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TECHNICAL MEMORANDUM

Date: April 14, 2023
To: Brooke White and Dylan Hickey, U.S. Bureau of Reclamation
From: Scour Hole Project Team
Project: 21-1024
Subject: Head of Old River Scour Hole Initial Options Technical Memorandum

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INTRODUCTION

This Technical Memorandum (Memo) describes the development and assessment of six Initial Options for reducing predation risk on juvenile California Central Valley (CCV) steelhead and spring-run chinook salmon at the "scour hole" located on the San Joaquin River (SJR) just downstream from the head of Old River (HOR, Figures 1 – 3). This scour hole was identified as a predator hotspot in the 2019 Final Environmental Impact Statement (EIS) and the Biological Opinion (BO) for the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project (USBR 2019 and NMFS 2019, respectively). Addressing predation risk in the Delta generally was included as Proposed Action 8.6.12.6 entitled "Predator Hot Spot Removal". Proposed action 8.6.12.6.7 relates specifically to the scour hole at HOR and states:

"Reclamation and DWR would form a project team to address the scour hole in the San Joaquin River at the Head of Old River. The project team would plan and implement measures to reduce the predation intensity at that site through modifications to the channel geometry and associated habitats."

Reclamation formed the project team in late 2021. This Memo describes the work conducted by this project team to date to develop and assess six Initial Options for consideration by Reclamation. Work to date is at the feasibility and appraisal level, under the assumption that Reclamation will select three of the options (or combinations of options) to accompany the No Action Alternative (as required by NEPA) as the project moves into the regulatory assessment phase.

SITE DESCRIPTION

HYDRO-GEOMORPHIC SETTING

The scour hole that is the subject of this Memo is located at approximately 37°48'31.26"N, 121°19'38.18"W, on the San Joaquin River just downstream from its junction with Old River (Figures 1 – 3). The scour hole reaches depths of about 30-35 feet during typical tidal and upstream low flow conditions (and is much deeper during major flow events), whereas depths in the SJR in the immediate vicinity are typically less than 10 feet. The bed of the river is nearly entirely sand in this reach. The likely cause of the scour hole is the sharp, nearly right-angle bend in the SJR just downstream from the Old River junction. Based on the hydrodynamic modeling results described in detail in Appendix A, this sharp turn in the path of the river results in the development of helical flow structures at the location of the scour hole. Helical flow structures are channel-scale, lateral-vertical circulation cells that develop in meandering channels due to channel curvature. In a river bend, downstream flow “piles up” on the outer bank leading to downwelling, and this outer bank downwelling is accommodated by upwelling along the inner bank. This downwelling and upwelling are illustrated in Figure 4 which shows results from 3D modeling at a cross-section through the scour hole (see Appendix A for details). These lateral and vertical rotating flow structures facilitate sediment transport along the channel bed from the outer bank to the inner bank, creating the mechanism that causes bank erosion and point-bar building in meandering channels. Evidence of these complex flow structures and high turbulence is also apparent at the water surface, as extensive boiling and micro-eddies can be observed at the scour hole. Because the outer bank of the SJR at the scour hole has erosion-resistant rip-rap, bank erosion and channel migration cannot occur, thus resulting in further scouring of the channel bed.

It is worth noting here that there are other meander bends with hardened banks in the area. Figure 2 shows multibeam sonar data from 2022 (provided to the project team by DWR) indicating that there are multiple scour holes of comparable depth on the SJR and Old River in the vicinity. Thus, while the HOR scour hole is particularly deep and located in a unique position just downstream from a major channel junction, it is not the only deep hole in the area. Another aspect of the HOR scour hole that might be unique is its persistence. Analysis of eight multibeam surveys between 2008 and 2019 indicated that the HOR scour hole experiences only minor changes in bathymetry, around the edges. It is not known if other deep holes in the area are similarly persistent as this was not assessed by the project team. It is common, however, for cycles of scour and fill to occur in alluvial rivers depending on reach geometry and hydrologic conditions.

The hydrology and hydrodynamics at the scour hole are complex. The scour hole is located near the upstream extent of tidally reversing flows, such that it experiences extended periods when the hydrodynamics are driven primarily by tides, and periods when hydrodynamics are strongly influenced by upstream river flows. This is illustrated in Figure 5 which shows discharges at the Mossdale Bridge gage (CDEC station MSD) approximately 3 miles upstream from the scour hole, for the period January 2008 through March 2023. The discharge time series indicates that the scour hole reach is subject to large floods from upstream runoff as well as daily tidal fluctuations, including reversing flows when upstream discharge is small. In addition, upstream flows are highly managed by controlled releases from multiple reservoirs on the SJR as well as the major upstream tributaries (Stanislaus River, Tuolumne River, Merced River). A complete review of the hydrology of the SJR basin is beyond the scope of this memo; however, certain aspects of the hydrodynamics (such as tidal and flood stages) are detailed in subsequent sections when relevant.

Another factor adding to the complexity of the hydrodynamics in the project reach is the use of a temporary barrier on Old River just downstream from its junction with the SJR. The Head-of-Old River Barrier (HORB) has been in use since the late 1960s and has historically been installed in the spring and/or fall. Spring installations are designed to keep out-migrating salmon and steelhead in the San Joaquin River. Fall installations are designed to provide increased attraction flows and improved dissolved oxygen levels for returning adult fish in the mainstem SJR. The barrier is not installed every year; the reasons that the barrier would not be installed include excessively high flows, adequate dissolved oxygen conditions, as well as general uncertainty about the benefits of installing the barrier. In recent years (since 2019), the barrier has not been installed because it is not required by the 2019 Biological Opinion on Coordinated Operations (NMFS, 2019). Due to the lack of recent installations and the uncertainty about the future of the HORB, its effects are not considered in the analyses described herein. However, as the project moves into more detailed analyses of alternatives in the future, the status of the HORB should be continually evaluated and potentially addressed if future installations are considered likely.

The reaches of the SJR and Old River in the vicinity of the HOR scour hole have levees on both sides of the rivers. The levees in the area are a mixture of federal "project" levees under the jurisdiction of the U.S. Army Corps of Engineers (USACE) as well as "non-project" or private levees. The levees of most interest to this project include 1) the levee directly to the north (on river left of the SJR) downstream from the Old River junction (Figure 2), and 2) the levee along river right of the SJR through the project reach. The river left levee to the north is maintained and operated by Reclamation District 544 (Upper Roberts Island Unit 1) and DWR. This is a federal levee that was authorized and constructed by USACE and subsequently turned over to public sponsors for operations and maintenance (National Levee Database). The river right levee along the SJR is also a federal project levee, authorized and constructed by USACE, that is operated and maintained by Reclamation District 17 (Mossdale Unit 1) and DWR. The RD17 levee has been the subject of ongoing studies and improvements to achieve urban level flood protection for the 200-year flow event. A complete review of the RD17 levee activities is beyond the scope of this memo; however, additional coordination with flood control agencies will be needed if any of the Initial Options with levee modifications are selected to move forward into the next phase of assessments.

BIOLOGICAL RESOURCES

The project team identified a biological study area (Study Area) by estimating the reasonable extent of direct and indirect effects on biological resources with implementation of any of the six Initial Options. Examples of direct impacts to biological resources would include those occurring from land clearing or rock slope armoring, while examples of indirect impacts might include elevated noise or turbidity during construction. Using this broad definition, the defined Study Area includes the SJR near the head of Old River upstream (south) to the head of Paradise Cut (Figure 2), a 200 foot buffer from the SJR levee crowns, and the developed lands north and west of the head of Old River, as shown in Figure 6.

LAND COVERS/HABITATS

The SJR within the approximately 1,800-acre Study Area is a relatively wide, shallow, low-gradient, meandering system located within the southern portion of the Sacramento-San Joaquin River Delta. Land covers within the Study Area are shown in Figure 7 and described below.

Open Water/Riverine Habitat. Open water generally identifies the plan-view extent of the SJR and Old River in the Study Area (collectively referred to as Riverine habitat). The maximum areal extent of Riverine habitat is realized during high river flow events combined with high tide events. In the Study Area, Riverine habitat was mapped as that area below the mean high water (MHW) elevations of the SJR and the Old River. Mean high water at this location is located at an elevation of approximately +6.0 ft NAVD88. Several open water areas are located in the Study Area adjacent to the SJR mainstem. These are all located south of the I-5 crossing of the SJR.

Riparian Habitat. Riparian habitat is defined as near-water vegetation. It may be highly water-dependent (e.g., hydrophytes or phreatophytes) or only moderately to not-at-all water dependent (e.g., oaks atop levees). In the Study Area, Riparian habitat is typically confined to the interior bank slopes of the SJR and Old River. Impacts to Riparian habitat are regulated and may be conditionally permitted by state and federal resource agencies.

Agriculture. Agricultural lands are extensively distributed in the Study Area but are particularly abundant near the head of the Old River. Field assessment work completed in April 2022 indicated that Study Area crops included alfalfa and tomatoes (in rotation). This category included idle fields that were obviously prepped for planting but did not currently support agricultural crops.

Urban. Urban development is defined here as all anthropogenic development, combining a number of development categories (residential, commercial, industrial).

Disturbed/Ruderal. The balance of the Study Area was mapped as Disturbed/Ruderal. This generally indicated graded or otherwise cleared areas, roads of all surfaces, and unvegetated portions of levees.

SENSITIVE BIOLOGICAL RESOURCES

Commonly used and publicly accessible databases were queried to understand the potential occurrence of sensitive biological resources in and near the defined Study Area. The summarized results of these queries are attached to this memorandum as Appendix B. Of the 26 sensitive/rare plants identified historically in the vicinity of the Study Area, none are expected to occur in the Study Area based on current land covers and land uses. Of the 46 sensitive/rare non-plant resources historically documented near the Study Area, 17 have a high potential to occur or are known to occur in the Study Area, based on documented records, current land covers, and current land uses. These 17 resources are listed in Table 1 and described in detail below.

Table 1. Special-Status Wildlife Species that Occur or are Likely to Occur in the Study Area

Species/Resource	Status FESA	Status CESA	Status Other	Land Cover Association	Potential to Occur in Study Area
Valley Elderberry Longhorn Beetle	FT	N/A	N/A	Riparian	High
Sacramento Splittail	N/A	N/A	SSC	Riverine	Occurs
Central Valley Steelhead	FT	N/A	N/A	Riverine	Occurs
Spring-run Chinook Salmon	FT	CT	N/A	Riverine	Occurs
Fall-run Chinook Salmon	N/A	N/A	SSC	Riverine	Occurs
Pacific Lamprey	N/A	N/A	SSC	Riverine	Occurs
CV Steelhead Critical Habitat	CH	N/A	N/A	Riverine	Occurs
s. Green Sturgeon Critical Habitat	CH	N/A	N/A	Riverine	Occurs
Delta Smelt Critical Habitat	CH	N/A	N/A	Riverine	Occurs
Chinook Salmon EFH*	N/A	N/A	EFH	Riverine	Occurs
Western Pond Turtle	N/A	N/A	SSC	Riverine, Riparian	Occurs

Species/Resource	Status FESA	Status CESA	Status Other	Land Cover Association	Potential to Occur in Study Area
Tricolored Blackbird	N/A	CT	SSC	Riparian, Agriculture	High
Burrowing Owl	N/A	N/A	SSC	Agriculture, Ruderal	High
Swainson's Hawk	N/A	CT	N/A	Riparian, Agriculture	Occurs
White-Tailed Kite	N/A	N/A	CFP	Riparian, Agriculture	High
Modesto Song Sparrow	N/A	N/A	SSC	Riparian	High
Riparian Brush Rabbit	FE	CE	N/A	Riparian, Ruderal	High

Status codes

FE Federal Endangered
FT Federal Threatened
CH Critical Habitat
EFH Essential Fish Habitat
CE California Endangered
CT California Threatened
SSC California Species of Special Concern
CFP California Fully Protected Species

Valley Elderberry Longhorn Beetle. Habitat for Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*) is restricted to blue elderberry shrubs (*Sambucus nigra* ssp. *caerulea*). Elderberry shrubs were observed at several locations within the Study Area, in association with mapped Riparian habitat.

Sensitive Fish Species. Several sensitive fish species are known to occur in the Study Area. These include CCV steelhead (*Oncorhynchus mykiss*), Spring-run Chinook salmon (*Oncorhynchus tshawytscha*), fall-run Chinook salmon (*Oncorhynchus tshawytscha*), Sacramento splittail (*Pogonichthys macrolepidotus*), and Pacific lamprey (*Entosphenus tridentatus*). These are associated with the mapped Riverine habitat of the SJR.

