DRAFT PARTIAL BIOLOGICAL OPINION
For the California WaterFix

Tails No. 08FBDT00-2016-F-0247

U.S. Fish and Wildlife Service
San Francisco Bay-Delta Fish and Wildlife Office
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Appendix A. Changes in X2 position.

LIST OF ACRONYMS

Act	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et* seq.)
af	acre feet
AFRP	Anadromous Fish Restoration Program
AMM	Avoidance and Minimization Measures
BA	Biological Assessment
BCDC	Bay Conservation and Development Commission
BDFWO	San Francisco Bay-Delta Fish and Wildlife Office
BiOp	Biological Opinion
BMP	Best Management Practices
CCF	Clifton Court Forebay
CCPP	Clifton Court Pumping Plant
CDFW	California Department of Fish and Wildlife
CFR	Code of Federal Regulations
cfs	cubic feet per second
CNOR	Candidate Notice of Review
COA	Coordinated Operation Agreement
Corps	U.S. Army Corps of Engineers
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWF	California WaterFix
DCC	Delta Cross Channel
DHCCP	Delta Habitat and Conservation Conveyance Program
DJFMP	Delta Juvenile Fish Monitoring Program

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DOI	Department of the Interior
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DWR	Department of Water Resources
EDSM	Enhanced Delta Smelt Monitoring
ERP	Ecosystem Restoration Program
ESA	Endangered Species Act
FCCL	Fish Conservation and Culture Laboratory
FL	forklength
FFTT	Fish Facilities Technical Team
FMWT	Fall Midwater Trawl
ft	feet
FR	Federal Register
ha	hectares
HCP	Habitat Conservation Plan
HOR	Head of Old River
HORG	Head of Old River Gate
IEP	Interagency Ecological Program
IF	Intermediate Forebay
ITS	Incidental Take Statement
LFWO	Lodi Fish and Wildlife Office
LSNFH	Livingston Stone National Fish Hatchery
MHHW	mean high high water
MLLW	mean low low water
mm	millimeter
NCCF	North Clifton Court Forebay
NCCP	Natural Community Conservation Planning
NDD	North Delta Diversion
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
OMR	Old and Middle River
PA	Proposed Action
PCE	Primary Constituent Elements
PG&E	Pacific Gas and Electric
ppt	parts per thousand
Reclamation	U.S. Bureau of Reclamation
RIT	Recovery Implementation Team
RM	river mile
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RTM	Reuseable Tunnel Material
SBFNC	Suisun Bay Federal Navigation Channels
SCCF	South Clifton Court Forebay
SDD	South Delta Diversions
SDWSC	Stockton Deep Water Ship Channel
Secretary	Secretary of the Interior

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SERP	Small Erosion Repair Program
Service	U.S. Fish and Wildlife Service
SKT	Spring Kodiak Trawl
SLC	California State Lands Commission
SMUD	Sacramento Municipal Utility District
SRDWSC	Sacramento River Deep Water Ship Channel
Strategy	Delta Smelt Resiliency Strategy
SWP	State Water Project
SWRCB	California State Water Resources Control Board
TBM	Tunnel Boring Machine
TNS	[summer] Townet Survey
UW	University of Washington
VELB	Valley Elderberry Longhorn Beetle
WSU	Washington State University
Western	Western Area Power Administration
WQCP	Water Quality Control Plan
WSE	Water Surface Elevation
WY	water year

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6.0 DESCRIPTION OF THE PROPOSED ACTION

The proposed action (PA) includes: (1) construction of the new water conveyance facility including preconstruction geotechnical surveys; (2) new conveyance facility operation in coordination with operation of existing Central Valley Project (CVP) and State Water Project (SWP) Delta facilities; (3) maintenance of the existing facilities and newly constructed facilities; (4) implementation and maintenance of conservation measures including preconstruction surveys; and (5) required monitoring pre- and post-construction and adaptive management activities.

We have summarized this description of the PA from the California WaterFix (CWF) biological assessment (BA) and incorporated the BA and appendices by reference. We also incorporated information that resulted from exchanges between the agencies during early technical assistance and consultation and made minor changes for clarity. The *BiOp Resolution Log* articulates some of these changes and is included as an appendix to this biological opinion (BiOp). Portions of Chapter 3 in the CWF BA that articulate or summarize existing actions that have been previously analyzed, permitted, or authorized under the Act will not be included in our summary of the PA. However, these items may be discussed in the environmental baseline section of this BiOp.

Department of Water Resources (DWR) is the entity undertaking all construction-related activities including those related to the intakes, the associated tunnels, and their associated structures. The in-water construction activities associated with the intakes, tunnels, and associated structures, as well as the change in SWP Delta operations, requires a combination of Rivers and Harbors Act Section 10, Clean Water Act Section 404, and 33 U.S.C. 408 (408) approvals from the Corps. The Corps has divided the Clean Water Act Section 404, Section 10 of the Rivers and Harbors Act, and 408 permit approvals into two phases. The first phase will involve permit decisions for the construction of tunnels, Intermediate Forebay (IF), Clifton Court Forebay (CCF) modifications, and associated infrastructure. The second phase will involve permit decisions for the North Delta Diversion (NDD) intakes and the Head of Old River Gate (HORG). DWR and/or its designees will operate and maintain the facilities, and U.S. Bureau of Reclamation (Reclamation) will adjust operation of the CVP to utilize the dual conveyance.

Effects resulting from operations, maintenance and monitoring of the new conveyance facility are addressed at a programmatic-level in this BiOp. Reclamation and the U.S. Army Corps of Engineers (Corps) have proposed to prepare future site-specific BAs when subsequent Federal actions occur for these activities. Either Reclamation or the Corps will be the lead Federal action agency for these future consultations (Reclamation 2016a), depending on the triggers and processes for each activity and those agencies discretionary authority over the action and effects to listed species and critical habitat.

As described in Chapter 1 of the CWF BA, for section 7 consultation under the Act, Reclamation is the lead Federal Agency and Action Agency for coordinated operation of the CVP and SWP ("Operations") and the Corps is the Action Agency for construction. DWR is the applicant. Reclamation has requested consultation on the CWF on behalf of both agencies as the lead Federal Agency.

6.1 Consultation Approach

The purpose of this section 7 consultation is to evaluate the effects of the CWF on listed species and designated critical habitat. For some of the project elements, the PA provides a framework for the development of future Federal actions that will be authorized, funded, or carried out at a later time within the next 6 years based on the construction schedule in CWF BA Appendix 3.D, while other project elements are described at a site-specific level for near term implementation with no future Federal action required. This BiOp uses a programmatic approach to evaluate some of the elements of the proposed action that will be subject to future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on listed species and their designated critical habitats, and examines how the parameters of the CWF align with the survival and recovery needs of listed species occurring in the Action Area. The remainder of the project elements not addressed programmatically are addressed as a standard, project-level consultation because they are not subject to future Federal approvals; therefore, this BiOp contains an Incidental Take Statement (ITS) for those elements when incidental take is reasonably certain to occur.

Although the CWF provides descriptions of program activities and the overall goals for a variety of project elements, it does not provide the level of specificity needed to address the amount or extent of incidental take that will occur for some of the project elements because they are still in development and largely conceptual. In addition, some of these project elements will be subject to future Federal approvals which will be subject to their own project-level consultations. However, the U.S. Fish and Wildlife Service (Service) is required to address all direct and indirect effects that are likely to result from the action in order to determine if the CWF is likely to jeopardize listed species or destroy or adversely modify critical habitat. For subsequent actions that will be authorized consistent with this overall program and that may affect listed species, subsequent section 7 consultations will occur. During those subsequent consultations, if incidental take is reasonably certain to occur and the PA is compliant with the requirements of section 7(a)(2), then an action-specific ITS will be provided that ensures any incidental take from the specific action(s) under the program is addressed. This approach allows for the broad-scale evaluation of the CWF program to ensure that the basic goals and approaches of the program do not jeopardize the survival or recovery of listed species or adversely modify critical habitat, while also providing a reliable mechanism for site-specific consultation at the stepped-down, project-level scale.

For other project elements lacking the necessary specificity but not requiring future Federal approval, reinitiation of consultation may be required when additional information is available. This approach is consistent with the requirement for the action agency to reinitiate consultation under certain circumstances. 50 CFR 402.16 outlines the circumstances that require reinitiation of consultation, which apply to the PA. In addition, this BiOp describes some additional specific conditions under which consultation will need to be reinitiated. These are included in the *Effects of the Action* sections.

After reviewing the CWF as proposed by Reclamation and the Corps and the Corps' permitting schedule, the Service has determined that CWF presents a mixed programmatic action, as defined in 50 CFR 402.03. The Service's consultation includes a mix of standard consultation (which includes an ITS) and programmatic consultation (which can include an ITS or defers the ITS to a later time associated with subsequent Federal actions). An analysis and conclusion of whether or not the entire action is likely to jeopardize listed species or destroy or adversely modify critical habitat is included in this BiOp. [NOTE TO REVIEWERS: conclusion section not included at this time]All activities addressed programmatically will be subject to a subsequent consultation in order to proceed. Some project elements and their effects on listed species or critical habitat will change as DWR continues to develop the PA and may require reinitiation.

Programmatic portions of the PA will require separate section 7 consultation as part of the subsequent approval. This document provides a framework analysis for the subsequent consultation. The Service anticipates the subsequent consultations to be initiated by either Reclamation or the Corps (depending on the specific project element) providing sufficient information as outlined in 50 CFR 402.12(f).

Portions of the project that require future approvals and will be addressed programmatically are: (1) construction of the NDD intakes and associated structures; (2) construction of the HORG; (3) operations of new and existing CVP/SWP water facilities under dual conveyance; (4) future maintenance; (5) future monitoring; and (6) compensatory mitigation associated with construction of the NDDs and HORG. Construction of the tunnels, CCF, associated infrastructure, geotechnical surveys, compensatory mitigation associated with construction except the NDDs and HORG, and specific construction related conservation measures including preconstruction surveys for terrestrial listed species will be addressed as a standard consultation. Additionally, some of these actions may require reinitiation. We have organized the *Description of the Proposed Action* into mixed programmatic and standard actions for purposes of this section 7 consultation.

6.2 Programmatic Actions

North Delta Diversions

Intakes

The PA includes construction of three intakes (Intake 2, Intake 3, and Intake 5) on the east bank of the Sacramento River between Clarksburg and Courtland, in Sacramento County, California. Each intake can divert a maximum of 3,000 cubic feet per second (cfs) of river water. Each intake consists of an intake structure fitted with on-bank fish screens; gravity collector box conduits extending through the levee to convey flow to the sedimentation system; a sedimentation system consisting of sedimentation basins to capture sand-sized sediment and drying lagoons for sediment drying and consolidation; a sedimentation afterbay providing the transition from the sedimentation basins to a shaft that will discharge into a tunnel leading to the IF; and an access road, parking area, electrical service, and fencing. Intake 2 will be located at

river mile 41.1 and will be 1,969 feet in length, Intake 3 will be located at river mile 39.4 and will be 1,497 feet in length, and Intake 5 will be located at river mile 36.8 and will be 1,901 feet in length along the Sacramento River bank. Text in Section 3.2.2.1 of the CWF BA refers to Appendices 3.A-C for renderings, drawings, and components of the intakes. At the conclusion of construction, the intake facilities will be landscaped, fenced, and provided with security lighting.

Fish Screen Design

Each intake will include fish screens designed to minimize the risk that fish or larvae will be entrained into the intakes or injured by impingement on the fish screens. A general description is provided in Section 3.2.2.2 and references Appendix 3.C, *Conceptual Engineering Report, Volume 2*, but final design is not complete. Final design is subject to review and approval by the fish and wildlife agencies (i.e., Service, NMFS, and CDFW). DWR will evaluate screen design using recommendations from the Fish Facilities Technical Team and has described the process to be subject to extensive collaborative discussions with the fish agencies. Additionally a variety of preconstruction studies are proposed to aid in refinement of the fish screen design and are listed in Table 3.4-17 items 1-8 in the CWF BA, as required prior to final intake design.

Levee Work

Levee modifications will be needed to facilitate intake construction and to provide continued flood management. The levee modifications are described in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 15 *Levees*, and in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 6, 10 to 17, 19, 44, and 45. Additional information on cofferdam construction (one element of the levee work) appears in Appendix 3.B, Section 6.2.1, *General Constructability Considerations*. The Sacramento River levees are Federal Flood Control Project levees under the jurisdiction of the Corps and the Central Valley Flood Protection Board, and specific requirements are applicable to penetrations of these levees. Authorizations for this work have not yet been issued. All construction on these levees will be performed in accordance with conditions and requirements set forth in the Corps permit authorizing the work.

Principal levee modifications necessary for conveyance construction are summarized here. See the referenced text in Appendices 3.B and 3.C, *Conceptual Engineering Report, Volumes 1 and 2,* respectively, for detailed descriptions of the work. Appendix 3.B, Section 15.2, *Sequence of Construction at the Levee,* includes a table detailing the sequence of construction activities in levee work.

New facilities interfacing with the levee at each intake site will include the following elements:

<u>Levee Widening</u>

Levees near the intakes will be widened on the land-side to increase the crest width, facilitate intake construction, provide a pad for sediment handling, and accommodate the State Route (SR) 160 realignment. Levee widening is done by placing low permeability levee fill material on the

land-side of the levee. The material is compacted in lifts and keyed into the existing levee and ground. The levee will be widened by about 250 feet at each intake site. The widened levee sections will allow for construction of the intake cofferdams, associated diaphragm walls, and levee cutoff walls within the existing levee prism while preserving a robust levee section to remain in place during construction.

SR 160 will be impacted by construction activities at each of the three intake sites. During the levee widening, the highway will be permanently relocated from its current alignment along the top of the river levee to a new alignment established on top of the widened levee aligned approximately 220 feet farther inland from the river. The location of the new permanent SR 160 alignment is shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 13, 14, 15 and 16.

<u>On-Bank Intake Structure, Cofferdam, and Cutoff Walls</u>

The intake structure and a portion of the box conduits will be constructed inside a dual sheet pile cofferdam installed within the levee prism on the river-side (Appendix 3.C, Conceptual Engineering Report, Volume 2, Drawings 15, 16, 17 and 19; construction techniques are described in Appendix 3.B, Conceptual Engineering Report, Volume 1, Sections 6.2.1, General Constructability Considerations; 15.1, Configuration of Facilities in the Levee; and 15.2, Sequence of Construction at the Levee. See Section 3.2.2.5, Pile Installation for Intake Construction, for detail on the pile placement required for cofferdam construction). The intake structure foundation will use a combination of ground improvement and steel-cased driven piles or drilled piers. The cofferdams will project from 10 to 35 feet into the river, relative to the final location of the intake screens, dewatering up to 5 acres of channel at each intake site. The river width varies from 475 feet at Intake 3 to 615 feet at Intake 5, so this represents 1.6% to 7.4% of the channel width.

The back wall of the cofferdam along the levee crest will be a deep slurry diaphragm cutoff wall designed for dual duty as a structural component of the cofferdam and to minimize seepage through and under the levee at the facility site. The diaphragm wall will extend along the levee crest upstream and downstream of the cofferdam and the fill pad for the sedimentation on the land-side, which will allow for a future tie-in with levee seepage cutoffs that are not part of the PA. The other three sides of the cofferdam, including a center divider wall, will be sheet pile walls. The cofferdam will include a permanent, 5-foot-thick tremie concrete seal in the bottom to aid dewatering and constructability within the enclosed work area.

Once each cofferdam is completed and the tremie seal has been poured and has cured, the enclosed area will be dewatered with fish rescue occurring at that time, in accordance with a fish rescue plan that will be developed by DWR or its contractors and approved by CDFW, NMFS, and the Service. Following dewatering, areas within the cofferdam will be excavated to the level of design subgrade using clam shell or long-reach backhoe before ground improvements (jet grouting and deep soil mixing) and installation of foundation piles.

In conjunction with the diaphragm wall, a slurry cutoff wall (soil, bentonite, and cement slurry) will be constructed around the perimeter of the construction area for the land-side facilities. This slurry wall will be tied into the diaphragm wall at the levee by short sections of diaphragm wall perpendicular to the levee. The slurry cutoff wall will overlap for approximately 150 feet along the diaphragm wall at the points of tie-in. The slurry wall is intended to help prevent river water from seeping through or under the levee during periods when deep excavations and associated dewatering are required on the land-side. By using the slurry wall in conjunction with the diaphragm wall, the open cut excavation portion of the work on the land-side will be completely surrounded by cutoff walls. These walls will minimize induced seepage from the river through the levee, both at the site and immediately adjacent to the site, and serve as long-term seepage control behind the levee.

At the upstream and downstream ends of the intake structure, a sheet pile training wall will transition from the concrete intake structure into the river-side of the levee. Riprap will be placed on the levee-side slope upstream and downstream of the structure to prevent erosion from anomalies in the river created by the structure. Riprap will also be placed along the face of the structure at the river bottom to resist scour.

After intake construction is complete the cofferdammed area will be flooded and underwater divers using torches or plasma cutters will trim the sheet piles at the finished grade/top of structural slab. A portion of the cofferdam will remain in place after intake construction is complete to facilitate dewatering as necessary for maintenance and repairs, as shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawing 16.

Box Conduits

Large gravity collector box conduits (12 conduits at each intake) will lead from the intake structure through the levee prism to the land-side facilities. The box conduits will be constructed by open-cut methods after the intake portion of the cofferdam is backfilled. Backfill above the box conduits and reconstruction of the disturbed portion of the levee prism will be accomplished using low-permeability levee material in accordance with Corps specifications.

Pile Installation for Intake Construction

Table 6.2-1 summarizes proposed pile driving at the intake sites, including the type, size, and number of piles required, as well as the number of piles driven per day, the number of impact strikes per pile, and whether piles will be driven in-water or on land. Table 3.2-7 specifies 42-inch steel piles for the intake foundations; however, depending on the findings of the geotechnical exploration, it may be feasible to replace some or all of those steel piles with cast-in-drilled-hole (CIDH) foundation piles. The CIDH piles are installed by drilling a shaft, installing rebar, and filling the shaft with concrete; no pile driving is necessary with CIDH methods. Use of concrete filled steel piles will involve vibratory or impact-driving hollow steel piles, and then filling them with concrete. Table 3.2-7 assumes that all piles will be driven using impact pile driving, but the design intent is to use impact pile driving only for placement of the intake structure foundation piles. All other piles will be started using vibratory pile driving and

driving will be completed using impact pile driving. Based on experience during construction of the Freeport diversion facility, it is expected that approximately 70% of the length of each pile can be placed using vibratory pile driving, with impact driving used to finalize pile placement. In-water pile driving will be subject to abatement, hydroacoustic monitoring, and compliance with timing limitations as described in CWF BA Appendix 3.F.

Table 6.2-1. Pile driving for intake construction.

Feature	On-land or In-water	Pile Type/ Sizes	Total Piles	Number of Pile Drivers in Concurrent Use	Piles/ Day	Strikes / Pile	Strikes/ Day
Intake Cofferdam – Intakes 2, 3, and 5	In-water	Sheet pile	2,500	4	60	210	12,600
Intake Structure Foundation – Intake 2	In-water	42-inch diameter steel	1,120	4	60	1,500	90,000
Intake Structure Foundation – Intake 3	In-water	42-inch diameter steel	850	4	60	1,500	90,000
Intake Structure Foundation – Intake 5	In-water	42-inch diameter steel	1,120	4	60	1,500	90,000
SR-160 Bridge (Realignment) at Intake	On-land	42-inch diameter steel	150	2	30	1,200	36,000
Control Structure at Intake	On-land	42-inch diameter steel	650	4	60	1,200	72,000
Pumping Plant and Concrete Sedimentation Basins at Intake	On-land	42-inch diameter steel	1,650	4	60	1,200	72,000

Sheet piles will be installed in two phases starting with a vibratory hammer and then switching to impact hammer if refusal is encountered before target depths. Sheet pile placement for cofferdam installation will be performed by a barge-mounted crane equipped with vibratory and impact pile-driving rigs. Foundation pile placement within the cofferdammed area may be done before or after the cofferdammed area is dewatered. If it is done after the cofferdammed area is dewatered and the site is dry, a crane equipped with pile driving rig will be used within the cofferdam. If done before the cofferdam is dewatered, pile driving will be performed by a barge-mounted crane positioned outside of the cofferdam or a crane mounted on a deck on top of the cofferdam. In-water pile driving will be subject to abatement (e.g., use of a bubble curtain), hydroacoustic monitoring, and compliance with timing limitations as described in Appendix 3.F.

Construction Overview for North Delta Diversions

The NDD construction timeline is presented in Appendix 3.D, *Construction Schedule for the Proposed Action*. The schedule is complex, with work simultaneously occurring at all major

facilities for a period of years. During construction, the sequence of activities and duration of each schedule element will depend on the contractor's available means and methods, definition and variation of the design, departure from expected conditions, and perhaps other variable factors.

Each intake has its own construction duration with Intakes 2, 3, and 5 each projected to take approximately 4 to 5 years. Early phase tasks to facilitate construction will include mobilization, site work, and establishing concrete batch plants, pug mills, and cement storage areas. During mobilization the contractors will bring materials and equipment to construction sites, set up work areas, locate offices, staging and laydown areas, and secure temporary electrical power. Staging, storage, and construction zone prep areas for each intake site will cover approximately 5 to 10 acres.

Site work consists of clearing and grubbing, constructing site work pads, and defining and building construction access roads and barge access. Before site work commences, the contractor will implement erosion and sediment controls in accordance with the Stormwater Pollution Prevention Plan (SWPPP). Site clearing and grubbing and site access to stockpile locations have not yet been developed, but will be subject to erosion and dust control measures as specified in the SWPPP and other permit authorizations.

Although DWR plans to use existing roads to the greatest extent possible, some new roads and bridges will be constructed to expedite construction activities and to minimize impact to existing commuters and the environment. Access roads and environmental controls will be maintained consistent with best management practices (BMPs) and other requirements of the SWPPP and permit documents.

Substantial amounts of engineered fill will be placed landward of the levee, amounting to approximately 2 million cubic yards at each intake site. This fill material will be used primarily in levee work, pad construction for the fills, and other placements needed to ensure that the permanent facilities are at an elevation above the design flood (i.e., a 200-year flood with additional allowance for sea level rise). The required engineered fill material will preferably be sourced onsite from locations within the permanent impact footprint, for instance from excavations to construct the sedimentation basins, but may be sourced from offsite locations.

Head of Old River Gate

In the CWF BA, DWR recognizes that design of the HORG is in the early stages. As such, DWR proposes to convene a CCF Technical Team with representatives from DWR, Reclamation, NMFS, CDFW, and the Service upon initiation of formal consultation for the PA and will meet periodically until DWR completes final design for the proposed gate (a time period expected to be at least two years). The general concepts and construction components are summarized below and reference the CWF BA where appropriate.

An operable gate will be constructed at the Head of Old River (HOR). The gate will be located at the divergence of the HOR and the San Joaquin River, within the confines of the existing

channel, with no levee relocation, as shown in Appendix 3.A, *Map Book for the Proposed Action*, Sheet 16; this location is approximately 300 feet west of the temporary rock barrier that is annually installed and removed under current conditions. Preliminary design of the HORG specifies that it will be 210 feet long and 30 feet wide overall, with top elevation of +15 feet (Appendix 3.C3, *Conceptual Engineering Report, Volume 2*, Sheets 95 and 96). Design and construction of the structure are further detailed in Appendix 3.B3, *Conceptual Engineering Report, Volume 1*, Section 17, *Operable Barrier*.

This structure will include seven bottom-hinged gates, totaling approximately 125 feet in length. Other components associated with this barrier are a fish passage structure, a boat lock, a control building, a boat lock operator's building, and a communications antenna. Appurtenant components include floating and pile-supported warning signs, water level recorders, and navigation lights. The barrier will also have a permanent storage area (180 by 60 feet) for equipment and operator parking. Fencing and gates will control access to the structure. A propane tank will supply emergency power backup.

The boat lock will be 20 feet wide and 70 feet long. The associated fish passage structure will be designed according to guidelines established by NMFS and the Service, and will be 40 feet long and 10 feet wide, constructed with reinforced concrete. Stop logs will be used to close the fish passage structure when not in use to protect it from damage. When the gate is partially closed, flow will pass through the fish passage structure traversing a series of baffles. The fish passage structure is designed to maintain a 1-foot-maximum head differential across each set of baffles. The historical maximum head differential across the gate is 4 feet; therefore, four sets of baffles will be required. The vertical slot fish passage structure will be entirely self-regulating and will operate without mechanical adjustments to maintain an equal head drop through each set of baffles regardless of varying upstream and downstream water surface elevations.

Construction

The HORG will be constructed using cofferdam construction, which will create a dewatered construction area for ease of access and egress. To ensure the stability of the levee, a sheet pile retaining wall will be installed in the levee where the operable barrier connects to it. Construction will occur in two phases. The first phase will include construction of half of the operable barrier, masonry control building, operator's building, and boat lock. The second phase will include construction of the second half of the operable barrier, the equipment storage area, and the remaining fixtures, including the communications antenna and fish passage structure. The construction period is estimated to be up to 32 months, with a maximum construction crew of 80 people. A temporary work area of up to 15 acres will be sited in the vicinity of the barrier for such uses as storage of materials, fabrication of concrete forms or gate panels, placing of stockpiles, office trailers, shops, and construction equipment maintenance. The operable barrier construction site, including the temporary work area, has for many years been used for seasonal construction and removal of a temporary rock barrier, and all proposed work will occur within the area that is currently seasonally disturbed for temporary rock barrier construction. Site access roads and staging areas used in the past for rock barrier installation and removal will be used for construction, staging, and other construction support facilities for the proposed gate.

All in-water work, including the construction of cofferdams, sheet pile walls and pile foundations, and placing rock bedding and stone slope protection, will occur during the proposed in-water work windows to minimize effects on fish. All other construction will take place from a barge or from the levee crown and will occur throughout the year.

The construction of the cofferdam and the foundation for the HORG will require in-water pile driving. The installation of the cofferdams will require approximately 550 sheet piles (275 per season). Approximately 15 piles, a maximum of 50 feet long and to a depth of 13.5 to 15 feet, will be set per day with an estimated 210 strikes per pile over a period of approximately 18 days per season. Sheet piles will be installed starting with a vibratory hammer, then switching to impact hammer if refusal is encountered before target depths. The installment of the foundation for the operable barrier will require 100 14-inch steel pipe or H-piles (50 per season) to be set with 1 pile driver on site. Approximately 15 piles, a maximum of 50 feet long and to a depth of 13.5 to 15 feet, will be set per day with an estimated 1,050 strikes per pile over a period of approximately 3 days per season. Foundation pile driving may be done in the dry or in the wet. It is possible that cast-in-drilled-hole concrete foundation piles will be used, in which case pile driving of foundation piles will not be required, but that determination awaits results of geotechnical analysis and further design work.

The first construction phase involves installing a cofferdam in half of the channel and then dewatering the area. The cofferdam will remain in the water until the completion of half of the gate. The cofferdam will then be flooded, and removed or cut off at the required invert depth, and another cofferdam installed in the other half of the channel. In the second phase, the gate will be constructed using the same methods, with the cofferdam either removed or cut off. Cofferdam construction will in both phases begin in August and last approximately 18 days. Construction has been designed so that the south Delta temporary barriers at this site can continue to be installed and removed as they are currently until the permanent gates are fully operable.

<u>Dredging</u>

Dredging to prepare the channel for gate construction will occur along 500 feet of channel, from 150 feet upstream to 350 feet downstream from the proposed barrier. A total of up to 1,500 cubic yards of material will be dredged. Dredging will last approximately 15 days, will be performed during the in-water work window. Dredging may use either a hydraulic or a sealed clamshell dredge, in either case operated from a barge in the channel.

Dredging is proposed to deviate from the procedure described in Avoidance and Minimization Measure (AMM) 6 in Appendix 3.F, *General Avoidance and Minimization Measures,* in one respect. Assuming that on-land disposal of dredged material is determined by the appropriate review authorities to be suitable, the material will be spread on adjacent agricultural fields in a layer approximately 1-foot thick, subject to landowner approval. If required to use an existing dredged material disposal site, the site currently used for dredged material disposal in association with temporary rock barrier placement and removal will be used.

Operations

In the CWF BA, Reclamation and DWR have described and analyzed one operational scenario under a dual conveyance system. This BiOp analyzes this scenario at a programmatic-level. However, the consultation on the near-term operations of the south Delta water facility has been reinitiated and the State Water Resources Control Board's Water Quality Control Plan process will influence operational standards that the PA will be required to adhere to for the current existing facilities (near-term) and future operations under a dual conveyance system (long-term). Both of these processes will likely result in changes to near-term and long-term operations, and these changes are not reflected in the PA at this time because the operational standards are not yet known. Therefore, the operational scenario that is described in the CWF BA will almost certainly change between now and when the dual conveyance system goes online. Adverse effects associated with operations described within the effects analysis of this consultation may occur under the real-time operations of a future dual conveyance system; however, Reclamation and DWR have committed to propose future actions that will avoid jeopardizing the continued existence of delta smelt and destroying or adversely modifying their designated critical habitat (Reclamation 2016b). Those future actions could include: new or modified operational criteria, minimizing project footprints during the final design phase, conservation efforts to maintain or increase trends in delta smelt abundance, efforts to restore and/or improve habitat conditions that support delta smelt, and other actions to be defined in the future. These future actions will be informed by the State Board process, reinitiation of the 2008 Service BiOp, the Adaptive Management Framework, and other state and federal processes.

Implementation

Implementation of the PA will include operations of both new and existing water conveyance facilities once the new NDD facilities are completed and become operational. Most existing facilities will continue to be operated consistent with existing regulatory authorizations, including the Service (2008) and NMFS (2009) BiOps or successor biological opinions. See CWF BA Table 3.1-1 for a complete summary of facilities and actions included in the PA. The PA also includes operational criteria for spring outflow and new minimum flow criteria at Rio Vista during the months of January through August that will apply when the proposed NDD becomes operational. The NDDs and the HORG are 'new' facilities for the SWP and will be operated consistent with the PA criteria presented in CWF BA for these facilities.

Criteria

The CWF BA attempts to describe the temporal scale at which some of the operational criteria will be implemented (e.g. north Delta bypass flow requirements and Old and Middle River requirements), a detailed operations plan will be developed by Reclamation and DWR in coordination with CDFW, NMFS and the Service prior to the new facilities becoming operational, which will detail implementation of the criteria presented in Table 6.2-2 and 6.2-3. Additionally DWR collaborated with CDFW to develop longfin smelt spring (March–May) outflow criteria that are consistent with existing water conveyance/operations including climate

conditions. The proposed longfin smelt spring outflow criteria determine March outflow targets based on the Eight River Index and achieve the targets with export curtailments down to a minimum of 1,500-cfs exports; the March outflow target is capped at 44,500 cfs at an Eight River Index of 4,217 TAF and greater (Table 6.2-4). April and May outflow targets are based on the San Joaquin River inflow:export ratio included in the NMFS (2009) BiOp, up to a maximum outflow target of 44,500 cfs; this again involves curtailment of exports as necessary.

Table 6.2-2. New and existing water operations flow criteria and relationship to assumptions in CalSim II modeling.

Parameter	Criteria	Summary of CalSim II Modeling Assumptions[a]
New Criteria Included in the Proposed Action		
North Delta bypass flows[1]	• Bypass Flow Criteria (specifies bypass flow required to remain downstream of the North Delta intakes): ◦ October, November: Minimum flow of 7,000 cfs required in river after diverting at the North Delta intakes. ◦ December through June: see below ◦ July, August, September: Minimum flow of 5,000 cfs required in river after diverting at the North Delta intakes. • Initial Pulse Protection: ◦ Low-level pumping of up to 6% of total Sacramento River flow at Freeport such that bypass flow never falls below 5,000 cfs. No more than 300 cfs can be diverted at any one intake. ◦ Low level pumping maintained through the initial pulse period. ◦ Sacramento River pulse is determined based on the criteria specified in Table 3.3-2, and real-time monitoring of juvenile fish movement. ◦ If the initial pulse begins and ends before Dec 1, <u>post-pulse criteria for the month of May go into effect</u> after the pulse until Dec 1. On Dec 1, the Level 1 rules defined below apply unless a second pulse occurs. If a second pulse occurs before June 30th, will have the same protective operation as the first pulse. • Post-pulse Criteria (specifies bypass flow required to remain downstream of the North	• Initial Pulse Protection: ◦ Low-level pumping of up to 6% of total Sacramento River flow such that bypass flow never falls below 5,000 cfs. No more than 300 cfs can be diverted at any one intake. ◦ If the initial pulse begins and ends before Dec 1, criteria for the appropriate month (Oct–Nov) go into effect after the pulse until Dec 1. On Dec 1, the Level 1 rules defined in Table 3.3-2 apply until a second pulse, as defined in Table 3.3-3 occurs. The second pulse will have the same protective operation as the first pulse.

[1] Sacramento River flow upstream of the intakes to be measured flow at Freeport. Bypass flow is the Sacramento River flow quantified downstream of the Intake 5. Sub-daily north Delta intakes' diversion operations will maintain fish screen approach and sweeping velocity criteria.

