maintenance and monitoring strategies may be required for permit compliance.

TABLE 10
ANTICIPATED MONITORING STRATEGIES FOR THE PREFERRED CONCEPTUAL DESIGN PRIOR TO AND DURING CONSTRUCTION

Project Components	Category of Mitigation/ Monitoring Strategies	Type of Mitigation/Monitoring	Assumptions About Level of Effort
Dredging and Channel Maintenance	Turbidity monitoring to monitor sediment resuspensions	Water quality sampling	• Discrete water quality sampling
	Silt curtain	Water quality protection	• Installation of turbidity curtain
Habitat Enhancement	Monitor existing riparian habitats	Landcover mapping	• Existing landcover will be mapped throughout project site to the vegetation alliance level. • The existing conditions landcover mapping data will eventually be used to confirm increases in riparian habitat post-project • Aquatic resources delineation will have already been conducted as part of project planning (i.e., not part of monitoring in period immediately preceding or during construction)
Biological Resources Protection	Special-status species pre-construction surveys	Focused pre-construction nesting bird surveys, including Swainson's hawk, burrowing owl, least Bell's vireo, tricolored blackbird, and western yellow-billed cuckoo	• Once construction starts, assume that construction continue, obviating the need to re-conduct nesting bird surveys which can be triggered with lapses in construction of periods of 14 days.
		Preconstruction bat roost surveys	• Once construction starts, assume that construction continue, obviating the need to re-conduct bat roosting surveys which can be triggered (depending on CEQA mitigation measures/permit conditions) with lapses in construction of periods of ~14 days or more.
		Giant garter snake/western pond turtle pre-construction survey and construction monitoring	• Assume biological will be needed daily, with one biological monitor assigned to each construction crew (if multiple construction contractors are working). • Assume a designated biologist for giant garter snake would need to be available daily
		Fisheries/dredging monitoring	• Assume at least one fisheries biologist will be present during any point of in-water work • Assume that no in-water pile driving will be necessary (i.e., no need for collection of hydrophone data).
		Inspections of Species Buffers and Exclusion Fencing	• Assumes comprehensive barrier/exclusion fencing inspections will be required to occur at least once per week.
		Rare plant botanical pre-construction surveys.	• Assume that no more than two survey periods are necessary to cover all rare plant species with a potential to occur within the project footprint.
		Pre-construction surveys for elderberry shrubs	• Assume that limited disturbance to elderberry shrubs with stems greater 1 inch in diameter would occur.
Cultural Resources Protection	Cultural Resources Surveys	Cultural Resources Monitoring for Archaeological Resources and Tribal Cultural Resources	• Sensitivity of site for potential occurrence of cultural resources will be based on the Section 106 NHPA Act compliant report that will be prepared as part of permitting for the project. • Assume that at least one archeologist will be present on site during period of active construction. • Assume that Tribal Cultural Resources are present and that Tribal monitors would be present.

TABLE 11
ANTICIPATED POST-CONSTRUCTION MAINTENANCE STRATEGIES FOR THE PREFERRED CONCEPTUAL DESIGN

Project Components	Maintenance and Monitoring Strategies	Assumptions About Level of Effort
Channel Conveyance and Levee	Repairs to levee slopes, including any rock revetment materials	• Assume annual inspections and following inundation events • Assumes project would result in creation of approximately 10 miles of new setback levees • Assumes annual mowing within Paradise Bypass corridor to prevent establishment of woody vegetation in areas not designated for riparian restoration.
	Vegetation management to identify repairs and ensure levee integrity	
	Rodent abatement and damage repair	
	Debris clearing and trash cleanup	
Dredging and Channel Maintenance	Debris clearing	• Assumed to occur following Paradise cut inundation events (e.g., on order of once a decade) • Most material is expected to be large woody debris washed into Paradise Cut from upstream sources following flood events.
	Trash cleanup	• Trash management of Paradise Cut area would be part of standard land management practice
Habitat Enhancement	Long-term management of aquatic invasive plant species	• Assumed to be implemented by providing funding to Division of Boating and Waterways
	Terrestrial Weed Management	• Assume that non-native invasive terrestrial weeds will be mapped at least annually for five years • Control methods may include hand or mechanical removal, chemical treatment, and/or targeted livestock grazing.

TABLE 12
ANTICIPATED POST-CONSTRUCTION MONITORING STRATEGIES FOR THE PREFERRED CONCEPTUAL DESIGN

Project Components	Maintenance and Monitoring Strategies	Assumptions About Level of Effort
Channel Conveyance and Levee	Inspections of levee/weir integrity, including due to erosion or rodent damage	• Assume annual inspections and following inundation events
Habitat Enhancement	Inspection of revegetation/mitigation installation	Annual performance monitoring for a minimum of 5 years Assume performance monitoring period would be extended if vegetation establishment fails to meet performance standards within the 5 year time period Assumes metrics to evaluate successful establishment of riparian vegetation include • Plant survival • Plant vigor • Vegetative cover (canopy), by species • Percent cover by invasive plants Assume enhancement of 29 acres of riparian habitat Assume 83 acres (3.5 linear miles) of restored shaded riverine aquatic habitat. Assume 41 acres of native grassland restoration Assume 810 acres of restored riparian habitat
	Monitoring of aquatic invasive plant species	• Annual evaluation of aquatic invasive plant species extent, based on either land-based reconnaissance or aerial imagery.
	Fish stranding monitoring	• Would occur following major Paradise Cut inundation events. • Sampling gear may include hand nets, beach seines, electrofishing, as appropriate • Would also map out depressions in Bypass corridor that need to be re-graded to prevent future stranding events.

For any construction-related impacts to native trees and shrubs, it is expected that CDFW will require preparation of a project-specific habitat restoration and revegetation plan. The plan is expected to require the replacement on-site of any native trees and shrubs greater than four inches diameter breast height removed to construct the project, on no less than 3:1 ratio (replaced: removed), or in accordance with guidance and/or requirements form other regulatory agencies. It is also expected that CDFW will require monitoring of the replacement plantings to confirm they have successfully established. A typical success criterion is 70 percent survival of new plants after five years. If performance of replacement plantings falls below specified criteria, generally CDFW will requires further compensation.