Western Pond Turtle. In riverine systems such as the SJR, western pond turtles (*Actinemys marmorata*) are associated with low-slope basking sites and deep pools with aquatic refugia such as submerged logs or vegetation. Additionally, off-channel pools and adjacent wetlands serve as important habitat features for turtles in rivers. This species was observed during our site assessments.

Sensitive Bird Species. Several sensitive bird species are known to occur, or have a high potential to occur, in the Study Area. These include tricolored blackbird (*Agelaius phoeniceus*), Swainson's hawk (*Buteo swainsoni*), white-tailed kite (*Elanus leucurus*), burrowing owl (*Athene cunicularia*), and the Modesto song sparrow (*Melospiza melodia mailliardi*). Tricolored blackbirds and song sparrows may nest in the scrubby vegetation in the mapped Riparian land cover. Swainson's hawks and white-shouldered kites commonly nest in taller riparian trees and may forage in agricultural lands in the Study Area. Burrowing owls may nest and forage in Agricultural and ruderal lands within the Study Area.

Riparian Brush Rabbit. Riparian brush rabbits (*Sylvilagus bachmani riparius*) may associate with Riparian areas mapped in the Study Area. Other habitat types in the Study Area including ruderal/disturbed, agriculture, and the fringes of urban areas along the levees provide potential movement/linkage habitat as well as refugia from flooding in the SJR.

Regulated Habitats. Critical Habitat is a regulatory term for habitat that is considered important for the recovery of federal-listed species under the Endangered Species Act. This designation is relevant during project permitting if there is federal involvement. Essential Fish Habitat (EFH) is also a regulatory term that identifies important habitat for species managed under the Magnusson-Stevens Fishery Conservation and Management Act. EFH is relevant for commercially-harvested fish species. Critical habitat for CCV steelhead, southern Distinct Population Segment of green sturgeon, and Delta smelt is designated within the Study Area. EFH for Chinook salmon (all races/runs) is also designated in the Study Area.

CULTURAL RESOURCES

The project team queried the Central California Information Center (CCIC) of the California Historical Resources Information System (CHRIS) at the California State University-Stanislaus on February 22, 2022, to determine the nature of previously reported archaeological sites, architectural resources, or traditional cultural properties within the same Study Area defined for biological resources assessments. The CHRIS database survey returned results from 74 previous surveys completed within the buffered (0.5-mile) Study Area. Forty-eight (48) recorded "sites" were recorded in the buffered Study Area, with 21 sites intersecting the unbuffered Study Area.

Cultural sites recorded within the buffered Study Area include prehistoric habitat sites and artifacts (middens and stone tools), and historic structures and items (wagons, train trestles, single family homes, silos, sheds, and water canals, etc.).

Because the Study Area is located along a valley floor riverine system, its entire area would be considered highly-sensitive, as historic and prehistoric people and settlements commonly were located near rivers. Specific locations of the Study Area would be considered very highly sensitive based on their potential to harbor native American human remains.

Due to the confidentiality of the locations of cultural sites, the results from the database queries will be delivered to Reclamation separately from this memo.

STAKEHOLDER OUTREACH

The first step in the development of the Initial Options was to conduct stakeholder outreach. To ensure appropriate involvement from and share information with relevant parties and stakeholders, the project team conducted interviews, briefings, and the facilitation of the Structured Decision Making Working Group (SDM WG). Chapter 4 provides detailed information on the Work Group while this section provides a broad overview of stakeholder outreach. Appendix C contains a more detailed synthesis of outreach, complete notes from stakeholder briefings, complete SDM WG summaries, and expert elicitation details. These engagement efforts took place according to the schedule shown in Figure 8.

STAKEHOLDER INTERVIEWS

The project team conducted ten stakeholder interviews in the spring of 2022. These interviews had two primary goals: 1) brief stakeholders and assess potential SDM WG candidates, and 2) gather interests and concerns of stakeholders to inform the project team.

The project team interviewed the following individuals:

- Gretchen Murphey – California Department of Fish and Wildlife (CDFW)
- Jacob McQuirk – California Department of Water Resources (DWR)
- Ching-Fu Chang – Contra Costa Water District (CCWD)
- Barbara Byrne – National Marine Fisheries Service (NMFS)
- Cyril Michel – National Oceanic and Atmospheric Administration (NOAA)
- James Stone – Nor-Cal Guides & Sportsmen's Association (NCGASA)
- John Cain – River Partners
- Natalie Stauffer-Olsen and Rene Henery – Trout Unlimited
- Bryan Matthias – United States Fish and Wildlife Service (USFWS)
- Jon Burau – United States Geological Survey (USGS)

The following themes were identified during the stakeholder interviews:

- Recognition of predation as a key threat to juvenile salmonids. Participants were aware of this threat both at the scour hole and across the South Delta.
- Concern about efficacy of a short-term, hyper-localized solution. Participants expressed concern about allocating extensive resources to one specific location and questioned whether filling the scour hole would be effective at reducing predation in the long term.
- Curiosity about nexus and alignment with other projects. Multiple participants expressed interest in distributing funds and resources across different projects or possible coordination with other projects in the area.
- Varied knowledge, experience, and interests. Participants represent different sectors and possess a variety of expertise in topics including fish science, hydrology, water quality, and river conservation.
- Potential options to measure success. Participants suggested predation detection acoustic tags, acoustic telemetry, and survival rates as potential approaches.

SDM WG participants were selected based on several criteria including: their expertise in a relevant subject area (e.g., fish biology, hydrology, geomorphology, etc.); their familiarity with the South Delta; their willingness and availability to participate in and prepare for meetings; their willingness to engage collaboratively and in good faith with other WG members, Reclamation, and the project and facilitation teams; and their ability to represent their organization's interests. Based on these criteria, the following 8 entities were selected and agreed to provide representatives to the SDM WG:

- CDFW: Gretchen Murphey; Alternate: Steve Tsao
- DWR: Tommy Agosta; Alternate: Curtis Yip
- CCWD: Ching-Fu Chang; Alternate: Yuan Liu
- NMFS: Barb Byrne
- Reclamation District (RD) 544: Steve Sinnock
- NOAA: Cyril Michel
- USFWS: J.D. Wikert
- USGS: Jon Burau

FLOOD CONTROL AGENCY BRIEFINGS

In early summer 2022, the project team conducted a series of briefings with various flood control agencies. These briefings were coordinated in response to the SDM WG's development of a decision objective related to maintaining flood capacity particularly on the SJR downstream from the scour hole. The main goals for these briefings were to 1) brief stakeholders on the scour hole project; 2) gather interests and concerns in order to inform the project team; 3) answer outstanding questions about the project; and 4) identify other stakeholders and referrals from interviewees.

The following stakeholders participated in the flood control briefings:

- Mark Meissner and Rick Caguiat – City of Lathrop
- Chris Neudeck and Dante John Nomellini – RD 17
- Pam Forbus and Steve Sinnock – RD 544
- Chris Elias – San Joaquin Area Flood Control Agency (SJAFCA)
- Cynthia Ovdenk – US Army Corps of Engineers (USACE)

Key takeaways from the flood control briefing participants included:

- Strong development pressure in the area. Multiple participants shared that the Lathrop area is one of the fastest-growing residential areas in the state and that planned new developments may place constraints on potential actions for the project.
- Importance of speaking with property owners. All participants recommended that the project team brief and confer with property owners adjacent to the scour hole.
- Strong interest in hydrodynamic and geomorphic modeling. Multiple participants expressed concern about changes to the river causing flow and flooding issues downstream and expressed the importance of conducting extensive modeling before making any decisions.
- Concern about flow levels. Multiple stakeholders expressed concern about the lack of adequate flow in the SJR being the underlying cause of low juvenile survival.
- Curiosity around history and potential options. All participants expressed curiosity about the history of the scour hole and what different potential options the project might include.
- Potential ongoing briefings. All participants expressed interest in being kept informed at least quarterly, which raised the prospect of quarterly briefings for flood control (and other) stakeholders by the project team.

ADDITIONAL SJAFCA BRIEFINGS

In early 2023, the project team coordinated two additional briefings with SJAFCA, as well as SJAFCA's attendance at the final SDM WG meeting. Full notes from both briefings and the SDM WG meeting can be found in Appendix C.

For the first briefing, the project team presented the Initial Option sketches at a SJAFCA meeting. At this meeting, substantial overlap was identified between the project team's options four and five and proposed actions in SJAFCA's Mossdale Tract Urban Flood Risk Reduction Project.

At the second briefing, the SJAFCA team presented to the scour hole project team. SJAFCA and DWR completed an initial phase of the Flood Risk Reduction Project in 2021; their recommended Alternative 4a includes levee improvements and ecosystem restoration elements on the bank southeast of the scour hole. Their team anticipates release of the Draft EIR, 65% levee designs, and 35% restoration concepts by December 2023. Coordination with the SJAFCA team is ongoing.

STRUCTURED DECISION MAKING PROCESS

Structured Decision Making (SDM) was used as a framework for stakeholder engagement and capturing stakeholder input. SDM is based on an extensive literature base and currently represents the 'best management practices' for decision making. It seeks to guard against cognitive biases and works to improve (or maximize) the chance for a positive outcome.

The goal of the SDM WG was to use the framework and processes of SDM to elicit relevant stakeholder values and decision objectives, develop a creative set of initial project options, and use a relatively coarse-scale assessment of how well different options met different objectives to explore potential risks, tradeoffs, and linked decisions. The goal was *not* to make a decision or even to rank options based on performance; it was to gain insights that would help Reclamation decide whether to move forward with a project and to refine and select options to carry forward to the next phase of the process. It may also help the consultant team refine approaches to stakeholder identification and outreach and to analyzing effects of alternatives.

In brief, SDM breaks decision problems into component parts, which helps clarify core issues or challenges and apply appropriate tools and techniques for those challenges. The component parts of a decision are:

1. Problem: Are you solving the right problem? Is everyone who should be involved in framing the problem in the room?
2. Decision objectives: Have you captured all important values in the form of objectives that can be used to generate and evaluate options?
3. Alternatives: Do you have a creative set of alternatives from which to choose, and are all objectives addressed in at least some of those alternatives?
4. Consequences: Do you have a way to predict how well each alternative performs on each objective? This could be verbal, visual, or mathematical descriptions of the relationship between actions and outcomes.
5. Tradeoffs, Uncertainty, and Linked Decisions: What are the key tradeoffs and uncertainties that must be addressed by the decision maker? Are there any linked decisions that need to be considered? A common mistake is trying to address values-based challenges (tradeoffs and risks) with science alone rather than with deliberation.

Most SDM processes include an initial “prototype” round where consequence analysis is relatively coarse. This allows the decision maker and stakeholders to assess whether the problem is well-framed, whether relevant values have been captured by the decision objectives, whether the analytic approach will support the necessary risk and tradeoff analysis, and whether relevant linked decisions have been identified. The SDM process undertaken as part of this project was essentially a prototype round.

The aspects of SDM that make it well-suited to stakeholder engagement include approaching decisions with an inquiry rather than an advocacy mindset and focusing on insight rather than answers, particularly in the prototype round of deliberation and analysis. By expressing stakeholder values explicitly as decision objectives, SDM allows stakeholders to see that their concerns have in fact been included in the decision making process. By recognizing the distinct roles of science and values in decision making (values define desired goals and objectives, while science helps to predict how well different actions meet those goals and objectives), SDM clarifies the distinct roles of scientists, stakeholders, and decision makers. Science can quantify risk and tradeoffs, but not determine which risks and tradeoffs are worth taking. Trying to resolve values differences with science or vice versa diminishes both.

At the first SDM WG meeting the facilitator presented a draft set of WG guidelines to clarify and come to agreement on the decision context, the roles of different parties in the SDM process, core process principles for the WG, and the basics of SDM (see Appendix C). In brief, the group recognized that Reclamation is the ultimate decision maker and that the SDM WG will provide input to the project team and to Reclamation on the development of decision objectives, performance metrics, initial options, tradeoffs, risks, and uncertainty. Although the WG was advisory rather than decisional, it is expected that Reclamation and the project team will take its input seriously.

DECISION STATEMENT

The SDM process begins with developing a clear, shared understanding of the decision context and the decision itself. To do this, SDM WG and project team members were sent into break out groups to fill out a Miro Board discussing the following questions:

- Decision Makers – Who is the decision maker? Who is ultimately responsible?
- Actions – What kinds of actions need to be taken?
- Goals / Objectives – What are the things you would like to achieve?
- Temporal Extent – What is the time scale of the issue?
- Spatial Extent – What is the spatial scope of the issue?
- Constraints – What constraints on the decision are there?