	Delta intakes): ◦ December through June: once the initial pulse protection ends, post-pulse bypass flow operations will not exceed Level 1 pumping unless specific criteria have been met to increase to Level 2 or Level 3. If those criteria are met, operations can proceed as defined in Table 3.3-2. The specific criteria for transitioning between and among pulse protection, Level 1, Level 2, and/or Level 3 operations, will be developed and based on real-time fish monitoring and hydrologic/behavioral cues upstream of and in the Delta as discussed in Section 3.3.3.1, *North Delta Diversion*. During operations, adjustments to the default allowable diversion level specified in Table 3.3-2 are expected to be made to improve water supply and/or migratory conditions for fish by making real-time adjustments to the diversion levels at the north Delta intakes. These adjustments are expected to fall within the operational bounds analyzed for the CWF BA and will be managed under real time operations (RTOs).	
South Delta operations	• October, November: No south Delta exports during the D-1641 San Joaquin River 2-week pulse[2], no OMR flow[3] restriction during 2 weeks prior to pulse, and a 3-day average of −5,000 cfs in November after pulse. • December: OMR flows will not be more negative than an average of −5,000 cfs when the Sacramento River at Wilkins Slough pulse (same as north Delta diversion bypass flow pulse defined in Table 3.3-2) triggers[4], and no more negative than an average of −2,000 cfs when the delta smelt Service (2008) BiOp action 1 triggers. No OMR flow restriction prior to the	• October, November: Assumed no south Delta exports during the D-1641 San Joaquin River 2-week pulse, no OMR restriction during 2 weeks prior to pulse, and −5,000 cfs in November after pulse. • December: −5,000 cfs only when the Sacramento River pulse based on the Wilkins Slough flow (same as the pulse for the north Delta diversion) occurs. If the Service (2008)

[2] San Joaquin River based OMR action triggered when the leading edge of the pulse releases are measured at Vernalis.

[3] OMR measured through the currently proposed index-method (Hutton 2008) with a 14-day averaging period consistent with the current operations (USBR 2014).

[4] December Sacramento River pulse determined by flow increases at Wilkins Slough of greater than 45% within 5-day period and exceeding 12,000 cfs at the end of 5-day period, and real-time monitoring of juvenile fish movement. Reclamation and DWR will require lead time of no less than 3 days to change operations in response to the pulse.

	Sacramento River pulse or delta smelt action 1 triggers. • January, February[5]: OMR flows will not be more negative than a 3-day average of 0 cfs during wet years, −3,500 cfs during above-normal years, or −4,000 cfs during below-normal to critical years, except −5,000 in January of dry and critical years. • March[6]: OMR flows will not be more negative than a 3-day average of 0 cfs during wet or above- normal years or −3,500 cfs during below-normal and dry year and -3,000 cfs during critical years. • April, May[7]: Allowable OMR flows depend on gaged flow measured at Vernalis, and will be determined by a linear relationship. If Vernalis flow is below 5,000 cfs, OMR flows will not be more negative than -2000 cfs. If Vernalis is 6,000 cfs, OMR flows will not be less than +1000 cfs. If Vernalis is 10,000 cfs, OMR flows will not be less than +2,000 cfs. If Vernalis is 15,000 cfs, OMR flows will not be less than +3,000 cfs. If Vernalis is at or exceeds 30,000 cfs, OMR flows will not be less than 6,000 cfs. • June: Similar to April and May, allowable flows depend on gaged flow measured at Vernalis (except without interpolation). If Vernalis is less than 3,500 cfs, OMR flows will not be more negative than −3,500 cfs. If Vernalis exceeds 3,500 cfs up to 10,000 cfs, OMR flows will not be less than 0 cfs. If Vernalis exceeds 10,000 cfs up to 15,000 cfs, OMR flows will not be less than +1,000 cfs. If Vernalis exceeds 15,000 cfs,	BiOp Action 1 is triggered,−2,000 cfs requirement for 14 days is assumed. Remaining Dec days were assumed to have an allowable OMR of -8000 cfs to compute a composite monthly allowable OMR level. • April, May: OMR requirement for the Vernalis flows between 5000 cfs and 30000 cfs were determined by linear interpolation. For example, when Vernalis flow is between 5,000 cfs and 6,000 cfs, OMR requirement is determined by linearly interpolating between −2,000 cfs and +1,000 cfs. • January–March and June–September: Same as the criteria • New OMR criteria modeled as monthly average values.

[5] WY type based on the Sacramento 40-30-30 index to be based on 50% forecast per current approaches; the first update of the WY type to occur in February. CalSim II modeling uses previous WY type for October through January, and the current WY type from February onwards.

[6] WY type as described in the above footnote.

[7] When OMR target is based on Vernalis flow, will be a function of 5-day average measured flow.

	OMR flows will not be less than +2,000 cfs. • July, August, September: No OMR flow constraints[8]. • OMR criteria under 2008 Service and 2009 NMFS BiOps or the above, whichever results in more positive, or less negative OMR flows, will be applicable[9].	
HORG operations	• October 1–November 30: RTO management – HORG will be closed in order to protect the D-1641 pulse flow designed to attract upstream migrating San Joaquin origin adult Fall-Run Chinook Salmon (Section 3.3.3, *Real-Time Operational Decision-Making Process*). HORG will be closed approximately 50% during the time immediately before and after the SJR pulse and it will be fully closed during the pulse unless new information suggests alternative operations are better for fish. • January: When salmon fry are migrating (determined based on real time monitoring), initial operating criterion will be to close the gate subject to RTO for purposes of water quality, stage, and flood control considerations. • February–June 15th: Initial operating criterion will be to close the gate subject to RTO for purposes of water quality, stage, and flood control considerations (Section 3.3.3, *Real-Time Operational Decision-Making Process*). Reclamation, DWR, NMFS, Service, and CDFW will actively explore the implementation of reliable juvenile salmonid tracking technology that may enable shifting to a more flexible real time operating criterion based on the presence/absence of listed fishes. • June 16 to September 30, December: Operable gates will be open.	• Assumed 50% open from January 1 to June 15, and during days in October prior to the D-1641 San Joaquin River pulse. Closed during the pulse. 100% open in the remaining months.
Spring Outflow		• 2011 NMFS RPA for San

[8] The PA operations include a preference for south Delta pumping in July through September months to provide limited flushing flows to manage water quality in the south Delta.

[9] Change in CVP/SWP pumping from the south Delta will occur to comply with OMR targets will be achieved to the extent exports can control the flow. The OMR targets would not be achieved through releases from CVP/SWP reservoirs. The combined CVP/SWP export rates from the proposed north Delta intakes and the existing south Delta intakes will not be required to drop below 1,500 cfs to provide water supply for health and safety needs, critical refuge supplies, and obligation to senior water rights holders.

	March, April, May: Initial operations will maintain the March–May average delta outflow that would occur with existing facilities under the operational criteria described in the 2008 Service BiOp and 2009 NMFS BiOp (Service 2008; NMFS 2009a). The 2011 NMFS BiOp action IV.2.1 (San Joaquin River i-e ratio) will be used to constrain Apr–May total Delta exports under the PA to meet March–May Delta outflow targets per current operational practices (National Marine Fisheries Service 2009).[10] March–May average delta outflow targets representative of the modeled outflows under the current BiOps with existing facilities at the time the North Delta Diversion will be operational are tabulated below for 10% exceedance intervals (Service 2008; National Marine Fisheries Service 2009).	Joaquin River i-e ratio constraint is the primary driver for the Apr-May Delta outflow under the No Action Alternative, this criterion was used to constrain Apr-May total Delta exports under the PA to meet Mar-May Delta outflow targets.
Rio Vista minimum flow standard[11]	• January through August: flows will exceed 3,000 cfs • September through December: flows per D-1641	• Same as PA criteria
Key Existing Delta Criteria Included in Modeling[12]		
Fall Outflow	• No change. September, October, November: implement the Service 2008 BO Fall X2 requirements in wet (W) and above normal (AN) year types.	• September, October, November: implement the 2008 Service BiOp "Action 4: Estuarine Habitat During Fall" (Fall X2) requirements (Service 2008).
Winter and summer outflow	• No change. Flow constraints established under D-1641 will be followed if not superseded by criteria listed above.	• SWRCB D-1641 Delta outflow and February – June X2 criteria.
Delta Cross Channel Gates	• No change in operational criteria. • Operating criteria as required by NMFS (2009)	• Delta Cross Channel gates are closed for a certain number of

[10] For example, if best available science resulting from collaborative scientific research program shows that Longfin Smelt abundance can be maintained in the absence of spring outflow, and CDFW concurs, an alternative operation for spring outflow could be to follow flow constraints established under D-1641. Any changes in the PA will be implemented consistent with the Collaborative Science and Adaptive Management Program, including coordination with the Service and NMFS.

[11] Rio Vista minimum monthly average flow in cfs (7-day average flow not be less than 1,000 below monthly minimum), consistent with the SWRCB D-1641.

[12] All the CalSim II modeling assumptions are described in CWF BA Appendix 5.A, *CALSIM Methods and Results*.

	BiOp Action IV.1 and D-1641	days during October 1 through December 14 based on the Wilkins Slough flow, and the gates may be opened if the D-1641 Rock Slough salinity standard is violated because of the gate closure. Delta Cross Channel gates are assumed to be closed during December 15 through January 31. February 1 through June 15, Delta Cross Channel gates are operated based on D-1641 requirements.
Suisun Marsh Salinity Control Gates	• No change. Gates will continue to be closed up to 20 days per year from October through May.	For the DSM2 modeling, used generalized seasonal and tidal operations for the gates. • Seasonal operation: The radial gates are operational from Oct to Feb if Martinez EC is higher than 20000, and for remaining months they remain open. • Tidal operations when gates are operational: Gates close when: downstream channel flow is < 0.1 (onset of flood tide); Gates open when: upstream to downstream stage difference is greater than 0.3 ft (onset of ebb tide)
Export to inflow ratio	• Operational criteria are the same as defined under D-1641, and applied as a maximum 3-day running average. • The D-1641 export/inflow (E/I) ratio calculation was largely designed to protect fish from south Delta entrainment. For the PA, Reclamation and DWR propose that the NDD be excluded from the E/I ratio calculation. In other words, Sacramento River inflow is defined as flows downstream of the NDD and only south Delta exports are included for the export component of the criteria.	• Combined export rate is defined as the diversion rate of the Banks Pumping Plant and Jones Pumping Plant from the south Delta channels. • Delta inflow is defined as the sum of the Sacramento River flow downstream of the proposed north Delta diversion intakes, Yolo Bypass flow, Mokelumne River flow, Cosumnes River flow, Calaveras River flow, San Joaquin River flow at Vernalis, and other miscellaneous in-Delta flows.
[a] See Table 3.3-2 for Proposed Action CALSIM II Modeling Assumptions		

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Table 6.2-3. Proposed Action CalSim II criteria and modeling assumptions.

Dual Conveyance Scenario with 9,000 cfs North Delta Diversion (includes Intakes 2, 3 and 5 with a maximum diversion capacity of 3,000 cfs at each intake)

1. North Delta Diversion Bypass Flows

These parameters define the criteria for modeling purposes and provide the real-time operational criteria levels as operations move between and among the levels. Actual operations will be based on real-time monitoring of hydrologic conditions and fish presence/movement as described in Section 3.3.3.1, *North Delta Diversions*.

Low-Level Pumping (Dec-Jun)

Diversions of up to 6% of total Sacramento River flow such that bypass flow never falls below 5,000 cfs. No more than 3,000 cfs can be diverted at any one intake.

Initial Pulse Protection

Low level pumping as described in Table 3.3-1will be maintained through the initial pulse period. For modeling, the initiation of the pulse is defined by the following criteria: (1) Sacramento River flow at Wilkins Slough increasing by more than 45% within a five-day period and (2) flow on the fifth day greater than 12,000 cfs.

The pulse (and low-level pumping) continues until either (1) Sacramento River flow at Wilkins Slough returns to pre-pulse flow level (flow on first day of pulse period), or (2) Sacramento River flow at Wilkins Slough decreases for 5 consecutive days, or (3) Sacramento River flow at Wilkins Slough is greater than 20,000 cfs for 10 consecutive days.

After pulse period has ended, operations will return to the bypass flow table (Sub-Table A).

If the initial pulse period begins and ends before Dec 1st in the modeling, then any second pulse that may occur before the end of June will receive the same protection, i.e., low level pumping as described in Table 3.3-1.

Post-Pulse Operations

After initial pulse(s), allowable diversion will go to Level I Post-Pulse Operations (see Sub-Table A) until 15 total days of bypass flows above 20,000 cfs occur. Then allowable diversion will go to the Level II Post-Pulse Operations until 30 total days of bypass flows above 20,000 cfs occur. Then allowable diversion will go to the Level III Post-Pulse Operations.

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows

Implement following bypass flow requirements sufficient to minimize any increase in the upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to minimize any increase in upstream transport toward the proposed intakes or into Georgiana Slough. Allowable diversion will be greater of the low-level pumping or the diversion allowed by the following bypass flow rules.

Level I Post-Pulse Operations			**Level II Post-Pulse Operations**			**Level III Post Pulse Operations**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
Dec–Apr								
0 cfs	5,000 cfs	100% of the amount over	0 cfs	5,000 cfs	100% of the amount over	0 cfs	5,000 cfs	100% of the amount

		0 cfs			0 cfs			over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over

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		cfs			cfs			20,000 cfs
Jun								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs

Bypass flow requirements in other months:		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**
Jul–Sep		
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	No limit	A minimum of 5,000 cfs
Oct–Nov		
0 cfs	7,000 cfs	100% of the amount over 0 cfs
7,000 cfs	No limit	A minimum of 7,000 cfs

2. South Delta Channel Flows

OMR Flows

All of the baseline model logic and input used in the No Action Alternative as a surrogate for the OMR criteria required by the various fish protection triggers (density, calendar, turbidity and flow based triggers) described in the 2008 Service and the 2009 NMFS CVP/SWP BiOps were incorporated into the modeling of the PA except for NMFS BO Action IV.2.1 – San Joaquin River i/e ratio. The PA includes the proposed operational criteria, as well. Whenever the BiOps' triggers require OMR be less negative or more positive than those shown below, those OMR requirements will be met. These newly proposed OMR criteria (and associated HORG operations) are in response to expected changes under the PA, and only applicable after the proposed north Delta diversion becomes operational. Until the north Delta diversion becomes operational, only the OMR criteria under the current BiOps

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apply to CVP/SWP operations.

Combined Old and Middle River flows must be no less than values below[a] (cfs)

(Water year type classification based Sacramento River 40-30-30 index)

Month	W	AN	BN	D	C
Jan	0	-3,500	-4,000	-5,000	-5,000
Feb	0	-3,500	-4,000	-4,000	-4,000
Mar	0	0	-3,500	-3,500	-3,000
Apr	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
May	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
Jun	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	varies[c]	varies[c]	varies[c]	varies[c]	varies[c]
Nov	varies[c]	varies[c]	varies[c]	varies[c]	varies[c]
Dec	-5,000[d]	-5,000[d]	-5,000[d]	-5,000[d]	-5,000[d]

[a] Values are monthly averages for use in modeling. The model compares these minimum allowable OMR values to 2008 Service BiOp RPA OMR requirements and uses the less negative flow requirement.

[b] Based on San Joaquin inflow relationship to OMR provided below in Sub-Table B.

[c] Two weeks before the D-1641 pulse (assumed to occur October 16-31 in the modeling), No OMR restrictions (for modeling purposes an OMR requirement of -5,000 cfs was assumed during this 2 week period).
Two weeks during the D-1641 pulse, no south Delta exports.
Two weeks after the D-1641 pulse, -5,000 cfs OMR requirement (through November).

[d] OMR restriction of -5,000 cfs for Sacramento River winter-run Chinook salmon when North Delta initial pulse flows are triggered or OMR restriction of -2,000 cfs for delta smelt when triggered. For modeling purposes (to compute a composite Dec allowable OMR), remaining days were assumed to have an allowable OMR of -8000 cfs.

Head of Old River Operable Gate Operations/Modeling assumptions (% OPEN)

MONTH	HORG[a]	MONTH	HORG[a]
Oct	50% (except during the pulse)[b]	May	50%
Nov	100% (except during the post-pulse period)[b]	Jun 1–15	50%
Dec	100%	Jun 16–30	100%
Jan	50%[c]	Jul	100%
Feb	50%	Aug	100%
Mar	50%	Sep	100%
April	50%		

[a] Percent of time the HORG is open. Agricultural barriers are in and operated consistent with current practices. HORG will be open 100% whenever flows are greater than 10,000 cfs at Vernalis.

HORG operation is triggered based upon State Water Board D-1641 pulse trigger. For modeling assumptions only, two weeks before the D-1641 pulse, it is assumed that the HORG will be open 50%.

[b] During the D-1641 pulse (assumed to occur October 16-31 in the modeling), it is assumed the HORG will be closed.
For two weeks following the D-1641 pulse, it was assumed that the HORG will be open 50%.
Exact timing of the action will be based on hydrologic conditions.

[c] The HORG becomes operational at 50% when salmon fry are migrating (based on real time monitoring). This generally occurs when flood flow releases are being made. For the purposes of modeling, it was assumed that salmon fry are migrating starting on January 1.

In the CALSIM II modeling, the "HORG open percentage" specified above is modeled as the percent of time within a month that HORG is open. In the DSM2 modeling, HORG is assumed to operate such that the above-specified percent of "the flow that would have entered the Old River if the HORG were fully open" would enter the Old River.

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Sub-Table B. San Joaquin Inflow Relationship to OMR			
April and May		**June**	
If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (interpolated linearly between values)	If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (no interpolation)
≤ 5,000 cfs	-2,000 cfs	≤ 3,500 cfs	-3,500 cfs
6,000 cfs	+1,000 cfs	3,501 to 10,000 cfs	0 cfs
10,000 cfs	+2,000 cfs		
15,000 cfs	+3,000 cfs	10,001 to 15,000 cfs	+1,000 cfs
≥30,000 cfs	+6,000 cfs	>15,000 cfs	+2,000 cfs

3. Delta Cross Channel Gate Operations

Assumptions

Per SRWCB D-1641 with additional days closed from Oct 1 – Jan 31 based on NMFS BiOp (2009) Action IV.1.2 (closed during flushing flows from Oct 1 – Dec 14 unless adverse water quality conditions). This criterion is consistent with the No Action Alternative.

4. Rio Vista Minimum Instream Flows

Assumptions

Sep–Dec: Per D-1641; Jan-Aug: Minimum of 3,000 cfs.

5. Delta Outflow

Delta Outflow

SWRCB D-1641 requirements, or outflow per requirements noted below, whichever is greater

Months	Delta Outflow Requirement
Spring (Mar–May):	Additional spring outflow requirement[a]
Fall (Sep–Nov):	Implement Service 2008 BiOp Fall X2 requirement

Notes:

[a] Additional Delta Outflow required during the Mar-May period to maintain Delta outflows that would occur under the No Action Alternative at the time North Delta Diversion would become operational (for modeling purposes this is represented by the No Action Alternative model with projected climate (Q5) and sea level conditions at Early Long-Term). Mar–May average Delta outflow targets for the PA are tabulated below for 10% exceedance intervals based on the modeled No Action Alternative Mar-May Delta outflow. Since 2009 NMFS BiOp San Joaquin River i-e ratio constraint is the primary driver for the Apr-May Delta outflow under the No Action Alternative, this criterion was used to constrain Apr-May TOTAL Delta exports under the PA to meet Mar-May Delta outflow targets.

Percent Exceedance:	10%	20%	30%	40%	50%	60%	70%	80%	90%
Proposed Mar-May Delta Outflow Target (cfs)*:	44,500	44,500	35,000	27,900	20,700	16,800	13,500	11,500	9,100

* values based on the flow frequency of Mar – May average Delta Outflow modeled under No Action Alternative under Early Long-Term Q5 climate projections, without San Joaquin River Restoration Flows for the CWF BA.

6. Operations for Delta Water Quality and Residence Time

Assumptions

Jul–Sep: Prefer south delta intake up to total pumping of 3,000 cfs; no specific intake preference beyond 3,000 cfs.

Oct–Jun: Prefer north delta intake (real-time operational flexibility).

7. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements

Assumptions

Existing D-1641 AG and MI standards.

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8. D-1641 E-I Ratio Computation
Assumptions In computing the E-I Ratio in the CalSim II model, the North Delta Diversion is not included in the export term, and the Sacramento River inflow is as modeled downstream of the North Delta Intakes.

Flow criteria are applied seasonally (month by month) and according to the following five water-year types. Under the observed hydrologic conditions over the 82-year period (1922–2003), the number of years of each water-year type is listed below. The water-year type classification, unless otherwise noted, is based on the Sacramento Valley 40-30-30 Water Year (WY) Index defined under Revised D-1641.

- Wet (W) water-year: the wettest 26 years of the 82-year hydrologic data record, or 32% of years.
- Above-normal (AN) water-year: 12 years of 82, or 15%.
- Below-normal (BN) water-year: 14 years of 82, or 17%.
- Dry (D) water-year: 18 years of 82, or 22%.
- Critical (C) water-year: 12 years of 82, or 15%.

The above noted frequencies are expected to change slightly under projected climate conditions at year 2030. The number of years of each water-year type per D-1641 Sacramento Valley 40-30-30 WY Index under the projected climate condition assumed for the CWF BA, over the 82-year period (1922–2003) is provided below. CWF BA Appendix 5.A, Section 5.A.3, *Climate Change and Sea Level Rise*, provides more information on the assumed climate change projection at year 2030.

- Wet water-year: the wettest 26 years of the 82-year hydrologic data record, or 32% of years.
- Above-normal water-year: 13 years of 82, or 16%.
- Below-normal water-year: 11 years of 82, or 13%.
- Dry water-year: 20 years of 82, or 24%.
- Critical water-year: 12 years of 82, or 15%.

Refer to the CWF BA and appendices for further discussion of the operational criteria and assumptions, the Real Time Operation Decision-Making Process, the Collaborative Science and Adaptive Management Program, and future drought procedures.

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Table 6.2-4. Proposed longfin smelt spring outflow criteria: Monthly Net Delta Outflow Index in relation to Eight River Index.

Eight River Index (March), TAF	Monthly Net Delta Outflow Index (March), cfs
0	0
545	6,200
1,488	8,800
1,911	12,700
2,140	17,100
2,421	20,000
2,575	25,200
3,104	35,000
3,492	43,700
≥4,217	44,500
Note: Net Delta Outflow Index targets are linearly interpolated for Eight River Index values falling between those shown on the table. This approach is based on the 90% forecast.	

[1] The Eight River Index refers to the sum of the unimpaired runoff for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; American River, total inflow to Folsom Reservoir; Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake.

Maintenance of the Facilities

The PA includes the maintenance of the proposed NDDs, tunnels, IF, CCF and Pumping Plant, connections to Banks and Jones Pumping Plants, power supply and grid connections, HORG, and the south Delta facilities. Refer to the *BiOp Resolution Log* for additional detail on the frequency of the maintenance activities.

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North Delta Diversions

CWF BA Appendix 3.B*, Conceptual Engineering Report, Volume 1,* Section 6.3, *Maintenance Considerations*, discusses maintenance needs at the intakes. These include intake dewatering, sediment removal, debris removal, biofouling, corrosion, and equipment needs.

Intake Dewatering

The intake structure on the land side of each screen bay group (i.e., a group of 6 fish screens) will be dewatered by closing the slide gates on the back wall of the intake structure, installing bulkheads in guides at the front of the structure, and pumping out the water with a submersible pump; see CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 15, 16, 17, 19, and 22, for illustrations of this structure. The intake collector box conduits can be dewatered by closing the gates on both sides of the flow control sluice gates and flowmeter and pumping out the water between the gates. Dewatering could be done to remove accumulated sediment (described below) or to repair the fish screens.

Intake dewater would likely be disposed by discharge to conveyance. Any discharge of dewatering waters to surface water (the Sacramento River) would occur only in accordance with the terms and conditions of a valid National Pollutant Discharge Elimination System (NPDES) permit and any other applicable Central Valley Regional Water Quality Control Board requirements.

Sediment Removal

Maintenance sediment removal activities include activities that will occur on the river side of the fish screens, as well as activities that will occur on the land side of the fish screens. They include suction dredging around the intake structure, and mechanical excavation around intake structures using track-mounted equipment and a clamshell dragline. Mechanical excavation will occur behind a floating turbidity control curtain. These maintenance activities will occur on an approximately annual basis, depending upon the rates of sediment accumulation.

Sediment will also be annually dredged from within the sedimentation basins using a barge mounted suction dredge, will periodically be removed from other piping and conduits within the facility by dewatering, and will be annually removed from the sediment drying lagoons using equipment such as a front-end loader. The accumulated sediment will be tested and disposed in accordance with the materials reuse provisions of AMM6.

Maintenance dredging will occur only during DWR's proposed in-water work windows. Subsequent regulatory authorizations for the dredging work typically include a permit for in-water work from the Corps and a water quality certification from the Central Valley Regional Water Quality Control Board.

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Debris Removal

After heavy-to-extreme hydrologic events, the intake structures will be visually inspected for debris. If a large amount of debris has accumulated, the debris must be removed. Intake screens, which remove debris from the surface of the water, are maintained by continuous traveling cleaning mechanisms, or other screen cleaning technology. Cleaning frequency depends on the debris load.

A log boom system will be aligned within the river alongside the intake structure to protect the fish screens and fish screen cleaning systems from being damaged by large floating debris. Spare parts for vulnerable portions of the intake structure will be kept available to minimize downtime, should repairs be needed.

Biofouling

Biofouling, the accumulation of algae and other biological organisms, could occlude the fish screens and impair function. A key design provision for intake facilities is that all mechanical elements can be moved to the top surface for inspection, cleaning, and repairs. The intake facilities will have top-side gantry crane systems for removal and insertion of screen panels, tuning baffle assemblies, and bulkheads. All panels will require periodic removal for pressure washing. Additionally, screen bay groups will require periodic dewatering (as described above) for inspection and assessment of biofouling rates. With the prospective invasion of quagga and zebra mussels into inland waters, screen and bay washing will become more frequent. Coatings and other deterrents to reduce the need for such maintenance will be investigated during further facility design. In-water work is not expected to be necessary to address biofouling, as the potentially affected equipment is designed for ready removal. However, if needed, in-water work would be performed consistent with DWR's proposed in-water work windows.

Corrosion

Materials for the intake screens and baffles will consist of plastics and austenitic stainless steels. Other systems will be constructed of mild steel, provided with protective coatings to preserve the condition of those buried and submerged metals and thereby extend their service lives. Passive (galvanic) anode systems can also be used for submerged steel elements. Maintenance consists of repainting coated surfaces and replacing sacrificial (zinc) anodes at multi-year intervals.

Equipment Needs

Operation and maintenance equipment for the intake facilities include the following: (1) a self-contained portable high-pressure washer unit to clean fish screen and solid panels, concrete surfaces, and other surfaces; (2) submersible pumps for dewatering; (3) a floating work platform for accessing, inspecting, and maintaining the river side of the facility; (4) a hydraulic suction dredge; and (5) a man basket or bridge inspection rig to safely access the front of the intake structure from the upper deck.

Sedimentation Basins and Drying Lagoons

The sedimentation system at each intake will consist of a jetting system in the intake structure that will resuspend accumulated river sediment through the box conduits to two unlined earthen sedimentation basins where it will settle out, and then on to four drying lagoons (Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Sheets 10-13, 18-21, and 28-30; see also Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 6.1.2, *Sedimentation System General Arrangement*, for detailed description of the sedimentation system). Sediment particles larger than 0.002 mm are expected to be retained (settle out) in the sedimentation basins, while particles smaller than 0.002 mm (i.e., colloidal particles) will flow through to the tunnel system to the Intermediate Forebay (IF).

At each intake, a barge-mounted suction dredge will hydraulically dredge the sedimentation basins through a dedicated dredge discharge pipeline to 4 drying lagoons. Dredging will occur annually. Dredged material will be disposed at an approved upland site.

Tunnels

Maintenance requirements for the tunnels have not yet been finalized. Some of the critical considerations include evaluating whether the tunnels need to be taken out of service for inspection and, if so, how frequently. Typically, new water conveyance tunnels are inspected at least every 10 years for the first 50 years and more frequently thereafter. In addition, the equipment that the facility owner must put into the tunnel for maintenance needs to be assessed so that the size of the tunnel access structures can be finalized. Equipment such as trolleys, boats, harnesses, camera equipment, and communication equipment will need to be described prior to finalizing shaft design, as will ventilation requirements. As described above, it is anticipated that, following construction, large-diameter construction shafts will be modified to approximately 20-foot diameter access shafts.

Intermediate Forebay

The IF embankments will be maintained to control vegetation and rodents. Embankments will be repaired in the event of island flooding and wind/wave action. Maintenance of control structures could include roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the outlet culverts.

The majority of easily settled sediments are removed at the sedimentation basins at each intake facility. The IF provides additional opportunity to settle sediment. It is anticipated that over a 50-year period, sediments will accumulate to a depth of approximately 4.1 feet, which is less than one-half the height of the overflow weir at the outlet of the IF. Thus maintenance dredging of the IF is not expected to be necessary.

Clifton Court Forebay and Pumping Plant

The Clifton Court Forebay (CCF) embankments and grounds, including the vicinity of the consolidated pumping plant as well as the North Clifton Court Forebay (NCCF) and South Clifton Court Forebay (SCCF), will all be maintained to control of vegetation and rodents. They will also be subject to embankment repairs in the event of island flooding and wind/wave action. Maintenance of forebay control structures could include roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the structure. Riprap slope protection on the water-side of the embankments will require periodic maintenance to monitor and repair any sloughing. In-water work, if needed (e.g. to maintain riprap below the ordinary high-water mark), would be performed during DWR's proposed in-water work window.

The small fraction of sediment passing through the IF is transported through the tunnels to NCCF. Given the upstream sediment removal and the large storage available at the forebay, sediment accumulation at NCCF is expected to be minimal over a even 50-year period, and no maintenance dredging is expected to be needed during the life of the facility.

Connections to Banks and Jones Pumping Plants

Maintenance requirements for the canal will include erosion control, control of vegetation and rodents, embankment repairs in the event of island flooding and wind wave action, and monitoring of seepage flows. Sediment traps may be constructed by over-excavating portions of the channel upstream of the structures where the flow rate will be reduced to allow suspended sediment to settle at a controlled location. The sediment traps will be periodically dredged to remove the trapped sediment.

Power Supply and Grid Connections

Three utility grids could supply power to the PA conveyance facilities: Pacific Gas and Electric Company (PG&E) (under the control of the California Independent System Operator), the Western Area Power Administration (Western), and/or the Sacramento Municipal Utility District (SMUD). The electrical power needed for the conveyance facilities will be procured in time to support construction and operation of the facilities. Purchased energy may be supplied by existing generation, or by new generation constructed to support the overall energy portfolio requirements of the western electric grid. It is unlikely that any new generation will be constructed solely to provide power to the PA conveyance facilities. It is anticipated the providers of the three utility grids that supply power to the PA will continue to maintain their facilities.

Head of Old River Gate

For the operable barrier proposed under the PA, maintenance of the gates will occur every 5 to 10 years. Maintenance of the motors, compressors, and control systems will occur annually and require a service truck.

Each miter or radial gate bay will include stop log guides and pockets for stop log posts to facilitate the dewatering of individual bays for inspection and maintenance. Each gate bay will be inspected annually at the end of the wet season for sediment accumulation. Maintenance dredging around the gate will be necessary to clear out sediment deposits. Dredging around the gates will be conducted using a sealed clamshell dredge. Depending on the rate of sedimentation, maintenance dredging is likely to occur at intervals of 3 to 5 years, removing no more than 25% of the original dredged amount. The timing and duration of maintenance dredging will comply with the proposed in-water work windows. Spoils will be dried in the areas adjacent to the gate site. A formal dredging plan with further details on specific maintenance dredging activities will be developed prior to dredging. Guidelines related to dredging are given in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures,* AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material.* AMM6 requires preparation of a sampling and analysis plan; compliance with relevant NPDES and State Water Resources Control Board (SWRCB) requirements; compliance with proposed in-water work windows; and other measures intended to minimize adverse effects to listed species.

Existing South Delta Export Facilities

The PA will include maintenance of CVP/SWP facilities in the south Delta after the proposed intakes become operational. Maintenance means those activities that maintain the capacity and operational features of the CVP/SWP water diversion and conveyance facilities described above. Maintenance activities include maintenance of electrical power supply facilities; maintenance as needed to ensure continued operations; replacement of facility or system components when necessary to maintain system capacity and operational capabilities; and upgrades and technological improvements of facilities to maintain system capacity and operational capabilities, improve system efficiencies, and reduce operations and maintenance costs.

Monitoring

Monitoring activities will occur prior to operations and after operations commence. Monitoring and studies of listed fish species will be focused on the construction and operation of conveyance facilities. This monitoring will begin with baseline data collection needed to compare with similar results post-construction. While a detailed effort has been made regarding proposed monitoring for the NDD, monitoring prior to operations will be required throughout the Action Area. DWR has committed to working with the Service and other agencies to develop the specifics (including timeframes) of monitoring using various technical teams. Monitoring and studies related to operations that must occur after operation of the new facilities has commenced consist of four types: monitoring addressing the operation of the proposed new facilities, monitoring related to species condition and habitat that may be influenced by operations of the

new facilities, monitoring to evaluate the effectiveness of the proposed facilities, and monitoring addressing the performance of the habitat protection and restoration sites.

If monitoring activities that are not subject to future Section 7 consultation or approvals (*i.e.,* the Corps' Phase 1 permit) may affect listed species or critical habitat, reinitiation of this consultation is required to address those effects. Monitoring activities associated with all other aspects of the PA will require future approvals and will be subject to future consultations if those activities may affect listed species or critical habitat.