Visual inspections and evaluations are recommended across the entire project and are intended to identify deficiencies and direct any operations, maintenance, repair, replacement, or rehabilitation work required to correct the noted deficiencies. The frequency of inspections may be based on the project component; however, at least annual inspections are recommended, especially prior to the beginning of the flood season, following each major high-water period, and otherwise at intervals recommended by permitting authorities. Conditions to be evaluated would include indications of slides or sloughs developing along the levees, wave wash or scouring action, and any other conditions that might endanger the structures integrity (e.g., levee and replacement weir).

Upon completion of construction, monitoring and adaptive management activities are recommended to ensure proper functioning of newly constructed components and long-term viability of the newly restored ecosystem. Post-construction site monitoring and adaptive management should be designed to be flexible and adaptive based on changing conditions in the Delta, and use the best available science to inform decision-making. Compliance monitoring required by permitting authorities would verify whether permitting requirements and avoidance mitigation strategies are fulfilled.

8. Costs and Benefits for Avoidance, Mitigation, Maintenance and Monitoring Activities

8.1 Estimated Dredging Costs, including Maintenance Dredging

Anchor (2021) presents a comprehensive strategy for dredging and channel depth restoration in the South Delta, including the reaches of Old River and Grant Line Canal that the Paradise Cut Project identifies for dredging. This report includes conceptual cost estimates for various dredging activities and techniques in the South Delta, presented on a volumetric (dollars per 100,000 cubic yards of material) or length (dollars per mile) basis. Because this study is very recent and based upon the same geography of interest to the Project, its estimates and findings are used as the basis for cost estimations of dredging in the Project.

As noted in Section 3, the Project involves dredging five miles of channel to a depth of two feet. For purposes of cost estimation, it is assumed that the entire width of the channel is dredged to this average depth, resulting in approximately 141 acres of dredging area, and 282 acre-feet of dredging volume. The latter equates to approximately 455,000 cubic yards of dredging. Using this dredging volume and a five-mile length, approximate dredging costs for the Project are presented in **Table 13**. These estimates are in 2021 dollars.

SJAFCA will need to refine cost estimates after SJAFCA identifies a preferred alternative and further project specifications (such as the precise extent, location and method of dredging). Maintenance dredging costs can be assumed to be roughly proportional on a per-volume basis to those presented here, but the potential extent of required maintenance dredging cannot be reasonably estimated until further sedimentation analysis of the Project is conducted.

TABLE 13

PRELIMINARY ESTIMATES OF DREDGING COSTS

		Unit costs		Estimated project costs	
	Unit	Low	High	Low	High
Soft costs					
Hydrographic Surveying	100k cy	8,000	10,000	36,397	45,496
Hydrodynamic and Water Quality Modeling	100k cy	75,000	300,000	341,220	1,364,880
Geotechnical Investigation	mi	30,000	50,000	150,000	250,000
Geotechnical Evaluations	100k cy	25,000	25,000	113,740	113,740
Sediment Characterization	100k cy	150,000	250,000	682,440	1,137,400
Engineering Design and Bid Support Services	100k cy	150,000	150,000	682,440	682,440
CEQA/NEPA Documentation	100k cy	150,000	350,000	682,440	1,592,360
Env and Tech Studies	100k cy	150,000	150,000	682,440	682,440
Regulatory Permitting	100k cy	125,000	225,000	568,700	1,023,660
Subtotal		863,000	1,510,000	3,939,816	6,892,415
Option A. Mechanical dredging with landfilling					
Mobilization and demobilization	1	200,000	200,000	200,000	200,000
Surveying	1	20,000	20,000	20,000	20,000
Dredging	100k cy	8,000,000	8,000,000	36,396,792	36,396,792
Tipping fee	100k cy	1,500,000	1,500,000	6,824,399	6,824,399
Subtotal		9,720,000	9,720,000	43,441,191	43,441,191
Option B. Mechanical dredging with placement at adjacent upland					
Mobilization and demobilization	1	300,000	300,000	300,000	300,000
Surveying	1	20,000	20,000	20,000	20,000
Site preparation	1	250,000	250,000	250,000	250,000
Land lease	6 mos	180,000	180,000	180,000	180,000
Dredging and placing upland	100k cy	5,000,000	5,000,000	22,747,995	22,747,995
Dewatering (working/disking)	100k cy	1,500,000	1,500,000	6,824,399	6,824,399
Subtotal		7,250,000	7,250,000	30,322,394	30,322,394
Option C. Hydraulic dredge with geotextile tub dewatering at adjacent upland					
Mobilization and demobilization	1	500,000	500,000	500,000	500,000
Surveying	1	20,000	20,000	20,000	20,000
Site preparation	1	200,000	200,000	200,000	200,000
Land lease	6	180,000	180,000	180,000	180,000
Dredging and placing upland	100k cy	2,500,000	2,500,000	11,373,998	11,373,998
Dewatering (working/disking)	100k cy	2,000,000	2,000,000	9,099,198	9,099,198
Subtotal		5,400,000	5,400,000	21,373,196	21,373,196
Contingency for all items	25%				
Totals by Scenario		Option A		59,226,259	62,917,007
		Option B		42,827,762	46,518,511
		Option C		31,641,265	35,332,013

NOTES: Each scenario assumed to include soft costs plus costs itemized under each Option subheading, with a 25% contingency assumption included; all unit costs drawn from Anchor (2021)

8.2 Estimated Mitigation, Monitoring and Maintenance Costs

Potential costs associated with mitigation, monitoring and maintenance during and after the Project are described and estimated below. Potential levee maintenance costs associated with hydraulic impact mitigation cannot be estimated until further analysis confirms the location and extent of both structural and non-structural avoidance and mitigation strategies.