The answers to these questions formed the basis for an initial decision statement. This initial statement went through several iterations; in particular, the SDM WG sought clarity from Reclamation on what sideboards if any they wanted to put on the decision scope and scale. At the July 15, 2022, meeting the SDM WG agreed on the following preliminary decision statement:

> Reclamation is deciding what actions it might take to increase survival of juvenile San Joaquin Basin origin California Central Valley steelhead and Central Valley spring-run Chinook salmon to Chipps Island with a focus on decreasing predation at the HOR scour hole, keeping in mind other socio-economic, recreational, regulatory, and operational considerations and uncertainty around effectiveness.
>
> The action area will be within a few km of the HOR scour hole. Actions to be reviewed can include channel modification, modification to levees, and habitat restoration, but will not include changes to water operations. Survival can be affected through multiple mechanisms created by the scour hole including predation, routing, and habitat quality. Actions should improve survival but do not need to solely focus on reducing predation.

DECISION OBJECTIVES

A core feature of the SDM process is a focus on values, rather than on pre-established targets or agency mandates, to guide the development of these objectives. In SDM, these values are captured as "decision objectives" that serve several important functions:

- Communicate what is important to consider when making decisions for a specific decision context.
- Help to guide the development of alternatives.
- Provide the foundation for the analysis of consequences and trade-offs.

The SDM WG began by, individually and in small groups, generating lists of concerns and goals related to the decision. Initial lists were refined over a series of meetings with the goal of having as many decision objectives as needed to capture the full suite of relevant values and concerns but to have as few as possible to facilitate analysis and deliberation. The final list of decision objectives, sub-objectives, and rationale are presented in Table 2.

Table 2. Summary of objectives, subobjectives, and why they matter

Objective	Sub-objective	Rationale/comments
Maximize effectiveness at reducing mortality of target species	Mortality related to predation and Mortality related to habitat	Consider effectiveness under different conditions including different water year types, weather extremes, and with and without the Head of Old River (HOR) Barrier. Explore projects “that would increase survival of juvenile steelhead and chinook past Chipps Island with a focus on decreasing predation at the scour hole.” Reduction in mortality could occur in the vicinity of the HOR scour hole or elsewhere upriver of Chipps Island.
Maximize durability	N/A	Addresses concern that a project might fail to deliver intended benefits over the longer term. Specific concerns include the likelihood that the scour hole will re-form over time, or that options that include ongoing actions would become ineffective if staff, equipment, or funding were not available.
Effects on other species of concern	N/A	Includes immediate effects of construction or other activities as well as longer-term impacts resulting from any changes in flow, habitat, etc. Effects may include possible fish passage issues for up-migrating adult salmonids and sturgeon, or other impacts not related to predation and habitat.
Minimize cost	N/A	Costs include start-up costs as well as O&M costs over a 50-year time horizon, regardless of who is covering costs. Also consider potential mitigation costs related to impacts on species of concern.
Maintain or improve flood capacity	N/A	This objective focuses on flooding that’s harmful to people and sometimes other terrestrial species (e.g., brush rabbits). The SJR in the scour hole reach experiences periodic flooding and the project should not make it worse
Minimize adverse impacts on beneficial uses of water	Water quality and Induced water costs	Beneficial uses may be adversely affected by changes in water surface elevation, water quantity, and water quality. The likelihood that water costs will be induced is also included in this objective.
Minimize adverse/maximize beneficial impacts to recreational use	Boating And Fishing	Recreational value may be adversely affected by changes in water surface elevation, water quantity, and water quality, or by physical changes affecting land and boat access through the site
Minimize landowner concerns	N/A	Any project that involves levee set-backs would require landowner agreement. This may function more as a constraint than as an objective.

Objective	Sub-objective	Rationale/comments
Maximize learning	N/A	Reflects interest in informing future efforts in the HOR vicinity or to address other predation hotspots and floodplain restoration efforts. How will project design and implementation, including pre- and post-action studies and monitoring, influence the ability of this effort to inform other projects in the Delta?

PERFORMANCE METRICS

Following initial definition of decision objectives, the SDM WG developed candidate performance metrics (PM) for each objective, which are the metrics that will be used to characterize predictions of how the Initial Options perform relative to the decision objectives. The performance metrics are summarized in Table 3.

Table 3. Summary of Decision Objectives and Performance Measures

Decision objective	Performance Metric	PM Description
Maximize effectiveness at reducing mortality of target species	Survival to Chipps Island (%)	Survival to Chipps was seen as more appropriate than a local survival metric because actions may affect survival beyond the HOR scour hole, e.g., through routing changes or changes in growth. For this preliminary analysis survival was not broken out by flow regime or water year type.
Maximize durability	Likelihood solution will operate as intended over next 50 years (L-M-H)	The group discussed an alternative PM, the # of years the solution will function as intended, but felt the selected PM was more tractable and appropriate for this initial evaluation. Evaluation should consider thresholds as well as gradual changes.
Effects on other species of concern	Tiered: -1, 0, +1 for each species, then 1 – 10 as possible or important	The purpose of the tiered system is to scale scoring effort to available information and anticipated severity of effects. This metric combines adverse and beneficial impacts. Note that for this preliminary round of analysis only the first tier (-, 0, +) of assessment will occur.
Minimize cost	Total lifetime cost in USD	Includes design and build, right of way acquisition, mitigation costs, and O&M. Some SDM WG members suggested using the costs of rock barrier installation/removal annually for contextualizing costs.
Maintain or improve flood capacity	Y/N: Is the option flood control positive/neutral?	Although there are more precise approaches to this PM, the WG felt this simple approach was sufficient for this decision since any option with negative effects on flood capacity would not go forward. There was some discussion of the definition of flood control neutral; technically it's something like "less than 1/10' at any of the flood stages," although there's some flexibility.

Decision objective	Performance Metric	PM Description
Minimize adverse impacts on beneficial uses of water	Negative effects on HABs, water quality, stage and Possibility that water costs are induced	The SDM WG felt that there were a variety of concerns that could be captured here and found narrowing the list of concerns challenging without a better sense for how much they would be affected by the options under consideration.
Minimize adverse/maximize beneficial impacts to recreational use	-2, -1, 0, 1 for ability to boat, sport fishing, access	This metric combines adverse and beneficial impacts.
Minimize landowner concerns	Will landowners fight the project?	Further refining this PM was challenging because landowner concerns may end up being the focus of negotiation and compromise. For this initial round of analysis, consequences may end up being a more qualitative description of concerns and degree of flexibility.
Maximize learning	None, Low, High for 6 individual areas of learning	The SDM WG identified six specific areas of potential learning to evaluate: 1) learning related to the dynamics leading to fish loss at the head of Old River; 2) learning related to the dynamics leading to fish loss at other scour holes in the San Francisco Bay Delta; 3) learning related to the effectiveness of different approaches to reducing fish loss at the head of Old River; 4) learning related to the effectiveness of different approaches to reducing fish loss at other scour holes in the San Francisco Bay Delta; 5) learning related to the effectiveness of different floodplain habitat restoration approaches in the San Francisco Bay Delta; and 6) opportunities to provide broadly applicable monitoring information related to salmonid and ecosystem restoration in the San Francisco Bay Delta.

DEVELOPMENT OF INITIAL OPTIONS

Using system knowledge and the decision objectives, the SDM WG brainstormed possible actions. Although the six Initial Options do not include specifics as to monitoring or special studies, the SDM WG discussed the value of pre- and post-project monitoring as a means to maximize learning. The six Initial Options developed through the SDM process are described in the following section.

DESCRIPTION OF INITIAL OPTIONS

CONCEPT DESIGNS

Based on the discussions with the SDM WG and input from other stakeholders, six concept designs were developed as Initial Options for assessment. The six concepts include four options (Options 2 – 5) with channel realignments and levee setbacks to improve rearing habitat in the reach and two options that would not affect channel alignment or levees (Options 1 and 6). These Initial Options are described below and shown schematically in Figures 9 – 14.

Option 1 entails simply filling the scour hole with non-erodible material, such as large rocks. This would reduce or eliminate the development of the helical flow structures that are the likely cause of the scour hole (see Appendix A) and be more resistant to any residual scouring forces. This concept is shown schematically in Figure 9.

Option 2 includes a levee setback on river left (north) of the SJR downstream from the Old River junction and potentially a slight setback on river right, to allow the river to curve more gradually in the reach around the scour hole. New off-channel habitats would be created at desired elevations within the new levee footprint. The re-grading would also include constructing a new main channel through the scour hole. This concept is illustrated schematically in Figure 10.

Option 3 includes a more substantial levee setback on river left (north) that extends approximately one mile downstream. The new main channel would follow the new levee and reconnect with the existing main channel at the next downstream bend. This would allow for a very gradual bend in the river to replace the existing sharp right turn. New off-channel habitats would be created at desired elevations within the new levee footprint, including filling the existing main channel. This concept is illustrated schematically in Figure 11.

Option 4 includes a levee setback along river right of the SJR and a new main channel along the new levee that bypasses the scour hole completely. This is shown schematically in Figure 12. The river right levee and adjacent floodplain would be lowered to desired elevations to create new off-channel habitats. In this option, the existing San Joaquin main channel will be left as is (without the levee) and would continue to convey tidal flows.

Option 5 is identical to Option 4 in terms of the levee setback on river right and lowering of interior levees and the floodplain. The only differences from Option 4 are that the existing SJR channel downstream from the Old River junction would be closed off and filled in (including the scour hole). This option is shown schematically in Figure 13.

Option 6 differs substantially from Options 1 – 5 in that it does not include any changes to the river channel geometry. Option 6 proposes to capture some proportion of outmigrating juvenile salmonids before they reach the Head of Old River junction and to provide those captured fish with safe, boat-based transport to the Western Delta. Option 6 allows juvenile outmigrants to bypass: 1) the Scour Hole area-- including poor survival reaches from the Scour Hole to Chipps Island, 2) the Old River route where juvenile salmonids are exposed to predation mortality and to entrainment at the CVP and SWP diversion facilities.

This option is shown conceptually in Figure 14, which also includes additional information about the components of a system and how it could be operated. A number of different methods and approaches could be considered for Option 6. However, key common elements are expected to include: a net or floating structure to direct flow and juvenile fish into a trap, a trap that is effective for small and larger juvenile salmonids (fyke, inclined plane, rotary screw trap), design and anchoring to allow the trap to function under elevated flows and when debris is present in the river. Transport of juvenile salmonids downstream would be accomplished by boat such that fish would have an imprint on the migratory route, enhancing their ability to return successfully as adults.

DIGITAL TERRAIN MODEL DEVELOPMENT

In order to estimate costs and to provide necessary information for hydrodynamic modeling, digital terrain models (DTMs) were developed for the existing conditions and for Options 1 – 5 (Option 6 does not include terrain changes). For this initial round of surface development, the HEC-RAS Mapper tool was used. While HEC-RAS is not being used for the modeling, the Mapper tool is more efficient for the development of initial terrain surfaces than CAD/design programs.

A digital terrain model (DTM) for existing conditions was developed from a combination of 2017 Delta LiDAR and channel bathymetry from the San Francisco Bay and Sacramento-San Joaquin Delta DEM for Modeling, Version 4.2 released in 2020. Additionally, higher-resolution bathymetry near the scour hole was included from the 2019 multibeam survey obtained by the project team from DWR. All datasets were converted to NAD83 State Plane III (US Feet) and NAVD88 (feet). The existing conditions DTM is shown in Figure 15.

Option 1 terrain modifications included filling the scour hole with erosion-resistant materials in a manner that mimicked the shape of the existing depression, but much less deep. Terrain modification tools were used to draw a polygon that extended from the Old River junction to roughly 650 feet downstream. Control points were used at the edges of the polygon to specify an upstream tie-in at the edge of the scour hole and a downstream tie-in at the existing -3 foot contour. Internal control points were set in contour-like shapes to create a smooth shallow depression at the site. Option 1 design grading extents and the resulting terrain are shown in Figure 16.

Initial Options 2 – 5 all include levee setbacks and floodplain lowering to create new off-channel habitat. Thus, the elevations of the new off-channel areas must be specified in order to make the terrain modifications. For this initial round of assessments, the off-channel areas were assumed to be sloping slightly toward the main channel with elevations of 5 – 6 feet NAVD88. Existing elevations of the agricultural fields are about 13 feet NAVD88 such that the required lowering would be about 7 feet. The 6 foot elevation corresponds roughly to the MHW tide level as well as the elevations during moderate upstream runoff events (based on analyses of gages in the vicinity). The 6 foot elevation is likely as low, or lower, than final designs would incorporate, as the new off-channel habitats would be slightly inundated at this elevation on some (but not all) days due to tidal fluctuations. A relatively low elevation was chosen for these initial assessments in order to result in a high-range estimate of costs and maximum potential influences on water surface elevations. Future iterations of the design options will likely include various habitat features at a range of elevations.