Prior to Operations

Monitoring and studies related to operation of the proposed new facilities, that must occur prior to operation of the new facilities, is focused on the conveyance facilities and their potential effects on listed fish species. This monitoring begins with gathering baseline data to compare with post-construction monitoring and studies. While a more detailed effort has already been made regarding monitoring for the NDD, monitoring prior to operations will be required throughout the Action Area, including CCF, the HORG, and key habitat areas downstream and upstream of the new facilities. DWR will commit to working with the fish agencies to develop the specifics of that monitoring, which will be a key charge of both the Clifton Court Forebay Technical Team and HORG Technical Team.

For the NDD, specific monitoring studies will be also developed in collaboration with the Service, CDFW, and NMFS that are focused on preconstruction conditions and on design of the diversions. These monitoring efforts prior to operations will build off the work done by the Fish Facilities Technical Team (FFTT 2011), which identified monitoring associated with the NDDs and their effects. The preconstruction studies identified by this group were focused on specific key questions rather than general monitoring needs and are listed in Table 6.2-5. Monitoring studies focused on the NDDs were developed during the Bay Delta Conservation Plan process and include items 7 and 8 as listed in Table 6.2-6. These studies and their projected timeframes will be revisited as the final monitoring plan is developed.

Table 6.2-5. Preconstruction studies at the North Delta Diversions.

Potential Research Action[1]	Key Uncertainty Addressed	Timeframe
1. This action includes preconstruction study 1, *Site Locations Lab Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to develop physical hydraulic models to optimize hydraulics and sediment transport at the selected diversion sites.	What is the relationship between proposed north Delta intake design features and expected intake performance relative to minimization of entrainment and impingement risks?	Ten months to perform study; must be complete prior to final intake design.
2. This action includes preconstruction study 2, *Site Locations Numerical Study*, as described by the Fish Facilities Working Team (FWTT 2013). The purpose of this study is to develop site-specific numerical studies (mathematical models) to characterize the	How do tides and diversion rates affect flow conditions at the north Delta intake screens and at the Georgiana Slough	Eight months to perform study; must be complete prior to final intake design.

tidal and river hydraulics and the interaction with the intakes under all proposed design operating conditions.	junction?	
3. This action includes preconstruction study 3, *Refugia Lab Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to test and optimize the final recommendations for fish refugia that will be incorporated in the design of the north Delta intakes.	How should north Delta intake refugia be designed in principle to achieve desired biological function?	Nine months to perform study; must be complete prior to final intake design.
4. This action includes preconstruction study 4, *Refugia Field Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to evaluate the effectiveness of using refugia as part of north Delta intake design for the purpose of providing areas for juvenile fish passing the screen to hold and recover from swimming fatigue and to avoid exposure to predatory fish.	How do alternative north Delta intake refugia designs perform with regard to desired biological function?	Two years to perform study; must be complete prior to final intake design.
5. This action includes preconstruction study 5, *Predator Habitat Locations*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to perform field evaluation of similar facilities (e.g., Freeport, RD108, Sutter Mutual, Patterson Irrigation District, and Glenn Colusa Irrigation District) and identify predator habitat areas at those facilities.	Where is predation likely to occur near the new North Delta intakes?	One to two years to perform study; must be complete prior to final intake design.
6. This action includes preconstruction study 6, *Baseline Fish Surveys*, as described by the Fish Facilities Working Team (FFWT 2013), somewhat modified based on discussions with NMFS during 2014. The purpose of this study is to perform literature search and potentially field evaluations at similar facilities (e.g., Freeport, RD108, Sutter Mutual, Patterson Irrigation District, and Glenn Colusa Irrigation District), to determine if these techniques also take listed species of fish, and to assess ways to reduce such by-catch, if necessary.	What are the best predator reduction techniques, i.e., which techniques are feasible, most effective, and best minimize potential impacts on listed species?	Two years to perform study; must be complete prior to final intake design.
7. This action includes preconstruction study 7, *Flow Profiling Field Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to characterize the water velocity distribution at river transects within the proposed diversion reaches for differing flow conditions. Water velocity distributions in intake reaches will identify how hydraulics change with flow rate and tidal cycle, and this information will be used in fish screen final design and in model-based testing of fish screen performance (preconstruction study 8, below).	What is the water velocity distribution at river transects within the proposed intake reaches, for differing river flow conditions?	One year to perform study; must be complete prior to final intake design.
8. This action includes preconstruction study 8, *Deep Water Screens Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to use a computational fluid dynamics model to identify the hydraulic characteristics of deep	What are the effects of fish screens on hydraulic performance?	Nine months to perform study; must be complete prior to final intake design.

fish screen panels.		
9. This action includes preconstruction study 9, *Predator Density and Distribution*, as described by the Fish Facilities Working Team (FFWT 2013); and includes post-construction study 9, *Predator Density and Distribution*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this study is to use an appropriate technology (to be identified in the detailed study plan) at two to three proposed screen locations; the study will also perform velocity evaluation of eddy zones, if needed. The study will also collect baseline predator density and location data prior to facility operations, compare that to density and location of predators near the operational facility; and identify ways to reduce predation at the facilities.	What are predator density and distribution in the north Delta intake reaches of the Sacramento river?	Start in 2016 to collect multiple annual datasets before construction begins. The post-construction study will cover at least 3 years, sampling during varied river flows and diversion rates.
10. This action includes preconstruction study 10, *Reach-Specific Baseline Juvenile Salmonid Survival Rates*, as described by the Fish Facilities Working Team (FFWT 2013); and includes post-construction study 10, *Post-Construction Juvenile Salmon Survival Rates*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this study is to determine baseline rates of survival for juvenile Chinook salmon and steelhead within the Sacramento River near proposed north Delta diversion sites for comparison to post-project survival in the same area, with sufficient statistical power to detect a 5% difference in survival. Following initiation of project operations, the study will continue, using the same methodology and same locations. The study will identify the change in survival rates due to construction/operation of the intakes.	How will the new north Delta intakes affect survival of juvenile salmonids in the affected reach of the Sacramento River?	The preconstruction study will cover at least 3 years and must be completed before construction begins. The post-construction study will cover at least 3 years, sampling during varied river flows and diversion rates.
11. This action includes preconstruction study 11, *Baseline Fish Surveys*, as described by the Fish Facilities Working Team (FFWT 2013) and includes post-construction study 11, *Post-Construction Fish Surveys*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this study is to determine baseline densities and seasonal and geographic distribution of all life stages of delta and longfin smelt inhabiting reaches of the lower Sacramento River where the north Delta intakes will be sited. Following initiation of diversion operations, the study will continue sampling using the same methods and at the same locations. The results will be compared to baseline catch data to identify potential changes due to intake operations.	How will the new north Delta intakes affect delta and longfin smelt density and distribution in the affected reach of the Sacramento River?	Preconstruction study will cover at least 3 years. Post-construction study will be performed for duration of project operations (or delisting of species), with timing and frequency to be determined.

Notes

[1] All research actions listed in this table are part of the PA. For all proposed research actions, a detailed study design must be developed prior to implementation. The study design must be reviewed and approved by CDFW, NMFS, and the Service prior to implementation.

Table 6.2-6. Monitoring actions for listed species of fish for the North Delta Diversions.

Monitoring Action(s)	Action Description[1]	Timing and Duration
1. Fish screen hydraulic effectiveness	This action includes post-construction study 2, *Long-term Hydraulic Screen Evaluations*, combined with post-construction study 4, *Velocity Measurement Evaluations*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this monitoring is to confirm screen operation produces approach and sweeping velocities consistent with design criteria, and to measure flow velocities within constructed refugia. Results of this monitoring will be used to "tune" baffles and other components of the screen system to consistently achieve compliance with design criteria.	Approximately 6 months beginning with initial facility operations.
2. Fish screen cleaning	This action includes post-construction study 3, *Periodic Visual Inspections*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this monitoring is to perform visual inspections to evaluate screen integrity and the effectiveness of the cleaning mechanism, and to determine whether cleaning mechanism is effective at protecting the structural integrity of the screen and maintaining uniform flow distribution through the screen. Results of this monitoring will be used to adjust cleaning intervals as needed to meet requirements.	Initial study to occur during first year of facility operation with periodic re-evaluation over life of project.
3. Refugia effectiveness	This action includes post-construction study 5, *Refugia Effectiveness*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose is to monitor refugia to evaluate their effectiveness relative to design expectations. This includes evaluating refugia operation at a range of river stages and with regard to effects on target species or agreed proxies. Results of this monitoring will be used to "tune" the screen system to consistently achieve compliance with design criteria.	Approximately 6 months beginning with initial facility operations.
4. Fish screen biological effectiveness	This action includes post-construction study 7, *Evaluation of Screen Impingement*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this monitoring is to observe fish activity at the screen face (using technology to be identified in the detailed study plan) and use an appropriate methodology (to be identified in the detailed study plan) to evaluate impingement injury rate. Results of this monitoring are to be used to assess facility performance relative to take allowances, and otherwise as deemed useful via the collaborative adaptive management process.	Study to be performed at varied river stages and diversion rates, during first 2 years of facility operation.
5. Fish screen entrainment	This action includes post-construction study 8, *Screen Entrainment*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this monitoring is to measure entrainment rates at screens using fyke nets located behind screens, and to identify the species and size of entrained organisms. Results of this monitoring are to be used to assess facility performance relative to take allowances, and otherwise as deemed useful via the collaborative adaptive management process.	Study to be performed at varied river stages and diversion rates, during first 2 years of facility operation.
6. Fish screen calibration	Perform hydraulic field evaluations to measure velocities over a designated grid in front of each screen panel. This monitoring	Initial studies require

	will be conducted at diversion rates close to maximum diversion rate. Results of this monitoring will be used to set initial baffle positions and confirm compliance with design criteria.	approximately 3 months beginning with initial facility operations.
7. Fish screen construction	Document north Delta intake design and construction compliance with fish screen design criteria (note, this is simple compliance monitoring).	Prior to construction and as-built.
8. Operations independent measurement	Document north Delta intake compliance with operational criteria, with reference to existing environmental monitoring programs including (1) Interagency Ecological Program Environmental Monitoring Program: Continuous Multi-parameter Monitoring, Discrete Physical/ Chemical Water Quality Sampling; (2) DWR and Reclamation: Continuous Recorder Sites; (3) Central Valley RWQCB: NPDES Self- Monitoring Program; and (4) USGS Delta Flows Network and National Water Quality Assessment Program. The purpose of this monitoring is to ensure compliance and consistency with other relevant monitoring programs, and to ensure that this information is provided to CDFW, NMFS, and the Service in association with other monitoring reporting.	Start prior to construction of water diversion facilities and continue for the duration of the PA.
9. Operations measurement and modeling	Document north Delta intake compliance with the operational criteria using flow monitoring and models implemented by DWR. The purpose of this monitoring is to ensure and demonstrate that the intakes are operated consistent with authorized flow criteria.	Start prior to completion of water diversion facilities and continue for the duration of the permit term.
10. North Delta intake reach salmonid survivorship	Determine the overall impact on survival of juvenile salmonids through the diversion reach, related to the operation of the new north Delta intakes. Use mark/recapture and acoustic telemetry studies (or other technology to be identified in the detailed study plan) to evaluate effects of facility operations on juvenile salmonids, under various pumping rates and flow conditions. Results of this monitoring are to be used to assess whether survival objectives for juvenile salmonids traversing the diversion reach are being met, to determine whether take allowances are exceeded, and otherwise as deemed useful via the collaborative adaptive management process	Study to be performed at varied river flows and diversion rates, during first 2 to 5 years of facility operation.

Notes

[1] All monitoring actions are part of the PA. For all proposed monitoring actions, a detailed study design must be developed prior to implementation. The study design must be reviewed and approved by CDFW, NMFS, and the Service prior to implementation.

Monitoring after Operations Commence

Monitoring and studies related to CVP and SWP Delta operations, that must occur after operation of the new facilities has commenced, broadly consists of four types of monitoring, performed to assess system state and effects on listed species: monitoring addressing the operation of the proposed new facilities, monitoring related to species condition and habitat that may be influenced by operations of the new facilities, monitoring to evaluate the effectiveness of the proposed facilities, and monitoring addressing the habitat protection and restoration sites.

Compensatory Mitigation

This section summarizes the proposed mitigation. As part of compensatory mitigation for impacts to listed species from the PA, DWR has proposed the following options: (1) restoration with protection in perpetuity; (2) enhancement with protection in perpetuity; (3) purchasing credits at an approved conservation bank; (4) creating and establishing a conservation bank; and (5) protection in perpetuity without restoration or enhancement. DWR has proposed to develop and implement management plans for restoration and protection sites but has not identified specific sites. The action agencies proposed that all compensatory mitigation will be constructed and protected prior to PA impacts. All mitigation ratios below reflect protected:lost habitat.

The PA includes a commitment that all lands protected and restored for compensation of effects on listed species will be protected and managed in perpetuity, and DWR will ensure adequate funding for this perpetual management. DWR will dedicate an endowment fund or other Service-approved perpetual funding mechanism for this purpose, and designate the party or entity that will be responsible for long-term management of these lands. Further, the endowment or other Service-approved financial assurance will designate the party or entity that will be responsible for the long-term management of these lands and associated waterways as applicable. The Service will be provided with written documentation that funding and management of mitigation lands will be provided in perpetuity.

For activities under the Corps' Phase 1 permitting process, if it is determined that listed species or critical habitat are present and may be affected as a result of the compensatory mitigation, the Corps is required to reinitiate this consultation to address these effects. Effects of the compensatory mitigation associated with the Corps Phase 2 and Reclamation's actions will be addressed in subsequent consultations. Phase 2 compensatory mitigation activities will be subject to approvals by either Reclamation or the Corps, depending on the nature of the activities and authority and oversight over the activities. Therefore, subsequent consultations with either of these agencies will occur in order to assess the effects of Phase 2 compensatory mitigation.

NMFS Species

The PA includes restoration of 154.8 acres of tidal perennial habitat suitable for NMFS species and 4.3 miles of channel margin habitat to mitigate for permanent and temporary losses of migration and rearing habitat. Refer to the CWF BA for further discussion.

Delta Smelt

The PA proposes restoration of approximately 348 acres of habitat suitable for delta smelt, of which nearly 103 acres is intended to minimize or mitigate construction effects on individuals and their habitat, and 245 acres are intended to mitigate potential impaired access to shallow water critical habitat in the vicinity of the NDDs. Restoration will be performed at a site to be approved by the Service in the vicinity of Sherman Island, Cache Slough, or the north Delta. Of this total, the PA proposes to mitigate 245 acres of shallow water habitat for impacts related to

the potential changes in access to shallow water critical habitat upstream of the proposed NDD. The 245 acres of proposed restoration represents a 1:1 mitigation ratio for the entire area of shallow water critical habitat, minus the approximately 5 acres of habitat related to construction of the NDD that will be mitigated at a 5:1 ratio. Of the 245 acres, sandy beach habitat will be mitigated at a 3:1 ratio, and therefore will comprise 108 acres of the total 245 acres related to the presence of the NDD. Refer to the CWF BA for further discussion.

San Joaquin Kit Fox

DWR will compensate for loss of habitat by protecting San Joaquin kit fox habitat at a ratio of 3:1 at a location subject to Service approval, adjacent to other modeled San Joaquin kit fox habitat to provide a large, contiguous habitat block. San Joaquin kit fox habitat protection will be accomplished either through the purchase of mitigation credits through an existing, Service-approved conservation bank or will be purchased in fee-title by DWR or a DWR partner organization with approval from the Service. If purchased in fee-title, a permanent, Service-approved conservation easement will be placed on the property. Suitable San Joaquin kit fox habitat will be acquired for protection in the Byron Hills area, subject to Service approval, where there is connectivity to existing protected habitat and to other adjoining San Joaquin kit fox habitat. Grassland protection will focus in particular on acquiring the largest remaining contiguous patches of unprotected grassland habitat, which are located south of State Route (SR) 4. This area connects to over 620 acres of existing habitat that was protected under the East Contra Costa County Habitat Conservation Plan (HCP)/ Natural Community Conservation Plan (NCCP) (East Contra Costa County Habitat Conservancy 2006). Refer to the CWF BA for siting details.

Western Yellow-Billed Cuckoo

DWR will offset the loss of 32 acres of western yellow-billed cuckoo migratory habitat through the creation or restoration at a 2:1 ratio, for a total of 64 acres of migratory riparian habitat creation or restoration in the Action Area. DWR will develop a riparian restoration plan that will identify the location and methods for riparian creation or restoration, and this plan will be subject to Service approval. Refer to the CWF BA for further discussion.

Giant Garter Snake

Where identified and delineated giant garter snake habitat cannot be avoided, compensation for the loss of the habitat will occur at a ratio of 3:1 for each, aquatic and upland habitat. An estimated 775 acres of giant garter snake habitat will be affected; therefore, approximately 2,325 acres of giant garter snake habitat will be protected or restored. Insofar as mitigation is created/protected in a Service agreed-to high-priority conservation area, such as the eastern protection area between Caldoni Marsh and Stone Lakes, a mitigation ratio of 2:1 for each, aquatic and upland habitat type, will apply which may lower the above example to 1,550 acres of mitigation. This ratio and locations will be reviewed and approved by the Service.

Giant garter snake upland mitigation will be placed and protected adjacent to aquatic habitat protected for giant garter snake. The upland habitat will not exceed 200 feet from protected aquatic habitat (unless research shows a larger distance is appropriate and the Service agrees).

Incidental injury and/or mortality of giant garter snakes within protected and restored habitat will be avoided or minimized by establishing 200-foot buffers between protected giant garter snake habitat and roads (other than those roads primarily used to support adjacent cultivated lands and levees). Protected and restored giant garter snake habitat will be at least 2,500 feet from urban areas or areas zoned for urban development.

Characteristics of restored and protected habitat may change from the above descriptors if new information and best available science indicate greater benefits as agreed to by the Service. Specific mitigation locations have not been proposed at this time. Siting criteria as described in the CWF BA are still in discussion between DWR, the Service, and CDFW.

California Red-Legged Frog

California red-legged frog aquatic and upland habitat will be protected at a ratio of 3:1 within the East San Francisco Bay core recovery area, at locations subject to Service approval. Three acres of aquatic habitat and 153 acres of upland cover and dispersal habitat will be protected. The compensation ratios apply only if protection occurs prior to or concurrent with the impact. If protection occurs after an impact, the ratio will increase. Refer to the CWF BA for further discussion.

California Tiger Salamander

DWR will protect California tiger salamander habitat at a ratio of 3:1 at locations subject to Service approval, adjacent to or near occupied, protected upland habitat, with a management plan and endowment, or similar funding mechanism, to direct and fund management in perpetuity. California tiger salamander habitat protection will be located in the Byron Hills area, west of the worksite. Grasslands targeted for protection will be located near important areas for conservation that were identified in the East Contra Costa County HCP/NCCP (East Contra Costa County Habitat Conservancy 2006) (not all of which will be acquired by that plan) and will include appropriate upland and aquatic features, e.g., rodent burrows, stock ponds, intermittent drainages, and other aquatic features, etc. An estimated 150 acres of habitat will be protected. Refer to the CWF BA for further discussion.

Valley Elderberry Longhorn Beetle

DWR will mitigate impacts to valley elderberry longhorn beetle (VELB) habitat by either creating valley elderberry longhorn beetle habitat or by purchasing the equivalent credits at a Service-approved conservation bank with a service area that overlaps with the Action Area consistent with the 1999 VELB Conservation Guidelines. These guidelines require replacement of each impacted valley elderberry bush stem measuring one inch or greater in diameter at ground level, in the Conservation Area, with valley elderberry seedlings or cuttings at a ratio

ranging from 1:1 to 8:1 (new plantings to affected stems), and planting of associated native riparian plants. These ratios will apply if compensation occurs prior to or concurrent with the impacts. If compensation occurs after the impacts, a higher ratio may be required by the Service. The planting area will provide at a minimum 1,800 square feet for each transplanted valley elderberry shrub. As many as five additional valley elderberry plantings (cuttings or seedlings) and up to five associated native species plantings may also be planted within the 1,800 square foot area with the transplant. An additional 1,800 square feet will be provided for every additional 10 conservation plants. Refer to the CWF BA for further discussion.

Vernal Pool Fairy Shrimp and Tadpole Fairy Shrimp

For every acre of habitat directly or indirectly affected, at least two vernal pool credits will be purchased within a Service-approved ecosystem preservation bank. Alternatively, based on Service evaluation of site-specific conservation values, three acres of vernal pool habitat may be preserved at the affected site or on another non-bank site as approved by the Service. For every acre of habitat directly affected, at least one vernal pool creation credit will be dedicated within a Service-approved habitat conservation bank, or, based on Service evaluation of site-specific conservation values, two acres of vernal pool habitat will be created and monitored at the affected site or on another non-bank site as approved by the Service.

Compensation ratios for non-bank compensation may be adjusted if the Service considers the conservation value of the non-bank compensation area to approach that of Service-approved conservation banks. If protection occurs outside a Service-approved conservation bank, protection will be prioritized in the Livermore recovery unit, which is one of the core recovery areas identified in the Vernal Pool Recovery Plan (Service 2005) and is adjacent to an existing protected vernal pool complex. Protected sites will be prioritized within the affected critical habitat unit for vernal pool fairy shrimp, unless an adequate rationale is provided to the Service for lands to be protected outside of the critical habitat unit. Protected sites will include the surrounding upland watershed necessary to sustain the vernal pool functions (e.g., hydrology, uplands to provide for pollinators, etc.).

If vernal pool restoration is conducted outside of a Service-approved conservation bank, the restoration sites will meet the following site selection criteria: (1) the site has evidence of historical vernal pools based on soils, remnant topography, remnant vegetation, historical aerial photos, or other historical or site-specific data; (2) the site supports suitable soils and landforms for vernal pool restoration; (3) the adjacent land use is compatible with restoration and long-term management to maintain natural community functions (e.g., not adjacent to urban or rural residential areas); and (4) ensure sufficient land is available for protection to provide the necessary vernal pool complex restoration and surrounding grasslands to provide the local watershed for sustaining vernal pool hydrology, with a vernal pool density representative of intact vernal pool complex in the vicinity of the restoration site.

Acquisition of vernal pool restoration sites will be prioritized based on the following criteria: (1) the site will contribute to establishment of a large, interconnected vernal pool and alkali seasonal wetland complex reserve system (e.g., adjacent to an existing protected vernal pool complex or

alkali seasonal wetland complex) and (2) the site is close to known populations of vernal pool fairy shrimp or vernal pool tadpole shrimp. Refer to the CWF BA for further discussion.

Least Bell's Vireo

DWR will mitigate the loss of 32 acres of least Bell's vireo habitat through the creation or restoration at a 2:1 ratio, for a total of 64 acres of riparian habitat creation or restoration in the Action Area. DWR will develop a riparian restoration plan that will identify the location and methods for riparian creation or restoration, and this plan will be subject to Service approval.

Sacramento River Sediment Reintroduction

Sacramento River sediment removed from the water column at the intake sedimentation basins will be reused. However, to the maximum extent practicable, the first and preferred disposition of this material will be to reintroduce it to the water column in order to maintain Delta water quality (specifically, turbidity, as a component of delta smelt critical habitat). DWR will collaborate with the Service and CDFW to develop and implement a sediment reintroduction plan that provides the desired beneficial habitat effects of maintained turbidity while addressing related permitting concerns (the proposed sediment reintroduction is expected to require permits from the Central Valley Regional Water Quality Control Board and Corps). The Service and NMFS will have approval authority for this plan and for monitoring measures, to be specified in the plan, to assess its effectiveness. Current conceptual design for the plan suggests that it will incorporate placement of sediment during low flow periods at a seasonally inundated location along the mainstem river, such as a bench constructed for the purpose. The sediment would then be remobilized and carried downstream following inundation during seasonal high flows (generally, the winter and spring months). The sediment reintroduction would be designed for consistency with Basin Plan objectives for turbidity, namely, "For Delta waters, the general objectives for turbidity apply subject to the following: except for periods of storm runoff, the turbidity of Delta waters shall not exceed 50 NTUs (Nephelometric Turbidity Units) in the waters of the Central Delta and 150 NTUs in other Delta waters. Exceptions to the Delta specific objectives will be considered when a dredging operation can cause an increase in turbidity. In this case, an allowable zone of dilution within which turbidity in excess of limits can be tolerated will be defined for the operation and prescribed in a discharge permit" (Central Valley Water Board 1998, p. III-9.00).

6.3 Standard (Non-programmatic) Actions

As stated in the 6.1 *Consultation Approach*, some of the project elements are not subject to subsequent consultation and, therefore, must be addressed under standard (non-programmatic) consultation in this BiOp. Effects and any "reasonably certain to occur" incidental take are included in this BiOp. Additionally, the "Effects of the Action" section describes some additional specific conditions under which consultation will need to be reinitiated.

Geotechnical Explorations

DWR will perform a series of geotechnical investigations along the selected water conveyance alignment, at locations proposed for facilities, and at material borrow areas. The proposed exploration is designed as a two-part program (referred to as Phases 2a and 2b) to collect geotechnical data. The land-based portion will occur at approximately 1,380 geotechnical exploration locations and will be active for a period ranging from a few hours to 12 work days, depending on exploration type and target depth. The overwater portion will occur at approximately 90 to 100 exploration locations. DWR will conduct overwater drilling only during June-November depending on location between the hours of sunrise and sunset. Duration of drilling at each location will vary depending on the number and depth of the holes, drill rate, and weather conditions, but activities are not expected to exceed 60 days at any one location. Total duration for land-based explorations will require approximately 24 months and will typically occur from April through November. Total duration overwater explorations will require approximately 14 months, using two drill rigs operating concurrently for 6 days per week from June-November depending on location. The schedule for geotechnical explorations is not included in Appendix 3.D, *Construction Schedule for the Proposed Action*.

Refer to Section 3.2.1 of the CWF BA for the applicant's description of the geotechnical exploration. Section 3.2.1 references CWF BA Appendix 3.G, *Geotechnical Exploration Plan—Phase 2*, a draft 2014 document for Delta Habitat Conservation and Conveyance Program.

Conveyance Tunnels

Design

The conveyance tunnels will extend from the proposed intake facilities to the North Clifton Court Forebay (NCCF). The tunneled conveyance includes the North Tunnels, which consist of three reaches that connect the intakes to the Intermediate Forebay (IF); and two parallel Main Tunnels, connecting the IF to the NCCF. Final surface conveyance connecting the NCCF to the existing export facilities is described in Section 3.2.6, *Connections to the Banks and Jones Pumping Plants*, of the CWF BA. The water conveyance tunnels will be operated with a gravity feed system, delivering to a pumping station located at the NCCF.

Each tunnel segment will be excavated by a tunnel boring machine (TBM), which is a very large and heavy electrically-powered machine that will be launched from the bottom of a launch shaft, and will tunnel continuously underground to a reception shaft. For a detailed explanation of the tunneling work, see the CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Sections 3.1, *Proposed Alignment and Key Components*, 3.2, *Reach Descriptions*, and 11.0, *Tunnels;* Sections 11.2.5, *Tunnel Excavation Methods*, and 11.2.6, *Tunnel Support*, in particular, detail the process of tunneling. The cutterhead of the TBM will be hydrostatically isolated from the remainder of the machine, so that the inside of the tunnel will be dry and at atmospheric pressure. As the TBM proceeds, precast concrete tunnel lining sections will be assembled within the TBM to produce a rigid, watertight tunnel lining. Typically very little dewatering will be needed to keep the interior of the tunnel dry. A electrically-powered conveyor will carry

excavated material from the TBM back to the launch shaft, where a vertical conveyor will carry the material to the surface for disposal. A narrow-gauge railway may be installed in the tunnel with a diesel locomotive, or rubber wheeled diesel engine trucks may be used to carry workers, tunnel lining segments, and other materials from the launch shaft to the TBM.

The TBM launch facilities will be relatively large and active construction sites because they are continuously active during a TBM tunnel drive, when they will provide the only surface access to the tunnel. Thus they will require stockpiles of materials used by the TBM, will provide access to the TBM for its operation and maintenance, and will receive all materials excavated by the TBM. Conversely, TBM reception facilities will be used to recover the TBM at the end of its drive, and thus have a smaller footprint and a more limited operating scope than the launch facilities. Table 6.3-1 summarizes all of the proposed tunnel drives, identifying launch and reception shafts, tunnel lengths, and tunnel diameters. CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Figure 11-1, shows this information on a map. Note that Bouldin Island and the IF will be the primary tunneling sites; the IF will be the launch point for 25.1 miles of two 40-foot tunnels and 4.8 miles of a 28-foot tunnel, while Bouldin Island will be the launch point for four 40-foot tunnels with a total length of 25.4 miles. Bacon Island will be the launch point for two 40-foot tunnels with a total length of 16.6 miles, while Intake 2 will be a relatively small site, acting as launch point for one 28-foot tunnel that will be 2.0 miles long.

Refer to the map book showing all of the tunnel drives presented in CWF BA Appendix 3.A, *Map Book for the Proposed Action*. Design drawings showing tunnel routing, design of the shaft structures, and layout of the surface facilities at launch and reception sites appear in CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*; see Drawings 44 to 54, showing the tunnel routing and all associated areas of surface activity. A detailed project schedule, showing periods of tunneling and associated activities, is given in CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*. Each TBM launch or retrieval shaft will require barge access for equipment and materials. Avoidance and minimization measures (AMMs) to be implemented during construction work at all surface facilities supporting the tunneling work appear in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*.

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Table 6.3-1. Tunnel drive summary.

Reach	Launch Shaft	Reception Shaft	Inside Diameter (ft)	Length (miles)
1	Intake 2	Intake 3 junction structure	28	1.99
2	IF inlet	Intake 3 junction structure	40	6.74
3	IF inlet	Intake 5	28	4.77
4 (west tunnel)	IF	Staten Island	40	9.17
4 (east tunnel)	IF	Staten Island	40	9.17
5 (west tunnel)	Bouldin Island	Staten Island	40	3.83
5 (east tunnel)	Bouldin Island	Staten Island	40	3.83
6 (west tunnel)	Bouldin Island	Bacon Island	40	8.86
6 (east tunnel)	Bouldin Island	Bacon Island	40	8.86
7 (west tunnel)	NCCF	Bacon Island	40	8.29
7 (east tunnel)	NCCF	Bacon Island	40	8.29

Tunnel Construction Components

Shaft Site Facilities

Facilities at launch shaft sites will include a concrete batch plant and construction work areas including offices, parking, shop, short-term segment storage, fan line storage, crane, dry houses, settling ponds, daily spoils piles, temporary reusable tunnel material (RTM) storage, electrical power supplies, air, water treatment, and other requirements. There will also be space for slurry ponds at sites where slurry wall construction is required. Work areas for RTM handling and permanent spoils disposal will also be necessary. Facilities at reception shafts will be similar but more limited, as there will be no need for a concrete batch plant or for RTM storage.

Shaft Site Preparation

Shaft site preparation is detailed in CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 11.2.1, *Advance Works Contracts*. During shaft site preparation, vehicular access will be established and electrical service will be provided via temporary transmission line. The shafts will be located on pads elevated to above the 200-year flood elevation; fill will be placed to construct these pads and to preload the ground to facilitate settling. The site will be fenced for security and made ready for full construction mobilization. Due to the pervasive nature of these activities, all surface disturbance associated with construction at each shaft site will occur very early during the period of activity at each site; the entire site footprint will be disturbed and will remain so for the duration of construction activity.

Access Routes

Access routes for each shaft site are shown in Appendix 3.A, *Map Book for the Proposed Action*, and in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 44 to 54. These

sources also depict the footprint for new permanent access roads, which will be a feature of every shaft site. SR 160 provides access to the intakes and their associated shafts, but for all other shafts (including atmospheric safe haven access shafts), access roads will be constructed. Those roads will be permanent features except at atmospheric safe haven access shafts, where they will be temporary.

Fill Pads

Permanent conveyance facilities (intakes, permanent shaft sites, IF, and CCF facilities) will require fill pads with a top surface elevation of approximately 25 feet to 35 feet, depending upon location (Appendix 3.B, Table 3-4). These sites are currently near or below sea level, so substantial fill material volumes will be needed and will be sourced by borrow sites, the placement of which will cause consolidation settlement of underlying delta soils at the construction sites. The shafts at the IF are an exception; these will initially be constructed at near existing site grades, and final site grades will be established in conjunction with final IF inlet and outlet facilities. The permanent elevated pad perimeters are assumed to extend to 75 feet from the outside of the shafts to facilitate heavy equipment access for maintenance and inspection. As the existing ground elevations are significantly lower than the final planned elevations, the pad fills will slope down to the adjacent existing site grades at an inclination of between 3 horizontal to 1 vertical (3H to 1V) to 5H to 1V.

Due to the soft ground conditions expected at the construction sites, it will also be necessary to improve existing sites to support heavy construction equipment, switchyards, transformers, concrete and grout plants, cranes and hoists, TBMs, and water treatment plants.

Pad construction will precede other work at the shaft site; at the IF, for instance, earthwork will begin 2.5 years prior to ground improvement, and will then be followed by a 9-month period of ground improvement, before the site will be ready for mobilization.

Shaft Construction

Shaft construction procedures are described in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 11.2.3, *Shaft Construction*. Shafts are circular in plan with a 100-foot diameter for 28-foot tunnels and a 113-foot diameter for 40-foot tunnels. These minimum sizes are constrained by the equipment needs to launch and retrieve the TBM from the bottom of the shaft.

Final design of shafts is not complete, but the basic objective is to use concrete construction methods to create a watertight shaft sufficiently strong to resist hydrostatic pressure within the delta sediments. This will be done by constructing a concrete cylinder prior to removing the sediment from the structure. Potential construction methods include overlapping concrete caisson walls, panel walls, jet-grout column walls, secant piles walls, slurry walls, precast sunken caissons, and potentially other technologies. In the areas where TBMs enter and exit, a special break-in/break-out section will be constructed as an integral part of the shaft.