8.2.1 Mitigation and Monitoring Costs

Projects of this type are typically expected to establish a robust construction/dredging monitoring program. Such a monitoring program is needed to prevent unintended impacts on sensitive biological resources and to evaluate any archaeological finds that may arise during earthwork. This construction monitoring program can be generally divided into the following phases:

- Mobilization and Initial Clear and Grub (expected to last a few months at beginning of construction implementation)
- Building Setback Levees (expected to last two years)
- Degrading Existing Levees (expected to last several months, following completion of setback levees)
- Weir Construction (expected to be completed within a year, concurrent with setback levee construction)
- Dredging (assumed for budgeting purposes to be completed in a single year, although may extend to two as allowable work windows for dredging within a given year are expected to be relatively short)
- On-site Restoration/Enhancement (expected to occur over a couple months over two years).

The Compliance Team is expected to include the following roles:

- **Oversight Manager:** The Oversight Manager will be more involved earlier in the project implementation phase to ensure the compliance program runs smoothly. It is assumed that the first big construction period will uncover more issues and challenges that will need to be elevated to the Oversight Manager to resolve. This additional involvement covers minor permit amendments (from a budget assumption standpoint, it is assumed that a major permit amendment is not needed).

- **Field Manager:** The Field Manager will be frequently on the project site during construction phase to coordinate with construction contractors and the archaeological and biological monitoring team. The Field Manager will be responsible for helping to troubleshoot issues that arise in the field to the extent of their abilities.

- **Archeological Lead:** Would be main point of contact between Tribal monitor team and the archaeological team. The Archaeological Lead would work closely with the Field Manager.

- **Biological Monitors:** Would be responsible for ensuring that permit measures regarding biological resources (including special-status species and aquatic resources) are implemented.

If special-status species are observed, the biological monitor would be responsible for establishing no-work buffers (e.g., around active bird nests) and/or relocating species out of the way of construction, if appropriate and allowed under the permit conditions.

- **Archaeological Monitors:** For any work involving excavations in areas with a potential to encountered archaeological resources, the archaeological monitor will be in place to monitor excavation work and process any potential discoveries that are encountered during construction work.
- **Tribal Monitors:** These monitors are sent by the Tribes and are expected to work with Archaeological Monitors. The Archeological Lead is expected to help coordinate the work of the Tribal Monitors. Allowing for Tribal Monitoring is an AB 52 requirement.

Implementation of the construction phase of the project is expected to take approximately three years. The duration of construction plays a critical factor in budgetary assumptions for implementation of a compliance monitoring program, as delays in construction (e.g., construction taking 4 years instead of three) will be tied to a commensurate increased in compliance monitoring effort.

In general, it is estimated that this program would cost approximately $8 million to implement, which roughly breaks down to approximately $2.67 million per year of active construction. It is expected that the highest rate of spend associated with implementing a monitoring program would occur approximately during the middle portion of the projected three-year construction schedule, as construction is expected to be operating at its highest intensity. Conversely, it is expected that monthly average monitoring costs would be lower initially at the start of the project as construction ramps up as well as towards the tail-end of the construction period as work activities start to wind down.

Additionally, it is estimated that the cost for post-construction monitoring and reporting to track performance of restored and enhanced habitat types at around $250,000[2]. This assumes 5-years of performance monitoring and that the restoration/enhancement sites achieve the performance targets set forth by the resource agencies during the permitting process; failure to achieve the performance metrics within five years may require an extension of the post-construction performance monitoring.

8.2.2 Restoration Maintenance Costs

Habitat restoration areas must be maintained until such time as they become self-sustaining vegetation communities. Costs associated with site preparation and the initial planting of vegetation will be incorporated into the capital cost of the construction of the Project, but the vegetation will likely need to be irrigated and cultivated for a period of three years after planting to ensure robust plant establishment. In addition, it is prudent to assume SJAFCA will need to replant approximately 15% of the vegetation each year to compensate for the expected mortality rate of young vegetation.

[2] That cost estimate assumes two site visits/year for grassland establishment and 1 visit/year for riparian or tree plantings. It also includes the cost of the required reports that go out to agencies.

The Paradise Cut project covers an extensive area, with approximately 900 acres of habitat restoration. For purposes of initial cost estimation, it is assumed that all of these acres require comparable treatment in terms of irrigation and weed control, and that the latter is best performed through periodic mowing. **Table 14** shows the assumed labor pattern throughout the year associated with these activities.

TABLE 14
ASSUMED RESTORATION MAINTENANCE LABOR CALENDAR (IN FTE MONTHS)

Activity	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Weeding/mowing			4	4	4					1			13
Irrigation maintenance						2	2	2	2				8
Replacement planting										2			2
General upkeep	0.25	0.25									0.25	0.25	1
Total	**0.25**	**0.25**	**4**	**4**	**4**	**2**	**2**	**2**	**2**	**3**	**0.25**	**0.25**	**24**

This labor schedule equates to an assumed two annual full-time-equivalent employees. For purposes of initial estimation, it is assumed that this labor would be obtained through contractors at a billing rate of approximately $63/hr. It is assumed that mowing would occur four times per year, requiring usage of a tractor and mower with vehicle and machinery operating costs assumed at $25/hr (UC Cooperative Extension 2020), and an assumed mowing rate of five acres per hour. Irrigation water is assumed to be applied at a rate of three acre-feet per acre per year, at an assumed cost (including pumping) of $100/acre-foot (UC Cooperative Extension 2020), or an equivalent of $300 per acre per year. Assuming a 15% annual mortality rate for restoration plantings is equivalent to the re-planting of 135 acres per year, with replacement plant materials assumed to cost approximately $2,000/acre. These costs are summarized in **Table 15** below.

TABLE 15
PRELIMINARY ESTIMATE OF RESTORATION PLANTING MAINTENANCE COSTS (PER YEAR)

	Qty	$/hr	Hrs	$/ac	Acres	Total
Labor Annual FTE	2	63	2080			262,080
Equipment usage	4	25	180			18,000
Irrigation water				300	900	270,000
Plant materials				2000	135	270,000
						820,080

8.3 Conceptual Finance Considerations for Ongoing Costs

Flood risk reduction projects are comprised of capital costs, costs associated with required mitigation and monitoring, and operation and maintenance (O&M) costs. Capital costs for the Project – i.e. the one-time expenses needed to plan, design, permit and construct the Project – are beyond the financing capacity of local and regional entities in the lower San Joaquin Valley, and thus will require a combination of state and potentially federal funds with local and regional matches. The precise potential sources of these funds will depend on a range of factors, including the characteristics of the final design of the Project, the availability (or not) of funds from future

State bond issues, and the outcome of forthcoming investigations by the US Army Corps of Engineers to determine the scope of any potential federal participation in the Project.