Option 2 terrain modifications included realigning the main channel to account for the levee setback on river left and the addition of new off-channel habitats. Using the HEC-RAS terrain modification tools, floodplain polygons were created that roughly mimicked the shapes in the concepts. Control points were used to specify the river-side and levee-side elevations of these polygons. The placement of these control points promoted a smoothly decreasing slope throughout the extents of the floodplain features. The new levee was built to mimic the characteristics of existing levee features in the area, including 4:1 side slopes and a 20-foot crest width. The levee features targeted existing agricultural field elevations on the outside and tied into newly constructed floodplain feature elevations on the inside. Finally, the smooth channel realignment was designed to tie into the new floodplain features. The channel was shaped to mimic existing characteristics with a roughly 150-foot bottom width, 3:1 side slopes, and endpoint elevations that tie into the existing bathymetry. The resulting terrain for Option 2 is shown in Figure 17.

Option 3 includes a longer levee setback on river left and a new main channel realignment that follows the shape of this new levee. New off-channel habitats are created by the levee setback. The existing channel would be filled to the same elevation as the off-channel area (about 6 feet NAVD88). Option 3 also includes a narrow floodplain bench along the new levee at elevations of 12.5 to 15 feet (approximately 10-year recurrence interval). The newly constructed levee ties into this feature and has side slopes of 3:1, a crest width of 15 feet, and an average crest elevation of 27.5 feet. The new main channel ties into these new floodplain features with 3:1 side slopes and a 150-foot bottom width. The resulting terrain for Option 3 is shown in Figure 18.

Option 4 includes a levee realignment and setback on river right near the River Islands Parkway bridge. Existing channels are left as-is, with a new main channel designed to follow the path of this levee and connect back with the SJR downstream from the scour hole. New off-channel features consisted of a narrow bench adjacent to the new levee and a large area of lowered floodplain. These features are at the same elevations as Option 3. Terrain modification tools were used to draw the new levee alignment, polygon shapes, and new main channel. Using control points, the narrow floodplain bench and new floodplain were tied into levee and channel features. The newly constructed levee is roughly 0.56 miles long and ties into the floodplain features at a 3:1 side slope. The new channel mimics existing channel characteristics at its upstream and downstream tie-in locations with side slopes of 3:1 and a bottom width of 150 feet. The resulting terrain for Option 4 is shown in Figure 19.

Option 5 is identical to Option 4 except that it includes cutting off and filling the existing channel between the Old River junction and the new main channel downstream tie-in point (this filled reach includes the scour hole). Rather than tie in the new large off-channel feature to the existing channel at its north end, the feature ties into the north bank levee. The resulting terrain for Option 5 is shown in Figure 20.

ASSESSMENTS OF INITIAL OPTIONS

REDUCED MORTALITY OF TARGET SPECIES

Michel et al. (2020) modeled factors and environmental conditions associated with predation risk in the Delta and found that 'bottom roughness' – the coefficient of variation in depth at a site – was positively associated with predation risk. Applying this model to the scour hole reach, Michel et al. (2020) reported a 77-fold increase in predation risk relative to mean conditions elsewhere in the South Delta. However, this result was not based on direct observations of predation losses or predation risk at the site, but instead was driven by the scour hole's unique 'bottom roughness'. The twenty-one sites which were the basis of the Michel et al. (2020) predation risk model did not include the HOR scour hole, or any sites with 'bottom roughness' comparable to the scour hole. Therefore, estimating predation risk at the scour hole required the Michel et al. (2020) model to extrapolate beyond the boundaries of its underlying data.

Thus, rather than relying on the Michel et al. (2020) model to assess predation risk, our analysis is based on empirical evidence provided by predation risk assessments and acoustic tagging studies conducted in the SJR and South Delta. This empirical data and analyses are described in the following sections.

PREDATION RISK ASSESSMENT

NMFS staff conducted fifteen separate predation risk assessments for the scour hole area that were not included in Michel et al. (2020) study. In all, 428 predation event recorders (PERs) were released upstream of the HOR junction between March and May of 2014 and 2015 (Cyril Michel pers comm). The average relative predation rate among all 428 PERs deployed and allowed to drift through the scour hole area was 0.45 (±0.18 StDv). In 2017, between April and May, NMFS released 254 PERs into the SJR approximately 7 river miles downstream of the HOR junction (Cyril Michel pers comm). This site provides the best available point of comparison for the HOR area; that is, predation risk in a nearby portion of the SJR that does not include the HOR scour hole. The average relative predation rate for PERs deployed at this site was 0.19 (±0.11 StDv), suggesting the predation risk at the HOR scour hole is about 2.4 times higher (0.19 vs. 0.45). These results confirm the scour hole as a site with elevated predation risk, albeit at a much lower level than suggested in Michel et al. (2020).

While quantifying relative predation risk among sites and reaches is useful, it does not provide a basis for estimating the predation-related mortality that migrating juvenile salmonids are likely to experience in migrating through an area. Acoustic tagging studies are the best source of empirical evidence for juvenile salmonid survival, and indirectly, the influence of predation on mortality.

ACOUSTIC TAGGING STUDIES

Thousands of acoustically tagged juvenile Chinook salmon (e.g., Buchanan and Skalski 2020) and steelhead smolts (e.g., Buchanan, Buttermore and Israel 2021) have been released into the San Joaquin River upstream of the HOR junction since 2010. These studies yield reach-specific survival estimates for relatively long segments (up to 67 km) of the SJR between Mossdale and Chipps Island. Though survival estimates specific to the scour hole area (<1 km) are not available, estimated survival for the 7 km reach from Mossdale to the HOR junction (SJR1, Figure 21) is available. The poorest per kilometer (km) survival rate observed in SJR1 was 80% for juvenile Chinook salmon and 86% for steelhead smolts. For this analysis, it was assumed that this lowest per km survival rate occurred in the 1 km reach which includes the HOR junction and the scour hole area. It was further assumed that survival in the remaining 6 km of reach SJR1 was 95% per km for juvenile Chinook and 99% per km for steelhead smolts.

Initial Options 1 through 5 each propose modifications (fill or channel realignment) to reduce or eliminate the HOR scour hole located in reach SJR1. Because of these similarities, and in the absence of more detailed information at this concept stage that might allow for an option-specific survival assessment, it was assumed that each of these five options would be equally effective in reducing predation mortality. Though exact equivalency in reduction in predation mortality is unlikely, the information needed to make option-specific assessments is not currently available. Habitat enhancement related benefits to growth and survival of juvenile Chinook salmon associated with each of the options is considered in a separate analysis (next section).

For juvenile Chinook salmon, it was assumed that survival in the 1 km HOR junction reach would improve from 80% to 95% per km with Options 1 through 5, where survival of 80% and 95% per km represented the lowest and highest estimated per km survival rates available from acoustic tagging studies. For steelhead smolts, it was assumed that survival in the 1 km HOR junction reach would improve from 86% to 99% per km, where survival of 86% and 99% per km represented the lowest and highest estimated per km survival rates available from acoustic tagging studies. Though only applicable to a single 1 km reach, these are large magnitude improvements in survival, representing a best-case-scenario response to scour hole Initial Options.

Converting per km survival rates into survival through SJR1 as a whole shows survival improving from 59% to 70% for juvenile Chinook and improving from 81% to 93% for steelhead (Table 4). Reaches downstream of SJR1 (SJR2 and SJR3) would not be affected by scour hole options and average survival rates were used for juvenile Chinook and steelhead smolts in those reaches (Table 4). For juvenile Chinook in SJR3, acoustic tagging studies conducted April – May have consistently shown very poor survival (<1%) regardless of environmental conditions. However, acoustic tagging studies conducted on spring-run Chinook juveniles earlier in the year indicated survival to Delta exit (Chipps Island) of 2%, 10% and 31% in 2017, 2018 and 2019, respectively (Singer, Hause, and Agosta 2022). The median of these survival estimates (10%) was applied to represent a best-case scenario for juvenile Chinook survival through SJR3.

Despite assuming optimistic survival improvements in SJR1 resulting from Options 1 through 5, estimated survival of juvenile Chinook to Chipps Island improved by just 0.5% and survival of steelhead smolts to Chipps Island improved by 4% (Table 4). These modest improvements in survival to Chipps Island are the result of high rates of mortality occurring downstream of the scour hole area. For example, even if survival in SJR1 were 100%, survival to Chipps Island would rise to just 4.6% and 33% for Chinook salmon and steelhead smolts, respectively. This equates to improvements in survival over existing conditions of 1.9% for Chinook salmon and 5% for steelhead smolts.

Option 6 proposes to capture some proportion of juvenile salmonids before they enter the HOR junction area, and to provide those captured fish with safe, predator-free, transportation to the western Delta. Effectively, Option 6 bypasses the scour hole and the remaining downstream migratory corridor. The effectiveness of Option 6 in improving survival to Chipps Island is largely determined by the assumed effectiveness of the trap; that is, how frequently the trap is operated and the proportion of juvenile salmonids arriving at the sampling site that are captured. Juvenile outmigrant bypass systems associated with hydroelectric dams operate continuously and capture ~90% of passing juvenile salmon (Tomanova et al. 2021). Rotary screw traps (RSTs) deployed in Central Valley tributaries to monitor outmigrating juvenile salmonids typically have low capture efficiency (<3%) but have not been designed or operated with the intention of achieving higher efficiencies. Higher capture efficiencies can be achieved, as demonstrated during an experimental reintroduction into the McCloud River in 2022, where CDFW achieved a 38% capture efficiency for juvenile winter-run Chinook by deploying two RSTs and two fyke traps (Johnson 2023). For evaluating Option 6, it was conservatively assumed that a juvenile outmigrant trap operating on the SJR upstream of the HOR junction would be 10% efficient and that 95% of captured juvenile salmonids would survive to release in the western Delta. For juvenile Chinook salmon, survival to Chipps Island improved from 2.7% under existing conditions to 12% with Option 6 (Table 4). For steelhead smolts, survival to Chipps Island improved from 28% under existing conditions to 35% with Option 6 (Table 4). Even with conservative assumptions about capture efficiency, Option 6 produced substantially larger improvements in survival to Chipps Island than Option 1 through 5. The reason for this is that Option 6 addresses low survival through downstream SJR reaches in addition to the HOR scour hole.

Table 4. Estimated survival benefits associated with the Initial Options, by reach and to Chipps Island

Reach Name	Reach Description	Reach Length (km)	JCS[1] Existing	JCS[1] Options 1 – 5	JCS[1] Option 6	SSS[2] Existing	SSS[2] Options 1 – 5	SSS[2] Option 6
SJR1	Mossdale to HOR (including scour hole)	7	59%	70%	Not reach specific	81%	93%	Not reach specific
SJR2	HOR to Stockton	15	46%	46%	Not reach specific	69%	69%	Not reach specific
SJR3	Stockton to Chipps Island	67	10%	10%	Not reach specific	50%	50%	Not reach specific
N/A	N/A	Survival to Chipps Island	2.7%	3.2%	12%	27.9%	32.1%	35%
N/A	N/A	Improvement from Existing	0%	**0.5%**	**9.3%**	0%	**4.2%**	**7.1%**

[1]Juvenile Chinook Survival
[2]Steelhead Smolt Survival

HABITAT ENHANCEMENT GROWTH AND SURVIVAL BENEFITS

Reducing direct predation losses in the scour hole is one mechanism by which the survival of juvenile salmonids to Chipps Island can be improved. Improving rearing habitat in the scour hole area would allow juvenile salmonids to escape predation while also allowing them to grow to a size where predation mortality would be less severe. The benefits of habitat enhancements associated with the Initial Options were evaluated by making the following assumptions:

- Young-of-the-year spring-run Chinook would reach the HOR junction area in sufficient numbers to fully saturate rearing habitat provided by each option.
- The capacity of rearing habitat to support juvenile spring-run was determined by their largest size before emigrating, where territory size for each fish at 100 mm fork length is 0.6 m^2.
- Of the total area of new off-channel habitat created by each option, 25% would be inundated and of sufficient quality to support juvenile Chinook growing to smolt size (10 mm fork length).
- Fall-run Chinook juveniles do not compete or otherwise interfere with spring-run juveniles in utilizing new rearing habitat.
- 10% of juvenile spring-run Chinook growing to 100 mm fork length on newly created habitat would survive to reach Chipps Island.

Applying these assumptions, Option 5 would produce approximately an additional 22,000 spring-run juvenile Chinook smolts to Chipps Island (Table 5). Option 2, Option 3, and Option 4 would produce approximately 3,000, 16,000, and 19,000 additional spring-run juvenile Chinook at Chipps Island (Table 5). Option 1 and Option 6 do not improve rearing habitat and therefore do not show benefits in this analysis.