Shaft bottoms will be stabilized to resist uplift associated with external hydrostatic pressures, during both excavation and operation. It may be necessary to pretreat ground at the shaft area from the surface to the bottom of the shaft to control blowouts during excavation of the shaft. Concrete working slabs capable of withstanding uplift will be required at all shaft locations to provide a stable bottom and a suitable working environment. To place the bottom slab, the shaft will be excavated to approximately 30 to 50 feet below the invert level of the tunnel, and a concrete base will be placed underwater using tremie techniques. It is expected that this will be an unreinforced mass concrete plug to withstand ground water pressure, with optional relief wells to relieve uplift pressure during tunnel construction. The launch and reception of the TBMs will require that large openings be created in the shaft walls. To maintain structural stability, it will be necessary to provide additional structural support. This will be provided by a reinforced concrete buttress or frame structure within the shaft.

Dewatering will be required during shaft construction and operation. Dewatering of sediments surrounding the shaft may be needed during construction, depending upon the construction method selected. Dewatering will also be needed during excavation within the shaft, following placement of the tremie seal, and continuously thereafter until completion of construction work within the shaft.

Tunnel Excavation

The tunnel excavation procedure is described in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Sections 11.2.5, *Tunnel Excavation Methods*, to 11.2.8, *Logistics*. Tunnel excavation will occur entirely underground and thus will entail no surface impacts, apart from those associated with the TBM launch and reception shafts and the construction access shafts. Tunnel dewatering needs will be minor, compared to those associated with shaft construction.

Intermediate Tunnel Access

In the event that maintenance, inspection, or repair of the TBM cutterhead will be needed, contractors will be able to access their equipment either from inside the TBM or from the surface using construction access shafts. Such access points are termed “safe havens” because they constitute points where humans can work on the outside of the TBM in conditions of comparative safety.

Access to the cutterhead from inside the TBM will occur at a “pressurized safe haven intervention.” Pressurized safe haven interventions will be constructed by injecting grout from the surface to a point in front of the TBM, or by using other ground improvement techniques such as ground freezing. Once the ground has been stabilized by one of these techniques, the TBM will then bore into the treated area. Surface equipment required to construct the safe haven intervention site will include a small drill rig and grout mixing and injection equipment, and facilities to control runoff from dewatering. Disturbance at the site is expected to be limited to an area of approximately 100 feet by 100 feet. The surface drilling and treatment operation will typically take about 8 weeks to complete. Once complete, all equipment will be removed and the surface features reestablished. To the greatest extent possible, established roadways will be used

to access the intervention sites. If access is not readily available, temporary access roads will be established.

Access to the cutterhead from the surface, referred to as an "atmospheric safe haven interventions," will require construction of a shaft. These construction access shafts will not require pad construction to elevate the top of the shaft to above the 200-year flood level. At these sites, a shaft roughly equal to the diameter of the TBM cutterhead will be excavated to tunnel depth. Approximately 3 acres will be required at each of these locations to set up equipment, construct flood protection facilities, excavate/construct the shaft, and set up and maintain the equipment necessary for the TBM maintenance work. It is anticipated that all work associated with developing and maintaining these shafts will occur over approximately 9 to 12 months. At the completion of the TBM maintenance at these sites, the TBM will mine forward, and the shaft location will be backfilled. Dewatering at construction access shafts may be required. Drilling muds or other materials required for drilling and grouting will be confined on the work site and such materials will be disposed of offsite at a permitted facility. Disturbed areas will be returned to preconstruction conditions by grading and appropriate revegetation.

Final determination of the number and siting of shaft locations will depend upon determinations by the tunnel construction contractor(s). Table 6.3-2 shows the number of safe haven interventions expected to be associated with each tunnel, based upon current understanding of site conditions.

Table 6.3-2. Expected safe haven interventions.

Reach	Length (miles)	Number of Safe Haven Interventions	
		Pressurized	Atmospheric
1	1.99	1	1
2	6.74	5	1 to 3
3	4.77	3	1 to 2
4 (twin tunnel)	9.17	7	1 to 4
5 (twin tunnel)	3.83	2	1
6 (twin tunnel)	8.86	7	1 to 4
7 (twin tunnel)	8.29	6	1 to 3

The tunnel construction timeline is presented in CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*. The TBM launch shafts will be most active, producing RTM on a nearly continuous basis, for the following time periods:

- CCF: May 2020 to February 2025
- Bouldin Island: October 2020 to May 2025
- IF: May 2021 to October 2026
- Intake 2: October 2021 to July 2025

Overall, the peak period of activity will be from October 2020 to April 2025. Considering time required to prepare each site, as well as time required to stabilize and restore RTM storage areas, each site will remain active throughout essentially the whole period of construction (2018 to 2030). Since the CCF, IF, and Intake 2 are essential components of the conveyance system, these sites will remain permanently active. The Bouldin Island site, however, will close following attainment of revegetation and restoration objectives for the associated RTM storage areas, although a small permanent tunnel access shaft will remain.

During mobilization, construction manpower, stockpiles of materials, and needed equipment will be stationed at the construction site. The construction phase at both permanent and temporary shaft sites will conclude with landscaping and the installation of safety lighting and security fencing.

Intermediate Forebay

The IF will receive water from the three NDDs and discharge it to the twin tunneled conveyance to CCF. The IF, located on Glannvale Tract, will store water between the proposed intake and conveyance facilities and the main tunnel conveyance segment. The IF provides an atmospheric break in the deep tunnel system and buffer volume for the upstream intake sites and the downstream Clifton Court Power Plant (CCPP). This buffer provides make-up water and storage volume to mitigate transients generated as a result of planned or unplanned adjustments of system pumping rates. The IF also facilitates isolating segments of the tunnel system, while maintaining operational flexibility. Thus each tunnel, into and out of IF, can be hydraulically isolated for maintenance, while maintaining partial system capacity.

Design

Appendix 3.A, *Map Book for the Proposed Action*, Sheet 5, shows the IF, access routes, and related facilities in the area. Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 55 to 68, show an artist's concept of the completed forebay, as well as drawings showing the complete forebay and various design details. Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 14, *Forebays*, provides detail on the design, construction and operations of the IF; see particularly Sections 14.1. (description and site plan), 14.2. (construction methodology), 14.2.4 (embankment completion), 14.2.6 (spillway), and 14.2.8 (inlet and outlet structures). Section 5.3.1, *Intermediate Forebay Size Evaluation*, describes the basis for design sizing of the IF.

The IF will have a capacity of 750 acre feet (af) and an embankment crest elevation of +32.2 feet, which meets Delta Habitat Conservation and Conveyance Program (DHCCP) flood protection standards (i.e., a 200-year flood with provision for sea level rise). Current ground surface elevation at the site averages +0 feet. The water surface elevation (WSE) varies between a maximum elevation of +25 feet and a minimum elevation of -20 feet. The IF will include an emergency spillway and emergency inundation area to prevent the forebay from overtopping. This spillway will divert water during high flow periods to an approximately 131-acre emergency inundation area adjacent to and surrounding the IF. From the IF, water will be

conveyed by a gravity bypass system through an outlet control structure into a dual-bore 40-foot-diameter tunnel that runs south to the CCF. The IF will serve to enhance water supply operational flexibility by using forebay storage capacity to regulate flows from the intakes to the CCF. The IF footprint will have a water surface area of 54 acres at maximum water elevation.

Construction

Construction of the IF entails first excavating the embankment areas down to suitable material (Table 6.3-3). A slurry cutoff wall is then emplaced to a depth of -50 feet to eliminate the potential for piping or seepage beneath the embankment. The embankment is then constructed of compacted fill material. Inlet and outlet shafts (which also serve as TBM launch shafts) are then constructed. Then the interior basin is excavated to design depth (-20 feet), and the spillway is constructed. All excavations are expected to require dewatering, and dewatering is expected to be continuous throughout construction of the IF. Ground improvement may be needed beneath structures, depending upon the outcomes of the geotechnical explorations.

The IF will have a surface footprint of 243 acres, all of which is permanent (under 2016 conditions, the area is a vineyard). Approximately 1 million cubic yards (cy) of excavation and 2.3 million cy of fill material are required for completing the IF embankments. Much of the excavated material is expected to be high in organics and unsuitable for use in embankment construction and requires disposal. However, fill material may be sourced onsite from locations within the permanent impact footprint. Material sourced from offsite will be obtained as described in the Borrow Fill section of the CWF BA. The construction phase at the IF will conclude with landscaping and the installation of safety lighting and security fencing.

Table 6.3-3. Summary construction schedule for the Intermediate Forebay.

Description	Start[a]	End[a]	Duration
Contract management, supervision, administration, temporary facility operations, and delivery of construction supplies	7/1/2026	7/11/2031	61 months
Earthworks	7/1/2026	12/25/2029	42 months
Inlet & outlet ground improvements	12/28/2028	10/12/2030	23 months
Inlet & outlet site work	9/27/2029	4/12/2030	8 months
Operate concrete batch plant; inlet & outlet concrete work	3/27/2030	4/11/2031	13 months
Inlet & outlet gates, mechanical & electrical work	12/25/2030	7/11/2031	7 months

[a] Dates given in this table assume a Record of Decision date of 1/1/2018 and a construction end date of 7/11/2031.

Clifton Court Forebay

Design

In the CWF BA, DWR recognizes that design of the modifications and expansion of Clifton Court Forebay are in early stages. As such, DWR proposes to convene a Clifton Court Forebay Technical Team upon initiation of formal consultation for the PA and will meet periodically until DWR completes final design for the proposed CCF modifications (a time period expected to be

at least two years). The general concepts and construction components are summarized below and reference the CWF BA where appropriate.

The CCF will be divided into two separate but contiguous forebays: North Clifton Court Forebay (NCCF) and South Clifton Court Forebay (SCCF). The NCCF will receive screened water from the new river intakes, while the SCCF will continue to receive flows from the existing Old River intake gate on CCF. The NCCF will be sized to meet the hydraulic needs of balancing water entry from the North Delta Diversions with discharge via the CVP/SWP export pumps. The SCCF will continue to meet the needs of SWP export pumps taking in south Delta water; as such it will function as a replacement for the current CCF, and thus must be enlarged south in order to maintain its current size while still accommodating the creation of the NCCF. SCCF will consist of the southern portion of the existing CCF, with expansion to the south into Byron Tract 2.

The CCF will be expanded by approximately 590 acres to the southeast of the existing forebay. The existing CCF will be dredged, and the expansion area excavated, to design depths of -8 feet for the NCCF and -10 feet for the SCCF. A new embankment will be constructed around the perimeter of the forebay, as well as an embankment dividing the forebay into the NCCF and the SCCF. The tunnels from the Sacramento River intakes will enter the CCPP at the northeastern end of the NCCF, immediately south of Victoria Island, and flows will typically enter the NCCF via pumping.

An emergency spillway will be constructed in the NCCF east side embankment, south of the CCPP fill pad. The spillway will be sized to carry emergency overflow (9,000 cfs, the maximum inflow from the North Delta Diversions) to the Old River, so a containment area will not be necessary. The shallow foundation beneath this structure must be improved to prevent strength loss and seismic settlement. The ground improvement will be to elevation -50.0 feet within the footprint of the structure and beyond the structure by a distance of approximately 25 feet. The work will be performed within the sheet pile installed for embankment filling.

Detailed information on design of the proposed facilities at CCF is given in Appendix 3.B3, *Conceptual Engineering Report, Volume 1*, Sections 4.4.6, *Clifton Court Forebay Pump Plant (CCFPP) Operations*; 4.4.7, *North Clifton Court Forebay Operations*. Section 7*, CCF Pumping Plant*, describes the design and construction of the CCF pumping plant, while the north and south CCF and their construction methodology are described in Sections 14.1.2, *North Clifton Court Forebay*; 14.1.3, *South Clifton Court Forebay*; 14.2.2, *General Excavation for the NCCF and SCCF*; 14.2.3, *General Excavation for the Existing South Embankment of Clifton Court Forebay*; 14.2.5, *New Clifton Court Forebay Embankment*; 14.2.6, *New Spillway and Stilling Basin*; and 14.2.8, *New Forebay Structures*.

Per the CWF BA, Appendix 3.A, *Map Book for the Proposed Action*, Sheet 13, shows the CCF, access routes, and related facilities in the area. Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawing 2, provides an overview of the CCF facilities in relation to the rest of the conveyance facilities, and Drawing 54 provides a site-scale view of the proposed facilities at CCF. Drawing 74 shows an artist's concept of the completed CCF pumping plant, and Drawings 75 to 78 show details of the proposed pumping plant. Drawing 82 is a detailed overall CCF site

plan, and Drawings 85 to 87 provide sectional views of the proposed embankments that contain the CCF. Drawings 90 and 91 provide plan and section views of the proposed spillway from the NCCF into Old River.

The NCCF will be designed to accommodate hydraulic surges and transitions related to short-term (typically less than 24 hours) differences in the rate of water delivery to NCCF and the rate of export by the CVP/SWP pumps. The NCCF will also be the site for a pump station, the operations of which form the primary control and constraints on the rate of water diversion through the river intakes (although that rate is also subject to control at the river intakes). Collective operations of these facilities will be coordinated through an operations center sited at the NCCF pump station. The SCCF will continue to operate as under current conditions. The proposed size of the CCF and its appurtenant facilities have been optimized consistent with the overall design goal of the PA to achieve diversion rates at the North Delta Diversions not exceeding 9,000 cfs, and to achieve overall CVP/SWP water export rates consistent with existing authorizations for those facilities, subject to operational and regulatory constraints detailed in Section 3.3, *Operations and Maintenance of the New and Existing Facilities*.

Construction

Due to the duration and complexity of the proposed work at CCF, a phased work schedule is planned and is described further in the CWF BA. The phases include the following:

- Phase 1 – SCCF expansion (eastern and western parts of expansion area shown in CWF BA -Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 54 and 82)
- Phase 2 – Dredge to design depth within the portion of CCF located south of the proposed embankment separating NCCF and SCCF
- Phase 3 – Remove embankment separating the existing CCF from the expansion area
- Phase 4 – Construct embankment separating NCCF and SCCF, with subsequent dewatering, fish rescue, and excavation to design depth within NCCF
- Phase 5 – Construct West and East Side Embankments located south of the proposed embankment separating the NCCF and SCCF
- Phase 6 – Construct NCCF East Side Embankment
- Phase 7 – Construct NCCF West Side Embankment
- Phase 8 – Construct NCCF North Side Embankment

The overall schedule for activities at CCF is shown in Appendix 3.D, *Construction Schedule for the Proposed Action*; see drawings in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, for locations of the referenced structures. Four major elements of the proposed construction will

occur in the CCF area: tunneling, the CCPP, the modifications to the current CCF to create a North and South CCF, and connections to the Banks and Jones pumping plants.

- Tunneling (Reach 7) will start from the CCPP construction site and will excavate north to Bacon Island, as described in Section 3.2.3, *Tunneled Conveyance*; RTM from the tunnels will be disposed near CCF as described in Section 3.2.10.6, *Dispose Spoils*. Tunneling activity will begin 47 months after project start (scheduled to occur in January; the start year depends upon the date of project authorization and the time needed to prepare contract specifications and issue contracts) and will proceed continuously for 61 months.

- The CCPP will be constructed at the northeast corner of the CCF complex and includes the shafts used to launch the TBMs. Construction will start at the CCPP will begin 36 months after project start and will proceed continuously for 100 months.

- CCF work will occur throughout the site, and will be continuously active from 84 months after project start until 147 months after project start. Apart from startup activities (access improvement, mobilization, etc.), embankment and canal work will continue from 90 months to 130 months after project start. Work on control structures and spillways will occur from 108 months to 144 months after project start.

Clifton Court Pumping Plant

Design

Each of the two units at CCPP will have a design pumping capacity of 4,500 cfs and will include 4 large pumps (1,125 cfs capacity) and 2 smaller pumps (563 cfs capacity). One large pump at each plant will be a spare. Each pumping plant will be housed within a building and will have an associated electrical building. The pumping plant buildings will be circular structures with a diameter of 182 feet and each will be equipped with a bridge crane that will rotate around the building and allow for access to the main floor for pump removal and installation. The total site for the pumping plants, electrical buildings, substation, spillway, access roads, and construction staging areas is approximately 95 acres. The main floor of the pumping plants and appurtenant permanent facilities will be constructed at a minimum elevation of 25 feet to provide flood protection. The bottom of the pump shafts will be at an elevation of approximately -163 feet, though a concrete base slab, shaft lining, and diaphragm wall will be constructed to deeper levels (to an elevation of -275 feet). A control room within an electrical building at the pumping facility site will be responsible for controlling and monitoring the communication between the intakes, pumping plants, and the Delta Field Division Operations and Maintenance Center, DWR Headquarters, and the Joint Operations Center.

The CCPP shafts will be larger in inside diameter (150 feet instead of 113 feet) than most shafts serving 40-foot tunnel bores due to the design needs of the pumping plant. As shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 75 and 76, the appurtenant facilities will be more extensive than at most tunnel shaft sites, including a permanent electrical

substation, two electrical buildings, and an office/storage building, as well as temporary facilities for storage, staging, construction electrical, and water treatment (for stormwater). All of these facilities will be sited on the CCF embankment, at the design flood elevation (i.e., a 200-year flood with provision for sea level rise) of 25 feet.

A 230 kV transmission line and associated 230Kv–115kV substation used during construction will be repurposed and used to power the pumping plants at the CCF location during operations. The repurposed substation will provide power to a new substation that will convert power from 115kV to 13.8kV. This substation will then include 13.8 kV feeder lines to a proposed electrical building to distribute the power to the major loads including the main pumps, dewatering pumps, and 13.8kV to 480V transformers.

Clifton Court Pumping Plant Construction Components

A detailed account of CCPP construction appears in Appendix 3.B3, *Conceptual Engineering Report, Volume 1*, Section 7.2, *Construction Methodology*.

Site Access

Vehicular site access during construction will use existing roads: from the east, from Byron Highway via Clifton Court Road and the Italian Slough levee crest road or the NCCF embankment crest road. Access from the south will be from the Byron Highway via NCCF embankment crest road and West Canal levee crest road. Barge access will also be needed, for transport of heavy TBM sections and other very large equipment and materials, and possibly for transport of bulk materials (fill material or excavated material). Barge access will be from the West Canal using a proposed barge unloading facility.

Cofferdam and Fill Work

A sheet pile cofferdam will be placed to enclose the portion of the CCPP fill pad adjoined by water (Appendix 3.C3, *Conceptual Engineering Report, Volume 2,* Drawings 75 and 83; however note that, as detailed below, the design has been modified to dewater NCCF prior to CCPP construction; thus no sheet pile cofferdam will be placed in the portions of the CCPP fill pad adjoining the NCCF). Sheet pile placement for cofferdam installation will be performed by a barge-mounted crane and/or a crane mounted on the existing levee, equipped with vibratory and impact pile-driving rigs. Fill pad construction will then proceed within the dewatered area, including fill placement, compaction, and ground improvement.

Dewatering

Extensive dewatering will be required during construction of the CCPP shafts.

Connections to Banks and Jones Pumping Plants

Construction at CCF will also include connections to the existing Banks and Jones pumping plants. The new system configuration will allow both the Banks PP and the Jones PP to draw water from existing sources and/or from the NCCF.

The new system configuration will require canals and control structures and two new siphons, shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 83 and 84. One siphon will convey NCCF water beneath the SCCF outlet canal. The second siphon will convey NCCF water to the Banks PP underneath the Byron Highway and the adjacent Southern Pacific Railroad line. Each siphon will have a control structure fitted with radial gates at the inlet, to regulate upstream WSE and flow through the siphons. In order to isolate a siphon for repairs and inspections, stop logs will also be provided at the downstream end of the siphon barrel. Control structures, fitted with radial gates, will also be located at the end of the new approach channels to control the amount of flow delivered to Jones PP and Banks PP. Refer to the CWF BA for further description and construction details for the canals, siphons and control structures.

Power Supply and Grid Connections

During construction, the PA will rely primarily upon electrical power sourced from the grid via temporary transmission lines to serve the TBMs and other project components. Use of diesel generators or other portable electrical power sources will be minimized due to the adverse air quality impacts of onsite power generation. Once operational, the largest power consumption will be for the pumping plant at CCF, where a grid connection will be available nearby. The intakes and IF will have relatively low operational power demands, which will be met via relatively short and lower-voltage connections to nearby grid sources.

Electric power will be required for intakes, pumping plants, operable barriers, boat locks, and gate control structures throughout the proposed conveyance alignment. Temporary power will also be required during construction of water conveyance facilities. New temporary electrical transmission lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary electrical transmission lines. Both temporary and permanent electrical transmission lines serving the PA are shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 94. Temporary and permanent transmission lines are also shown in the map book, Appendix 3.A, *Map Book for the Proposed Action*, Sheets 1 to 15.

Transmission lines to construct and operate the water conveyance facilities will connect to the existing grid in two different locations. The northern point of interconnection will be located north of Lambert Road and west of Highway 99 (Appendix 3.A, *Map Book for the Proposed Action*, Sheet 4). From here, a new 230 kV transmission line will run west, along Lambert Road, where one segment will run south to the IF on Glannvale Tract, and one segment will run north to connect to a substation where 69 kV lines will connect to the intakes. At the southern end of

the conveyance alignment, the point of interconnection will be in one of two possible locations: southeast of Brentwood near Brentwood Boulevard (Appendix 3.A, Sheet 15) or adjacent to the Jones Pumping Plant (Appendix 3.A, Sheet 13). A 230 kV line will extend from one of these locations to a tunnel shaft northwest of CCF, and will then continue north, following tunnel shaft locations, to Bouldin Island. Lower voltage lines (Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 94) will be used to power intermediate and reception shaft sites between the main drive shafts. Because the power required during operation of the water conveyance facilities will be much less than that required during construction, and because it will largely be limited to the pumping plants, all of the new electrical transmission lines between the IF and the CCF will be temporary.

An existing 500kV line, which crosses the area proposed for expansion of the CCF, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Temporary substations will be constructed at each intake, at the IF, and at each of the launch shaft locations. To serve permanent pumping loads, a permanent substation will be constructed adjacent to the pumping plants at CCF, where electrical power will be transformed from 230 kV to appropriate voltages for the pumps and other facilities at the pumping plant site. For operation of the three intake facilities and IF, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Utility interconnections are planned for completion in time to support most construction activities, but for some activities that need to occur early in the construction sequence (e.g., constructing raised pads at shaft locations and excavating the shafts), onsite generation may be required on an interim basis. As soon as the connection to associated utility grid power is completed, electricity from the interim onsite generators will no longer be used.
Temporary lines will be constructed from existing facilities to each worksite where power will be necessary for construction. Construction of new transmission lines will require three phases: site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line stringing phase. For stringing transmission lines between 230 kV towers, cranes and helicopters will be used.

Construction of 230 kV and 69 kV transmission lines will require a corridor width of 100 feet and, at each tower or pole, a 100- by 50-foot area will be required for construction laydown, trailers, and trucks. Towers or poles will be located at intervals of 450 feet for 69kV lines, and 750 feet for 230kV lines. Construction will also require about 350 feet along the corridor (measured from the base of the tower or pole) at conductor pulling locations, which includes any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes have not yet been determined.

For construction of 12 kV lines (when not sharing a 69 kV line), a corridor width of 25–40 feet will be necessary, with 25 feet in each direction along the corridor at each pole. Construction will also require 200 feet along the corridor (measured from the base of the pole) and a 50-foot-wide

area at conductor pulling locations, which will include any turns greater than 15° and/or every 2 miles of line. For a pole-mounted 12 kV/480 volt transformer, the work area will only be that normally used by a utility to service the pole (typically about 20 by 30 feet adjacent to pole). For pad-mounted transformers, the work area will be approximately 20 by 30 feet adjacent to the pad (for construction vehicle access). Construction of 12kV lines will also require vehicular access to each tower or pole location and routes have not yet been determined.

Temporary Access and Work Areas

Temporary access and work areas are defined for this project as areas or structures that will be removed and not the duration of the activity. Construction work areas for the conveyance facilities will include areas for construction equipment and worker parking, field offices, a warehouse, maintenance shops, equipment and materials laydown and storage, and stockpiled topsoil strippings saved for reuse in landscaping.

Surface vehicular access will be needed for construction of all water conveyance facilities. Geotechnical exploration sites on water or on agricultural lands can be accessed by suitable vehicles, but all other construction sites will require road access. All-weather roads (asphalt paved) will be needed for year-round construction at all facilities, while dry-weather roads (minimum 12 inch thick gravel or asphalt paved) can be used for construction activities restricted to the dry season. Heavy construction equipment, such as diesel-powered dozers, excavators, rollers, dump trucks, fuel trucks, and water trucks will be used during excavation, grading, and construction of access/haul roads. Detour roads will be needed for all intakes and for traffic circulation around the work areas.

Temporary barge unloading facilities will be constructed, used, and decommissioned.

Temporary concrete batch plants will be needed due to the large amount of concrete required for construction and the schedule demands of the PA. A batch plant is proposed for siting at each TBM launch shaft or TBM retrieval shaft location. The area required for these plants will be within the construction footprint for these facilities but precise facility siting within the construction site has not yet been determined. Other facilities to be co-located with concrete batch plants within the construction site footprint will include fuel stations, pug mills, soil mixing facilities, cement storage, and fine and coarse aggregate storage. Fuel stations will be needed for construction equipment fueling. Pug mills will be needed for generating processed soil materials used at the various sites. Soil mixing facilities will be needed for some of the muck disposal and for ground improvement activities. Cement and required admixtures will be stored at each site to support concrete, slurry walls, ground improvement, soil mixing, and other similar needs. TBM launch sites may also contain facilities for production of precast tunnel segments. If constructed, these will be located adjacent to concrete plants, and will also be within the construction site footprint. It is likely that each precast segment plant would require approximately 10 acres for offices, concrete plant, materials storage, and casting facilities.

All storage and processing areas will be properly contained as required for environmental and regulatory compliance. In addition, work at all sites will be required to comply with terms of all applicable avoidance and minimization measures.

Common Construction-Related Activities

Clearing

Essentially all lands within the temporary and permanent impact footprint are assumed to be cleared; the only exceptions are lands that are underlain by a structure (TBM-excavated tunnels), or that are beneath a structure (electrical transmission line wires, between the towers), or that are underwater (in association with the Delta intakes, the CCF, the Banks and Jones connections, and the HORG). Grading will be performed where required by the project design. Clearing and grading will be performed using standard equipment such as bulldozers. Topsoil from cleared areas will be stockpiled and reused at the close of construction.

Site Work

Site work will occur within previously cleared areas. It will include construction of site access, establishment of stockpiles and staging and storage areas, site fencing, onsite electric (such as a substation), and erection of temporary construction buildings (primarily offices and storage). Equipment used during site work mainly will include large vehicles and vehicle-mounted equipment such as cranes, which have the potential to create noise and light comparable to other construction equipment. Performance of site work will entail the risk of spills associated with vehicles and with materials transport, and the potential for erosion or stormwater effects associated with cleared areas.

Ground Improvement

Ground improvement will occur within previously cleared areas. Ground improvement serves to improve existing substrates at a site so that they can bear heavy loads and otherwise support the design of the proposed construction. Activities performed in ground improvement will include drilling, and injection of materials. Ground improvement commonly will occur in association with grading and dewatering. Improved ground will remain in place for the duration of the PA and thereafter. Equipment used in ground improvement will include large vehicle-mounted drilling and injection equipment with potential to create noise and light comparable to other construction equipment. Performance of ground improvement will entail the risk of spills associated with vehicles and with materials transport.

Borrow Fill

The total amount of borrow material for engineered fill used in all aspects of the PA will be approximately 21 million cy (as bank cubic yards). This total amount will include approximately 3 million cy for tunnel shaft pads, 6.5 million cy for the CCF embankments, 2 million cy for the

IF embankments, 6.7 million cy at the three intake sites (approximately 2 million cy each), and 2.6 million cy at the CCPP site. Source locations for this borrow material will be within the work area footprint shown in Appendix 3.A, *Map Book for the Proposed Action*. Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 21, *Borrow Sites*, describes the criteria for selection of borrow sites and identifies suitable geological materials that could be used as sources of borrow material. Apart from engineering specifications, the criteria for selection of borrow sites will include the following: (1) borrow material should not require post-excavation processing (other than moisture conditioning); (2) borrow material should be exposed at surface and require no, or very limited, overburden removal; and (3) borrow areas should be selected to minimize the impact or encroachment on existing surface and subsurface development and environmentally sensitive areas as much as possible.

Fill to Flood Height

Permanent levees, embankments, and fills on which structures are sited at the intakes, the IF, the CCPP, and the Banks and Jones connections, will be filled to the design flood height, which is the level of the 0.5% annual exceedance flood (i.e., the 200-year flood), plus an 18-inch allowance for sea level rise. Since current ground elevations at most of the construction sites are at or slightly below sea level, substantial volumes of material will be needed to construct these fills, and the weight of this material will cause substantial compaction and settling in the underlying ground. Compaction and settling issues will be addressed by ground improvement and dewatering wells, which are used to reduce hydraulic pressure within the sediments and accelerate the rate of compaction.

Fills to flood height will occur at sites that have previously been cleared. The fill material will be sourced from borrow sites and transported using conventional earthmoving equipment, or possibly conveyors if the distances involved are short and are entirely within the area cleared for facility construction. Performance of this work will entail the risk of spills associated with vehicles and with materials transport, and the potential for erosion or stormwater effects associated with cleared areas.

Dispose Spoils

Spoils will include materials removed from the construction area and placed for nonstructural purposes. The principal sources of spoils will be materials removed during excavation of tunnels (RTM) and dredging of the CCF. Secondary sources will include structural excavations during facilities construction. Table 6.3-4 provides key construction information on spoils and reusable tunnel material storage.

RTM is the by-product of tunnel excavation using a TBM. The RTM will be a plasticized mix consisting of soil cuttings, air, water, and may also include soil conditioning agents. Soil conditioning agents such as foams, polymers, and bentonite may be used to make soils more suitable for excavation by a TBM. Soil conditioners are non-toxic and biodegradable. During tunnel construction the daily volume of RTM withdrawn at any one shaft location will vary, with an average volume of approximately 6,000 cubic yards per day. It is expected that the transport

of the RTM out of the tunnels and to the RTM storage areas will be nearly continuous during mining or advancement of the TBM. The RTM will be carried on a conveyor belt from the TBM to the base of the launch shaft. The RTM will be withdrawn from the tunnel shaft with a vertical conveyor and placed directly into the RTM work area using another conveyor belt system. From the RTM work area, the RTM will be roughly segregated for transport to RTM storage and water treatment (if required) areas as appropriate. Appendix 3.A, *Map Book for the Proposed Action*, Sheets 1–5 and 7–15 show conveyor belt and RTM storage area locations.

RTM must be dewatered in order to stabilize it for long-term placement in a storage area. Atmospheric drying by tilling and rotating the material, combined with subsurface collection of excess liquids will typically be sufficient to render the material dry and suitable for long-term storage or reuse. Leachate will drain from ponds to a leachate collection system, then be pumped to leachate ponds for possible additional treatment. Disposal of the RTM decant liquids will require permitting in accordance with NPDES and Regional Water Quality Control Board regulations. A retaining dike and underdrain liquid collection system (composed of a berm of compacted soil, gravel and collection piping, as described below), will be built at each RTM storage area. The purpose of this berm and collection system will be to contain any liquid runoff from the drying material. The dewatering process will consist of surface evaporation and draining through a drainage blanket consisting of rock, gravel, or other porous drain material. The drainage system will be designed per applicable permit requirements. Treatment of liquids (primarily water) extracted from the material could be done in several ways, including conditioning, flocculation, settlement/sedimentation, and/or processing at a package treatment plant to ensure compliance with discharge requirements.

Designated spoils storage areas are shown in the map book, CWF BA Appendix 3.A, *Map Book for the Proposed Action*. RTM will be the largest source of this material, and disposition of that material will be, on an acreage basis, one of the largest impacts of the PA (see Table 6.3-5). Dredged material from the CCF will be the second largest source of spoils.

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Table 6.3-4. Spoils and Reusable Tunnel Material storage: key construction information.

- Final locations for storage of spoils, RTM, and dredged material will be selected based on the guidelines presented in *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*).
- Conventional earthmoving equipment, such as bulldozers and graders, would be used to place the spoil. Some spoil, with the exception of RTM, may be placed on the land-side toes of canal embankments and/or setback levees.
- Spoils may temporarily be placed in borrow pits or temporary spoil laydown areas pending completion of embankment or levee construction. Borrow pits created for this project will be the preferred spoil location.
- RTM that may be have potential for re-use in the PA (such as levee reinforcement, embankment or fill construction) will be stockpiled. The process for testing and reuse of this material is described further in *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*).
- A berm of compacted imported soil will be built around the perimeter of the RTM storage area to ensure containment. The berm will conform to USACE guidelines for levee design and construction.
- RTM will be stacked to an average depth of 10 ft; precise stacking depth will vary across disposal sites.
- Maximum capacity of RTM storage ponds will be less than 50 af.
- RTM areas may be subdivided by a grid of interior earthen berms in RTM ponds for dewatering.
- Dewatering will involve evaporation and a drainage blanket of 2 ft-thick pea gravel or similar material placed over an impervious liner.
- Leachate will drain from ponds to a leachate collection system, then be pumped to leachate ponds for possible additional treatment.
- Transfer of RTM solids to disposal areas may be handled by conveyor, wheeled haul equipment, or barges, at the contractor's discretion.
- Where feasible, the invert of RTM ponds will be a minimum of 5 ft above seasonal high groundwater table.
- An impervious liner will be placed on the invert and along interior slopes of berms, to prevent groundwater contamination.
- RTM will not be compacted.
- Spoil placed in disposal areas will be placed in 12-inch lifts, with nominal compaction.
- The maximum height for placement of spoil is expected to be 6 ft above preconstruction grade (10 ft above preconstruction grade for sites adjacent to CCF), and have side slopes of 5H:1V or flatter.
- After final grading of spoil is complete, the area will be restored based on site-specific conditions following project restoration guidelines.