Local and regional funding contributions are most commonly financed by property-based assessment districts because flood risk reduction projects provide a special benefit to property owners. These assessments typically differentiate capital costs from long-term O&M costs because capital costs (often one-time expenses) are financed over a fixed period while long-term O&M costs (often repeating expenses) are perpetual. In general, ongoing costs such as O&M are primarily borne by local maintaining agencies (LMAs) such as reclamation districts or regional flood control agencies.

Mitigation costs represent a gray area. They can be treated as a one-time capital cost where the cost of mitigation implementation and required O&M are combined into a single settlement payment to a third party, or as a one-time construction cost for a mitigation project (or projects) plus a single, up-front O&M payment or establishment of an endowment for estimated O&M costs. However, mitigation costs can also be split between capital costs and long-term O&M costs where the long-term O&M costs are addressed through annual payments.

Funding for mitigation and monitoring, and O&M activities will be dependent upon the type of mitigation and the potential beneficiaries of the action. Some costs may be most appropriately borne by project proponents, i.e. those groups that directly benefit from the construction of the Project. That may include not only the communities on the San Joaquin River downstream of the Project but also local reclamation districts that experience reductions in flood risk as a result of the Project, possibly including those where the Project invests in levee enhancements or other flood risk reduction measures.

Changes to existing infrastructure by the Project may or may not change the cost of O&M to LMAs. It is possible that in some cases current maintenance assessments may be sufficient if the cost of O&M is estimated to decrease or remains unchanged as a result of Project implementation. In some cases changes to existing infrastructure by the Project may result in an overall improved level of infrastructure performance and constitute a betterment relative to the without-project condition. In this case, the LMA may elect to accept any estimated increase in O&M cost. This acceptance may or may not require the need to increase any existing maintenance assessment.

9. Permitting and Environmental Impact Assessments

Table 16 identifies the permits and approvals that may potentially be required for Project implementation. These permits and approvals are discussed in greater detail in ESA (2019).

TABLE 16
ENVIRONMENTAL PERMITS CONSIDERED FOR THE PROJECT

Jurisdiction	Permit	Description
Federal	Federal Endangered Species Act (FESA) Incidental Take Permits	The USACE needs to consult with the US Fish and Wildlife Service and National Marine Fisheries Service under Section 7 of FESA to obtain Biological Opinions and Incidental Take Permits. The formal consultation would be initiated by submitting biological assessments that represent the USACE's determination of the project effects on federally listed species that may include Central Valley steelhead, spring-run Chinook salmon (experimental population), green sturgeon, delta smelt, giant garter snake, valley elderberry longhorn beetle, western yellow-billed cuckoo, San Joaquin kit fox, riparian brush rabbit, riparian woodrat, and least Bell's vireo.
	Clean Water Act Section 404 Individual Permit/Rivers and Harbors Act Section 10 Permit	A permit needs to be obtained for discharging dredge or fill materials in Waters of the United States. This would require preparing a wetland delineation and obtaining USACE verification of the delineation; conducting an alternatives analysis according to Section 404(b)(1) guidelines, and obtaining National Historic Preservation Act (NHPA) Section 106 authorization, requiring consultation with the State Historic Preservation Officer (SHPO) on cultural resources impacts.
	Clean Water Act Section 401 Water Quality Certification	A Water Quality Certification needs to be obtained from the Central Valley Regional Water Quality Control Board (CVRWQCB) that certifies that the activity complies with all applicable water quality standards, limitations, and restrictions. The USACE may not issue a Section 404 permit until this certification has been granted. New State wetland regulations enforced by the CVRWQCB are likely to be issued in 2019 that would expand the requirements under Section 404.
	USACE Section 408	Because the Project would modify federal infrastructure facilities, a permit would be required under Section 14 of the Rivers and Harbors Appropriations Act of 1899 (33 USC 408). The CVFPB initiates the Section 408 process with the US Army Corps of Engineers (USACE) after the CVFPB permit application has been made. The Project would affect federal levees on both sides of Paradise Cut, and the left bank of the San Joaquin River. National Environmental Policy Act (NEPA) compliance would be required prior to a final Section 408 decision from the USACE.
State	CVFPB Encroachment Permit	The Project would alter the State-Federal flood control system and would need a CVRPB Encroachment Permit. Although an encroachment permit may be applied for prior to completion of California Environmental Quality Act (CEQA) review, CEQA would need to be completed prior to issuance of the permit. The CVFPB would require an endorsement of the proposed Project by the local maintaining agencies (LMAs) at the time of application for the encroachment permit. In addition to the LMAs, the Project would need clearance from Caltrans and the Southern Pacific and Union Pacific Railroad Companies for alterations to their facilities.
	California Endangered Species Act (CESA) Incidental Take Permit	An Incidental Take Permit application should be prepared to receive permission to take State listed species from the California Department of Fish and Wildlife (CDFW). State-listed species could include spring-run Chinook salmon (experimental population), giant garter snake, tricolored blackbird, Delta button-celery, and Mason's lilaeopsis. Impacts to State-listed species would need to be fully mitigated.
	Lake and Streambed Alteration Agreement under Section 1602 of the California Fish and Game Code	Activities that (1) divert or obstruct the natural flow of any river, stream, or lake, (2) change the bed, channel, or bank of any river, stream, or lake, (3) use material from any river, stream, or lake, or (3) deposit or dispose of material into any river, stream, or lake, require notification to CDFW, who would require that the Project proponent would enter into a Lake and Streambed Alteration

TABLE 16
ENVIRONMENTAL PERMITS CONSIDERED FOR THE PROJECT

Jurisdiction	Permit	Description
		Agreement, which would include mitigation measures for any impacts of the activity to fish and wildlife resources.
	Delta Stewardship Council (DSC) Consultation	Early consultation with the Delta Stewardship Council (DSC) regarding consistency of the project with the Delta Reform Act, and relevant provisions of the Delta Plan is encouraged by the DSC. The lead agency would determine via the DSC web-site's self-certification process after CEQA and permitting is completed, whether the project is consistent with the Delta Reform Act and relevant provisions of the Delta Plan.