Table 5. Acres of new off-channel habitat associated with Initial Options, estimated number of juvenile spring-run Chinook smolts produced, and estimated number surviving to reach Chipps Island

Option	**New rearing habitat (acres)**	**# of juvenile Chinook supported at 100 mm fork length**	**Rearing fish surviving to Chipps Island**
1	0	0	0
2	16	27,072	2,703
3	96	162,162	16,216
4	115	194,257	19,426
5	132	222,973	22,297
6	0	0	0

DURABILITY

The "durability" objective addresses the concern that a project might fail to deliver intended benefits over the longer term. Specific concerns include the likelihood that the scour hole will re-form over time, that shallow rearing habitat would degrade over time, or that options that include ongoing actions (e.g., trap and barge) would become ineffective if staff, equipment, or funding were not available.
The SDM WG discussed a variety of options and determined that the performance metric "likelihood solution will perform as intended over the next 50 years" was the most tractable and appropriate for this first round of consequences predictions. "Likelihood" will be represented as low, medium, or high.

MODEL SUMMARIES/INFLUENCE DIAGRAM

Because durability was defined relative to "performing as intended," and "performing as intended" focuses on increasing survival to Chipps Island, two conceptual models were developed for this exercise.

One describes factors leading to low survival to Chipps Island and the second links proposed actions to survival to Chipps Island (Figure 22).

CALCULATIONS AND/OR SCORING

For this preliminary assessment, alternatives were scored qualitatively based on expert judgment. Each alternative was assigned a score on a scale of 1 – 5 for likelihood of performing as intended over the next 50 years, with 1 representing the lowest likelihood and 5 the highest. Initial scoring for options 1 – 5 was completed by Scott Wright (cbec), and for option 6 by Brad Cavallo (Cramer). Scores and scoring were then reviewed by the SDM WG.

For Options 1 – 5, the following assumptions were employed:

- The primary driver of scour hole formation is the right-angle turn the main channel makes at the HOR.
- Project design will ensure that material used to fill in the hole will be effectively non-erodible over a 50-year time period and also unlikely to be displaced by high-flow conditions.
- Benefits associated with added shallow rearing habitat are not affected by whether a scour hole reforms but could be degraded over time by tidal inundation leading to "swampification."

Each alternative was scored for likelihood of durability with and without ongoing operations and maintenance; results are shown in Table 6 (lower scores assume no maintenance). If there is a single score, scorers felt that there was no difference in durability likelihood with and without ongoing maintenance.

Table 6. Durability Results

Option	Score	Comments/rationale
1	Scour hole: 2-4	The factors leading to the creation of the scour hole aren't addressed: there is still a right-angle bend in the river. There may be downstream erosion or creation of a new scour hole. This could be addressed by adding additional fill as new holes form.
2	Scour hole: 4 and Habitat: 4	The bend is still moderately tight but more like other bends in the river. While a deeper area would likely form on the outer bend the formation of a new scour hole of similar depth is unlikely. The habitat area is small and linked to the channel, making it less likely to become a "swamp."
3	Scour hole: 3-4 and Habitat: 3-4	Similar to option 2, but more complex hydrodynamics make durability less certain without later intervention.
4	Scour hole: 4 and Habitat: 4	The original bend remains but don't anticipate hole reforming because the old channel will function more like a backwater.

Option	Score	Comments/rationale
5	Scour hole: 4 and Habitat: 4	Since the current channel would be blocked off and filled, there is no chance of a scour hole reforming there.
6	Scour hole: 5	Similar projects in the region tend to be implemented as planned over decades, e.g., entrained fish have been salvaged and transported on a regular basis to the Western Delta from CVP and SWP pumps in the South Delta for more than 50 years.

EFFECTS ON OTHER SPECIES

The project team worked with the SDM WG to understand the relative benefits and detriments of each of the six initial remedy options on important biological resources. The results of this ranking/scoring exercise are shown in Table 7. Positive outcomes are noted with a plus (+) symbol, negative outcomes are noted with a minus (-) symbol, and a zero (0) represents no obvious change. Several species not assessed in Table 1 were included in the ranking process summarized in Table 7. There are: longfin smelt, Delta smelt, and southern DPS green sturgeon. The SDM WG included these fish species in the ranking exercise because the Study Area intersects their designated Critical Habitat (Delta smelt and sDPS green sturgeon), or because they were until somewhat recently documented in or near the Study Area (i.e., longfin smelt).

Table 7**.** Scoring of Potential Biological Changes by Initial Option: positive (+), negative (-), no change (0)

Species or Habitat	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Notes
Longfin Smelt	0	+	+	+	+	0	Not known to currently occur in the study area. Floodplain improvements may benefit species over time.
Delta Smelt	0	+	+	+	+	0	Not known to currently occur in the study area. Floodplain improvements may benefit species over time.
Delta Smelt CH	0	+	+	+	+	0	SJR upstream to Stanislaus R. confluence
Steelhead	+	+	+	+	+	+	Study area likely provides move-through habitat only. Floodplain improvements may improve rearing or holding habitat. Trap/haul for salmonids only. Assume filling hole (#1) reduces predation
Steelhead CH	+	+	+	+	+	0	SJR upstream to Merced R. confluence

Species or Habitat	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Notes
Spring-run Chinook Salmon	+	+	+	+	+	+	Study area likely provides move-through habitat only. Floodplain improvements may improve juvenile rearing habitat. Trap/haul for salmonids only. Assume filling hole (#1) reduces predation
Chinook Salmon EFH	+	+	+	+	+	0	SJR upstream to Friant Dam
sDPS Green Sturgeon	+	+	+	+	+	0	Rare in SJR. No known spawning in SJR. Adult strays detected on occasion. Juvenile rearing possible.
sDPS Green Sturgeon CH	+	+	+	+	+	0	SJR upstream to Stanislaus R. confluence
VELB	0	+	+	+	+	0	obligate association with elderberry
Riparian Brush Rabbit	0	+	+	+	+	0	scrub/shrub wetland associate
FRC Salmon	+	+	+	+	+	+	Study area likely provides move-through habitat only. Floodplain improvements may improve rearing or holding habitat. Trap/haul for salmonids only. Assume filling hole (#1) reduces predation
Tricolored Blackbird	0	+	+	+	+	0	riparian/wetland nester
Swainson's Hawk	0	-	-	-	-	0	loss of AGR foraging habitat
White Tailed Kite	0	-	-	-	-	0	loss of AGR foraging habitat
Modesto Song Sparrow	0	+	+	+	+	0	riparian/wetland nester
Pond Turtle	0	+	+	+	+	0	wetland/open water associated
Burrowing Owl	0	-	-	-	-	0	loss of burrowing/foraging (AGR) habitat

Overall, floodplain habitat created under initial options 2, 3, 4, and 5 appears to benefit fish species, and wetland nesting and foraging birds. Option 1 (filling the hole) appears to benefit sensitive fish species that may currently be subject to excessive predation by striped bass (or other predatory fish species) in the deep pool feature at the Scour Hole.

APPROXIMATE COSTS

Previous sections of this memo have detailed concept design features and elevations for each of the five Initial Options that include channel modifications (Option 6 does not). Table 8 details areas and lengths of new floodplain and channel features for each option.

Table 8 Areas and lengths of new floodplain and channel features for each option.

Option	Levee Length (ft)	Grading Area (sq ft) Floodplain	Grading Area (sq ft) Channel	Grading Area (acres) Floodplain	Grading Area (acres) Channel
1	0	0	80,446	0	1.85
2	1,999	683,892	614,196	15.7	14.1
3	4,933	4,186,116	1,293,732	96.1	29.7
4	2,982	5,039,892	592,416	115.7	13.6
5	2,982	5,802,192	592,416	132.2	13.6

Levees require different design specifications and have different costs than other floodplain features. Levee linear feet and grading areas are shown in Table 9.

Table 9. Areas and lengths of new levee features for each option.

Option	Levee Length (ft)	Levee Grading Area (sq ft)	Levee Grading Area (acre)
1	0	0	0
2	1,999	317,988	7.3
3	4,933	479,160	11.0
4	2,982	361,548	8.3
5	2,982	361,548	8.3

To begin the cost estimate process for each of the five options, each option DTM raster was exported from HEC-RAS. Using the Raster Calculator tool in ArcGIS Pro, a raster was computed that detailed the differences between the existing ground surface and proposed grading at the site.

To compute fill values, or the amount of material to be added to existing ground, the difference raster was filtered to only show positive values. All positive fill values were then summed and converted to a volume by multiplying by the raster cell size (3 ft). The process was then repeated to compute cut values, or the amount of material to remove from existing ground. The resulting cut and fill volumes for non-levee areas and for levees are presented in Table 10, for each option.

Table 10. Cut and fill volumes for each of the Non- Levee areas options.

Option	Volume Cut (CY)	Volume Fill (CY)	Volume Moved (CY)	Cut/Fill Balance (CY)	Net Levee Cut/Fill (CY)
1	18,005	42,513	60,518	24,508	42,513
2	332,694	84,642	506,728	-248,052	84,642
3	1,762,509	349,879	2,266,704	-1,412,630	349,879
4	2,222,598	2,211	2,350,587	-2,220,387	2,212
5	2,217,218	187,038	2,530,033	-2,030,179	187,038

To estimate approximate construction costs, a table was developed that summarizes unit costs for common construction activities (Table 11). Most of these costs were adopted from a Tech Memo developed by DWR in 2019 for a planning level cost estimate for the proposed Paradise Cut Expansion Project (https://southdeltawater.org/paradise-cut-expansion). Cost information based on cbec's involvement in multiple other constructions projects was also incorporated into Table 11.

Table 11. Common construction unit costs.

Item	Action	Unit Cost (USD)	Units	Reference
1	Grading – cut	$13	Cubic Yards (CY)	DWR Tech Memo on Paradise Cut
2	Grading – fill	$16.50	Cubic Yards (CY)	Van Norden (Hanford estimate)
3	Hauling	$15	Cubic Yards (CY)	LAR rearing
5a	Levee construction	$26	Cubic Yards (CY)	DWR Tech Memo on Paradise Cut
5b	Levee aggregate base	$26	Linear foot (LF)	DWR Tech Memo on Paradise Cut
8	Revegetation	$42,000	Acre (Ac)	LAR SAFCA RM 0.5; River Partners, Urrutia Feasibility Study
9	Unallocated Items	5%	% of Items 1-8	DWR Tech Memo on Paradise Cut
10	Mobilization/ Site Prep/ Demobilization	5%	% of Items 1-8	DWR Tech Memo on Paradise Cut
11	Construction contingency	30%	% of Items 1-8	DWR Tech Memo on Paradise Cut
12	Design and Engineering	15%	% of Items 1-8	DWR Tech Memo on Paradise Cut
13	Permitting and legal costs	6%	% of items 1-8	DWR Tech Memo on Paradise Cut; GEI
14	Construction Oversight & Engineering Changes	5%	% of Items 1-8	DWR Tech Memo on Paradise Cut; cbec oversight estimate
15	Long-term Monitoring/ O&M	14%	% of Items 1-8	Urrutia Feasibility Study

Non-levee grading cut and fill costs were calculated by multiplying cut and fill volumes in Table 10 with line items 1 and 2 from Table 11. Hauling costs incorporate the total cut/fill volume from Table 10 and line item 3 from Table 11. Levee construction base costs incorporate net levee cut/fill volumes from Table 10 and line item 5a from Table 11. Finally, levee aggregate base costs were calculated by multiplying levee length numbers from Table 9 by line item 5b in Table 11. The resulting construction costs are shown in Table 12.

Table 12. Construction costs for levee and non-levee features in million USD.

Option	Grading (Cut) Cost	Grading (Fill) Cost	Hauling Cost	Levee Construction	Levee Aggregate Base
1	$0.23 M	$0.70 M	$0.37 M	$0	$0
2	$4.3 M	$1.4 M	$3.7 M	$1.8 M	$0.05 M
3	$22.9 M	$5.7 M	$21.2 M	$4.0 M	$0.13 M
4	$28.9 M	$0.04 M	$33.3 M	$3.1 M	$0.08 M
5	$28.8 M	$3.1 M	$30.5 M	$3.1 M	$0.08 M

Revegetation costs were computed from the floodplain area values in Table 8 and line item 8 in Table 11. The total construction and revegetation costs are shown in Table 13.

Table 13**.** Total construction and revegetation costs in million USD.

Option	Construction Cost (grading, hauling, levees)	Revegetation Cost
1	$1.3 M	$0
2	$11.3 M	$0.66 M
3	$53.9 M	$4.0 M
4	$65.4 M	$4.9 M
5	$65.6 M	$5.6 M

Permitting, oversight, and monitoring (POM) costs are shown in Table 14. Costs for each item were estimated by multiplying the total construction costs by the appropriate line item from Table 11.