Table 6.3-5. Spoils disposition, volumes and acreages.

Disposal Site	Volume (cy)	Disposal Area (acres)
RTM and dredged material disposal site near Intake 2	1,020,000	45.6
RTM disposal sites near IF	9,060,000	404.7
RTM disposal site on Bouldin Island	8,340,000	1,208.8
RTM and dredged material disposal sites near CCF	5,370,000 (RTM) 7,000,000 (dredged)	899.6
TOTAL	**30,790,000**	**2,558.7**

RTM is expected to be reusable, suitable as engineered fill for varied applications, and also suitable for restoration work such as tidal habitat restoration. However, end uses for that material

have not yet been identified. It is likely that the material will remain in designated storage areas for a period of years before a suitable end use is identified, and any such use will be subject to environmental evaluation and permitting independent of the PA. Therefore disposition of RTM is assumed to be permanent, and future reuse of this material is not part of the PA.

Materials removed during surface excavation and dredging, or from clearing of the sedimentation basins, may also be reusable. As with RTM, no end uses for this material have yet been identified, such use is not part of the PA, and the material will be permanently disposed in the designated RTM and dredged material storage areas. The exception to this statement is topsoil removed during clearing for construction. Topsoil is not classified as spoils; it will be stockpiled and reused for landscaping and restoration.

Dewatering

Due to the generally high groundwater table in the Delta, the location of much of the construction alignment at below-sea-level elevations, and the extensive construction of below-grade structures, dewatering will be needed for nearly all components of conveyance construction. "Dewatering" as used in this document refers to the removal of water from a work area or from excavated materials, and discharge of the removed water to surface waters in accordance with the terms and conditions of a valid NPDES permit and any other applicable Central Valley Regional Water Quality Control Board requirements.

Dewatering will generally be accomplished by electrically powered pumps, which will either dewater via groundwater wells (thereby drawing down the water table to minimize the amount of water entering a work area) or by direct removal of water from an excavation or other work area (such as a cofferdam or the bottom of a completed tunnel access shaft). Dewatering of excavated materials would be accomplished in a similar manner, by stockpiling the material and allowing the water to infiltrate to an impervious layer such as a liner or the bottom of a storage tank, and then pumping or draining it prior to treatment or discharge. At most conveyance facilities, dewatering will be an ongoing activity throughout most of the period of construction activity.

Dewatering water is subject to contamination. Dewatering waters will be stored in sedimentation tanks; tested for contaminants and treated in accordance with permit requirements; and discharged to surface waters. Treatment of the removed groundwater has not yet been determined and could include conditioning, flocculation, settlement/sedimentation, and/or processing at a package treatment plant. Velocity dissipation structures, such as rock or grouted riprap, will be used to prevent scour where dewatering discharges enter the river. Location of dewatering discharge points will be determined at time of filing for coverage under the NPDES general permit or before start-up of discharge as appropriate. Additional information will be developed during design and the contractor will be required to comply with permit requirements.

Dredging and Riprap Placement

For the purposes of this analysis, dredging and riprap placement are defined to be activities that occur in fish-bearing waters. This definition thus excludes, for instance, dredging that occurs in the sedimentation basins at the intakes, or riprap placement that occurs in a dewatered area. Dredging is subject to constraints imposed by the Federal permit for the activity. Riprap placement would also comply with relevant NPDES and SWRCB requirements; and with the proposed in-water work windows.

Barge Landing Construction and Barge Traffic

Contractors will use barges to deliver TBM components to TBM launch sites, and may also use barges to deliver other heavy or bulky equipment or materials to those sites, or to haul such materials from those sites. This activity will include barge landing construction, barge operations in the river, tug operations, and barge landing removal. Barge landings will be needed at these seven locations:

- Snodgrass Slough north of Twin Cities Road (adjacent to proposed IF)
- Little Potato Slough (Bouldin Island south)
- San Joaquin River (Venice Island south)
- San Joaquin River (Mandeville Island east at junction with Middle River)
- Middle River (Bacon Island north)
- Middle River (Victoria Island northwest)
- Old River (junction with West Canal at CCF)

Locations of the barge landings are shown in CWF BA Appendix 3.A, *Map Book for the Proposed Action*, CWF BA Chapter 6 page 6-22, and item no. 101 of the *BiOp Resolution Log* (CWF 2016; BiOp Resolution Log 2016). The *BiOp Resolution Log* also provides additional information related to barge traffic routes, including frequency and duration of travels. Locations are approximate; precise siting and dimensions of these docks are to be determined by DWR's construction contractors. Barge landings may also be needed to serve safe haven access sites, if they are sited in areas where existing surface roads will not be adequate to transport the equipment needed for shaft construction. Barge landings may also be needed, at contractors' discretion, at the Intake 3 and Intake 5 construction sites, at the Staten Island TBM retrieval shaft, and at the Banks and Jones Connections construction sites. See the CWF BA for further points characterizing the barge landings and barge uses.

Landscaping and Associated Activities

The construction phase at most conveyance facilities will conclude with landscaping. Revegetation of disturbed areas will be determined in accordance with guidance given by DWR's WREM No. 30a, Architectural Motif, State Water Project and through coordination with local agencies through an architectural review process. Landscaping in cleared areas will reuse topsoil stockpiled at the time of site clearing. Site revegetation plans will be developed for restoration of areas disturbed by PA activities.

Other activities occurring at the conclusion of construction will include site cleanup, installation of operational lighting, and installation of security fencing. Site cleanup will consist of removal of all construction equipment, materials, and debris from the site. Construction debris will be disposed at a regional facility authorized to receive such materials. The intakes, the IF, the consolidated pumping plant at CFF, and the HORG will be provided with security fencing to prevent unauthorized public access.

Operational lighting will be needed at the intakes, the IF, the consolidated pumping plant at CCF, at the HORG, and at the control structures associated with the Banks and Jones connections; operational lighting will also continue to be provided at the existing CVP/SWP facilities. Lighting for the proposed facilities will be designed in accordance with guidance given by DWR's WREM No. 30a, Architectural Motif, State Water Project and through coordination with local agencies through an architectural review process.

Pile Driving

Sheet pile and tubular steel pile driving will be required for intake construction, barge dock construction, embankment work at CCF, the Banks and Jones connections, and construction of the HORG. Both vibratory and impact pile driving are expected to occur at each of these locations, as structural requirements call for impact pile driving to refusal.

For all sheet pile cofferdams proposed at the Delta intakes, CCF, and HORG, it is assumed that approximately 70% of the length of each pile can be placed using vibratory pile driving, with impact driving used to finalize pile placement. Piles will be installed using vibratory methods or other non-impact driving methods for the intakes, wherever feasible, to minimize adverse effects on fish and other aquatic organisms. However, the degree to which vibratory driving can be performed effectively is unknown at this time due to as yet undetermined geologic conditions at the construction sites. The remaining pile driving would be conducted using an impact pile driver. Once constructed, if the foundation design for either the Delta intakes or HORG requires pile driving, such work would be conducted from within the cofferdam; it is still undetermined if the foundation would use piles or concrete-in-drilled-hole methods, which does not require pile driving. If driven foundation piles are included in the design, DWR will require contractors to isolate pile driving activities within dewatered cofferdams.

The barge docks would require pile driving of 24-inch tubular steel piles in the water. DWR will work with contractors to minimize pile driving, particularly impact pile driving, by using floating docks instead of pile-supported docks, wherever feasible considering the load requirements of the landings and the site conditions; floating docks would need fewer piles. If dock piles for barge landings cannot be installed using vibratory methods, the construction contractor will use a bubble curtain or other attenuation device to minimize underwater noise.

Table 6.3-6 shows the approximate channel widths, timing, and duration of pile driving for each facility or structure where pile driving is proposed to occur in open water or on land within 200 feet of open water.

Table 6.3-6. Pile driving sites and durations.

Facility or Structure	Average Width of Water Body (feet)	Year of Construction	Duration of Pile Driving (days)[1]
Intake 2 Cofferdam	700	Year 8	42
Intake 2 Foundation	700	Year 9	19
Intake 3 Cofferdam	500	Year 7	42
Intake 3 Foundation	500	Year 8	14
Intake 5 Cofferdam	600	Year 5	42
Intake 5 Foundation	600	Year 6	19
Barge Landings	265–1,030	Year 1 and 2	2
CCF Cofferdams	10,500	Year 9 and 10	337
CCFN Siphon Inlet	10,500	Year 9	72
CCFN Siphon Outlet	10,500	Year 7	72
HORG Cofferdams	150	Year 7	18
HORG Foundation	150	Year 7	4

Notes
[1] Indicates number of days required for one pile driver. Work may be completed more quickly if multiple pile driving rigs operate concurrently.

Conservation Measures

This section is intended to articulate the general construction and species-specific avoidance and minimization measures during construction. DWR will ground-truth impact areas prior to initiating proposed actions to determine the extent of suitable habitat present. After work is complete, DWR will field-verify the impacts that have actually occurred with implementation of avoidance and minimization measures. DWR will track predicted and actual impacts at each project site and provide that information in annual compliance reporting (outlined in Chapter 3, Section 3.7.4.2 of the CWF BA).

General Avoidance and Minimization Measures

Appendix 3.4 describes the general avoidance and minimization measures to reduce or avoid adverse effects to listed species that may result from the proposed action. Table 6.3-7 briefly summarizes the measures below. Refer to CWF BA Appendix 3.F for detailed descriptions.

Table 6.3-7. Summary of the General Avoidance and Minimization Measures.

Number	Title	Summary
AMM1	Worker Awareness Training	Includes procedures and training requirements to educate construction personnel on the applicable environmental rules and regulations, the types of sensitive resources in the project area, and the measures required to avoid and minimize effects on these resources.
AMM2	Construction Best Management Practices and Monitoring	Standard practices and measures that will be implemented prior to, during, and after construction to avoid or minimize effects of construction activities on sensitive resources (e.g., species, habitat), and monitoring protocols for verifying the protection provided by the implemented measures.
AMM3	Stormwater Pollution Prevention Plan	Includes measures that will be implemented to minimize pollutants in stormwater discharges during and after construction, and that will be incorporated into a stormwater pollution prevention plan to prevent water quality degradation related to project area runoff to receiving waters.
AMM4	Erosion and Sediment Control Plan	Includes measures that will be implemented for ground-disturbing activities to control short-term and long-term erosion and sedimentation effects and to restore soils and vegetation in areas affected by construction activities, and that will be incorporated into plans developed and implemented as part of the National Pollutant Discharge Elimination System permitting process for covered activities.
AMM5	Spill Prevention, Containment, and Countermeasure Plan	Includes measures to prevent and respond to spills of hazardous material that could affect navigable waters, as well as emergency notification procedures.
AMM6	Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material	Includes measures for handling, storage, and disposal of excavation or dredge spoils and reusable tunnel material, including procedures for the chemical characterization of this material or the decant water to comply with permit requirements, and reducing potential effects on aquatic habitat, as well as specific measures to avoid and minimize effects on species in the areas where reusable tunnel material would be used or disposed.
AMM7	Barge Operations Plan	Includes measures to avoid or minimize effects on aquatic species and habitat related to barge operations by establishing specific protocols for the operation of all project-related vessels at the construction and/or barge landing sites. Also includes monitoring protocols to verify compliance with the plan and procedures for contingency plans.
AMM8	Fish Rescue and Salvage Plan	Includes measures that detail procedures for fish rescue and salvage to avoid and minimize the number of Chinook salmon, steelhead, green sturgeon, and other listed species of fish stranded during construction activities, especially during the placement and removal of cofferdams at the intake construction sites.
AMM9	Underwater Sound Control and Abatement Plan	Includes measures to minimize the effects of underwater construction noise on fish, particularly from impact pile driving activities. Potential effects of pile driving will be minimized by restricting work to the least sensitive period of the year and by controlling or abating underwater noise generated during pile driving.

AMM10	Methylmercury Management	Design and construct wetland mitigation sites to minimize ecological risks of methylmercury production.
AMM11	Design Standards and Building Codes	Ensure that the standards, guidelines, and codes, which establish minimum design criteria and construction requirements for project facilities, will be followed. Follow any other standards, guidelines, and code requirements that are promulgated during the detailed design and construction phases and during operation of the conveyance facilities.
AMM12	Transmission Line Design and Alignment Guidelines	Design the alignment of proposed transmission lines to minimize impacts on sensitive terrestrial and aquatic habitats when siting poles and towers. Restore disturbed areas to preconstruction conditions. In agricultural areas, implement additional BMPs. Site transmission lines to avoid greater sandhill crane roost sites or, for temporary roost sites, relocate roost sites prior to construction if needed. Site transmission lines to minimize bird strike risk.
AMM13	Noise Abatement	Develop and implement a plan to avoid or reduce the potential in-air noise impacts related to construction, maintenance, and operations.
AMM14	Hazardous Material Management	Develop and implement site-specific plans that will provide detailed information on the types of hazardous materials used or stored at all sites associated with the water conveyance facilities and required emergency-response procedures in case of a spill. Before construction activities begin, establish a specific protocol for the proper handling and disposal of hazardous materials.
AMM15	Construction Site Security	Provide all security personnel with environmental training similar to that of onsite construction workers, so that they understand the environmental conditions and issues associated with the various areas for which they are responsible at a given time.
AMM16	Fugitive Dust Control	Implement basic and enhanced control measures at all construction and staging areas to reduce construction-related fugitive dust and ensure the project commitments are appropriately implemented before and during construction, and that proper documentation procedures are followed.
AMM17	Notification of Activities in Waterways	Before in-water construction or maintenance activities begin, notify appropriate agency representatives when these activities could affect water quality or aquatic species.

Delta Smelt

DWR proposes to implement varying in-water work windows within the Delta for components of the PA. Table 6.3-8 provides a breakdown of the proposed timing for in-water work for the various preconstruction and construction phases.

Table 6.3-8. Proposed timing for in-water work during the preconstruction and construction phases.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CWF Conveyance System Components												
Geotechnical Explorations												
Barge Landings												
North Delta Diversions												
Tunneled Conveyance	No proposed in-water work											
Intermediate Forebay	No proposed in-water work											
Clifton Court Forebay												
Connections to the Jones Pumping Plant												
Power Supply and Grid Connections	No proposed in-water work											
Head of Old River Gate												
Temporary Access and Work Areas	No proposed in-water work											

Riparian Brush Rabbit

1. DWR will implement the following measures to avoid and minimize noise and lighting related effects on riparian brush rabbit:
   a. Establish a 1,200-foot no disturbance buffer between any project activities and suitable habitat.
   b. Establish a 1,400-foot buffer between any lighting and pile driving and suitable habitat.
   c. Screen all lights and direct them down toward work activities away from potential occupied habitat. A Service-approved biologist will ensure that lights are properly directed at all times.
   d. Operate portable lights at the lowest allowable wattage and height, while in accordance with the National Cooperative Highway Research Program's *Report 498: Illumination Guidelines for Nighttime Highway Work*.
   e. Limit construction during nighttime hours (10:00 p.m. to 7:00 a.m.) such that construction noise levels do not exceed 50 dBA L_{max} at the nearest residential land uses.
   f. Limit pile driving to daytime hours (7:00 a.m. to 6:00 p.m.).
2. Geotechnical exploration for the PA will not occur in or near riparian brush rabbit suitable riparian habitat.
3. Power supply and grid connections for the PA will not occur within or near riparian brush rabbit suitable riparian habitat.
4. Restoration activities for the PA will not occur within riparian brush rabbit suitable riparian habitat, or within 100 feet of such habitat.

San Joaquin Kit Fox

Conservation Measures for Geotechnical Explorations

1. Geotechnical work in and within 200 feet of San Joaquin kit fox habitat will be limited to daytime hours.

2. Vehicles will access the work site following the shortest possible route from the levee road. All site access and staging shall limit disturbance to the riverbank or levee as much as possible and avoid sensitive habitats. When possible, existing ingress and egress points shall be used. The Service-approved biologist for San Joaquin kit fox will survey the sites for San Joaquin kit fox no less than 14 days and no more than 30 days prior to beginning of geotechnical exploration activities.

3. Project activities will not take place at night when San Joaquin kit foxes are most active.

4. Off-road traffic outside of designated project areas will be prohibited.

5. A Service-approved biologist will be stationed near the work areas to assist the construction crew with environmental issues as necessary. If San Joaquin kit foxes are encountered by a Service-approved biological monitor during construction, activities shall cease until appropriate corrective measures have been completed or it has been determined that the species will not be harmed.

6. To prevent inadvertent entrapment of San Joaquin kit foxes or other animals during the construction phase of a project, all excavated, steep-walled holes or trenches more than 2 feet (0.6 m) deep will be covered at the close of each working day by plywood or similar materials, or provided with one or more escape ramps constructed of earth fill or wooden planks. Before such holes or trenches are filled, they will be thoroughly inspected for trapped animals.

7. All construction pipes, culverts, or similar structures with a diameter of 4 inches (10 cm) or greater that are stored at a construction site for one or more overnight periods should be thoroughly inspected for San Joaquin kit foxes before the pipe is used or moved in any way. If a San Joaquin kit fox is discovered inside a pipe, construction activities will be halted and that section of pipe will not be moved until the Service-approved biologist monitoring the project construction site has contacted the Service. Once the Service has given the construction monitor instructions on how to proceed or the San Joaquin kit fox has escaped on its own volition, the pipe may be moved.

8. No firearms shall be allowed on the project site.

9. Noise will be minimized to the extent possible at the work site to avoid disturbing San Joaquin kit foxes.

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10. To prevent harassment, mortality of San Joaquin kit foxes or destruction of dens by dogs or cats, no pets are permitted on project sites.

11. Rodenticides and herbicides will not be used during geotechnical exploration.

12. If a San Joaquin kit fox is incidentally injured or killed or entrapped, the Service-approved biological monitor shall immediately report the incident to the Service. Notification must include the date, time, and location of the incident or of the finding of a dead or injured animal and any other pertinent information.

Conservation Measures for Construction Activities

13. Within 14 to 30 days prior to ground disturbance related to PA activities, a Service-approved biologist with experience surveying for and observing the species will conduct preconstruction surveys in those areas identified as having suitable habitat per the habitat model described in Section 4.A.6.6, *Suitable Habitat Definition*, of the CWF BA or per the recommendation of the Service-approved biologist. The Service-approved biologist will survey the worksite footprint and the area within 200 feet beyond the footprint to identify known or potential San Joaquin kit fox dens. Adjacent parcels under different land ownership will not be surveyed unless access is granted within the 200-foot radius of the construction activity. The Service-approved biologists will conduct these searches by systematically walking 30- to 100-foot-wide transects throughout the survey area; transect width will be adjusted based on vegetation height and topography (California Department of Fish and Game 1990). The Service-approved biologist will conduct walking transects such that 100% visual coverage of the worksite footprint is achieved. Dens will be classified in one of the following four den status categories outlined in the *Standardized Recommendations for Protection of the Endangered San Joaquin Kit Fox Prior to or During Ground Disturbance*[13]. Written results of the surveys will be submitted to Service within five calendar days of the completion of surveys and prior to the beginning of ground disturbance and/or construction activities in San Joaquin kit fox modeled habitat. Also, the Service-approved biologist will flag all potential small mammal burrows within 50 feet of the worksite to alert biological and work crews of their presence.

    a. **Potential den.** Any subterranean hole within the species' range that has entrances of appropriate dimensions for which available evidence is sufficient to conclude that it is being used or has been used by a San Joaquin kit fox. Potential dens comprise any suitable subterranean hole or any den or burrow of another species (e.g., coyote, badger, red fox, or ground squirrel) that otherwise has appropriate characteristics for San Joaquin kit fox use. If a potential den is found, the Service-approved biologist will establish a 50-foot buffer using flagging.

[13] The guidelines can be accessed at: https://www.fws.gov/sacramento/es/survey-protocols-guidelines/Documents/kitfox_standard_rec_2011.pdf

b. **Known den.** Any existing natural den or artificial structure that is used or has been used at any time in the past by a San Joaquin kit fox. Evidence of use may include historical records; past or current radiotelemetry or spotlighting data; San Joaquin kit fox sign such as tracks, scat, and/or prey remains; or other reasonable proof that a given den is being or has been used by a San Joaquin kit fox.

c. **Natal or pupping den.** Any den used by San Joaquin kit foxes to whelp and/or rear their pups. Natal/ pupping dens may be larger with more numerous entrances than dens occupied exclusively by adults. These dens typically have more San Joaquin kit fox tracks, scat, and prey remains near the den and may have a broader apron of matted dirt and/or vegetation at one or more entrances. A natal den, defined as a den in which San Joaquin kit fox pups are actually whelped but not necessarily reared, is a more restrictive version of the pupping den. In practice, however, it is difficult to distinguish between the two; therefore, for purposes of this definition, either term applies. If a natal den is discovered, a buffer of at least 200 feet will be established using fencing.

d. **Atypical den.** Any artificial structure that has been or is being occupied by a San Joaquin kit fox. Atypical dens may include pipes, culverts, and diggings beneath concrete slabs and buildings. If an atypical den is discovered, the Service-approved biologist will establish a 50-foot buffer using flagging.

14. If an atypical, natal, known or potential San Joaquin kit fox den is discovered at the worksite, the den will be monitored for three days by a Service-approved biologist using a tracking medium or an infrared beam camera to determine if the den is currently being used.

15. Unoccupied potential, known, or atypical dens will be destroyed immediately to prevent subsequent use. The den will be fully excavated by hand, filled with dirt, and compacted to ensure that San Joaquin kit foxes cannot re-enter or use the den during the construction period.

16. If an active natal or pupping den is found, Service will be notified immediately. The den will not be destroyed until the pups and adults have vacated and then only after further coordination with Service. All known dens will have at least a 100-foot buffer established using fencing.

17. If San Joaquin kit fox activity is observed at the potential, known, or atypical den during the preconstruction surveys, den use will be actively discouraged, as described below, and monitoring will continue for an additional five consecutive days from the time of the first observation to allow any resident animals to move to another den. For dens other than natal or pupping dens, use of the den can be discouraged by partially plugging the entrance with soil such that any resident animal can easily escape. Once the den is determined to be unoccupied, it may be excavated under the direction of the Service-approved biologist. Alternatively, if the animal is still present after five or more

consecutive days of plugging and monitoring, the den may have to be excavated by hand when, in the judgment of a Service-approved biologist, it is temporarily vacant (i.e., during the animal's normal foraging activities). If at any point during excavation a San Joaquin kit fox is discovered inside the den, the excavation activity will cease immediately and monitoring of the den, as described above, will be resumed. Destruction of the den may be completed when, in the judgment of the Service-approved biologist, the animal has escaped from the partially destroyed den.

18. Construction and operational requirements from *Standardized Recommendations for Protection of the San Joaquin Kit Fox prior to or during Ground Disturbance* or the latest guidelines will be implemented. The guidelines can be accessed at: https://www.fws.gov/sacramento/es/survey-protocols-guidelines/Documents/kitfox_standard_rec_2011.pdf

19. If potential, known, atypical, or natal or pupping dens are identified at the worksite or within a 200-foot buffer, exclusion zones around each den entrance or cluster of entrances will be demarcated. The configuration of exclusion zones will be circular, with a radius measured outward from the den entrance(s). No activities will occur within the exclusion zones. Exclusion zone radii for atypical dens and suitable dens will be at least 50 feet and will be demarcated with four to five flagged stakes. Exclusion zone radii for known dens will be at least 100 feet and will be demarcated with staking and flagging that encircle each den or cluster of dens but do not prevent access to the den by the foxes.

20. Vehicles will observe a daytime speed limit of 20-mph throughout the worksite, where it is practical and safe to do so, except on county roads and state and Federal highways; vehicles will observe a nighttime speed limit of 10-mph throughout the worksite; this is particularly important at night when San Joaquin kit foxes are most active. Nighttime construction in or adjacent to San Joaquin kit fox habitat will be minimized to the greatest extent practicable.

21. To prevent inadvertent entrapment of kit foxes or other animals during construction, all excavated, steep-walled holes or trenches more than 2 feet deep will be covered at the close of each working day by plywood or similar materials. If the trenches cannot be closed, one or more escape ramps constructed of earthen-fill or wooden planks will be installed. Before such holes or trenches are filled, they will be thoroughly inspected for trapped animals. If at any time a trapped or injured kit fox is discovered, the Service will be contacted.

22. San Joaquin kit foxes are attracted to den-like structures such as pipes and may enter stored pipes and become trapped or injured. All construction pipes, culverts, or similar structures with a diameter of 4 inches or greater that are stored at a construction site within suitable San Joaquin kit fox habitat for one or more overnight periods will be thoroughly inspected for San Joaquin kit foxes before the pipe is subsequently buried, capped, or otherwise used or moved in any way. If a San Joaquin kit fox is discovered inside a pipe, that section of pipe will not be moved until the Service has been consulted.

If necessary, and under the direct supervision of the Service-approved biologist, the pipe may be moved only once to remove it from the path of construction activity until the fox has escaped.

23. All food-related trash items such as wrappers, cans, bottles, and food scraps will be disposed of in securely closed containers and removed at least once a week from a construction site in suitable kit fox habitat.

24. No firearms will be allowed at worksites.

25. No pets, such as dogs or cats, will be permitted at worksites to prevent harassment, mortality of kit foxes, or destruction of dens.

26. Use of rodenticides and herbicides in areas that are in modeled San Joaquin kit fox habitat will be prohibited.

27. The Service-approved biologist for San Joaquin kit fox will be the contact source for any employee or contractor who might incidentally kill or injure a San Joaquin kit fox or who finds a dead, injured, or entrapped San Joaquin kit fox.

28. An employee education program (AMM1, *Worker Awareness Training*) will be conducted for any activities that will be conducted in San Joaquin kit fox habitat. The program will consist of a brief presentation by the Service-approved biologist for San Joaquin kit fox to explain endangered species concerns to all personnel who will be working in the construction area. The program will include the following: A description of the San Joaquin kit fox and its habitat needs; a report of the occurrence of San Joaquin kit fox at the worksite; an explanation of the status of the species and its protection under the Endangered Species Act; and a list of measures being taken to reduce impacts on the species during construction and operations. A fact sheet conveying this information will be prepared for distribution to all worksite personnel.

29. Upon completion of construction at a worksite, all areas subject to temporary ground disturbances will be re-contoured if necessary, and revegetated to promote restoration of the area to preconstruction conditions. An area subject to "temporary" disturbance means any area that is disturbed during construction, but after construction will be revegetated. Appropriate methods and plant species used to revegetate such areas will be determined on a site-specific basis in consultation with the Service.

30. Any personnel who are responsible for incidentally killing or injuring a San Joaquin kit fox will immediately report the incident to the Service-approved biologist. The Service-approved biologist will contact the Service immediately in the case of a dead, injured, or entrapped San Joaquin kit fox. The Service contact is the Assistant Field Supervisor of Endangered Species, at Bay-Delta Fish & Wildlife Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814, (916) 930-5604. Notification must include the date, time, and location of the incident or of the finding of a dead or injured animal and any other pertinent information.

31. New sightings of San Joaquin kit fox will be reported to the California Natural Diversity Database (CNDDB). A copy of the reporting form and a topographic map clearly marked with the location of where the San Joaquin kit fox was observed will also be provided to Service at the address below.

32. Following completion of Clifton Court Forebay modifications, the area to be operated and maintained within suitable San Joaquin kit fox habitat will be fenced with chain link fencing that prevents entry of San Joaquin kit fox. The fencing will be inspected annually to ensure there are no holes or gaps in the fencing that would allow San Joaquin kit foxes to enter.

33. Prior to final design for the transmission line alignments, a Service-approved biologist will survey potential transmission line locations where suitable San Joaquin kit fox habitat is present. These surveys will be conducted as described above, except that the surveys will be conducted early enough to inform the final transmission line design but no less than 14 days and no more than 30 days prior to beginning of PA activities. Therefore, multiple surveys may be required. If any occupied dens are found, the Service will be immediately contacted and the project will be designed to avoid the occupied dens by 200 feet. After the final transmission line alignment has been determined, the construction conservation measures will be applied.

California Least Tern

1. If suitable nesting habitat for California least tern (flat, unvegetated areas near aquatic foraging habitat) is identified during planning-level surveys, at least three preconstruction surveys for this species will be conducted during the nesting season by a Service-approved biologist with experience observing the species and its nests. Projects will be designed to avoid loss of California least tern nesting colonies. No construction will take place within 200 feet of a California least tern nest during the nesting season (April 15 to August 15, or as determined through surveys).

2. Only inspection, maintenance, research, or monitoring activities may be performed during the least tern breeding season in occupied least tern nesting habitat with Service and CDFW approval under the supervision of a qualified biologist.

3. Safe havens, RTM, and transmission lines will fully avoid California least tern foraging habitat. Transmission lines may cross waterways, but must avoid disturbance of open water habitat.

Western Yellow-Billed Cuckoo

Measures for Activities with Fixed Locations

1. Prior to construction, all suitable western yellow-billed cuckoo habitat in the construction area will be surveyed, with surveys performed in accordance with any required Service survey protocols and permits applicable at the time of construction.

2. If surveys find cuckoos in the area where vegetation will be removed, vegetation removal will be done when cuckoos are not present.
3. If an activity is to occur within 1,200 feet of western yellow-billed cuckoo habitat (or within 2,000 feet if pile driving will occur) during the period of from June 15 through September 1, the following measures will be implemented to avoid noise effects on migrating western yellow-billed cuckoos.
4. Prior to the construction, a noise expert will create a noise contour map showing the 60 dBA noise contour specific to the type and location of construction to occur in the area.
5. During the period between June 15 and September 1, a Service-approved biologist will survey any suitable migratory habitat for yellow-billed cuckoos within the 60 dBA noise contour on a daily basis during a two-week period prior to construction. While construction is occurring within this work window, the Service-approved biologist will conduct daily surveys in any suitable habitat where construction related noise levels could exceed 60 dBA (A-weighted decibel) L_{eq} (1 hour). If a yellow-billed cuckoo is found, sound will be limited to 60 dBA in the habitat being used until the Service-approved biologist has confirmed that the bird has left the area.
6. Limit pile driving to daytime hours (7:00 a.m. to 7:00 p.m.).
7. Locate, store, and maintain portable and stationary equipment as far as possible from suitable western yellow-billed cuckoo habitat.
8. Employ preventive maintenance including practicable methods and devices to control, prevent, and minimize noise.
9. Route truck traffic in order to reduce construction noise impacts and traffic noise levels within 1,200 feet of suitable western yellow-billed cuckoo migratory habitat during migration periods.
10. Limit trucking activities (e.g., deliveries, export of materials) to the hours of 7:00 a.m. to 10:00 p.m.
11. Screen all lights and direct them down toward work activities away from migratory habitat. A Service-approved biologist will ensure that lights are properly directed at all times.
12. Operate portable lights at the lowest allowable wattage and height, while in accordance with the National Cooperative Highway Research Program's *Report 498: Illumination Guidelines for Nighttime Highway Work*.

Measures for Activities with Fixed Locations

Geotechnical Exploration

1. During geotechnical activities, a Service-approved biologist will be onsite to avoid the loss or degradation of suitable western yellow-billed cuckoo habitat by exploration activities.

Safe Haven Work Areas

2. During the siting phase of safe haven construction, a Service-approved biologist will work with the engineers to avoid loss or degradation of suitable western yellow-billed

cuckoo migratory habitat. This includes ensuring that safe haven work areas are not sited in western yellow-billed cuckoo habitat. This also includes ensuring noise from safe haven work areas do not exceed 60 dBA at nearby western yellow-billed cuckoo migratory habitat.

Power Supply and Grid Connections

3. The final transmission line alignment will be designed to minimize removal of western yellow-billed cuckoo migratory habitat by removing no more than four acres of this habitat. To minimize the chance of western yellow-billed cuckoo bird strikes at transmission lines, bird strike diverters will be installed on project and existing transmission lines in a configuration that research indicates will reduce bird strike risk by at least 60% or more. Bird strike diverters placed on new and existing lines will be periodically inspected and replaced as needed until or unless the project or existing line is removed. The most effective and appropriate diverter for minimizing strikes on the market according to best available science will be selected.

Safe Havens

4. Safe haven sites will avoid western yellow-billed cuckoo migratory habitat. All work associated with safe haven sites will be conducted during daylight hours, and will not require any lighting.

Giant Garter Snake

Ground-Truthed Habitat Assessment and Giant Garter Snake Surveys

1. When each site is available for surveys, a giant garter snake expert, approved by the Service and CDFW, will then delineate giant garter snake habitat at each project site, based on the definition of suitable habitat, including both aquatic and upland habitat.

2. Once habitat has been delineated, the giant garter snake expert may use giant garter snake surveys performed using a method approved by the Service to determine presence/absence of the species on the project site to enable further determination of mitigation requirements.

3. For sites where such surveys are performed, the surveys will conform to protocol and reporting need per a plan to be jointly developed by DWR and the Service to provide population and occurrence data for the species in the Delta.