SOURCE: ESA, 2019.

10. References

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URS. 2015. Technical Memorandum on 2014 Performance Curve Development. Prepared for CA Department of Water Resources Division of Flood Management. Non-Urban Levee Evaluations Task Order. January 28, 2015.

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Appendix A
CEQA/NEPA Project Examples and Other Guidance Documents Reviewed

Project	Shared Project Components	Link
Statewide Restoration General Order (General Order), Draft Program Environmental Impact Report (PEIR), June 2021	Habitat Enhancements	https://www.waterboards.ca.gov/water_issues/programs/cwa401/generalordersunderdev.html
Lookout Slough Tidal Habitat Restoration and Flood Improvement Project, Final Environmental Impact Report (FEIR), December 2019	Levee Construction Habitat Enhancements	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/All-Programs/EcoRestore/Lookout-Slough/Full-Lookout-Slough-Draft-EIR-Compiled-12162019.pdf
Lower Elkhorn Basin Levee Setback Project, Environment Impact Statement/Environmental Impact Report (EIS/EIR), May 2018	Weir Construction (expansion/widening) Setback Levee Construction Channel Widening	https://www.spk.usace.army.mil/Portals/12/documents/regulatory/eis/201600457/201600457-DEIS/2018.05.25-LEBLS%20DEIS_DEIR-201600457.pdf?ver=2018-05-24-164239-697
Feather-Bear Rivers Levee Setback Project (an element of the Yuba-Feather Supplemental Flood Control Project), Final Environmental Impact Report, November 2004	Setback Levee Construction	https://cms9files1.revize.com/trlia/Environmental%20Docs/Feather-Bear%20Final%20EIR%20November%202004.No.2004072113.pdf
Port of Stockton West Complex Development Plan, Draft Environmental Impact Report, November 2003	Channel Dredging (downstream of the Project)	https://www.portofstockton.com/wp-content/uploads/2021/04/WCDP_DraftEIR_200311.pdf
Sacramento Deep Water Ship Channel Nutrient Enrichment Project, Environmental Assessment, June 2018	Channel Dredging	https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=33661
Long Term Management Strategy for the Placement of Dredged Material in the Bay Region (LTMS), Management Plan, July 2001	Channel Dredging	https://bcdc.ca.gov/LTMS/ltms_program.html
River Islands at Lathrop, Phase 2B Project, Draft Environmental Impact Statement (DEIS), October 2014	Levee Construction (near Paradise Cut) Habitat Enhancement	https://ceqanet.opr.ca.gov/1993112027/21
Reinitiation of Consultation on the Coordinated Long-Term Operations of the Central Valley Project and State Water Project	Relevant to all Project Components	https://www.usbr.gov/mp/bdo/lto/

Appendix B
Biological Species Considerations

Landcover Map Resources

Evaluation of landcover types (and associated impacts) within the Project area was solely based on published geospatial data from VegCAMP and the National Wetlands Inventory. The VegCAMP data uses 2016 aerial imagery where imagery mapping was completed via heads-up digitizing, and each delineated polygon was coded with a vegetation type. The National Wetlands Inventory maps out aquatic resources within the landscape based on analysis of aerial imagery. While both resources provide an adequate level of resolution for early planning purposes for this project, on the ground reconnaissance surveys will ultimately be necessary.

Special-status species are legally protected under the state and federal Endangered Species Acts or other regulations, or are species that are considered sufficiently rare by the scientific community to qualify for such listing. Special-status species considered for this analysis are based on the CNDDB, CNPS, and USFWS lists. Based on a desktop level reconnaissance, the following special-status species were projected to either be present and potentially be in the vicinity of construction activities when the Paradise Cut project is implemented, or benefit as a result of project implementation through the planned habitat restoration and enhancement actions. These include the following species listed in the following section.

Fish

Sacramento River winter-run Chinook salmon (Oncorhynchus tshawytscha)

Sacramento River winter-run Chinook salmon adults first enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate up the Sacramento River, past the Red Bluff Diversion Dam from mid-December through early August (National Marine Fisheries Service 1997). The majority of the run passes Red Bluff Diversion Dam from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). Spawning occurs primarily from mid-May to mid-August, with the peak activity occurring in June and July in the upper Sacramento River between Keswick Dam and Red Bluff Diversion Dam (Vogel and Marine 1991). Juvenile winter-run emigration into the Delta and estuary occurs primarily from November through early May. The average residence time in the Delta for juvenile winter-run is approximately 3 months based on median seasonal catch between Knights Landing and Chipps Island. Peak departure at Chipps Island regularly occurs in March. Winter-run smolts enter the Pacific Ocean mainly in spring (March–April), and grow rapidly on a diet of small fishes, crustaceans, and squid.

Since Sacramento River winter-run Chinook salmon do not spawn within the San Joaquin River basin, it greatly minimizes the likelihood that adult winter-run Chinook salmon would be affected by construction of the Project. Dredging within Grant Line Canal and Old River may affect juvenile winter-run Chinook salmon present in the area, including those potentially present in the south Delta as a result of volitional rearing behaviors or as a result of south Delta flow operations.

Central Valley spring-run Chinook salmon (O. tshawytscha) ESU

Central Valley spring-run Chinook salmon is an anadromous species. Adults migrate from the ocean to spawning streams beginning in late January to early February, with upstream migration peaking in May (Moyle 2002). They begin spawning in beds of coarse river gravels from mid-August through October. Adults die after spawning. After the eggs hatch, some juvenile salmon migrate downstream to the bay or ocean within a few months, while others may remain in freshwater rearing areas for up to a year in some systems. Younger fish remain in the ocean for several years before returning to freshwater streams and rivers to spawn. Like steelhead rainbow trout, Chinook salmon generally spawn in cool waters providing incubation temperatures no warmer than 55°F. Compared to steelhead, Chinook salmon are more likely to spawn in coarse gravels. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. Central Valley spring-run Chinook salmon were thought to have been extirpated from the San Joaquin River system for decades, although in recent years there have been discoveries of Chinook salmon adults exhibiting spring-run migration timing returning to the Stanislaus, Tuolumne, and Merced rivers; their origin is unknown and these individuals may be straying from their natal habitat rather than a reflection a self-sustaining population within the San Joaquin River basin. Central Valley spring-run Chinook salmon are being reintroduced to the upper San Joaquin River as a nonessential experimental population as part of the San Joaquin River Restoration Program.