Table 14. Construction costs for levee and non-levee features in million USD.

Option	Unallocated Items	Mobilization/ Site Prep/ Demobilization	Construction contingency	Design and Engineering	Permitting and legal costs	Construction Oversight & Engineering	Long-term Monitoring & O&M
1	$0.07 M	$0.07 M	$0.39 M	$0.20 M	$0.08 M	$0.07 M	$0.18 M
2	$0.60 M	$0.60 M	$3.6 M	$1.8 M	$0.72 M	$0.60 M	$1.7 M
3	$2.9 M	$2.9 M	$17.4 M	$8.7 M	$3.5 M	$2.9 M	$8.1 M
4	$3.5 M	$3.5 M	$21.1 M	$10.5 M	$4.2 M	$3.5 M	$9.8 M
5	$3.6 M	$3.6 M	$21.3 M	$10.7 M	$4.3 M	$3.6 M	$10.0 M

Table 15 summarizes the estimated project costs for all Initial Options (Option 6 methods are described below). Total POM costs are the sum of the columns in Table 14, for each option. Construction and revegetation costs are from Table 13.

Table 15. Summary of estimated project costs for all Initial Options in million USD.

Option	Total POM	Construction and revegetation	Total
1	$1.0 M	$1.3 M	$2.3 M
2	$9.6 M	$12.0 M	$21.6 M
3	$46.4 M	$57.9 M	$104.3 M
4	$56.1 M	$70.3 M	$126.4 M
5	$57.1 M	$71.2 M	$128.3 M
6	N/A	N/A	$37.6 M

The construction cost estimates provided here are approximate. Cost estimates can change rapidly based on a number of factors, including inflation. A 30% contingency has been allocated to each estimate to minimize the financial impact of unexpected factors. The purpose of these construction estimates is to enable a relative analysis to help to differentiate between options and should not be considered actual construction costs. The future design process will enable significantly more accurate construction cost estimates to be made.

Costs for Option 6 were estimated using different methods because Option 6 (trap and barge) does not include any changes to the existing channel geometry. Option 6 includes two types of cost: 1) up-front, one-time costs and 2) annual operations and maintenance costs. Up-front costs include design and permitting as well as materials, fabrication, and installation costs for the trapping system. Annual costs include staffing, data management, reporting, travel, fish barging, and general equipment maintenance. Costs for each of these items were estimated by the project team based on previous experience with similar projects. Up-front are estimated to be $200,000 total, with $50,000 for design and permitting and $150,000 for materials, fabrication, and installation. Annual costs were estimated to be $330,000 per year total, with $75,000 per year for barging and remainder accounting for labor, travel, and data management.

Because Option 6 includes substantial annual operations and maintenance costs, it is necessary to extrapolate these costs over longer time frames in order to make relevant comparisons with costs for the other options. Costs for Options 1 – 5 also include operations and maintenance (Table 14), however it is not expected that these costs would continue in perpetuity as these designs would be expected to become mostly self-sustaining over time. Option 6, on the other hand, would require continual operation and maintenance for as long as the system is operated. A duration of 50 years was chosen as a reasonable time frame for computing Option 6 costs as this aligns with the decision of the SDM WG to consider durability over a 50-year period. If cost inflation is ignored, 50-year total costs sum to $16.8M. Using a more realistic inflation estimate of 3% per year yields 50-year total costs of $37.6M.

IMPACTS ON FLOOD CAPACITY

The RMA2 Delta-scale hydrodynamic (Delta) model was applied to evaluate the potential flood flow impacts and benefits of the Initial Options. Versus a more local scale model, the use of the Delta scale model for the analysis allows for a less constrained development of the downstream stage boundaries for the San Joaquin River and Old River reaches below their junction and the partitioning of the flow from the junction to the two rivers.

A detailed discussion of the RMA2 Delta model and model calibration is presented in Appendix D. This document presents the results and analysis of the hydrodynamic modeling for the Initial Options for a 100-year flood flow event. The primary metric for evaluation is change in Water Surface Elevations (WSE) from the Base (existing conditions) run.

FLOOD IMPACTS EVALUATION

The Delta model domain and boundary conditions are presented in Figure 23. For the 100-year flood flow scenario, a constant flow boundary condition was used for the San Joaquin River inflow boundary, with other Delta boundary conditions developed from the historical January 1997 flood event. Detailed model grids were developed for the Base conditions and the five Initial Options that included channel modifications (Figures 24 and 25). The Base conditions model grid represented the present-day configuration of the south Delta, that is without consideration of any planned flood mitigation projects such as the Paradise Cut Expansion Project (https://southdeltawater.org/paradise-cut-expansion). The model grids for Options 1 – 5 were developed using the Digital Terrain Models for each option.

The 100-yr event flows for the project area were developed from the 2009 FEMA Flood Insurance Study for San Joaquin County (FEMA, 2009). The 100-yr event flows along the San Joaquin River from the 2009 FEMA study are listed in Table 16. The baseline RMA2 model was setup and calibrated to reproduce the flows from the FEMA study for the San Joaquin River above the Old River junction and the flow partition to the San Joaquin River below the junction (SJR at mouth of French Camp Slough), and to approximate the FEMA water surface elevations for the reaches.

Table 16. 100-year event flows along the San Joaquin River from the 2009 FEMA study.

Location	Peak discharge (cfs) 1% annual chance
San Joaquin River at Paradise Weir	71,800
San Joaquin River at Mossdale	44,500
San Joaquin River at Head of Old River	43,500
SJR at mouth of French Camp Slough	21,100

Table 16 indicates that the channel flow decreases moving downstream along the San Joaquin River, attributed to overbank losses and distributary type flows from the study reach (FEMA, 2009). Of note are the flow decreases for the San Joaquin River just above Paradise Cut to the junction with Old River. Details of the hydraulic modeling supporting the FEMA study, with the locations and quantity of overbank flow, were not available. The target for the setup of the RMA2 modeling was to reach the approximately 43,500 cfs for the San Joaquin River flow above the junction with Old River. As a result, for the model setup the San Joaquin River flow above the Paradise Cut overflow was set to 70,800 cfs. Friction was lowered in the Paradise Cut bypass to accommodate the diversion of 27,300 cfs from the San Joaquin River and approximating the 43,500 cfs flow into the junction for the Base conditions model configuration. The 100-year flow event was run as an unsteady flow simulation with a constant San Joaquin River inflow boundary condition, and with time varying tidal and other Delta inflow conditions.

The RMA2 Delta model results were post-processed to extract the peak WSE for the San Joaquin River and south Delta. The model WSE for each of the Initial Options were compared to the Base conditions result to estimate the potential flood impacts of the options. Changes in WSE were evaluated both in the project area and for the San Joaquin River and Old River reaches upstream and downstream of the project area.

Initial modeling results indicated that the Paradise Cut overflow plays a key role in WSEs and flow splits in the area. To evaluate this impact, two Scenarios were implemented for the location of the upstream flow boundary condition. The two flow scenarios evaluated were: 1) San Joaquin River inflow of 70,800 cfs at the upstream Vernalis location, and 2) the San Joaquin River model grid truncated upstream of the Mossdale Bridge, with the inflow boundary condition set to 43,500 cfs. Thus, Scenario 1 includes the influence of Paradise Cut while Scenario 2 does not. As will be seen in the results presented below, these two Scenarios produce different outcomes because the setback levee options influence WSEs upstream to Paradise Cut. Changes in WSE at Paradise Cut affect the amount of spill to the overflow channel, which in turn influences the flow magnitude downstream on the SJR below Paradise Cut.

RESULTS

Spatial plots of predicted peak WSE and WSE change from Base were produced for the five Initial Options that included channel modifications and for the two Scenarios of upstream boundary locations described above. For reference, Figure 26 shows the locations in the model domain where results are presented in subsequent figures.

SCENARIO 1 – SAN JOAQUIN RIVER BOUNDARY AT VERNALIS

Figure 27 presents the peak WSE and flow split for the Base conditions for Scenario 1, which is the case with the SJR inflow boundary at Vernalis (upstream from Paradise Cut). Figures 28 to Figure 37 present the plots of peak WSE and the WSE change from Base conditions for the five Initial Options. For each Option, two figures were produced to elucidate modeled changes from the Base condition: 1) far-field view showing WSE changes and differences in the flow spit (e.g. Figure 28); 2) near-field view of WSE and WSE changes (e.g. Figure 29). The changes in peak WSE from Base conditions for Scenario 1 are summarized in Table 17. Similarly, the flow entering the junction and the flow splits to the lower San Joaquin River and Old River reaches are summarized in Table 18.

Table 17**.** Change in peak WSE from the Base (feet) conditions at selected locations along the SJR and Old River, for Scenario 1 (SJR inflow at Vernalis).

Location	Option 1	Option 2	Option 3	Option 4	Option 5
SJR at Mossdale Bridge	+0.02	+0.01	-0.12	-0.30	-0.30
SJR above River Islands Pkwy	+0.02	+0.02	-0.18	-0.46	-0.46
SJR above Old River	+0.02	+0.01	-0.23	+0.20	+0.20
SJR near Lathrop	-0.06	-0.04	N/A	+0.32	+0.32
SJR above Dos Reis	-0.05	-0.04	+0.42	+0.40	+0.39
SJR at Brandt Bridge	-0.04	-0.04	+0.37	+0.35	+0.34
Old River at Head	+0.02	+0.03	-0.22	-0.08	-0.07
Old River below SJR	+0.02	+0.01	-0.21	-0.09	-0.08
Old River at Middle River	+0.01	+0.01	-0.16	-0.11	-0.10
Max Change in Project Area	+0.03	+0.16	+0.58	+0.57	+0.61

Table 18. Predicted flows for the San Joaquin River and Old River reaches for the Base conditions and the five scour hole project design options, for scenario 1 with the SJR inflow at Vernalis.

Reach	Base	Option 1	Option 2	Option 3	Option 4	Option 5
Old River	22,483	22,545	22,528	22,006	22,446	22,456
SJR below Old R	20,960	20,863	20,897	21,701	21,663	21,653
SJR above Old R	43,442	43,408	43,423	43,706	44,108	44,107

The results for Scenario 1 show that all options have the potential to affect WSEs, typically by a few tenths of a foot but with local changes as large as 0.61 feet. The options also influence the flow split, in particular Options 4 and 5 which have more of an influence on the Paradise Cut spill. Scenario 1 results are discussed further for each Initial Option below.

At the far-field view, Option 1 and Option 2 slightly increase stage for the SJR above the Old River junction and for the Old River reach, and slightly reduce stage for the SJR below the junction. WSE changes were generally small and less than 0.05 feet at all locations for Options 1 and 2. However, Figure 31 shows that Option 2 produces local WSE changes on the SJR and Old River in the vicinity of the junction of up to 0.16 feet. Thus, the Option 2 design would need to be modified to address these localized changes. No iterations of terrain modifications were carried out during this initial modeling effort.

Option 3 increases flow for the SJR below the Old River junction by +741 cfs and increases the stage along the reach by +0.58 feet in the project area and +0.42 and +0.37 feet at the Dos Reis and Brandt Bridge locations (Figure 26, Table 17). The increase in SJR flow below the Old River junction results from the levee setback which preferentially draws more flow to the lower SJR versus Old River, as compared to Base Secondly, Option 3 reduces the SJR stage above the junction which slightly decreases the Paradise Cut spill, with the overall effect of increasing the SJR flow into the junction by +283 cfs.

The Option 4 and Option 5 designs include a main channel and broad floodplain which shorten the path of the SJR flow from above the Old River junction to the lower reach. The near-field WSE contours shown in Figure 35 illustrate that the Option 4 configuration reduces the head loss over the area versus the more circuitous flow route of the existing channel. The effect both reduces the SJR stage above the Old River junction, which reduces the Paradise Cut spill and increases flow into the project reach, and preferentially directs the additional flow to the lower SJR. In the project area, the stage increases +0.57 feet along the existing river left levee, and +0.40 and +0.35 feet at the Dos Reis and Brandt Bridge locations, respectively.

The Option 5 results are similar to Option 4, for both WSE changes and flow split differences. Option 5 differs from Option 4 only in that it cuts off and fills in the existing SJR channel north of the new habitat area. This difference has very little effect on the hydrodynamics in the reach that control WSE at the 100-year flow event.

A sensitivity analysis was performed to evaluate the sensitivity of the predicted peak WSE for the Initial Options configurations to the friction coefficients selected for the new habitat/floodplain areas (Options 2-5) and for the scour hole fill in Option 1. Table 19 lists the friction coefficients used for the flood impacts analysis (default values) and for the sensitivity runs. The sensitivity simulations showed that the changes of predicted WSE were usually limited to 0.01 to 0.02 feet.