4. To the greatest extent possible, identified and delineated habitat will be completely avoided.

Measures for Activities with Fixed Locations

5. Initiate construction and clear suitable habitat in the summer months, between May 1 and October 1, and avoid giant garter snake habitat during periods of brumation (between October 1 and May 1). Suitability of aquatic and upland habitat characteristics will be determined by the Service-approved biologist consistent with the Service habitat description. Once a construction site has been cleared and exclusionary fencing is in place, work within the cleared area can occur between October 1 and May 1.

6. To the extent practicable, conduct all activities within paved roads, farm roads, road shoulders, and similarly disturbed and compacted areas; confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities.

7. For construction activities, dredging, and any conveyance facility maintenance involving heavy equipment, giant garter snake aquatic and upland habitat that can be avoided will be clearly delineated on the work site, with exclusionary fencing and signage identifying these areas as sensitive. The exclusionary fencing will be installed during the active period for giant garter snake (May 1–October 1) and will consist of 3-foot-tall non-monofilament silt fencing extending to 6 inches below ground level.

8. For activities requiring exclusionary fencing, the Service-approved biological monitor and construction supervisor will be responsible for checking the exclusionary fences around the work areas daily to ensure that they are intact and upright. Any necessary repairs will be immediately addressed. The exclusionary fencing will remain in place for the duration of construction.

9. The Service-approved biologist will also survey suitable aquatic and upland habitat in the entire work site for the presence of giant garter snakes, as well at 50 feet outside the work site exclusion fencing in suitable habitat.

10. If exclusionary fencing is found to be compromised, a survey of the exclusion fencing and the area inside the fencing will be conducted immediately preceding construction activity that occurs in delineated giant garter snake habitat or in advance of any activity that may result in take of the species. The Service-approved biologist will search along exclusionary fences, in pipes, and beneath vehicles before they are moved. Any giant garter snake found will be captured and relocated to suitable habitat a minimum of 200 feet outside of the work area in a location that is approved by the Service and CDFW prior to resumption of construction activity.

11. All construction personnel, and personnel involved in operations and maintenance in or near giant garter snake habitat, will attend worker environmental awareness. This training will include instructions to workers on how to recognize giant garter snakes, their habitat(s), and the nature and purpose of protection measures.

12. Within 24 hours prior to construction activities, dredging, or maintenance activities requiring heavy equipment, a Service-approved biologist will survey all of the activity area not protected by exclusionary fencing where giant garter snake could be present. This survey of the work area will be repeated if a lapse in construction or dredging activity of two weeks or greater occurs during the aestivation period (October 1 through May 1) or if the lapse in construction activity is more than 12 hours during active season (May 1–October 1). If a giant garter snake is encountered during surveys or construction, cease activities until appropriate corrective measures have been completed, it has been determined that the giant garter snake will not be harmed, or the giant garter snake has left the work area.

13. The Service-approved biological monitor will help guide access and construction work around wetlands, active rice fields, and other sensitive habitats capable of supporting giant garter snake, to minimize habitat disturbance and risk of injuring or killing giant garter snakes.

14. Report all observations of giant garter snakes to the Service-approved biological monitor.

15. Maintain all construction and operations and maintenance equipment to prevent leaks of fuel, lubricants, and other fluids and use extreme caution when handling and or storing chemicals (such as fuel and hydraulic fluid) near waterways, and abide by all applicable laws and regulations. Follow all applicable hazardous waste BMPs and keep appropriate materials on site to contain, manage, and clean up any spills as described in Appendix 3.F.

16. Conduct service and refueling procedures in uplands in staging areas and at least 200 feet away from giant garter snake upland habitat and waterways when practicable. See also Appendix 3.F.

17. During construction and operation and maintenance activities in and near giant garter snake habitat, employ erosion (non-monofilament silt fence), sediment, material stockpile, and dust control (BMPs on site). Avoid fill or runoff into wetland areas or waterways to the extent practicable.

18. Return temporary work areas to pre-existing contours and conditions upon completion of work. Where re-vegetation and soil stabilization are necessary in non-agricultural habitats, revegetate with appropriate non-invasive native plants at a density and structure similar to that of preconstruction conditions.

19. Properly contain and remove from the worksite all trash and waste items generated by construction and crew activities to prevent the encouragement of predators such as raccoons and coyotes from occupying the site.

20. Permit no pets, campfires, or firearms at the worksite.

21. Store equipment in designated staging areas at least 200 feet away from giant garter snake aquatic habitat to the extent practicable.

22. Confine any vegetation clearing to the minimum area necessary to facilitate construction activities.

23. Limit vehicle speed to 10 miles per hour (mph) on access routes (except for public roads and highways) and within work areas that are within 200 feet of giant garter snake aquatic habitat but not protected by exclusion fencing to avoid running over giant garter snakes.

24. Visually check for giant garter snakes under vehicles and equipment prior to moving them. Cap all materials onsite (conduits, pipe, etc.), precluding wildlife from becoming entrapped. Check any crevices or cavities in the work area where individuals may be present including stockpiles that have been left for more than 24 hours where cracks/crevices may have formed.

For activities that will occur within the giant garter snake inactive season (October 2 through April 30), and will last more than two weeks, DWR will implement the following additional avoidance and minimization measures.

25. For proposed activities that will occur within suitable aquatic giant garter snake habitat during the active giant garter snake season (May 1 through October 1), prior to proposed construction activities that will commence during the inactive period, and when unavoidable, all aquatic giant garter snake habitat will be dewatered for at least 14 days prior to excavating or filling the dewatered habitat. Dewatering is necessary because aquatic habitat provides prey and cover for giant garter snake; dewatering serves to remove the attractant, and increase the likelihood that giant garter snake will move to other available habitat. Any deviation from this measure will be done in coordination with, and with approval of, the Service.

26. Following dewatering of aquatic habitat, all potential impact areas that provide suitable aquatic or upland giant garter snake habitat will be surveyed for giant garter snake by the Service-approved biologist. If giant garter snakes are observed, they will be passively allowed to leave the potential impact area, or the Service will be consulted to determine the appropriate course of action for removing giant garter snake from the potential impact area.

27. Once habitat is deemed giant garter snake-free, exclusion fencing will be constructed around the construction site so no snakes may re-enter prior to or during construction.

The following avoidance and minimization measures will be applied to maintenance activities in suitable aquatic habitat, as delineated by a Service- approved biologist, and uplands within 200 feet of suitable aquatic habitat, to minimize effects on the giant garter snake.

28. Vegetation control will take place during the active period (May 1 through October 1) when snakes are able to move out of areas of activity.

29. Trapping or hunting methods will be used for rodent control, rather than poison bait. All rodent control methods will be approved by the Service. If trapping or other non-poison methods are ineffective, the Service will be consulted to determine the best course of action.

30. Movement of heavy equipment will be confined to outside 200 feet of the banks of giant garter snake aquatic habitat to minimize habitat disturbance.

31. All construction personnel, and personnel involved in operations and maintenance in or near giant garter snake habitat, will attend worker environmental awareness training as described in Appendix 3.F. This training will include instructions to workers on how to recognize giant garter snakes, their habitat(s), and the nature and purpose of protection measures.

Measures for Activities with Flexible Locations

Geotechnical Activities

32. Geotechnical activities will avoid giant garter snake aquatic habitat.

33. Geotechnical activity in giant garter snake upland habitat will be confined to the giant garter snake's active period (May 1 through October 1).

34. Movement of heavy equipment will be confined to existing roads as much as possible, and will avoid suitable upland giant garter snake habitat.

35. Construction personnel will receive Service-approved worker environmental awareness training instructing workers to recognize giant garter snakes and their habitat.

Safe Haven Work Areas

36. Safe haven work areas will avoid giant garter snake aquatic and upland habitat.

Power Lines and Grid Connections

37. Giant garter snake avoidance and minimization measures for transmission lines will be the same as described in *Measures for Activities with Fixed Locations.* These power lines and grid connections will be designed to avoid giant garter snake aquatic habitat.

The following avoidance and minimization measures will be applied to maintenance activities in suitable aquatic habitat, as delineated by a Service-approved biologist, and

uplands within 200 feet of suitable aquatic habitat, to minimize effects on the giant garter snake.

38. Vegetation control will take place during the active period (May 1 through October 1) when snakes are able to move out of areas of activity.

39. Trapping or hunting methods will be used for rodent control, rather than poison bait. All rodent control methods will be approved by the Service. If trapping or other non-poison methods are ineffective, the Service will be consulted to determine the best course of action.

40. Movement of heavy equipment will be confined to outside 200 feet of the banks of potential giant garter snake habitat to minimize habitat disturbance.

41. Construction personnel will receive Service-approved worker environmental awareness training instructing workers to recognize giant garter snakes and their habitat.

California Red-Legged Frog

1. A Service-approved biologist will conduct a field evaluation of the California red-legged frog modeled habitat to ascertain the distribution of suitable upland and aquatic habitat in the worksite vicinity. Surveys within suitable upland habitat will identify suitable aquatic features that may not have been identified during the habitat modeling.

Measures for Activities with Fixed Locations

2. If aquatic habitat cannot be avoided, aquatic habitats in potential work areas, will be surveyed for tadpoles and egg masses. If California red-legged frog tadpoles or egg masses are found, and the aquatic habitat cannot be avoided, the Service will be contacted, and if determined to be appropriate, measures will be developed to relocate tadpoles and eggs to the nearest suitable aquatic habitat, as determined by the Service-approved biologist.

3. The Service-approved biologist will conduct employee education training for employees working on earthmoving and/or construction activities. Personnel will be required to attend the presentation that will describe the California red-legged-frog avoidance, minimization, and conservation measures, legal protection of the animal, and other related issues. All attendees will sign an attendance sheet along with their printed name, company or agency, email address, and telephone number. The original sign-in sheet will be sent to the Service within seven (7) calendar days of the completion of the training.

4. Preconstruction surveys will be implemented after the planning phase and prior to any ground-disturbing activity.

5. The Service-approved biological monitor and construction supervisor will be responsible for checking the exclusion fences around the work areas daily to ensure that they are intact and upright. This will be especially critical during rain events, when flowing water can easily dislodge the fencing. Any necessary repairs will be immediately addressed. The amphibian exclusion fencing will remain in place for the duration of construction.

6. If the exclusion fence is found to be compromised at any time, a survey will be conducted immediately preceding construction activity that occurs in designated California red-legged frog habitat or in advance of any activity that may result in take of the species. The Service-approved biologist will search along exclusion fences, in pipes, and beneath vehicles before they are moved. The survey will include a careful inspection of all potential hiding spots, such as along exclusion fencing, large downed woody debris, and the perimeter of ponds, wetlands, and riparian areas. Any California red-legged frogs found will be captured and relocated to suitable habitat, a minimum of 300 feet outside of the work area that has been identified in the relocation plan (described below) and approved by a Service-approved biologist prior to commencement of construction.

7. Initial ground-disturbing activities will not be conducted between November 1 and March 31 in areas identified during the planning stages as providing suitable California red-legged frog habitat, to avoid the period when they are most likely to be moving through upland areas. Once the initial ground disturbance has occurred, the area has been cleared, and exclusionary fencing is in place, work within the disturbed area can occur outside the construction window.

8. Surface-disturbing activities will be designed to minimize or eliminate effects on rodent burrows that may provide suitable cover habitat for California red-legged frog. Surface-disturbing activities will avoid areas with a high concentration of burrows to the greatest extent practicable. In addition, when a concentration of burrows is present in a worksite, the area will be staked or flagged to ensure that work crews are aware of their location and to facilitate avoidance of the area.

9. No initial clearing activities will occur during rain events, or within 24 hours following a rain event, prior to clearing a site and installing exclusionary fencing. A Service-approved biologist will check the exclusion fencing daily to ensure it is intact, and if there are any breaches in the fencing, the Service-approved biologist will survey the work area for California red-legged frogs. If the species is found, the Service-approved biologist will relocate the frog consistent with an approved relocation plan.

10. To the maximum extent practicable, nighttime construction will be minimized or avoided when working in suitable California red-legged frog habitat. Because dusk and dawn are often the times when the California red-legged frog is most actively moving and foraging, to the greatest extent practicable, earthmoving and construction activities will cease no less than 30 minutes before sunset and will not begin again prior to no less than 30 minutes after sunrise. Except when necessary for driver or pedestrian safety, artificial lighting at a worksite will be prohibited during the hours of darkness when working in

suitable California red-legged frog habitat. No more than 24 hours prior to any ground disturbance that could affect potential California red-legged frog habitat, preconstruction surveys for California red-legged frog will be conducted by a Service-approved biologist. These surveys will consist of walking the worksite limits. The Service-approved biologist will investigate all potential areas that could be used by the California red-legged frog for feeding, breeding, sheltering, movement or other essential behaviors. This includes an adequate examination of mammal burrows, such as California ground squirrels or gophers. If any adults, subadults, juveniles, tadpoles, or eggs are found, the Service-approved biologist will contact the Service to determine if moving any of the individuals to a pre-approved location within the relocation plan is appropriate. If the Service approves moving animals, the Service-approved biologist will be given sufficient time to move the animals from the work site before ground disturbance is initiated. Only Service-approved biologists will capture, handle, and monitor the California red-legged frog.

11. If work must be conducted at night, all lighting will be directed away and shielded from California red-legged frog habitat outside the construction area to minimize light spillover to the greatest extent possible. If light spillover into adjacent California red-legged frog habitat occurs, a Service-approved biologist will be present during night work to survey for burrows and emerging California red-legged frogs in areas illuminated by construction lighting. If a California red-legged frog is found above-ground the Service-approved biologist has the authority to terminate the project activities until the light is directed away from the burrows, the California red-legged frog moves out of the illuminated area, or the California red-legged frog is relocated out of the illuminated area by the Service-approved biologist.

12. At least 15 days prior to any ground disturbance activities, DWR, as project applicant, will prepare and submit a relocation plan for the Service's written approval. The relocation plan will contain the name(s) of the Service-approved biologist(s) to relocate California red-legged frogs, the method of relocation (if different than described), a map and description of the proposed release site(s) within 300 feet of the work area or at a distance otherwise agreed to by the Service, and written permission from the landowner to use their land as a relocation site.

13. Aquatic habitats within the areas that will be permanently affected by the proposed action will be surveyed for California red-legged frog adults and metamorphs. Any California red-legged frog adults or metamorphs found will be captured and held for a minimum amount of time necessary to relocate the animal to suitable habitat a minimum of 300 feet outside of the work area. Prior to and after handling frogs, the Service-approved biologist will observe the appropriate decontamination procedures to ensure against spread of chytrid fungus or other pathogens.

14. If construction activities will occur in streams, temporary aquatic barriers such as hardware cloth will be installed both up and downstream of the stream crossing, and animals will be relocated and excluded from the work area. The Service-approved

biologists will establish an adequate buffer on both sides of creeks and around potential aquatic habitat and will restrict entry during the construction period.

15. The Service-approved biologist(s) will kill any aquatic exotic wildlife species, such as bullfrogs and crayfish, found on the worksite, to the greatest extent practicable.

16. Each encounter with the California red-legged frog will be treated on a case-by-case basis in coordination with the Service, but the procedure will follow the pre-approved Relocation Plan and will be conducted is as follows: (1) the animal will not be disturbed if it is not in danger; or (2) the animal will be moved to a secure location if it is in any danger. These procedures are further described below:

    a. When a California red-legged frog is encountered, all activities that have the potential to result in the harassment, injury, or death of an individual will cease immediately and the Onsite Project Manager and Service-approved biologist will be notified. The Service-approved biologist will then assess the situation and select a course of action to avoid or minimize adverse effects to the animal. To the maximum extent possible, contact with the frog will be avoided will allow it to move out of the potentially hazardous situation to a secure location on its own volition. This measure does not apply to animals that are uncovered or otherwise exposed or in areas where there is not sufficient adjacent habitat to support the species should the individual move away from the hazardous location.

    b. California red-legged frogs that are at risk of being injured or killed will be relocated and released by the Service-approved biologist outside the construction area within the same riparian area or watershed. If such relocation is not feasible (e.g., there are too many individuals observed per day), the Service-approved biologist will relocate the animals to a location previously approved by the Service. Prior to the initial ground disturbance DWR will obtain approval of the relocation plan from the Service in the event that a California red-legged frog is encountered and needs to be moved away from the worksite. Under no circumstances will a California red-legged frog be released on a site unless the written permission of the landowner has been obtained.

    c. The Service-approved biologist will limit the duration of the handling and captivity of the California red-legged frog to the minimum amount of time necessary to complete the task. If the animal must be held in captivity, it will be kept in a cool, dark, moist, aerated environment, such as a clean and disinfected bucket or plastic container with a damp sponge. The container used for holding or transporting the individual will not contain any standing water.

    d. The Service will be immediately notified once the California red-legged frog and the site are secure. The Service contact is the Assistant Field Supervisor of Endangered Species, at Bay-Delta Fish & Wildlife Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814, (916) 930-5604.

17. For onsite storage of pipes, conduits and other materials that could provide shelter for California red-legged frogs, an open-top trailer will be used to elevate the materials above ground. This is intended to reduce the potential for animals to climb into the conduits and other materials.

18. Plastic monofilament netting (erosion control matting), loosely woven netting, or similar material in any form will not be used at the worksite because California red-legged frogs can become entangled and trapped in such materials. Any such material found on site will be immediately removed by the Service-approved biologist or construction personnel. Materials utilizing fixed weaves (strands cannot move), polypropylene, polymer or other synthetic materials will not be used.

19. Dust control measures will be implemented during construction, or when necessary in the opinion of the Service-approved biologist, Service, or their authorized agent. These measures will consist of regular truck watering of construction access areas and disturbed soil areas with water or organic soil stabilizers to minimize airborne dust and soil particles generated from graded areas. Regular truck watering will be a requirement of the construction contract. Guidelines for truck watering will be established to avoid any excessive runoff that may flow into contiguous or adjacent areas containing potential habitat for the California red-legged frog.

20. Trenches or pits one (1) foot or deeper that are going to be left unfilled for more than forty eight (48) hours will be securely covered with boards or other material to prevent California red-legged frogs from falling into them. If this is not possible, wooden ramps or other structures of suitable surface that provide adequate footing for the California red-legged frog will be placed in the trench or pit to allow for their unaided escape. Auger holes or fence post holes that are greater than 0.10 inch in diameter will be immediately filled or securely covered so they do not become pitfall traps for the California red-legged frog. The Service-approved biologist will inspect the trenches, pits, or holes prior to their being filled to ensure there are no California red-legged frogs in them. The trench, pit, or hole also will be examined by the Service-approved biologist each workday morning at least one hour prior to initiation of work and in the late afternoon no more than one hour after work has ceased to ascertain whether any individuals have become trapped. If the escape ramps fail to allow the animal to escape, the Service-approved biologist will remove and transport it to a safe location, or contact the Service for guidance.

21. To minimize harassment, injury death, and harm in the form of temporary habitat disturbances, all vehicle traffic related to the PA will be restricted to established roads, construction areas, equipment staging, and storage, parking, and stockpile areas. These areas will be included in preconstruction surveys and, to the maximum extent possible, established in locations disturbed by previous activities to prevent further adverse effects.

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22. All vehicles will observe a 20-mile per hour speed limit within construction areas where it is safe and feasible to do so, except on County roads, and state and Federal highways. Off-road traffic outside of designated and fenced work areas will be prohibited.

23. If a work site is to be temporarily dewatered by pumping, intakes shall be completely screened with wire mesh not larger than five millimeters to prevent California red-legged frogs from entering the pump system. Water shall be released or pumped downstream at an appropriate rate to maintain downstream flows during construction. Upon completion of construction activities, any barriers to flow shall be removed in a manner that would allow flow to resume with the least disturbance to the substrate.

24. Uneaten human food and trash attracts crows, ravens, coyotes, and other predators of the California red-legged frog. A litter control program will be instituted at each worksite. All workers will ensure their food scraps, paper wrappers, food containers, cans, bottles, and other trash are deposited in covered or closed trash containers. The trash containers will be removed from the worksite at the end of each working day.

25. All grindings and asphaltic-concrete waste may be temporally stored within previously disturbed areas absent of habitat and at a minimum of 150 feet from any culvert, pond, creek, stream crossing, or other waterbody. On or before the completion of work at the site, the waste will be transported to an approved disposal site.

26. Loss of soil from runoff or erosion will be prevented with straw bales, straw wattles, or similar means provided they do not entangle, block escape or dispersal routes of the California red-legged frog.

27. Insecticides or herbicides will not be applied at the worksite during construction or long-term operational maintenance where there is the potential for these chemical agents to enter creeks, streams, waterbodies, or uplands that contain potential habitat for the California red-legged frog.

28. No pets will be permitted at the worksite, to avoid and minimize the potential for harassment, injury, and death of the California red-legged frog. No firearms will be allowed at the worksite except for those carried by authorized security personnel, or local, state, or Federal law enforcement officials to avoid and minimize the potential for harassment, injury, and death of the California red-legged frog.

Measures for Activities with Flexible Locations

Geotechnical Exploration

29. Geotechnical exploration will be sited outside of California red-legged aquatic habitat.

30. To the extent practicable, all activities will avoid impacts to California red-legged frog suitable habitat that possesses cracks or burrows that could be occupied by California red-legged frogs.

31. Preconstruction surveys will be conducted by a Service-approved biologist. A Service-approved biological monitor will be present during all drilling activities in California red-legged frog upland habitat to ensure there are no significant impacts to California red-legged frog.

32. Work will be done outside the wet season and measures, such as having vehicles follow shortest possible routes from levee road to the drill or CPT sites, will be taken to minimize the overall project footprint.

Power Lines and Grid Connections

33. The final transmission line alignments will be designed to avoid California red-legged frog aquatic habitat, and to minimize effects on upland habitat. The transmission lines will be sited at least 300 feet from occupied California red-legged frog aquatic habitat as determined through protocol-level surveys of any suitable aquatic habitat in the potential transmission line alignment. Occupancy may be assumed, in order to forego the need for protocol-level surveys. After the final transmission line alignment has been determined, the avoidance and minimization measures described above will be followed.

California Tiger Salamander

1. A Service-approved biologist familiar with the species and its habitat will conduct a field evaluation of suitable upland or aquatic habitat for California tiger salamander for all activities in the PA that occur within modeled habitat, or within areas of suitable habitat located by a Service-approved biologist during the field evaluation.

Measures for Activities with Fixed Locations

2. No aquatic habitat for California tiger salamander will be affected.

Site Preparation

3. The perimeter of construction sites will be fenced with amphibian exclusion fencing by October 15 or prior to the start of construction. The Onsite Project Manager and the Service-approved biologist (in cooperation with Service) will determine where exclusion fencing will be installed to protect California tiger salamander habitat adjacent to the defined site footprint and to minimize the potential for California tiger salamanders to enter the construction work area. The locations of exclusion fencing will be determined, in part, by the locations of suitable habitat for the species (defined above). A conceptual fencing plan will be submitted to the Service prior to the start of construction and the California tiger salamander exclusion fencing will be shown on the final construction plans. DWR will include the amphibian exclusion fence specifications including installation and maintenance criteria in the bid solicitation package special provisions. The amphibian exclusion fencing will remain in place for the duration of construction and will be regularly inspected and fully maintained. The Service-approved biological

monitor and construction supervisor will be responsible for checking the exclusion fencing around the work areas daily to ensure that they are intact and upright. This will be especially critical during rain events, when flowing water can easily dislodge the fencing. Repairs to the amphibian exclusion fence will be made within 24 hours of discovery. Where construction access is necessary, gates will be installed with the exclusion fence.

4. At least 15 days prior to any ground disturbance activities, DWR will prepare and submit a Relocation Plan for Service's written approval. The Relocation Plan will contain the name(s) of the Service-approved biologist(s) to relocate California tiger salamanders, the method of relocation (if different than described), a map, and a description of the proposed release site(s) within 300 feet of the work area or at a distance otherwise agreed to by Service, and written permission from the landowner to use their land as a relocation site.

5. Preconstruction surveys will be conducted by a Service-approved biologist immediately prior to the initiation of any ground-disturbing activities or vegetation clearing in areas identified as having suitable California tiger salamander habitat. Prior to initiating surveys, water trucks will spray the work area to influence emergence. Watering will occur at dusk, trucks will make a single pass, and the Service-approved biologist(s) will survey the watered area for one hour following the spraying. If California tiger salamander are found, they will be relocated consistent with the Relocation Plan described above.

Initial Clearance/Ground Disturbance

6. Except for limited vegetation clearing necessary to minimize effects to nesting birds, initial suitable habitat clearance and disturbance will be confined to the dry season, generally May through October 15. All initial clearing will be limited to periods of no or low rainfall (less than 0.08 inches per 24-hour period and less than 40% chance of rain). Clearing activities within California tiger salamander habitat will cease 24 hours prior to a 40% or greater forecast of rain from the closest National Weather Service (NWS) weather station. Clearing may continue 24 hours after the rain ceases, if no precipitation is in the 24-hour forecast. If clearing must continue when rain is forecast (greater than 40% chance of rain), a Service-approved biologist will survey the worksite before clearing begins each day rain is forecast. If rain exceeds 0.5 inches during a 24-hour period, clearing will cease until the NWS forecasts no further rain. Modifications to this timing may be approved by Service based on site conditions and expected risks to California tiger salamanders. Once the ground has been cleared and perimeter fencing is in place, these restrictions do not apply.

During Construction

7. The Service-approved biologist shall conduct clearance surveys at the beginning of each day and regularly throughout the workday when construction activities are occurring that

may result in take of California tiger salamander. These surveys will consist of walking surveys within the worksites and investigating suitable aquatic and upland habitat including refugia habitat such as small woody debris, refuse, burrow entries, etc. All mammal burrows within the worksite limits that cannot be avoided will be hand-excavated and collapsed so that they do not attract California tiger salamanders during construction.

8. If the exclusion fence is compromised during the rainy season, when California tiger salamanders are likely to be active, a survey will be conducted immediately preceding construction activity that occurs in modeled or suitable California tiger salamander habitat, as determined by a Service-approved biologist, or in advance of any activity that may result in take of the species. The Service-approved biologist will search along exclusion fences, in pipes, and beneath vehicles each morning before they are moved. The survey will include a careful inspection of all potential hiding spots, such as along exclusion fencing, large downed woody debris, and the perimeter of ponds, wetlands, and riparian areas. Any tiger salamanders found will be captured and relocated to suitable habitat with an active rodent burrow system at a location predetermined prior to commencement of construction in the Relocation Plan.

9. To avoid entrapment of animals during construction, pipes or similar structures will be capped if stored overnight. Excavated holes and trenches will have escape ramps, and any open holes and trenches more than 6 inches deep will be closed with plywood at the end of each workday. The Service-approved biologist will inspect all holes and trenches at the beginning of each workday and before the holes and trenches are filled. All pipes, culverts, or similar structures stored in the work area overnight will be inspected before they are subsequently moved, capped, and/or buried. If a California tiger salamander is discovered, the Onsite Project Manager and Service-approved biologist will be notified immediately, and the Service-approved biologist will move the animal to a safe nearby location (as described by the species observation and handling protocol below) and monitor it until it is determined that it is not imperiled by predators, or other dangers.

10. If verbally requested before, during, or upon completion of ground disturbance and construction activities where suitable California tiger salamander habitat is present, DWR will ensure that Service can immediately access and inspect the worksite for compliance with the description of the PA, and avoidance and minimization measures, and to evaluate effects on the California tiger salamander and its habitat. A Service-approved biologist will be onsite during all activities that may result in take of California tiger salamander. The Service-approved biologist will carry a working mobile phone whose number will be provided to Service prior to the start of construction and ground disturbance. The Service will consider the implementation of specific activities without the oversight of an onsite Service-approved biologist on a case-by-case basis.

11. The Service-approved biologist will have the authority to stop activities at the worksite if they determine that any of avoidance and minimization measures are not being fulfilled.

12. The Service-approved biologist will maintain monitoring records that include (1) the beginning and ending time of each day's monitoring effort; (2) a statement identifying the covered species encountered, including the time and location of the observation; (3) the time the specimen was identified and by whom and its condition; (4) the capture and release locations of each individual; (5) photographs and measurements (snout to vent and total length) of each individual; and (6) a description of any actions taken. The Service-approved biologist will maintain complete records in their possession while conducting monitoring activities and will immediately provide records to the Service upon request. If requested, all monitoring records will be provided to the Service within 30 days of the completion of monitoring work.

13. To the extent possible, earthmoving and construction activities will cease no less than 30 minutes before sunset and will not begin again until no less than 30 minutes after sunrise within 300 feet of California tiger salamander habitat. Except when necessary for driver or pedestrian safety, to the greatest extent practicable, artificial lighting at a worksite will be prohibited during the hours of darkness.

14. If work must be conducted at night within 300 feet of California tiger salamander habitat, all lighting will be directed away and shielded from California tiger salamander habitat outside the construction area to minimize light spillover to the greatest extent possible. If light spillover into adjacent California tiger salamander habitat occurs, a Service-approved biologist will be present during night work to survey for burrows and emerging California tiger salamanders in areas illuminated by construction lighting. If California tiger salamander is found above-ground the Service-approved biologist has the authority to terminate the project activities until the light is directed away from the burrows, the California tiger salamander moves out of the illuminated area, or the California tiger salamander is relocated out of the illuminated area by the Service-approved biologist.

15. No rodenticides will be used during construction or long-term operational maintenance in areas that support suitable upland habitat for California tiger salamander.

16. To prevent California tiger salamander from becoming entangled, trapped, or injured by erosion control structures, erosion control measures that use plastic or synthetic monofilament netting will not be used within areas designated to have suitable California tiger salamander habitat. This includes products that use photodegradable or biodegradable synthetic netting, which can take several months to decompose. Acceptable materials include natural fibers such as jute, coconut, twine, or other similar fibers. Following site restoration, erosion control materials, such as straw wattles, will be placed so as not to block movement of the California tiger salamander.

Species Observation and Handling Protocol

17. If a California tiger salamander is observed, the Service-approved biologist will implement the following species observation and handling protocol. Only Service-approved biologists will participate in activities associated with the capture, handling,

and monitoring of California tiger salamanders. If a California tiger salamander is encountered in a construction area, activities within 50 feet of the individual will cease immediately and the Onsite Project Manager and Service-approved biologist will be notified. Based on the professional judgment of the Service-approved biologist, if activities at the worksite can be conducted without harming or injuring the California tiger salamander, it may be left at the location of discovery and monitored by the Service-approved biologist. All personnel on site will be notified of the finding and at no time will work occur within 50 feet of the California tiger salamander without a Service-approved biologist present. If it is determined by the Service-approved biologist that relocating the California tiger salamander is necessary, the following steps will be followed:

a. Prior to handling and relocation, the Service-approved biologist will take precautions to prevent introduction of amphibian diseases in accordance with the Interim Guidance on Site Assessment and Field Surveys for Determining Presence or a Negative Finding of the California Tiger Salamander (Service 2003). Disinfecting equipment and clothing is especially important when Service-approved biologists are coming to the Action Area to handle amphibians after working in other aquatic habitats. California tiger salamanders will also be handled and assessed according to the Restraint and Handling of Live Amphibians. The Handling of Live Amphibians standard operating procedures can be accessed at: https://www.nwhc.usgs.gov/publications/amphibian_research_procedures/handling_and_restraint.jsp

b. California tiger salamanders will be captured by hand, dipnet, or other Service-approved methodology, transported, and relocated to nearby suitable habitat outside of the work area and released as soon as practicable the same day of capture. Individuals will be relocated no greater than 300 feet outside of the work area to areas with an active rodent burrow or burrow system (unless otherwise approved by Service). Holding/transporting containers and dipnets will be thoroughly cleaned, disinfected, and rinsed with freshwater prior to use within the Action Area. The Service will be notified within 24 hours of all capture, handling, and relocation efforts. The Service-approved biologists will not use soaps, oils, creams, lotions, repellents, or solvents of any sort on their hands within two hours before and during periods when they are capturing and relocating individuals. To avoid transferring disease or pathogens when handling the amphibians, Service-approved biologists will follow the Declining Amphibian Populations Task Force's "Code of Practice." The "Code of Practice" can be accessed on the internet at: https://www.fws.gov/ventura/docs/species/protocols/DAFTA.pdf

c. If an injured Central California tiger salamander is encountered and the Service--approved biologist determines the injury is minor or healing and the salamander is likely to survive, the salamander will be released immediately, consistent with the pre-approved Relocation Plan as described above. The California tiger

salamander will be monitored until it is determined that it is not imperiled by predators or other dangers.

d. If the Service-approved biologist determines that the California tiger salamander has major or serious injuries because of activities at the worksite, the Service-approved biologist, or designee, will immediately take it to a Service-approved facility. If taken into captivity, the individual will not be released into the wild unless it has been kept in quarantine and the release is authorized by the Service. DWR will bear any costs associated with the care or treatment of such injured California tiger salamanders. The circumstances of the injury, the procedure followed and the final disposition of the injured animal will be documented in a written incident report. Notification to the Service of an injured or dead California tiger salamander in the Action Area will be made as described under the Reporting Requirements measure, and reported whether or not its condition resulted from activities related to the PA. In addition, the Service-approved biologist will follow up with the Service in writing within two calendar days of the finding. Written notification to the Service will include the following information: the species, number of animals taken or injured, sex (if known), date, time, location of the incident or of the finding of a dead or injured animal, how the individual was taken, photographs of the specific animal, the names of the persons who observe the take and/or found the animal, and any other pertinent information. Dead specimens will be preserved, as appropriate, and held in a secure location until instructions are received from the Service regarding the disposition of the specimen.

Measures for Activities with Flexible Locations

<u>Geotechnical Explorations</u>

18. Geotechnical exploration will be sited outside of California tiger salamander aquatic habitat.

19. To the extent practicable, all project activities within California tiger salamander suitable habitat will avoid impacts to areas that possess cracks or burrows that could be occupied by California tiger salamanders.