Dredging within Grant Line Canal and Old River may affect juvenile spring-run Chinook salmon present in the area, including those potentially present in the south Delta as a result of volitional rearing behaviors or as a result of south Delta flow operations. The Project may affect adult spring-run Chinook salmon as well; this potential is currently minimal given that there is currently no known self-sustaining population of spring-run Chinook salmon in the San Joaquin River basin, however this evaluation could change if spring-run Chinook salmon re-establish spawning populations within the San Joaquin River or its tributaries in the future.

California Central Valley Steelhead (O. mykiss) distinct population segment (DPS)

California Central Valley steelhead occur in both the Sacramento River and the San Joaquin River watersheds. However the spawning population of fish is much greater in the Sacramento River watershed and accounts for nearly all of the DPS' population. Small, remnant populations of California Central Valley steelhead are known to occur on the Stanislaus River and the Tuolumne River and their presence is assumed on the Merced River due to proximity, similar habitats, and historical presence. California Central Valley steelhead smolts first start to appear in the action area in November based on the records from the south Delta fish salvage facilities. Their presence increases through December and January (21.6 percent of average annual salvage) and peaks in February (37.0 percent) and 60 March (31.1 percent) before rapidly declining in April (7.7 percent). By June, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP. Kodiak trawls conducted by the USFWS and CDFW on the mainstem of the San Joaquin River upstream from the City of Stockton routinely catch low numbers of outmigrating steelhead smolts from the San Joaquin Basin during the months of April and May.

Dredging within Grant Line Canal and Old River may affect juvenile and adult steelhead present in the area, given there are spawning populations of steelhead in the San Joaquin River tributaries. Work along the mainstem San Joaquin River to construct the new weir structure upstream of the existing Paradise Cut weir also has the potential to affect this fish species (e.g., through temporal loss of shaded riverine aquatic habitat if trees along the existing levee have to be removed), given the very close proximity of the weir construction work to riverine habitat.

Southern Distinct Population Segment (sDPS) of North American Green Sturgeon (Acipenser medirostris)

Green sturgeon is very marine-oriented, entering freshwater mainly to spawn, but residing in bays, estuaries, and near coastal marine environments for the vast majority of their lifespan. Critical habitat for sDPS green sturgeon includes the Sacramento-San Joaquin Delta. Adult sDPS green sturgeon leave the ocean and enter San Francisco Bay between January and early May. Migration through the bay/Delta takes about one week and progress upstream is fairly rapid to their spawning sites. Green sturgeon spawn primarily in the Sacramento River with most spawning activity concentrated in the mid-April to mid-June time period (Poytress et al. 2013). Larval green sturgeon hatch in the late spring or summer (peak in July) and progress downstream towards the Delta rearing into juveniles. It is unknown when they enter the Delta, but it is widely believed that they may typically rear for up to 2–3 years before entering the ocean. Ocean entry marks the transition from juvenile to sub-adults.

Dredging within Grant Line Canal and Old River may affect juvenile and adult green sturgeon present in this area of the south Delta.

Birds

Swainson's Hawk (Buteo swainsoni)

Swainson's hawk occurs as a breeding species in open habitats throughout much of the western United States and Canada, and in northern Mexico. In California, breeding populations of Swainson's hawks occur in desert, shrub steppe, grassland and agricultural habitats, however the overwhelming majority of the state's breeding sites are in two disjunct populations in the Great Basin and Central Valley. The Swainson's hawk is not an obligate riparian species; its relationship with riparian habitats is variable and largely dependent on the availability and distribution of suitable nesting trees in proximity to high-quality foraging habitats. In the Central Valley, nest sites are strongly associated with riparian forest vegetation, whereas in the Great Basin nest sites are widely distributed in upland habitats. The primary habitat requisite provided by riparian systems is nesting substrate, typically large trees. When Swainson's hawks arrive at their nesting sites in March or April, the males begin constructing nests on the ground, ledges or in trees seven to fifteen days after the birds arrive. The nest consists of twigs and grasses and can take up to two weeks to complete. One to three eggs are laid in May and incubated for about 28 days. The young fledge in late July and August. Nests with eggs range from early May to mid-July, but June is the common nesting month (Davis 1961).

Swainson’s hawk could be affected by construction activities, since the levee degrade, setback levee installation, and weir construction all have the potential to result in removal of large trees preferentially used by this species for nesting. Furthermore, activities associated with use of heavy machinery needed to construct the Paradise Cut project also increase the potential for indirect disruption of Swainson's hawk nesting and foraging behavior. Use of open space areas, including existing agricultural fields, for activities such as equipment staging, access and stockpiling can result in temporary losses of foraging habitat for the species.

*Northern harrier (*Circus cyaneus*)*

Although most of its original habitat in Central Valley has been destroyed or degraded, this region still supports the majority of nesting harriers in California. Harriers there breed mainly at private or public wetlands or other reserves, as well as in some types of agricultural fields and pasturelands. In California, northern harriers are common raptors in marsh and grassland ecosystems, as well as agricultural lands, throughout the Central Valley. Breeding season is generally from May-July. Incubation begins before egg-laying is complete and lasts 24-30 days. Hatching generally takes place in June, and young spend approximately five weeks in the nest, leaving by early August (Colorado Partners in Flight 2000).