Table 19. Friction values used for the design option habitat areas and scour hole fill for the primary simulation analysis (Default Value) and for the sensitivity runs.

Area Type	Default Value Manning's n	Sensitivity Run Manning's n
Scour hole fill, Option 1	0.045	0.039
Lower habitat area, Options 2-5	0.050	0.065
Upper habitat area, Options 3-5	0.065	0.075

SCENARIO 2 – SAN JOAQUIN RIVER BOUNDARY AT MOSSDALE BRIDGE

For scenario 2 the San Joaquin River inflow boundary condition was located at the Mossdale Bridge, with a constant 43,500 cfs flow. The scenario 1 simulations showed that the various Initial Options and increase or decrease the SJR stage above the junction with Old River. In that modeling analysis, this change in stage could reduce or increase the Paradise Cut spill, and thus increase or reduce the flow into the Old River junction. With a fixed SJR inflow applied at the Mossdale Bridge location, the Initial Options may be evaluated independent of the influence of the Paradise Cut bypass.

The WSE plots for the Base conditions and the five Initial Options with channel modifications are presented in Figures 38 to 48 and the changes in peak WSE from Base conditions are summarized in Table 20. Similarly, the flow splits to the lower San Joaquin River and Old River reaches are summarized for the Base conditions and the Initial Options in Table 21.

Table 20. Change in peak WSE from the Base (feet) conditions for the five scour hole project design options at selected locations along the SJR and Old River, for scenario 2 with the SJR inflow at Vernalis.

Location	Option 1	Option 2	Option 3	Option 4	Option 5
SJR at Mossdale Bridge	+0.02	+0.01	-0.20	-0.48	-0.48
SJR above River Islands Pkwy	+0.02	+0.01	-0.25	-0.62	-0.62
SJR above Old River	+0.03	+0.02	-0.28	+0.06	+0.06
SJR near Lathrop	-0.05	-0.03	N/A	+0.18	+0.18
SJR above Dos Reis	-0.04	-0.03	+0.38	+0.27	+0.27
SJR at Brandt Bridge	-0.04	-0.03	+0.32	+0.23	+0.23
Old River at Head	+0.04	+0.04	-0.27	-0.21	-0.20
Old River below SJR	+0.03	+0.03	-0.25	-0.18	-0.17
Old River at Middle River	+0.02	+0.01	-0.17	-0.12	-0.12
Max Change in Project Area	+0.04	+0.16	+0.52	+0.46	+0.46

Table 21. Predicted flows for the San Joaquin River and Old River reaches for the Base conditions and the five scour hole project design options, for scenario 2 with the SJR inflow at the Mossdale Bridge.

Reach	Base	Option 1	Option 2	Option 3	Option 4	Option 5
Old River	22,489	22,561	22,545	21,838	22,020	22,030
SJR below Old R	21,012	20,939	20,957	21,664	21,483	21,473
SJR above Old R	43,500	43,500	43,500	43,500	43,500	43,500

For Options 1 and 2, the changes from the Base conditions WSE are similar to those for Scenario 1, as those options do not notably change the SJR flow from Base conditions into the junction with Old River. This result is due to the fact that these options have a smaller zone of influence and overall smaller effect on WSE than the other options, and thus a limited effect on the flow over Paradise Cut in the Scenario 1 simulations.

For Options 3-5, which have more substantial levee setbacks and thus more potential influence on Paradise Cut spills, the WSE increases from Base conditions for the SJR below the junction are smaller for Scenario 2 than those for Scenario 1, particularly for Options 4 and 5. The WSE increases in the reach for the three options are still significant, with the increases for the SJR at Brandt Bridge of +0.32 feet for Option 3 and +0.23 feet for Options 4 and 5. Options 3 – 5 also increase the flow on the SJR below the Old River junction (and decrease Old River flows), despite the influence of the Paradise Cut spill be removed in Scenario 2. Thus, the increases in flow and WSE in the SJR below the Old River junction for the options with substantial levee setbacks (Options 3 – 5) are due to a combination of the effects on the Paradise Cut spill as well as the designs resulting in the flow splits becoming slightly more preferential down the San Joaquin versus the Old River route.

Overall, the hydrodynamic modeling results provide a preliminary assessment of how the various Initial Options perform with respect to changes in WSE and the SJR – Old River flow split. Options 1 and 2, which include relatively minor channel modifications, result in small WSE changes typically in the 0.01 to 0.05 range, with some locally higher differences in the immediate vicinity of the scour hole. Options 1 and 2 also have minimal influence on the flow split. Options 3 – 5, which include more substantial levee setbacks, result in larger WSE changes typically ranging from 0.1 to 0.5 feet but locally as high as 0.61 feet. Options 3 – 5 also have a larger influence on the flow split with all options increasing the flows (and resulting WSEs) down the SJR below Old River.

These initial modeling results indicate that the setback levee options would need to be modified to eliminate the increases in WSEs and to better maintain the existing SJR – Old River flow split. These iterations between design and modeling will occur in the next phase of the project once a set of options has been selected for future study.

MINIMIZE ADVERSE IMPACTS ON BENEFICIAL USES OF WATER

After some discussion the project team decided that meaningfully estimating consequences for this decision objective would require modeling and analysis that was beyond the scope of this initial phase. This is not a statement about the relative importance of this objective; adverse effects on beneficial uses of water should be included in the next round of analysis. As with other objectives, consequences should be evaluated under multiple water year types. For this objective, there was a suggestion for modeling a dry scenario and a scenario that is neither wet nor dry, for example 2015, 2018, 2021, and 2022.

Although no insights were developed from analyses for this decision objective, insights from discussions that may be useful for future analysis include:

- Beneficial uses could be affected by changes in water surface elevation, quantity, and quality, all of which could potentially be estimated. However, the SDM WG recommends using specific concerns as performance metrics, e.g., harmful algal blooms (HABs), salinity, etc. Developing influence diagrams linking changes in water surface elevation, quantity, and quality to these concerns would be useful both for designing the analysis and for ensuring stakeholder concerns are captured.
- One option for water quality analysis would be to use RMA’s salinity model to assess changes in salinity.
- HABs could be modeled in stagnant areas or dead-end channels.
- Analysis of likelihood that water costs are induced should specify costs to whom, when, and where. Analysis should include the effect of alternatives on the flow split at the head of Old River and OMR flow.

EFFECTS ON RECREATIONAL USE

The project team used the same ranking procedure and scoring basis (+, 0, -) used for biological resources to provide a snapshot of recreational benefits and detriments that could result from implementation of the six initial remedy options. Results of this ranking are shown in Table 22.

Recreational values assessed included:

- Public use of levees for walking or hiking
- Public use of levees for bird watching and naturalizing
- Recreational boating (not fishing)
- Fishing near the scour hole site
- Fishing elsewhere

Overall, the initial scoring indicated that all recreational values would be improved with implementation of options 2, 3, 4, or 5, with no material change associated with options 1 or 6. The SDM WG took exception with initial Recreation scoring, and suggested that fishing opportunities and experiences at the Scour Hole would be adversely affected by Option 1 (filling the hole), as striped bass would likely be selected against by removal of the deep pool near the head of the Old River. The SDM WG further suggested that stakeholder outreach with local fishers may provide justification for a "-" score, rather than "0", as shown in Table 22.

Table 22. Scoring of Potential Recreational Changes by Option: positive (+), negative (-), no change (0)

Recreational Use	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Notes
Walking + hiking along levees	0	+	+	+	+	0	Assumes current public access to south levee of Old River, south levee of SJR below divergence point, public access to west and east levees of SJR above divergence point. No changes anticipated with options 1 or 6. Potential increases in extent and/or value of public access with enhanced habitat areas and setback levees.
Bird watching + naturalizing along levees	0	+	+	+	+	0	Potential improved experiences with options 2-4.
Boating	0	+	+	+	+	0	No change in mainstem opportunities, but potential boating access to off-channel enhanced areas.

Recreational Use	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Notes
Fishing (at/near the scour hole)	0	+	+	+	+	0	Current fishing opportunities are warm-water species such as largemouth bass and striped bass. Potential warm-water fishing improvements with enhanced and expanded off-channel habitat areas. Uncertain how warm-water fishing opportunities will respond to reduced predation of juvenile salmonids realized with all options (1-6). Option 1 may contribute to the creation of predator refugia in RSP voids, unless voids are filled. Uncertain how warmwater fishery will respond to trap and haul of juv. salmonids under Option 6.
Fishing (elsewhere)	+	+	+	+	+	+	Improved survival of outmigrant salmonids with all options may contribute to improved ocean and riverine salmonid fishing opportunities. Perhaps not detectable until salmonid production increases substantially in SJR watershed.

LANDOWNER CONCERNS

The Initial Options include levee setbacks that would encroach on private property immediately to the north and south of the scour hole. The property to the north of the scour hole is owned by Anthony Machado Sr. Mr. Machado is the owner of over 600 acres of land on Upper Roberts Island, where he grows alfalfa and other feed crops for his dairy cows, which are located in Turlock, CA. He also owns a small trucking operation, which transports feed from Upper Roberts Island to Turlock. The project team spoke with Mr. Machado twice, once in September 2022, and again in January 2023. The purpose of the project team's initial call was to share basic project information, introduce the project team, and confirm Mr. Machado's ownership of the property and interests. He expressed interest in continued briefings and coordination with Reclamation and the project team. Mr. Machado expressed willingness to discuss solutions to the scour hole issue and was congenial. The purpose of the second briefing was to share the draft concepts and get input from Mr. Machado. He expressed skepticism about the project's impact on his property. The following are key takeaways from the conversation:

- Maintaining contiguous farming property on Upper Roberts Island. Mr. Machado grows his entire feed crop at Upper Roberts Island, allowing him to maintain a streamlined process directly from feed to dairy. This is worth more to him than the cash value of the property.

- Disinterest in compensation or division of his property. The project team is exploring potential solutions that could include channel realignment through his property. Mr. Machado shared that these channel realignments would ruin 400 of the 600 acres he owns for farming and would make it problematic for him to transport feed efficiently.
- When presented with the six Initial Options sketches, Mr. Machado shared a preference for Options 1, 4, or 5. He does not approve of Options 2 and 3, which would impact his property, but is willing to hold continued conversations and is not averse to further collaboration. Mr. Machado provided the following feedback on the options. Option 1: Easiest option as a farmer since this is minimally invasive to his property. Options 2 and 3: These options would devalue his property and are not compatible with continued farming (see second bullet above). Mr. Machado has a conservation easement on the property, which could create issues if Option 2 and 3 were chosen. Option 3 might cause further erosion in the northeast corner of his property, which is already experiencing erosion. Options 4 and 5: he suggested that if the goal of a channel realignment is to reduce the curve of the San Joaquin River, it may be better to cut the bank rather than going through his property.

The property to the south of the scour hole would be impacted by Options 4 and 5. This property is currently under debate about its future. The City of Lathrop has put forward a development plan for the parcel, termed Mossdale Landing West, that would convert the agricultural fields into a residential subdivision. The project team briefed the City of Lathrop early in the stakeholder outreach process; a second attempt to brief the City on the Initial Options was denied. Related to this development proposal, John Cain from River Partners provided the project team with a letter to the City from a group of environmental organizations in opposition to the development. The letter details opposition to the development on several legal grounds, and also notes that the subject property and levees are currently being evaluated as part of SJAFCA's ongoing Mossdale Tract Area Urban Flood Risk Reduction Project. Given the sensitivity surrounding this property and the unwillingness of the City of Lathrop to engage, the project team decided not to directly contact the property owner at this early stage in the scour hole project. However, if Options 4 or 5 (or any option that affects this property) are selected to move forward, extensive coordination will be needed with SJAFCA's project team for the flood risk reduction project, as well as with the private landowner. The scour hole project team began this coordination with SJAFCA's project team in February 2023 by conducting joint briefings on the two projects.

LEARNING

Respondents were asked to score each option's potential for learning as none, low, or high for six areas of learning. Scores were solicited via an online form; five experts responded. See Appendix C for specific elicitation materials and complete scoring. A single round of scoring was done and respondents' scores were not discussed beyond what was provided in comments. The results of the elicitation are shown in Table 23. In the Table, none, low, and high are represented by 0, 1 and 2; the results are also color coded with red denoting none, blue denoting low, and green denoting high learning potential. The five values shown in each cell correspond to the five experts, in same order in each cell.

Table 23. Results from learning potential expert elicitation. Each grid shows experts' responses for a single option. Within a grid, each column shows the answers of a single expert. Experts are in the same order in each grid.