20. Preconstruction surveys will be conducted by a Service-approved biologist. A Service-approved biological monitor will be present during all drilling activities to ensure there are no significant impacts to California tiger salamander.

21. Work will be done outside the wet season and measures, such as having vehicles follow shortest possible routes from levee road to the drill or CPT sites, will be taken to minimize the overall project footprint.

22. Geotechnical exploration activities will cease no less than 30 minutes before sunset and will not begin again until no less than 30 minutes after sunrise within 300 feet of California tiger salamander habitat.

Safe Havens

23. Safe havens will avoid suitable California tiger salamander habitat.

Power Supply and Grid Connections

24. The final transmission line alignments will be sited to avoid California tiger salamander aquatic habitat, and to minimize effects on upland habitat. The transmission lines will be sited at least 300 feet from occupied California tiger salamander aquatic habitat as determined through protocol-level surveys of any suitable aquatic habitat within the potential transmission line alignment. Occupancy may be assumed, in order to forego the need for protocol-level surveys. After the final transmission line alignment has been determined, the avoidance and minimization measures described in Activities with Fixed Locations, will be followed, with the following exception: Transmission line construction activities will cease no less than 30 minutes before sunset and will not begin again until no less than 30 minutes after sunrise within 300 feet of California tiger salamander habitat.

Valley Elderberry Longhorn Beetle

Measures for Activities with Fixed Locations

1. Preconstruction surveys for elderberry shrubs will be conducted within all facility footprints and areas within 100 feet by a Service-approved biologist familiar with the appearance of valley elderberry longhorn beetle exit holes in elderberry shrubs. Preconstruction surveys will be conducted in the calendar year prior to construction and will follow the guidance of Service's Conservation Guidelines for the Valley Elderberry Longhorn Beetle (Service 1999), herein referred to as the 1999 VELB Conservation Guidelines. The results of preconstruction surveys will be reported to the Service. Elderberry shrubs will be avoided to the greatest extent practicable. Complete avoidance (i.e., no adverse effects) may be assumed when a buffer of at least a 100 feet is established and maintained around elderberry plants containing stems measuring 1 inch or greater in diameter at ground level. Firebreaks may not be included in the buffer zone. The Service will be consulted before any disturbances, including construction, within the 100-foot buffer area are considered. Any damaged area within the buffer zones will be restored following the conclusion of construction in the work area.

   Elderberry shrubs that must be removed will be transplanted to Service-approved Conservation Areas (the areas where plantings will occur to offset impacts). Transplanting, avoidance measures, and associated compensation will follow the 1999 VELB Conservation Guidelines except where modified with site specificity as stated herein. Avoidance measures for shrubs not directly affected by construction but within

100 feet of ground-disturbing activities will follow the guidance outlined in the 1999 VELB Conservation Guidelines as well.

2. For shrubs not directly affected by construction but that occur between 20 feet and 100 feet from ground-disturbing activities, the following measures will be implemented.

    a. Fence and flag areas to be avoided during construction activities. In areas where encroachment on the 100-foot buffer has been approved by the Service, provide a minimum setback of at least 20 feet from the dripline of each elderberry plant.

    b. To the greatest extent practicable, construction will be limited during the valley elderberry longhorn beetle active season, March 15th through June 15th.

    c. Brief contractors on the need to avoid damaging the elderberry plants and the possible penalties for not complying with these requirements.

    d. Erect signs every 50 feet along the edge of the avoidance area with the following information: "This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment." The signs will be clearly readable from a distance of 20 feet, and must be maintained for the duration of construction.

    e. Instruct work crews about the status of the beetle and the need to protect its elderberry host plant.

    f. During construction activities, no insecticides, herbicides, fertilizers, or other chemicals that might harm the beetle or its host plant will be used in the 100-foot buffer area.

    g. To the greatest extent practicable, nighttime construction will be minimized or avoided between March 15th and June 15th where valley elderberry longhorn beetle is likely to be present. Because there is potential for valley elderberry valley longhorn beetles to be attracted to nighttime light and thus increase the potential for predation, activities will cease no less than 30 minutes before sunset and will not begin again prior to no less than 30 minutes after sunrise. Except when necessary for driver or pedestrian safety, to the greatest extent practicable, artificial lighting at a construction site will be prohibited during the hours of darkness where valley elderberry longhorn beetle is likely to be present.

    h. Night lighting of valley elderberry beetle habitat will be minimized to the extent practicable. If night lighting is to be used, to the greatest extent possible it will be pointed toward work areas and away from riparian, other sensitive habitats, and other areas that contain elderberry shrubs.

i. Restore any damage done to the buffer area (area within 100 feet of elderberry plants) during construction. Provide erosion control and re-vegetate with appropriate native plants.

j. For those parts of the water conveyance facility that will require ongoing maintenance (e.g., intake facilities, pump facilities at Clifton Court Forebay, in rights-of-way around permanent transmission lines, around vent shafts, etc.), buffer areas must continue to be maintained for the protection of the species after construction with measures such as fencing, signs, weeding, and trash removal as appropriate.

k. A written description of how the buffer areas are to be restored and maintained for the protection of the species will be provided to the Service.

l. To prevent fugitive dust from drifting into adjacent habitat, all clearing, grubbing, scraping, excavation, land leveling, grading, cut and fill, demolition activities, or other dust generating activities will be effectively controlled for fugitive dust emissions utilizing application of water or by presoaking work areas.

3. For shrubs directly affected by construction, and within 20 feet of disturbance activities if this area is also disturbed, the following measures will be followed for transplantation.
   a. A Service-approved biologist must be onsite for the duration of the transplanting of the elderberry plants to ensure that no unauthorized take of the valley elderberry longhorn beetle occurs. If unauthorized take occurs, the monitor must have the authority to stop work until corrective measures have been completed. The monitor must immediately report any unauthorized take of the beetle or its habitat to the Service and to the CDFW.

   b. Elderberry shrubs will be transplanted during their dormant season, which occurs from November, after they have lost their leaves, through the first two weeks in February. If transplantation occurs during the growing season, increased compensation ratios will apply. Compensation ratios could be up to three times the standard compensation ratios as determined in consultation with Service staff.

   c. Transplantation procedure will be as specified in the 1999 VELB Conservation Guidelines.

   d. Elderberry shrubs will be transplanted into the area where plantings will occur to offset impacts referred to in the 1999 VELB Conservation Guidelines as the Conservation Area.

   e. If a plant appears to be unlikely to survive transplantation, then transplantation is not required, but a higher compensation ratio may be applied. In this instance, the Service will be contacted to determine the appropriate action.

Measures for Activities with Flexible Locations

4. During the planning phase, for these not fully sited activities, preconstruction surveys for elderberry shrubs will be conducted in potential work areas by a Service-approved biologist familiar with the appearance of valley elderberry longhorn beetle exit holes in elderberry shrubs. Preconstruction surveys will be conducted in accordance with the protocol provided in the 1999 VELB Conservation Guidelines, and survey results will be reported to the Service. Elderberry shrubs will be avoided to the greatest extent practicable. Complete avoidance (i.e., no adverse effects) may be assumed when a buffer of at least a 100 feet is established and maintained around elderberry plants containing stems measuring 1 inch or greater in diameter at ground level. Firebreaks may not be included in the buffer zone. The Service will be consulted before any disturbances, including construction, within the 100-foot buffer area are considered. Any damaged area within the buffer zones will be restored following the conclusion of construction in work areas.

Geotechnical Activities

5. Geotechnical exploration activities for the PA will fully avoid effects on valley elderberry longhorn beetle and its habitat.

Safe Haven Work Areas

6. Workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. In addition, avoidance and minimization measures for safe haven interventions will be the same as described in Activities with Fixed Locations.

Power Lines and Grid Connections

7. Based on the planning level surveys, the siting of transmission towers and poles will avoid elderberry shrubs to the extent practicable. Valley elderberry longhorn beetle avoidance and minimization measures for transmission lines will be the same as described in Activities with Fixed Locations.

Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Activities with Known Locations

1. Staging areas will be designed so that they are more than 250 feet from vernal pool fairy shrimp or vernal pool tadpole shrimp habitat. All vehicles will access the work site following the shortest possible route from the levee road. All site access and staging shall

limit disturbance to the riverbank, or levee as much as possible and avoid sensitive habitats. When possible, existing ingress and egress points shall be used.

2. A vehicle inspection and fueling area will be established at least 250 feet away from any vernal pools or seasonal wetlands to reduce the potential for chemical pollution such as oil, diesel, or hydraulic fluid. An inspection and fueling plan will be developed and construction workers trained so that any contamination is minimized. An emergency spill response plan will be completed and all workers will be trained on how to respond to emergency spills of chemicals.

3. If habitat is avoided (preserved) at the site, a Service-approved biologist will inspect any construction-related activities at the activity site to ensure that no unnecessary take of listed species or destruction of their habitat occurs. The Service-approved biologist will have the authority to stop all activities that may result in take or destruction of habitat until appropriate corrective measures have been completed. The Service-approved biologist also will be required to immediately report any unauthorized impacts to the Service.

4. Topographic depressions that are likely to serve as seasonal vernal pools will be flagged and avoided where possible.

5. Silt fencing will be installed wherever activities occur within 250 feet of vernal pool type seasonal wetlands. To avoid additional soil disturbances caused by silt fence installation, the bottom portion of the fence will be secured by waddles instead of buried.

6. All onsite construction personnel will receive instruction regarding the presence of listed species and the importance of avoiding impacts on the species and their habitat.

7. All activities that are inconsistent with the maintenance of the suitability of remaining habitat and associated onsite watershed that supports vernal pool fairy shrimp or vernal pool tadpole shrimp habitat are prohibited. This includes, but is not limited to: (1) alteration of existing topography or any other alteration or uses for any purposes; (2) placement of any new structures on these parcels; (3) dumping, burning, and/or burying of rubbish, garbage, or any other wastes or fill materials; (4) building of any new roads or trails; (5) killing, removal, alteration, or replacement of any existing native vegetation; (6) placement of storm water drains; (7) fire protection activities not required to protect existing structures at the site; and (8) use of pesticides or other toxic chemicals.

Activities with Uncertain Locations

8. Geotechnical exploration activities, the construction and operation and maintenance of transmission lines, and restoration activities for the PA will fully avoid effects on vernal pool fairy shrimp and vernal pool tadpole shrimp and their habitat. Full avoidance requires a minimum 250-foot no-disturbance buffer around all vernal pools and other

aquatic features potentially supporting vernal pool fairy shrimp or vernal pool tadpole shrimp.

Least Bell's Vireo

1. Prior to disturbing an area potentially supporting habitat for the species, a Service-approved biologist will evaluate the area to identify suitable habitat

Measures for Activities with Fixed Locations

2. Prior to construction, all suitable least Bell's vireo habitat in the construction area will be surveyed, with surveys performed in accordance with any required Service survey protocols and permits applicable at the time of construction.

3. If surveys find least Bell's vireos in the area where vegetation will be removed, vegetation removal will be done when the birds are not present.

4. If an activity is to occur within 1,200 feet of least Bell's vireo habitat (or within 2,000 feet if pile driving will occur) during the breeding period for least Bell's vireos, the following measures will be implemented to avoid noise effects on least Bell's vireo.

    a. Prior to the construction, a noise expert will create a noise contour map showing the 60 dBA noise contour specific to the type and location of construction to occur in the area.

    b. During the breeding period for least Bell's vireo, a Service-approved biologist will survey any suitable habitat for least Bell's vireo within the 60 dBA noise contour on a daily basis during a two-week period prior to construction. While construction is occurring within this work window, the Service-approved biologist will conduct daily surveys in any suitable habitat where construction related noise levels could exceed 60 dBA (A-weighted decibel) Leq (1 hour). If a least Bell's vireo is found, sound will be limited to 60 dBA in the habitat being used until the Service-approved biologist has confirmed that the bird has left the area.

5. Limit pile driving to daytime hours (7:00 a.m. to 7:00 p.m.).

6. Locate, store, and maintain portable and stationary equipment as far as possible from suitable least Bell's vireo habitat.

7. Employ preventive maintenance including practicable methods and devices to control, prevent, and minimize noise.

8. Route truck traffic in order to reduce construction noise impacts and traffic noise levels within 1,200 feet of suitable least Bell's vireo habitat during migration periods.

9. Limit trucking activities (e.g., deliveries, export of materials) to the hours of 7:00 a.m. to 10:00 p.m.

10. Screen all lights and direct them down toward work activities away from migratory habitat. A Service-approved biologist will ensure that lights are properly directed at all times.

11. Operate portable lights at the lowest allowable wattage and height, while in accordance with the National Cooperative Highway Research Program's Report 498: Illumination Guidelines for Nighttime Highway Work (Ellis *et al.* 2003).

Measures for Activities with Flexible Locations

Geotechnical Explorations

12. During geotechnical activities, a Service-approved biologist will be onsite to avoid the loss or degradation of suitable least Bell's vireo habitat by exploration activities.

Safe Haven Work Areas

13. During the siting phase of safe haven construction, a Service-approved biologist will work with the engineers to avoid loss or degradation of suitable least Bell's vireo habitat. This includes ensuring that safe haven work areas are not sited in least Bell's vireo habitat. This also includes ensuring noise from safe haven work areas do not exceed 60 dBA at nearby least Bell's vireo habitat.

Power Supply and Grid Connections

14. The final transmission line alignment will be designed to minimize removal of least Bell's vireo habitat by removing no more than three acres of this habitat. To minimize the chance of least Bell's vireo bird strikes at transmission lines, bird strike diverters will be installed on project and existing transmission lines in a configuration that research indicates will reduce bird strike risk by at least 60% or more. Bird strike diverters placed on new and existing lines will be periodically inspected and replaced as needed until or unless the project or existing line is removed. The most effective and appropriate diverter for minimizing strikes on the market according to best available science will be selected.

Safe Havens

15. Safe haven sites will avoid least Bell's vireo habitat. All work associated with safe haven sites will be conducted during daylight hours, and will not require any lighting.

7.0 DESCRIPTION OF THE ACTION AREA

The Action Area is defined in 50 CFR § 402.02, as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The Action Area for this consultation encompasses the entire legal Delta, Suisun Marsh, Suisun Bay, and Byron Hills; and extends upstream within the channels of the Sacramento and American Rivers below Keswick and Nimbus Dams. See Figure 7.0-1 and 7.0-2. Byron Hills is 13,156 acres that is south of Highway 4, east of Los Vaqueros Reservoir, north of the Contra Costa/Alameda county line, and west of the Byron Highway.

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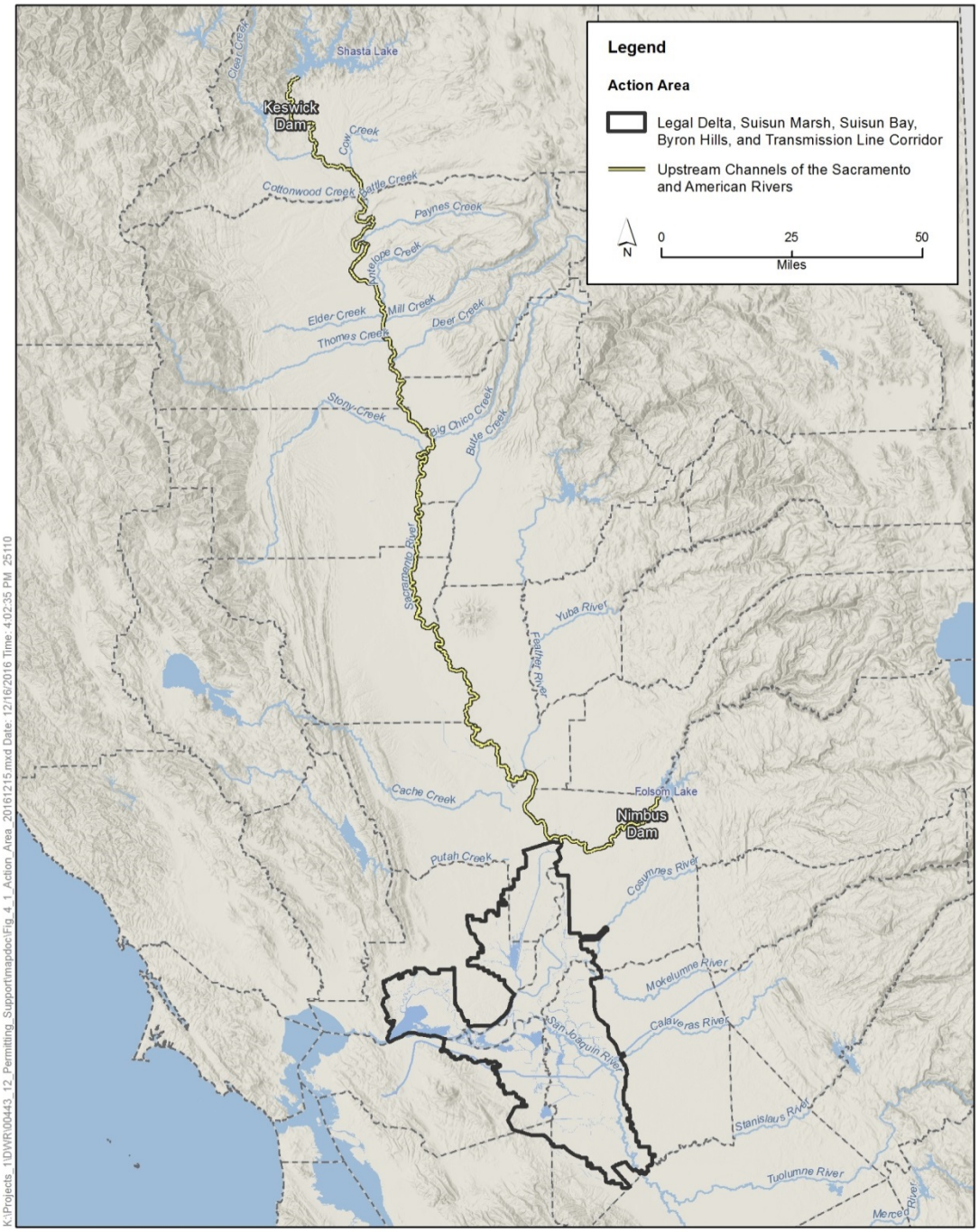

Figure 7.0-1. Map of California WaterFix Action Area.

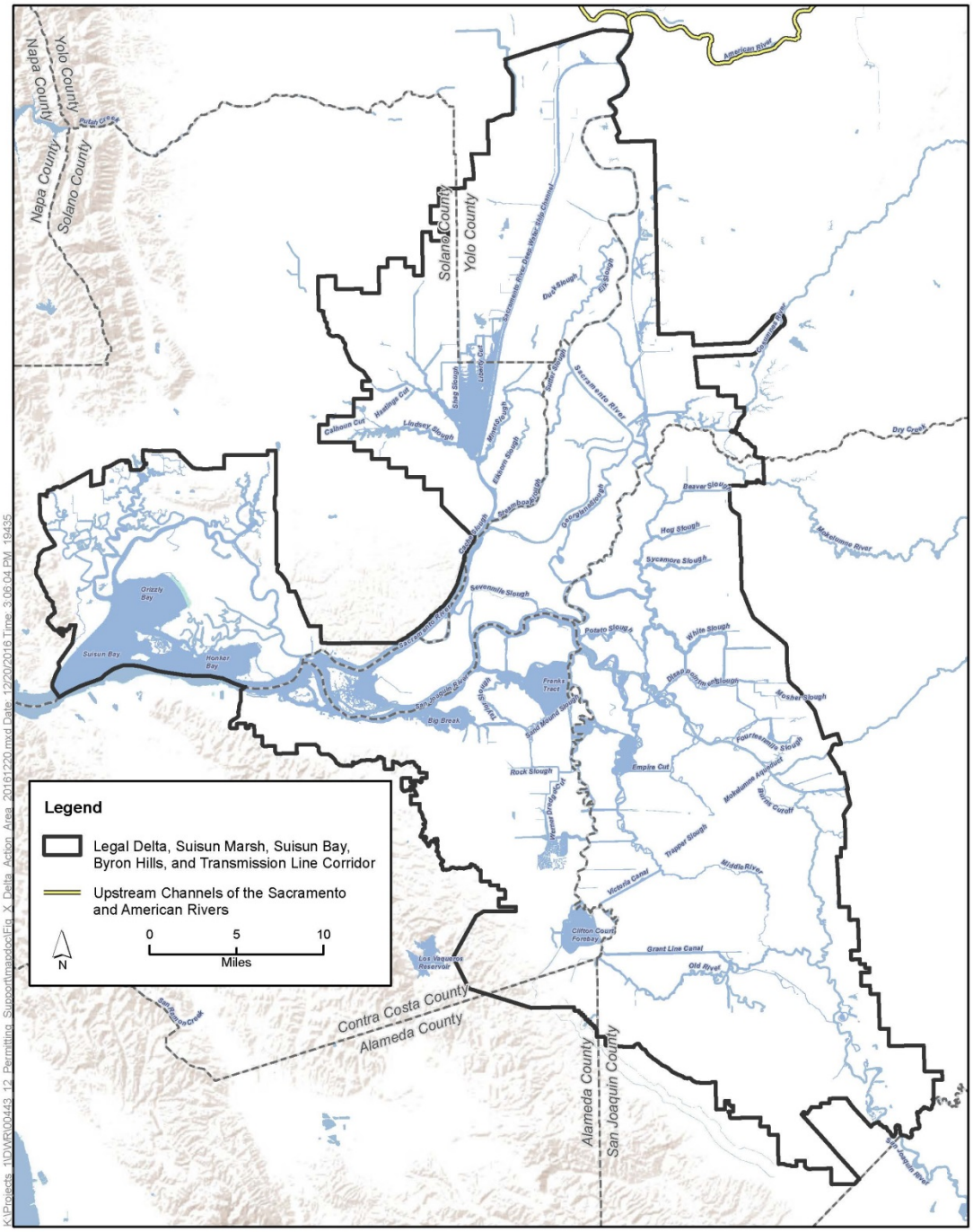

Figure 7.0-2. Detailed map of California WaterFix Action Area.

8.0 ANALYTICAL FRAMEWORK

8.1 Analytical Framework for the Jeopardy Determination

Section 7(a)(2) of the Endangered Species Act requires that Federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of listed species. "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR § 402.02).

The jeopardy analysis in this biological opinion considers the effects of the proposed Federal action, and any cumulative effects, on the rangewide survival and recovery of the listed species. It relies on four components: (1) the *Status of the Species*, which describes the rangewide condition of the species, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which analyzes the condition of the species in the Action Area, the factors responsible for that condition, and the relationship of the Action Area to the survival and recovery of the species; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the species; and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the Action Area on the species.

8.2 Analytical Framework for the Adverse Modification Determination

Section 7(a)(2) of the ESA requires that Federal agencies insure that any action they authorize, fund, or carry out is not likely to destroy or to adversely modify designated critical habitat. A final rule revising the regulatory definition of "destruction or adverse modification" was published on February 11, 2016 (81 FR 7214). The final rule became effective on March 14, 2016. The revised definition states:

> "Destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features."

The destruction or adverse modification analysis in this biological opinion relies on four components: (1) the *Status of Critical Habitat*, which describes the range-wide condition of the critical habitat in terms of the key components (i.e., essential habitat features, primary constituent elements, or physical and biological features) that provide for the conservation of the listed species, the factors responsible for that condition, and the intended value of the critical habitat overall for the conservation/recovery of the listed species; (2) the *Environmental Baseline*, which analyzes the condition of the critical habitat in the Action Area, the factors responsible for that condition, and the value of the critical habitat in the Action Area for the conservation/recovery of the listed species; (3) the *Effects of the Action*, which determines the

direct and indirect impacts of the proposed Federal action and the effects of any interrelated and interdependent activities on the key components of critical habitat that provide for the conservation of the listed species, and how those impacts are likely to influence the conservation value of the affected critical habitat; and (4) *Cumulative Effects*, which evaluate the effects of future non-Federal activities that are reasonably certain to occur in the Action Area on the key components of critical habitat that provide for the conservation of the listed species and how those impacts are likely to influence the conservation value of the affected critical habitat.

For purposes of making the destruction or adverse modification determination, the Service evaluates if the effects of the proposed Federal action, taken together with cumulative effects, are likely to impair or preclude the capacity of critical habitat in the Action Area to serve its intended conservation function to an extent that appreciably diminishes the range-wide value of critical habitat for the conservation of the listed species. The key to making that finding is understanding the value (*i.e.*, the role) of the critical habitat in the Action Area for the conservation/recovery of the listed species based on the *Environmental Baseline* analysis.

9.0 SPECIES ANALYSES

9.1 Considerations Applicable to All Species

The PA includes activities at various stages of development, for which little or no information exists at this time regarding effects to listed species or critical habitat. These activities include compensatory mitigation, maintenance of the proposed facilities, monitoring, and adaptive management of several aspects of the proposed action. Pursuant to the "Consultation Approach" in the *Description of the Proposed Action*, Reclamation or the Corps will ensure that effects to species or critical habitat are addressed by either reinitiating this consultation or initiating subsequent consultation, depending on the triggers and processes associated with each activity.

Compensatory Mitigation

DWR proposes to provide species-specific compensatory mitigation prior to construction, operations, and other activities at the ratios identified in *Description of the Proposed Action* for each species. DWR has proposed to use one or more of the following options to implement the species-specific mitigation: (1) restoration with protection in perpetuity; (2) enhancement with protection in perpetuity; (3) purchasing credits at an approved conservation bank; (4) creating and establishing a conservation bank; and (5) protection in perpetuity without restoration or enhancement. We anticipate that this compensatory mitigation will minimize effects to each species by replacing the function of the habitat that was lost, altered, or degraded as a result of construction, maintenance, and operations of the existing and proposed CVP and SWP facilities in the Action Area. DWR has proposed to develop and implement management plans for the mitigation lands, but has not yet identified specific sites. The CWF BA does not identify or analyze effects to listed species or critical habitat from implementation of the compensatory mitigation because without knowing where the mitigation will occur and how large individual parcels will be, effects are speculative at this time. Locations of the compensatory mitigation

sites and construction timelines are important to determining the extent, frequency, and duration of adverse and beneficial effects, if any, to listed species and critical habitat.

All compensatory mitigation activities will be subject to approvals by either Reclamation or the Corps (as described in Description of the Proposed Action), depending on the nature of the activity and which agency has authority and oversight. Therefore, either reinitiation of this consultation or subsequent consultations with either of these agencies will occur so that the Service can assess the effects of each compensatory mitigation project.

For activities under the Corps' Phase 1 permitting process, if it is determined that listed species or critical habitat are present and may be affected as a result of the compensatory mitigation, the Corps is required to reinitiate this consultation to address these effects. Effects of the compensatory mitigation associated with the Corps Phase 2 and Reclamation's actions will be addressed in subsequent consultations.

The action agencies and DWR have committed in the PA to protecting and managing mitigation sites in perpetuity and ensuring adequate funding for the perpetual management of all compensatory mitigation. Management plans will be developed for each compensatory mitigation site with a conservation easement or other Service-approved conservation mechanism that is held by a third party approved by the Service. DWR will secure an endowment or other Service-approved financial assurance that will be sufficient to fund any monitoring, operations, maintenance, and adaptive management of the restoration site. Further, the endowment or other Service-approved financial assurance will designate the party or entity that will be responsible for the long-term management of these lands and associated waterways as applicable. In addition, the Service will be provided with written documentation that funding and management of mitigation lands will be provided in perpetuity.

Therefore, based on these commitments and assurances provided by DWR described in the CWF BA, we anticipate that the proposed compensatory mitigation will minimize the adverse effects of PA activities to each species by replacing the function of the habitat that was lost, altered, or degraded as a result of implementing the PA. The proposed species-specific habitat ratios are described within our analysis of each species.

Maintenance

As described in the Description of the Proposed Action, future maintenance of the project facilities will be necessary. Table 9.1-1 describes some of the anticipated maintenance activities and their assumed frequencies once the facilities are built. Little information is known at the time of this consultation about when, how, and in some cases, where these maintenance activities will be implemented; therefore, no analysis was provided in the CWF BA as to how or if these activities would affect listed species or critical habitat. Addressing effects resulting from future maintenance activities would be speculative at this time. If maintenance activities may affect listed species or critical habitat that are not subject to future approvals (*i.e.,* the Corps' Phase 1 permit), reinitiation of this consultation is required to address those effects. Maintenance activities associated with all other aspects of the PA will require future approvals as described in

the Description of the Proposed Action and will be subject to future consultations if those activities may affect listed species or critical habitat.

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Table 9.1-1. Potential maintenance activities and assumed frequency associated with elements of the PA as described in the CWF BA.

North Delta Diversions

Activity	Assumed Frequency	
	Basic	Major
Dredging within sedimentation basins in areas isolated from river	Annually	
Dredging on river side of intake screen	Every 3-5 years (routine maintenance dredging)	Every 10-15 years based on frequency of flow events (>100,000 cfs)
Levee maintenance (responsibility transferred to USACE or CVFPB)	-Inspections: 4x/year (no more than 90 days apart) -Vegetation control: 2x/year -Approx. 20 days/year total -Assume maintenance occurs within 100 ft distance from intake structure	Dependent on major erosion or other stability issues
Fish screen and bay maintenance activities in areas isolated from river	Weekly inspections for normal operation of screens and cleaning system	Annual maintenance of fish screen (pressure washing) and bays (dewatering, sediment/debris removal, and mechanical maintenance)
Cleaning brush replacement	Annual inspections	Replacement (typically every 3 years)
Baffle adjustment	Tuning to achieve uniform approach velocity across screen face annually	As needed to comply with design/screening criteria
Debris removal (log boom, screen face) on river side of intake screen	Annually or as needed	
Inspection, maintenance, and monitoring of screen	Keep maintenance log	

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Clifton Court Forebay

Activity	Assumed Frequency	
	Basic	Major
Dredging of SCCF	Minimum of every 15 years	Unanticipated; potential dredging to address shoaling/scouring affecting gate operations
Embankment maintenance (per DSOD requirements)	-Inspections: 4x/year -Vegetation control: 2x/year -Approx. 20 days/year total	Frequency of repairs dependent on major erosion/stability issues
Vegetation control	Annually in summer (2-3 days per treatment)	
Predator control	Boat electrofishing: 3x/week (Jan-May)	
Labyrinth weir debris removal	None if not used	Periodically as weir is used for emergency overflow
Siphon	Debris removal annually or as needed	Sediment removal in siphon
Debris removal (roller gates, radial gates, stop logs)	Annually or as needed	

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Barge Landings

Activity	Assumed Frequency	
	Basic	Major
Dredging	Every 3-5 years after initial dredging (depending on lifespan of landing)	Spot dredging as needed to address potential grounding issues
Barge route dredging	Every 3-5 years after initial dredging (depending on duration of barge operations)	Spot dredging as needed to address potential grounding issues
Aquatic vegetation control	Annual inspections; spot treat annually or as needed	

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Head of Old River Gate

Activity	Assumed Frequency	
	Basic	Major
Dredging	Every 3-5 years (routine maintenance dredging)	-Removal of accumulated sediment after major flow events: Every 5-10 years based on Vernalis flows > 30,000 cfs -Spot dredging as needed to address potential grounding issues
Mechanical maintenance (motors, compressors, control systems)	-Annual inspections; servicing/repairs as needed	
Gate maintenance (Obermeyer-type gate assumed)	-Annual inspections; servicing/repairs as needed -Monthly testing of gate mechanism -Sediment/debris removal: Annually or as needed	Dewatering and repairs: Every 5-10 years
Boat lock maintenance	-Annual inspections; servicing/repairs as needed -Monthly testing of gate mechanism -Sediment/debris removal: Annually or as needed -Aquatic vegetation control: Annual inspections and treatment as needed	Dewatering and repairs: Every 5-10 years
Fish ladder maintenance	Maintain water surface elevation levels when the gate is in operation	-Annually or as needed (more frequent during winter months) -Sediment/debris removal after major flow events

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Compensatory Mitigation Sites

Activity	Assumed Frequency	
	Basic	Major
Levee maintenance (responsibility transferred to local maintenance agencies)	Inspections: 4x/year Vegetation control: 2x/year Approx. 20 days/year total	
Riparian plantings (replantings, watering, non-native removal)	Watering: 2x/week (summer) and 2x/month (growing season) for 2-3 years Non-native removal: 1x/2 months for 3-5 years	Annual inspections and applied treatments as necessary
Post-project habitat monitoring	After success criteria are achieved, inspections conducted once every 3-5 years to verify functionality and compliance with performance standards	Once per month for first 2 years
Aquatic species and water quality monitoring	Once per month for species of interest for years 1-3	Annually for years 4-10
Terrestrial species and Delta Smelt monitoring	Future Service-approved long term management and monitoring plan with future identified performance standards	

Monitoring

Monitoring activities will occur prior to operations and after operations commence. Monitoring and studies of listed fish species will be focused on the construction and operation of conveyance facilities. This monitoring will begin with baseline data collection needed to compare with similar results post-construction. While a detailed effort has been made regarding proposed monitoring for the NDD, monitoring prior to operations will be required throughout the Action Area. DWR has committed to working with the Service and other agencies to develop the specifics (including timeframes) of monitoring using various technical teams. Monitoring and studies related to operations that must occur after operation of the new facilities has commenced consist of four types: monitoring addressing the operation of the proposed new facilities, monitoring related to species condition and habitat that may be influenced by operations of the

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new facilities, monitoring to evaluate the effectiveness of the proposed facilities, and monitoring addressing the performance of the habitat protection and restoration sites.