Northern harriers prefer relatively open habitats characterized by tall, dense vegetation, and abundant residual vegetation (Duebbert and Lokemoen 1977, Dechant et al. 1999). They use native or tame vegetation in wet or dry grasslands, fresh to alkali wetlands, lightly grazed pastures, croplands, fallow fields, old fields, and brushy areas (MacWhirter and Bildstein 1996, Dechant et al. 1999). Although cropland and fallow fields are used for nesting, most nests are found in undisturbed wetlands or grasslands dominated by thick vegetation (Duebbert and Lokemoen 1977, Dechant et al. 1999). Nest success may be lower in cropland and fallow fields than in undisturbed areas (Dechant et al. 1999). Northern harriers nest on the ground or over water on platforms of vegetation in stands of cat-tail (*Typha* spp.) or other emergent vegetation (MacWhirter and Bildstein 1996, Dechant et al. 1999). Ground nests are well concealed by tall, dense vegetation, including living and residual grasses and forbs, or low shrubs, and are located in undisturbed areas with much residual cover.

Ground disturbance associated with existing levee degrade, setback levee installation, and weir construction all have the potential to interfere with ground nests for northern harrier. activities associated with use of heavy machinery needed to construct the Paradise Cut project also increase the potential for indirect disruption of Swainson's hawk nesting and foraging behavior.

White-Tailed Kite (Elanus leucurus)

White-tailed kites are common in savannas, open woodlands, marshes, desert grasslands, partially cleared lands, and cultivated fields. They tend to avoid heavily grazed areas. Perches atop tall vegetation in open landscapes including coastal plains and agricultural areas. White-tailed kites typically nest in the upper third of trees that may be 10–160 feet tall. These can be open-country trees growing in isolation, or at the edge of or within a forest. Nest-building occurs January through August (Dunk 1995). Egg laying begins in February and probably peaks in March and April. Peak fledging probably occurs in May and June with most fledging complete by October (Erichsen 1995).

Tree removal has the potential to result in loss of nesting habitat for this species. Furthermore, activities associated with use of heavy machinery needed to construct the Paradise Cut project also increase the potential for indirect disruption of nesting and foraging behavior.

Merlin (Falco columbarius)

Merlins nest in forested openings, edges, and along rivers across northern North America. They have also begun nesting in towns and cities. When it comes to nesting, Merlins choose their site carefully but do little nest-building or modification. A former crow or hawk nest is usually adopted, then perhaps barely modified before the female lays four or five rust-colored eggs marked with dark splotches. The nest is often high in a tree, frequently a conifer, and usually in a fairly open situation. A Merlin pair may also nest on a cliff or on the ground under heavy vegetative cover, or, rarely, in a tree cavity.

Merlins breed from April to July. Incubation usually takes a month. The female is the main incubator, although the male does share in the duties. The incubation period lasts 25-32 days. At the end of the incubation period, the eggs hatch in intervals. Once the eggs hatch, the female broods the young for about a week. During this time the male fends off intruders, vigorously chasing off crows and other large birds. The male brings in most of the food, which the female transfers to the young. Quills appear on the young after fourteen days, and by eighteen days the down is almost completely covered with feathers, except in the head region. Flight is achieved at 25-30 days after hatching. After about a month in the nest, the young birds may linger from a week to a month, being fed by their parents.

Tree removal has the potential to result in loss of nesting habitat for this species. Furthermore, activities associated with use of heavy machinery needed to construct the Paradise Cut project also increase the potential for indirect disruption of nesting and foraging behavior.

Tricolored Blackbird (Agelaius tricolor)

Tricolored blackbirds are highly social birds that nest, roost and forage in large groups. The tricolored blackbird prefers wetland and grassland habitats, although most native habitats have been lost. Within the Central Valley, breeding colonies live in the rice-growing regions of the Sacramento Valley and in the pasturelands of the lower Sacramento Valley and San Joaquin Valley. Nesting takes place in native emergent marshes, silage and other grain fields, thickets of the introduced Himalayan blackberry, and other flooded and upland habitats. Tricolored blackbirds breed in the spring in dense colonies. In the past, tricolored blackbirds nested in freshwater marshes with cattail, rushes, and willows. They now nest almost exclusively in triticale fields, especially those with invasive mustard or mallow plants. Females select the nesting site within a male's territory, typically close to freshwater with plenty of concealing vegetation. Females build nests in vegetation from just above ground level up to about 8 feet.

Loggerhead Shrike (Lanius ludovicianus)

Loggerhead shrikes inhabit open country with short vegetation and well-spaced shrubs or low trees, particularly those with spines or thorns. They frequent agricultural fields, pastures, old orchards, riparian areas, desert scrublands, savannas, prairies, golf courses, and cemeteries.

Loggerhead shrikes are often seen along mowed roadsides with access to fence lines and utility poles. Nests for eggs are always built in trees, usually about 8 to 15 feet above the ground. The nests are cup-shaped, and house approximately four to seven dull white to light grey spotted eggs.

Tree removal has the potential to result in loss of nesting habitat for this species. Furthermore, activities associated with use of heavy machinery needed to construct the Paradise Cut project also increase the potential for indirect disruption of nesting and foraging behavior.

Yellow Warbler (Dendroica petechia)

Yellow warbler prefers moist habitats with high insect abundance. Habitats include the edges of marshes and swamps, willow-lined streams, and leafy bogs. Yellow warbler also inhabits dry areas such as thickets, orchards, farmlands, forest edges, and suburban yards and gardens. They seem to prefer areas of scattered trees, dense shrubbery, and any other moist, shady areas (Nuttall and Chamberlin, 1971; USGS, 2000). (Celada, et al., 1999; Nuttall and Chamberlin, ed., 1903; U.S. Department of the Interior, U.S. Geological Survey, 2000). Yellow warblers usually breed in late May and early June. Females lay 4 to 5 eggs, incubation lasts 10 to 14 days, nestling period lasts from 8 to 12 days, and parental feeding may extend to two weeks after the young leave the nest, sometimes longer.

Mammals

Red Bat (Lasiurus borealis)

Red bats forage in a variety of habitats, mostly over land, along the edges of pastures, crop lands, or other openings dotted with large deciduous trees. They also have been found in cypress stands, and near pecan trees along rivers. They prefer forested environments.

During winter, hibernating red bats have been documented in a variety of locations, ranging from tree hollows and exposed tree trunks to areas on the ground covered in leaf litter. During summer, they roost in foliage. Breeding season is in fall, and females give birth in early summer. Pups learn to fly in approximately one month and are weaned one to two weeks later.