Area of Learning	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Causes of HOR salmonid loss	1 1 1 1 1	0 1 1 1 2	0 1 1 2 2	0 1 1 2 2	0 1 1 2 2	0 1 1 1 2
Reducing HOR salmonid loss	0 1 1 1 2	0 1 1 1 1	1 2 2 2 2	0 2 2 2 2	1 2 2 2 2	0 0 1 1 1
Causes of salmonid loss, other scour holes	0 0 1 1 1	0 0 1 1 1	0 0 1 1 1	0 0 1 1 1	0 1 1 1 1	0 0 1 1 1
Reducing salmonid loss, other scour holes	0 1 1 1 2	0 1 1 1 1	1 1 1 1 1	1 1 1 1 1	0 0 1 1 2	0 1 1 1 2
Floodplain restoration	0 0 0 0 0	1 1 1 1 1	1 1 2 2 2	0 1 2 2 2	1 2 2 2 2	0 0 0 0 0
Broadly applicable information	0 0 1 1 1	0 0 1 1 1	0 0 1 1 2	0 0 1 1 2	0 0 1 2 2	0 0 1 1 2

Most respondents thought options 3, 4, and 5 had high potential for learning about HOR actions and floodplain restoration. Learning potential was generally seen as low to none for options 1, 2, and 6. All respondents scored learning potential as low to none for causes of salmonid loss in other scour holes in the SF Bay Delta, and most scored it as low to none for approaches to reducing salmonid loss in other scour holes in the SF Bay Delta, and for broadly applicable monitoring data.

The most discussed area of learning was learning about the implementation and benefits to salmonids of floodplain restoration in in "valley floor"/leveed Delta/South Delta. Respondents noted that:

- Existing information is concentrated in Yolo Bypass, Consumnes.
- Limited information on low-gradient sand-bedded reaches.
- Localized setback levees are different in scale and dynamics from Yolo.
- Small floodplain benches may be only for creating floodplain/channel margin habitat in the leveed Delta.
- The degree to which local shallow water habitat provides refuge depends on duration/frequency of inundation, which is a big unknown.

Other areas of learning include:

- The effect of channel reconfiguration on streak line, rerouting, and survival.
- Longevity of fixes for both filling in a scour hole and for constructed floodplains in the San Joaquin Delta.
- How to monitor floodplains for presence and survival.
- Monitoring/run of river tagging supported by Option 6 could enhance existing monitoring, and provide information on causes of losses, estimates of passage timing and abundance of salmonids emigrating from the San Joaquin Basin.

Factors affecting learning potential include:

- Size of intervention: Respondents thought the small amount of floodplain created in Option 2 would make it difficult to see an impact or attribute change to the intervention.

- The unique nature of the HOR scour hole was cited as a reason why results from this location might not be easily transferable to other areas.
- Some respondents commented that Options 3-5 were so expensive, time-consuming, and site-specific that they were unlikely to be replicated elsewhere, limiting value of learning.
- Making multiple changes at once (e.g., filling the hole and creating new channels) would make the attribution of effects more difficult but could provide insights on interactions.
- Planning for post-project assessments that can be compared to studies already conducted will support learning.

In addition to providing scores, respondents were asked if there were existing surveys, monitoring projects, or related efforts in the area that USBR should take into consideration in the evaluation and winnowing of these options. Responses (direct quotations from respondents) were:

- The Mossdale Trawl samples in this reach so the installation of a trap would likely be a problem for trawl operations, and cause the data collected to be less useful if a portion of fish are removed.
- Although the HORB is not currently proposed it would be good to consider options that would still allow for installation if it became a proposal in the future.
- In addition to hydrology changes in the future (note recent storms!), USBR should ensure that project designs (especially for Options 2-5) should consider the potential for the flow regimes that might come from efforts such as the Voluntary Agreements and/or the SWRCB's WQCP update.

The above bullet points represent the views of individual experts only and were not discussed by the SDM WG as a whole. With regard to the Mossdale Trawl comment, this was discussed by the project team, and it is believed that the trap for Option 6 could be operated such that the trawl would not be affected.

SUMMARY OF INITIAL OPTIONS ASSESSMENTS

As emphasized in Section 4, the goal of the SDM process in this case was not to make a decision or even a recommendation; the SDM WG was designed to provide structured stakeholder engagement. In the context of this process, the evaluation of consequences should be viewed as draft and preliminary.

For the preliminary evaluation of consequences, a Simple Multi-Attribute Ranking Technique (SMART; Edwards 1977) was used. The raw scores from the assessments are shown in Table 24. The color coding is as follows: green (G) is the highest scoring option for a given objective, red (R) is the lowest score, and orange (O) scores fall in between. The raw scores were then normalized to a common scale between zero and one, using the maximum and minimum scores for each objective to set the normalization. Finally, each objective (or subobjective) was assigned a weight. For this first round of analysis, each objective was assigned an equal weight of one (with subobjective weights divided evenly). The results from this normalization and weighting are shown in Table 25.

Table 24. Summary of Raw Scores from the Consequences Assessments

Decision Objective	Desired direction	Initial Option 1	Initial Option 2	Initial Option 3	Initial Option 4	Initial Option 5	Initial Option 6
Max effectiveness - predation: Chinook	Max	R1	R1	R1	R1	R1	G4
Max effectiveness - predation: Steelhead	Max	R2	R2	R2	R2	R2	G4
Max effectiveness - Habitat	Max	R0	O1	G3	G3	G3	R0
Durability	Max	R3	O4	O3.5	O4	O4	G5
Effects on other species	Max	O7	G12	G12	G12	G12	R3
Cost	Min	G2.3	O21.6	O104.3	R126.4	R128.3	O37.6
Recreation - Boating	Max	R0	G3	G3	G3	G3	R0
Recreation - Fishing	Max	R1	G2	G2	G2	G2	R1
Landowner concerns	Min	G0	R1	R1	R1	R1	G0
Learning	Max	O4.2	O4.8	O7.0	O6.6	G7.4	R4

Table 25. Summary of Weighted Scores from the Consequences Assessments

Decision Objective	Weight	Initial Option 1	Initial Option 2	Initial Option 3	Initial Option 4	Initial Option 5	Initial Option 6
Max effectiveness - predation: Chinook	0.33	R0	R0	R0	R0	R0	G0.33
Max effectiveness - predation: Steelhead	0.33	R0	R0	R0	R0	R0	G0.33
Max effectiveness - Habitat	0.33	R0	O0.11	G0.33	G0.33	G0.33	R0
Durability	1.0	R0	O0.5	O0.25	O0.5	O0.5	G1
Effects on other species	1.0	O0.44	G1	G1	G1	G1	R0
Cost	1.0	1	O0.85	O0.19	R0.01	R0	O0.72
Recreation - Boating	0.50	R0	G0.5	G0.5	G0.5	G0.5	R0
Recreation - Fishing	0.50	R0	G0.5	G0.5	G0.5	G0.5	R0
Landowner concerns	1.0	1	R0	R0	R0	R0	G1
Learning	1.0	O0.06	O0.24	O0.88	O0.76	G1	R0
Sum of Weights (for all objectives)	7.0	N/A	N/A	N/A	N/A	N/A	N/A
Sum of weighted scores	N/A	O2.50	O3.69	O3.65	G3.61	O3.83	O3.39
N/A	Final Score (sum of weighted scores/sum of weights)	O0.36	O0.53	O0.52	G0.52	O0.55	O0.48

Flood capacity was not included in the assessment tables because it is a “yes/no” assessment, in terms of whether a given option increases flood risk. That said, Section 6.5 documents that the options have varying degrees of impacts on flood capacity, with the options that include substantial levee setbacks (Options 3 – 5) having the most potential to negatively affect flood capacity by increasing 100-year water surface elevations. Thus, these options would be ranked lower than Options 1 – 2 and 6, which have minimal to no impact on flood capacity. As noted in Section 6.5, the setback levee options require design modifications and additional simulations to reduce the flood capacity impacts revealed in this phase of the analysis.

A further step in the SDM process is to assign weights to the different objectives based on actual decision maker or stakeholder values rather than assuming all objectives are equally important. This is often done by eliciting weights from different stakeholders using SMARTS or SMARTER approaches (Edwards and Barron 1994). In this application, a sensitivity test on the weighting was conducted to see how the weights impact the ranking of options. In this approach, the weight on each objective was assigned weights of 0, 2, and 5 while the weights on other objectives were held constant at one. Because it was assumed that a project would only move forward with landowner approval, the landowner concerns objective was not included in this analysis. The results of this sensitivity testing are shown in Figure 49, and revealed that:

- With even weights, Option 5 was slightly preferred over Options 2, 3, and 4, and all four options that included habitat creation ranked above Options 1 and 6.
- Option 1 was ranked last or second to last under all scenarios except when cost was weighted 5 times as heavily as other objectives. Under this scenario, Option 1 was ranked second (behind Option 2) but was only slightly better than Option 6.
- There was no single option that performed better than others under all scenarios.
- Options 2-4 performed fairly similarly to each other across all scenarios. Option 5 was similar to options 2-4 under all effectiveness, durability, recreation, and effects on other species scenarios, but was differentiated by weight on costs and learning.
- Overall, the rankings were most sensitive to weights on cost, with option 5 changing from best to worst as the weight on cost increased.

The key insights and considerations from this process can be summarized as follows:

1. Problem framing and objectives
    a. Additional outreach is needed to locals who fish the HOR scour hole; initial outreach captured primarily the Delta-wide recreational fishing community.
    b. Although the implementation area may be limited to the immediate scour hole area, effects could be much more far-reaching (e.g., extending beyond Paradise Cut). Effects analysis must account for this reality.
2. Consequence evaluation
    a. Evaluation of options should consider not just effects of the action on predation of target fish, but also on possible improved growth and survival beyond predation. The population-level benefits of floodplain restoration will not be captured by analysis that focuses solely on predation. This was addressed with the growth/survival analysis

performed as part of this initial analysis, and similar analysis should be included in iterations.

   b. Preliminary analysis of consequences did not look at changes to flow streamlines and effects on routing of fish, which could be a significant factor in survival. Routing should be explicitly addressed in the next round of analysis.
   c. There was debate over whether to evaluate survival based on percent survival versus number of fish surviving to Chipps Island. Some WG members felt that percent may be a better measure because of year to year variability in fish numbers. In this initial analysis changes in survival related to predation effects were calculated as a percentage and changes in survival related to growth benefits were calculated as numbers, but both were converted to a 4-point scale. For more precise analyses that may occur in future iterations, consideration of year-to-year variability in fish numbers should be included in any interpretation.
3. Linked decisions
   a. There are at least two proposed projects that could influence the consequences of the HOR scour hole project: the SJAFCA-led flood risk reduction project, and the Paradise Cut Expansion project. The Head of Old River Barrier (HORB) would also affect the consequences of this project. Decisions about alternative design and evaluation for the HOR scour hole project should consider how alternatives would perform under different implementation scenarios for these other efforts.
4. Risks and Uncertainties
   a. Because there have been few if any similar scour hole filling projects, there is uncertainty around longevity of fill and whether filling simply displaces scouring forces to a nearby location.
   b. Because there is less experience with similar habitat creation efforts in the south Delta, there is uncertainty around whether shallow-water habitat will remain as high-quality habitat without ongoing intervention.
5. Trust was an important element in the preference of WG members. A major concern about trap and barge expressed by WG members is it would not continue to take place for logistical or financial reasons.
6. Some WG members expressed concern that including a focus on predation reduction in the problem statement could bias Reclamation towards “easy” options that address predation but not other, potentially bigger influences on survival to Chipps Island.

Specific gaps in analysis were identified that should be rectified as necessary in the next round of analyses. The SDM WG recommended that Reclamation review all considerations brought up during deliberations of objectives and performance metrics, instead of only focusing on the final results (see Appendix C for detailed SDM WG meeting notes). These considerations may inform the selection and design of alternatives brought forward for NEPA. Some specific concerns include:

1. There was dissatisfaction with elicitation around learning. Respondents felt that the questions did not capture all important learning that could be associated with different options, for example possible benefits to the CVPIA SIT model.

2. Analyses to date have not looked at low flow effects or water quality, or at how water year type and antecedent conditions may influence effects of different actions. Performance under different flow and water year type conditions will be important for the final NEPA analyses.
3. The options proposed are not mutually exclusive, and sequenced implementation is possible. For example, easier-to-implement actions such as trap and barge could take place in the near-term while permitting and other logistical elements of other actions were being addressed.
4. Analyses of population effects of the options, including habitat restoration, were extremely coarse. In particular, further consideration needs to be given to 1) whether and how quickly fish will find the new habitat, and 2) how the seasonal nature of fish migration might affect population benefits.

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