Tree removal has the potential to result in loss of suitable roosting habitat for this species. Furthermore, activities associated with use of heavy machinery needed to construct the Paradise Cut project also increase the potential for indirect disruption of roosting behavior.

Riparian Brush Rabbit (Sylvilagus bachmani riparius)

Historically, riparian brush rabbits inhabited dense, brushy areas of Valley riparian forests, marked by extensive thickets of wild rose (*Rosa* spp.), blackberries (*Rubus* spp.), and willows (*Salix* spp.). Thriving mats of low-growing vines and shrubs serve as ideal living sites where they build tunnels under and through the vegetation. Suitable existing habitat for riparian brush rabbits is characterized by an abundance of woody ground litter and fewer willows, signifying areas of higher ground not subject to regular or heavy flooding. Willows are mostly found where flooding occurs regularly.

Riparian brush rabbits feed at the edges of shrub covers rather than in large openings. Their diet consists of herbaceous vegetation, such as grasses, sedges, clover, forbs, and buds, bark, and leaves of woody plants. One preferred plant is green clover (*Trifolium wormskiolodii*). They consume herbaceous plants found along trails, fire breaks, or at the edge of brushy areas, and they eat the leaves, bark, and buds of many types of woody shrubs and vines within and at the edges of thickets.

The approximate breeding season of riparian brush rabbits occurs from January to May. the young remain in the nest for about 2 weeks, after which their eyes open. It is not until 4 or 5 months after birth that they are mature.

For the most part, riparian brush rabbits remain hidden under protective shrub cover. They seldom venture more than 1 meter (3.3 ft) from cover and refrain from too much movement.

Reptiles

Giant Garter Snake (Thamnophis gigas)

The giant garter snake is active during daylight hours from early spring to late fall. They are dormant or in a state of low activity from November to mid-March. Giant garter snakes breed from March through April. Young snakes are born from mid-July to early September. At birth, the young immediately scatter into dense cover and absorb their yolk sacs. Then they begin foraging on their own.

Giant garter snakes inhabit marshes, sloughs, ponds, small lakes, small streams and other waterways. They are also found in agricultural wetlands such as rice fields and irrigation and drainage canals. In order for the giant garter snake to be able to hunt and escape from predators, the wetlands should have tall vegetation growing in the water, at the water's edge and on the banks. Even though the giant garter snake is thought of as an aquatic snake, the adjacent uplands are extremely important to them as they use these uplands to bask or find shelter for the winter. The giant garter snake overwinters in burrows made by small mammals, including ground squirrels and other rodents. Giant garter snakes appear to be most numerous in rice growing regions. The rice fields provide a mix of habitat elements that the snake uses throughout the year. In the spring and summer, rice fields are flooded for rice production. The snake can be found in these flooded fields feeding on small aquatic species and using the vegetation for cover. The artificial levees create great upland habitat for the snake as parts of the levees are always dry. This is important during the winter months when rice fields are typically flooded again for waterfowl. Burrows found in these dry areas provide excellent shelter for the snake to use for overwintering. The giant garter snake is not found in or around larger rivers due to the presence of predators.

Western Pond Turtle (Actinemys marmorata)

Typically, active from February through November, with the length of the active season depending on the temperature of the habitat. Pond turtles may be active during warm periods in winter in warmer climates. Pond turtles are often seen on a log or rock basking above the water, but they will quickly slide into the water when they feel threatened.

The western pond turtle is found in permanent and intermittent waters of rivers, creeks, small lakes and ponds, marshes, irrigation ditches and reservoirs. Turtles bask on land or near water on logs, branches or boulders. Terrestrial habitat may be just as important as aquatic habitat for this turtle. In some populations, males may be found on land for some portion of ten months annually, while females can be found on land during all months of the year due to nesting and overwintering (a form of hibernation).

Mating typically occurs in late April or early May but may occur year-round. Females emigrate from their aquatic habitat to an upland location, usually along stream or pond margins in areas with full sunlight, to nest and deposit between one and 13 eggs. Females may lay more than one clutch a year, but they most commonly deposit eggs between May and August depending on local conditions. The western pond turtle usually nests on sandy banks near water or in fields with sunny spots up to a few hundred feet from water. The length of incubation is not known. It may vary with altitude and latitude. Eggs incubated in a laboratory hatched in 73-81 days. Hatchlings may emerge in late summer or fall, but some turtles may overwinter in the nest and emerge the following spring. (Ernst, Barbour, & Lovich, 2009)

Insects

Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus)

Valley elderberry longhorn beetles are found in riparian habitat only in the vicinity of their host plant, the elderberry (Sambucus species such as the Mexican elderberry (*Sambucus mexicana*). Elderberry beetles are intimately associated with their host plants (*Sambucus* spp.) for their entire lifecycle, displaying a mutualism in which a place to live is traded for help in reproduction. Females will lay their eggs on the bark of the elderberry; when the larvae hatch, they burrow into the stems. Valley elderberry longhorn beetles can stay in its larval stage for almost two years as it builds up energy and nutrient reserves. The larvae will pupate and emerge as adults between March and June. The spring and early summer are the best time to see these distinctive little beetles.

The complete life cycle of the valley elderberry longhorn beetle has four stages: egg, larva, pupa, and adult. The adult beetles are active, feeding and mating, from March until June. After mating, their eggs are deposited on live elderberry bushes, at the stem/trunk junctions, or at the stem/petiole junctions. After hatching the larvae bore through the bark into the pith of the elderberry stem where they tunnel and eat for up to two years. Typically, adult valley elderberry longhorn beetles emerge at about the same time as the elderberry flowers bloom (between mid-March and mid-June).

Crotch Bumble Bee (Bombus crotchii)

This species inhabits open grassland and scrub habitats. This species is classified as a short-tongued species, whose food plants include *Asclepias*, *Chaenactis*, *Lupinus*, *Medicago*, *Phacelia*, and *Salvia* (Williams et al. 2014).

Colonies are annual and only the new, mated queens overwinter. These queens emerge from hibernation in the early spring and immediately start foraging for pollen and nectar and begin to search for a nest site. Nests are often located underground in abandoned rodent nests, or above ground in tufts of grass, old bird nests, rock piles, or cavities in dead trees.