Little information is known at the time about when, where, and how monitoring will be implemented; therefore, no analysis was provided in the CWF BA as to how these activities would affect listed species or critical habitat. Addressing effects resulting from monitoring activities would be speculative at this time. If monitoring activities that are not subject to future Section 7 consultation or approvals (*i.e.,* the Corps' Phase 1 permit) may affect listed species or critical habitat, reinitiation of this consultation is required to address those effects. Monitoring activities associated with all other aspects of the PA will require future approvals as described in the Description of the Proposed Action and will be subject to future consultations if those activities may affect listed species or critical habitat.

Adaptive Management

Reclamation, DWR, the Service, NMFS, CDFW, and the public water agencies have agreed to develop a program of collaborative science, monitoring, and adaptive management in support of CWF (CWF BA *Appendix 3.H*). This draft framework outlines a collaborative process for assessing and adapting to effects to listed species stemming from the ongoing operation of the CVP and SWP, including future implementation and operation of the CWF. Under the adaptive management program, new information developed during the course of implementation is expected to inform operational decisions and conservation tactics. New information will need to be developed through scientific research to understand the ecological changes that the CWF and other cumulative effects will have on the Bay-Delta ecosystem, including delta smelt. However, currently little information is known about what, when, where, and how these effects will need to be adaptively managed, much less how they will be implemented. Therefore, no analysis was provided in the CWF BA as to how or if activities associated with adaptive management would affect listed species or critical habitat. Thus, addressing effects resulting from the implementation of the adaptive management plan would be speculative at this time. If activities that are identified as part of the framework are not subject to future approvals (*i.e.,* the Corps' Phase 1 permit) and may affect listed species or critical habitat, reinitiation of this consultation is required to address those effects. Activities associated with all other aspects of the PA will require future approvals as described in the *Description of the Proposed Action* and will be subject to future consultations if those activities may affect listed species or critical habitat.

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9.2 Delta Smelt and its Critical Habitat

9.2.1 Status of the Species and Critical Habitat /Environmental Baseline

The CWF Action Area encompasses almost the entire species range and the critical habitat designation. The Napa River is outside of the CWF Action Area, but delta smelt do occur in that River. However, this small area is on the fringe of the species range. For the purposes of this BiOp, the Status of the Species, Status of the Critical Habitat, and Environmental Baseline are combined.

The Environmental Baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed Federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of State or private actions, which are contemporaneous with the consultation in process (50 CFR 402.02). The key purpose of the Environmental Baseline is to describe the condition of the listed species/critical habitat that exist in the Action Area in the absence of the action subject to this consultation. Sections 9.2.1.2. and 9.2.1.4. describe in more detail the conditions in the Action Area and a description of previous actions that have contributed to these current conditions.

9.2.1.1 Status of the Species

Legal Status

The Service proposed to list the delta smelt (*Hypomesus transpacificus*) as threatened with proposed critical habitat on October 3, 1991 (Service 1991). The Service listed the delta smelt as threatened on March 5, 1993 (Service 1993), and designated critical habitat for the species on December 19, 1994 (Service 1994). The delta smelt was one of eight fish species addressed in the *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* (Service 1996), which is currently under revision. A 5-year status review of the delta smelt was completed on March 31, 2004 (Service 2004). The 2004 review concluded that delta smelt remained a threatened species. A subsequent 5-year status review recommended uplisting delta smelt from threatened to endangered (Service 2010a). A 12-month finding on a petition to reclassify the delta smelt as an endangered species was completed on April 7, 2010 (Service 2010b). After reviewing all available scientific and commercial information, the Service determined that re-classifying the delta smelt from a threatened to an endangered species was warranted but precluded by other higher priority listing actions (Service 2010c). The Service annually reviews the status and uplisting recommendation for delta smelt during its Candidate Notice of Review (CNOR) process. Each year, the CNOR has recommended the uplisting from threatened to endangered. Electronic copies of these documents are available at http://ecos.fws.gov/docs/five_year_review/doc3570.pdf and http://www.gpo.gov/fdsys/pkg/FR-2013-11-22/pdf/2013-27391.pdf (Service 2010a; Service 2010b).

Description and Life Cycle

The delta smelt is a small fish of the family Osmeridae. It is endemic to the San Francisco Bay-Delta where it primarily occupies open-water habitats in Suisun Bay and marsh and the Sacramento-San Joaquin Delta. The delta smelt is primarily an annual species, meaning that it completes its life cycle in one year which typically occurs from April to the following April plus or minus one or two months. In captivity delta smelt can survive to spawn at two years of age (Lindberg *et al.* 2013), but this appears to be rare in the wild (Bennett 2005). Very few individuals reach lengths over 3.5 inches (90 mm).

Population Numbers

The Service recently completed a new adult delta smelt abundance estimation procedure based on the Spring Kodiak Trawl (SKT) data for January and February (Table 9.2.1.1-1). The estimated population size of adult delta smelt last January-February (2016) was estimated to be between 6,000 and 28,000 fish with a point estimate of 13,000. At best, this estimate was half of the previous low abundance estimate in January-February 2015 and was most likely on the order of one-tenth of the 2015 abundance. These abundance estimates are new information, which suggest that the extreme drought conditions that occurred during 2013-2015 resulted in very high mortality and extremely low abundance.

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Table 9.2.1.1-1. Estimates of adult delta smelt population size during January-February of 2002 through 2016 with 95% confidence intervals. If the confidence intervals of any pair of years overlap, then the population may not have differed in size between those years.

Year	Point estimate (in thousands of fish)	Confidence Interval	Did the estimate statistically differ from the prior year?
2002	597	405-879	Not applicable
2003	519	238-1,130	No
2004	527	297-934	No
2005	385	248-598	No
2006	151	105-216	Yes – decline
2007	235	126-439	No
2008	262	120-576	No
2009	295	126-691	No
2010	134	83-217	No
2011	234	87-631	No
2012	623	346-1,120	No
2013	171	94-312	Yes – decline
2014	167	91-308	No
2015	112	54-233	No
2016	13	6-28	Yes – decline

In addition to the new abundance estimates, the CDFW conducts four fish surveys from which it develops indices of delta smelt's relative abundance (Figures 9.2.1.1-1 and 9.2.1.1-2). Each survey has variable and unquantified capture efficiency, and in each, the frequency of zero catches of delta smelt is very high, largely due to the species' rarity (*e.g.,* Latour 2015; Polansky *et al.* in review). The [summer] Townet Survey (TNS) is the longest running indicator of delta smelt relative abundance; it has been conducted since 1959. Although this survey was designed to index the relative abundance of metamorphosing juvenile striped bass (*Morone saxatilis)* (Turner and Chadwick 1972), delta smelt have been collected incidentally; most of the delta

smelt captured are age-0 and about 20-40 mm in length (Miller 2000). The Fall Midwater Trawl Survey (FMWT) is the second longest running indicator of delta smelt relative abundance; it has been conducted since 1967. This survey was also designed to index the relative abundance of age-0 striped bass (Stevens 1977), but as with the TNS, delta smelt are collected incidentally (Stevens and Miller 1983). Most of the delta smelt captured by the FMWT are age-0 "subadults" and are about 50-70 mm in length (Sweetnam 1999). The 20-mm Survey is the third longest running indicator of delta smelt relative abundance; it has been conducted since 1995. This survey was designed to monitor the distribution of late larval or metamorphosing juvenile delta smelt to assess their distribution and risk of entrainment into the large water export diversions of the CVP and SWP (Dege and Brown 2004). As its name suggests, most of the delta smelt collected by the 20-mm Survey are about 10-30 mm in length, with a peak catch of fish just under 20 mm (Kimmerer 2008). The newest indicator of delta smelt relative abundance is the Spring Kodiak Trawl Survey (SKT), which has been conducted since 2002. This survey was designed to monitor the distribution of pre-spawn and spawning adult delta smelt to assess their distribution and risk of entrainment. Most of the delta smelt captured in the SKT are 60-80 mm in length (Bennett 2005).

The TNS and FMWT abundance indices for delta smelt have documented the species' long-term decline, while the newer 20-mm and SKT abundance indices have generally confirmed the recent portions of the trends implied by the older surveys (Figures 9.2.1.1-1 and 9.2.1.1-2). During the period of record, juvenile delta smelt relative abundance has declined from peak levels observed during the latter 1970s (Figure 9.2.1.1-1), while subadult relative abundance was at its highest in 1970 and again in 1980 (Figure 9.2.1.1-2). Juvenile and subadult abundance indices both declined rapidly during the early 1980s, increased somewhat during the 1990s, and then collapsed in the early 2000s. Since 2005, the TNS and the FMWT have produced indices that reflect less year to year variation than their 20-mm and SKT analogs, but overall, the trends in both sets of indices are similar. During the past decade, each index has frequently reached new record low levels. The TNS index was 0.0 in 2015 and 2016, and the 2015 FMWT index and subsequent 2016 SKT index were record lows (about one half of one percent of the relative abundance recorded in 1970-1971).

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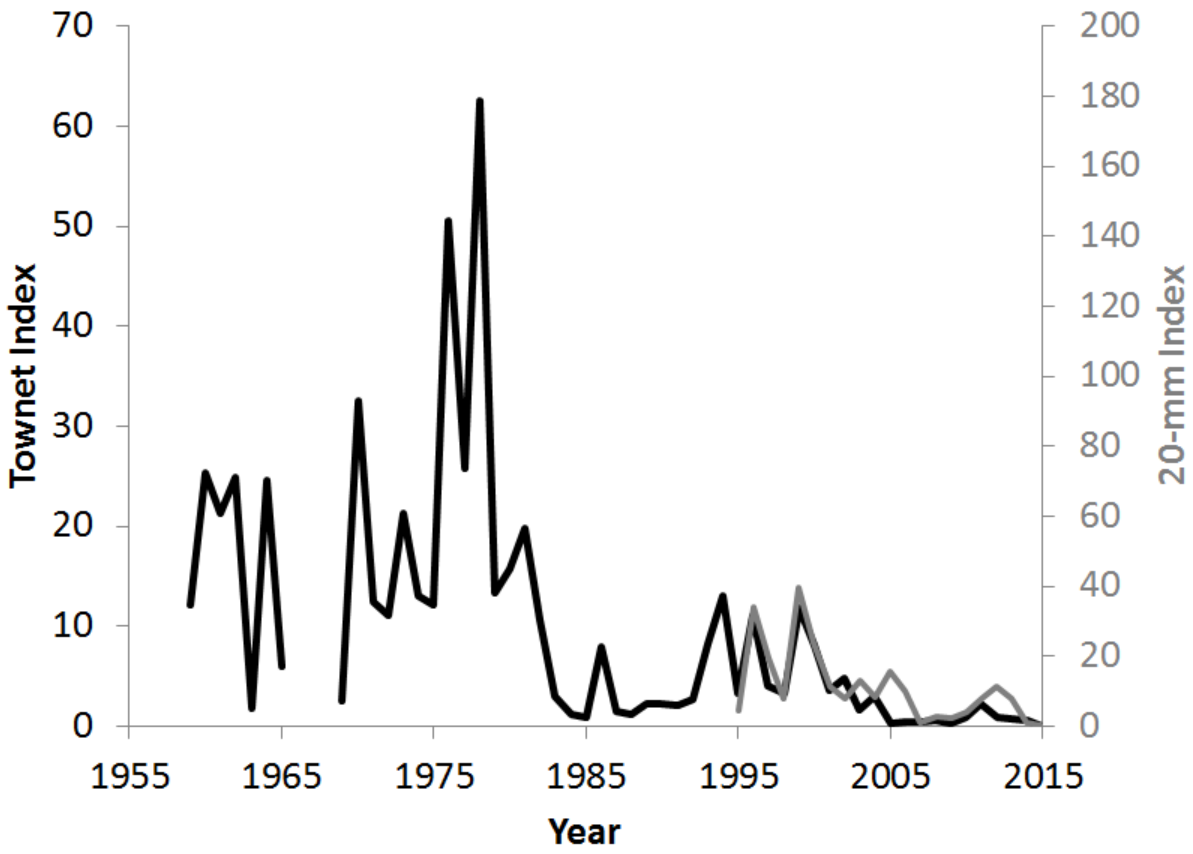

Figure 9.2.1.1-1. Time series of the California Department of Fish and Wildlife's Summer Townet Survey (black line; primary y-axis) and 20-mm Survey (gray line; secondary y-axis) abundance indices for delta smelt.

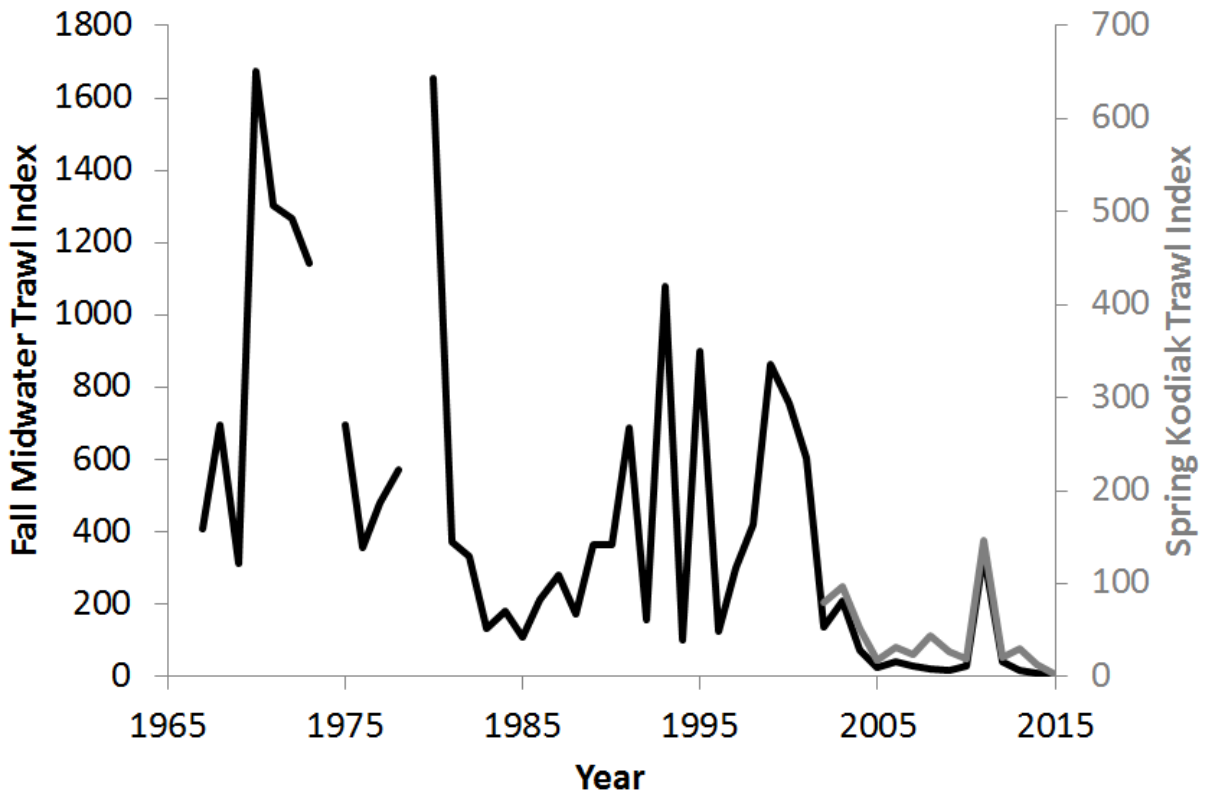

Figure 9.2.1.1-2. Time series of the California Department of Fish and Wildlife's Fall Midwater Trawl (black line; primary y-axis) and Spring Kodiak Trawl (gray line; secondary y-axis) abundance indices for delta smelt.

The abundance of adult delta smelt may have exceeded twenty million in 1980-1981 (Rose *et al.* 2013b). This may sound like a large number – and it is compared to the contemporary estimates listed in Table 9.2.1.1-1. However, decades of monitoring by CDFW has shown that the delta smelt has usually not been very abundant when compared to other pelagic (meaning offshore-oriented or open-water) fishes (Figure 9.2.1.1-3). In the TNS, delta smelt catches have usually been lower than age-0 striped bass, and in recent years, also lower than gobies and threadfin shad. In the FMWT, delta smelt catches have been persistently lower than at least five other species. Research and monitoring in shallower habitats like Suisun Marsh (Moyle *et al.* 1986; Matern *et al.* 2002), Delta beaches (Nobriga *et al.* 2005), and small tidal marshes in the upper estuary (Gewant and Bollens 2012) have reported even lower relative abundances of delta smelt. In each of the studies cited, the catches of delta smelt represented less than one percent of the total fish catch and there were usually more than a dozen more abundant fish species.

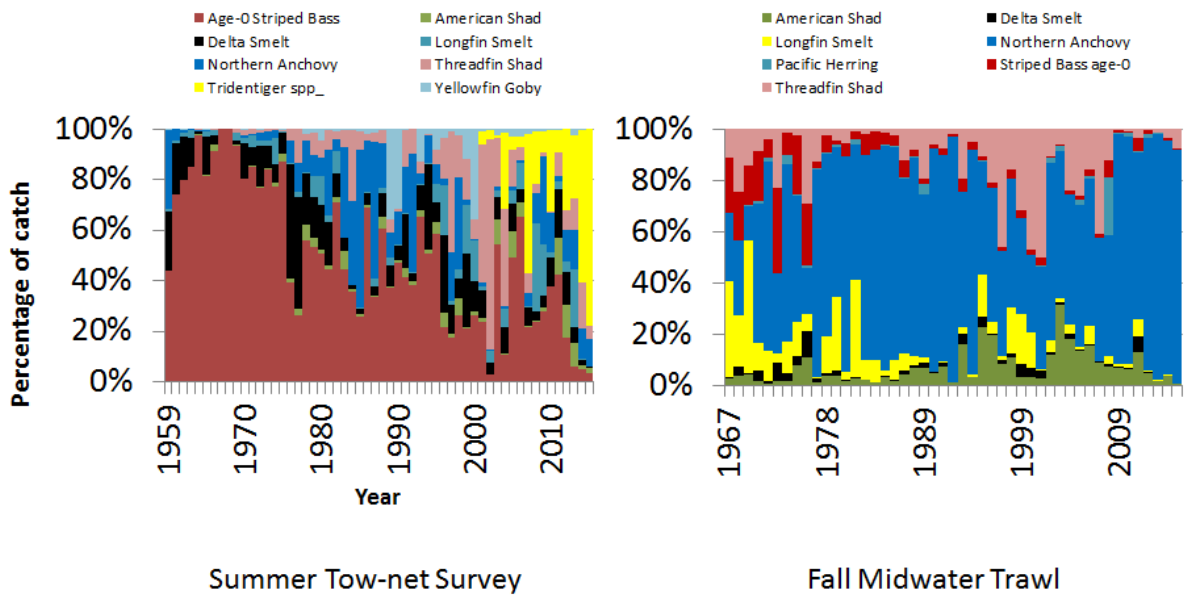

Figure 9.2.1.1-3. Fractional compositions of the eight most frequently collected fish species in the California Department of Fish and Wildlife's Summer Tow-net Survey (1959-2015), and the seven most frequently collected fish species in the Fall Midwater Trawl (1967-2015).

The long-term rarity of the delta smelt has had a consequence for understanding the reasons for their population decline, which generates uncertainty about how resource managers should intervene. Some pelagic fishes have shown long-term relationships between Delta inflow, Delta outflow, or X2 and their abundance or survival (Stevens and Miller 1983; Jassby *et al.* 1995; Kimmerer 2002; Kimmerer *et al.* 2009). There does seem to be some difference in the likelihood of whether the delta smelt population will increase or decrease in abundance from one year to the next based on hydrology (Figure 9.2.1.1-4), but there has never been any predictable relationship linking freshwater flow conditions to the relative abundance of delta smelt (Stevens and Miller 1983; Jassby *et al.* 1995; Kimmerer 2002; Kimmerer *et al.* 2009). Recently, several teams of researchers have built several varieties of conceptual (IEP 2015) and mathematical (Thomson *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012; Rose *et al.* 2013a) life cycle models for the delta smelt that attempt to describe the reasons the population has declined. Some of these models have been able to recreate the trend observed in abundance indices very well (Figure 9.2.1.1-5), but they have all done so using different approaches and different variables to do so. Collectively, these modeling efforts have been helpful in that they generally support water temperature and changes in the estuary's food web as 'universally supported' factors affecting delta smelt. However, they have also come to very different conclusions about the conservation value of more readily manageable factors like water project operations.

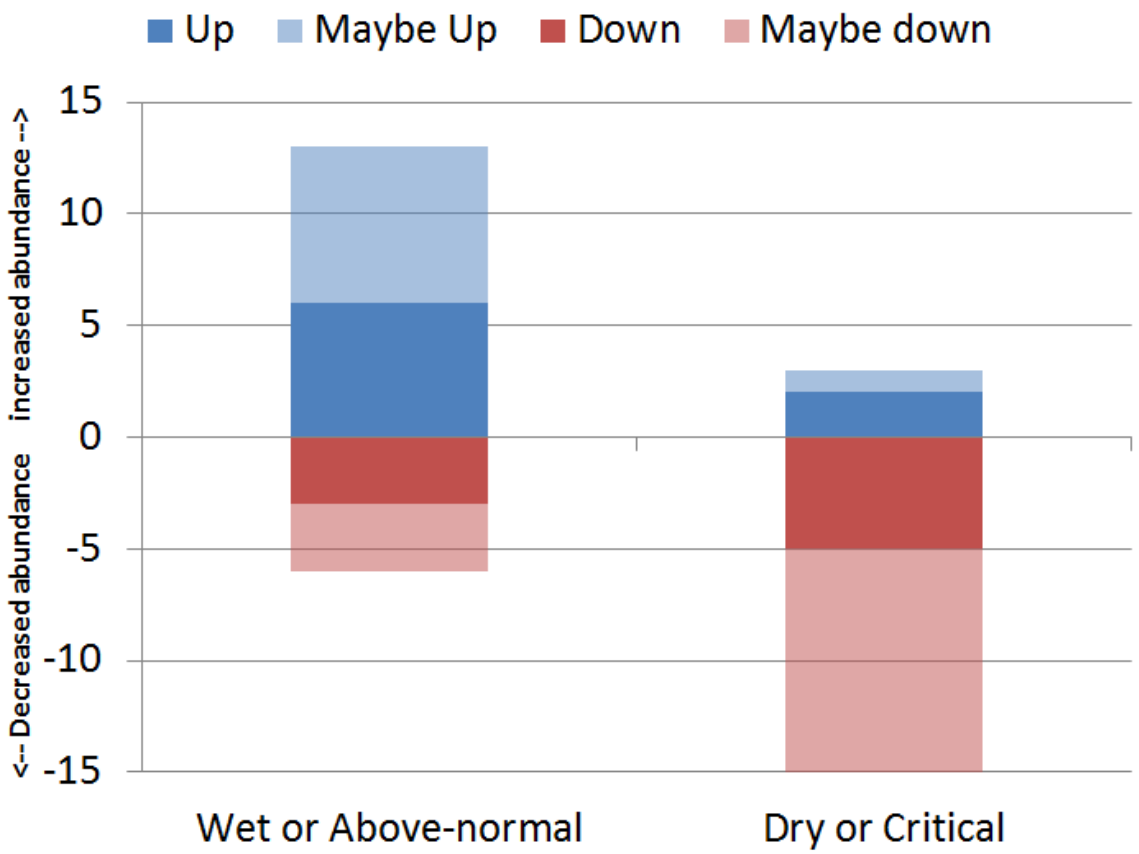

Figure 9.2.1.1-4. Frequencies of delta smelt population increases or decreases (red colored portions of each bar occurring below zero) based on the California Department of Fish and Wildlife's Fall Midwater Trawl Survey, 1967-2015. A population increase reflects an increase in relative abundance over the prior year's index and a population decrease reflects a decrease in relative abundance compared to the prior year's index. The Service performed bootstrap resampling on each year's catch per tow to generate a mean catch per tow with 95 percent confidence intervals. This resulted in four possible outcomes: (1) a statistically significant increase in relative abundance from one year to the next in which the confidence intervals of the two years did not overlap ("Up"; solid blue bar segments), (2) a statistically non-significant increase in relative abundance from one year to the next in which the confidence intervals of the two years overlapped ("Maybe Up"; lighter blue bar segments), (3) a statistically significant decrease in relative abundance from one year to the next in which the confidence intervals of the two years did not overlap ("Down"; solid red bar segments), or (4) a statistically non-significant decrease in relative abundance from one year to the next in which the confidence intervals of the two years overlapped ("Maybe Down"; lighter red bar segments). The counts in each of the four categories were combined by Sacramento Valley Water Year Types except that below-normal years were not plotted. The frequencies of population decline were converted into a negative number so that population increases would count up from the zero line on the y-axis and population decreases would count down from the zero line.

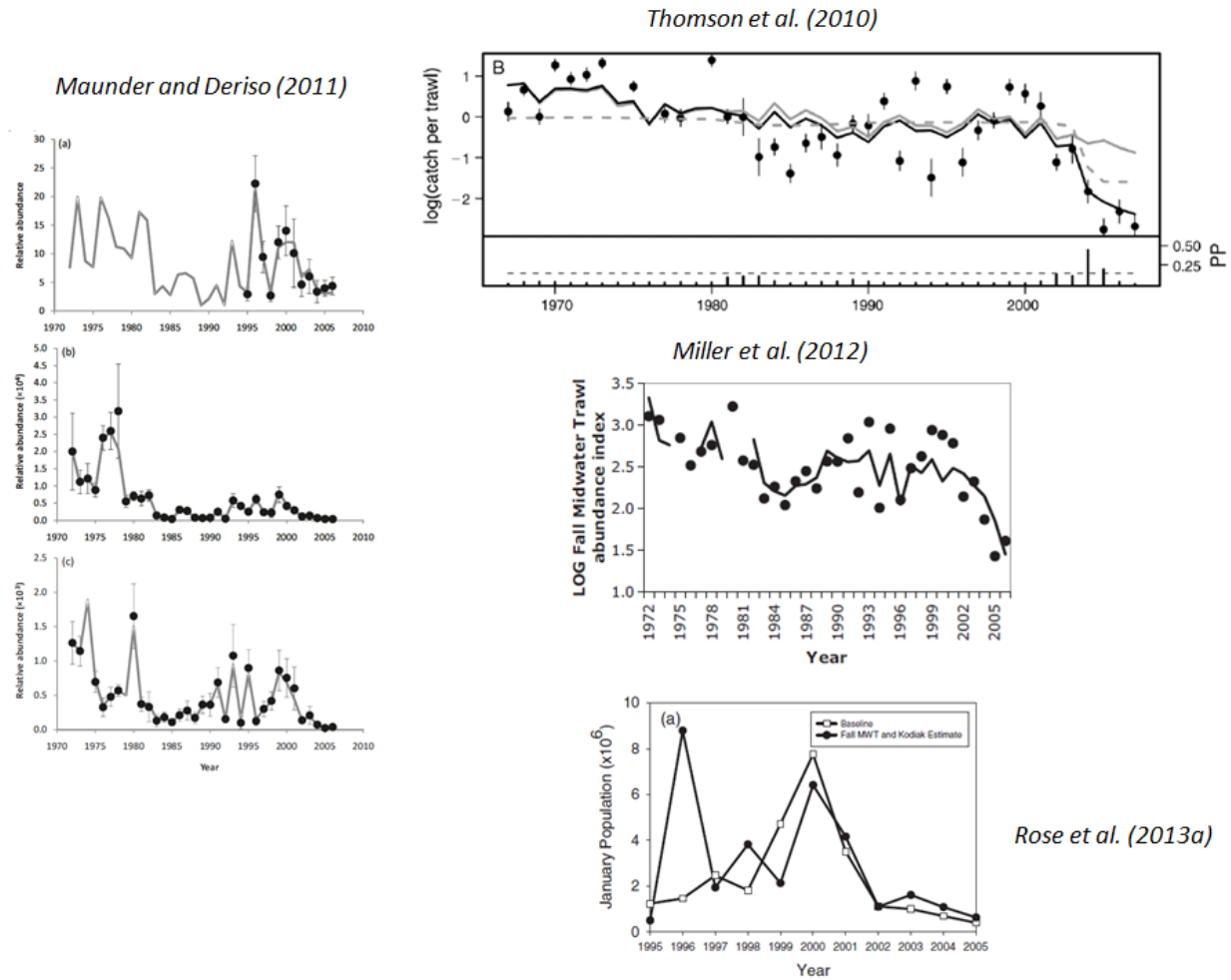

Figure 9.2.1.1-5. Examples of recent published model fits to time series of delta smelt relative abundance data. The source of each is referenced above or alongside each time series. In each plot, observed catches are depicted as black dots and model predictions of the data as gray or black lines. Model predictions from Rose *et al.* (2013a) are a black line with open symbols. In Maunder and Deriso (2011), the three panels represent the 20-mm Survey, Summer Tow-net Survey, and Fall Midwater Trawl (FMWT) Survey from top to bottom, respectively. The other three studies are fit to estimates of adult delta smelt relative abundance (FMWT catch in Thomson *et al.* 2010 and the FMWT index in Miller *et al.* 2012) or absolute abundance (Rose *et al.* 2013a). See each study for further details on Methods, Results, and the authors' interpretations of their Results.

Habitat and Distribution

Because the delta smelt only lives in one part of one comprehensively monitored estuary, its general distribution is well understood (Moyle *et al.* 1992; Bennett 2005; Hobbs *et al.* 2006; 2007; Feyrer *et al.* 2007; Nobriga *et al.* 2008; Kimmerer *et al.* 2009; Merz *et al.* 2011; Murphy and Hamilton 2013; Sommer and Mejia 2013). There are both location-based (*e.g.*, Sacramento River around Decker Island) and conditions-based (low-salinity zone) habitats that delta smelt permanently occupy. There are habitats that delta smelt occupy seasonally (*e.g.*, for spawning), and there are habitats that delta smelt occupy transiently, which we define here as occasional seasonal use. These include distribution extremes from which delta smelt are not collected every year or even in most years. Further details are provided in this section and in *Status of the Species at Proposed Action Area Construction Sites*.

Most delta smelt complete their entire life cycle within or immediately upstream of the estuary's low-salinity zone. The low-salinity zone is frequently defined as waters with a salinity range of about 0.5 to 6 ppt (Kimmerer 2004). The 0.5 to 6 ppt and similar salinity ranges reported by different authors were chosen based on analyses of historical peaks in phytoplankton and zooplankton abundance, but recent physiological and molecular biological research has indicated that the salinities that typify the low-salinity zone are also optimal for delta smelt (Komoroske *et al.* 2016). The low-salinity zone is a dynamic habitat with size and location that respond rapidly to changes in tidal and river flows. The USEPA recently finished a comprehensive set of maps that show how the low-salinity zone changes in size and shape when freshwater flows change the location of X2[14]. The low-salinity zone expands and moves downstream when river flows into the estuary are high, placing low-salinity water over a larger and more diverse set of nominal habitat types than occurs under low flow conditions. During periods of low outflow, the low-salinity zone contracts and moves upstream. Due to its historical importance as a fish nursery habitat, there is a long research history into the physics and biology of the San Francisco Estuary's low-salinity zone (Kimmerer 2004).

The ecological function of the low-salinity zone also varies depending mainly on freshwater flow (Jassby *et al.* 1995; Kimmerer 2002b; Kimmerer 2004). Low outflow can decrease the capacity of the low-salinity zone and adjacent habitats to support the production of delta smelt by reducing habitat diversity and concentrating the fish with their predators and competitors (Service 1993; 1994). During the past four decades, the low-salinity zone ecosystem has undergone substantial changes in turbidity (Schoellhamer 2011) and food web function (Winder and Jassby 2011) that cannot be undone by increasing Delta outflow. These habitat changes, which extend into parts of the Delta where water is fresher than 0.5 ppt, have also decreased the ability of the low-salinity zone and adjacent habitats to support the production of delta smelt (Thomson *et al.* 2010; Rose *et al.* 2013b; IEP 2015).

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14 http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_Delta/docs/cmnt081712/karen_schwinn.pdf

Delta smelt have been observed as far west as San Francisco Bay, as far north as Knight's Landing on the Sacramento River, as far east as Woodbridge on the Mokelumne River and Stockton on the Calaveras River, and as far south as Mossdale on the San Joaquin River (Figure 9.2.1.1-6). This distribution represents a range of salinity from essentially zero parts per thousand (ppt) up to about 20 ppt, which represents a salinity range well beyond definitions of the low-salinity zone or mixing zone near a salinity of 2 ppt emphasized in the critical habitat rule (Service 1994). It is also well beyond the geographic extent of the critical habitat rule (described below). However, most delta smelt that have been collected in the extensively surveyed San Francisco Estuary have been collected from locations within the bounds defined in the critical habitat rule. In addition, all habitats known to be occupied year-around by delta smelt occur within the bounds defined in the critical habitat rule.

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Figure 9.2.1.1-6. Delta smelt range map. Waterways colored in purple depict the delta smelt distribution described by Merz *et al.* (2011). The Service has used newer information to expand the transient range of delta smelt further up the Napa and Sacramento rivers than indicated by Merz *et al.* (2011). The red polygon depicts the designated critical habitat for the delta smelt.

Delta smelt permanently occupy the Cache Slough 'complex' including Liberty Island and the adjacent reach of the Sacramento Deepwater Shipping Channel (Sommer and Mejia 2013), Cache Slough to its confluence with the Sacramento River and the Sacramento River from that confluence downstream to Chipps Island, Honker Bay, and the eastern part of Montezuma Slough (Figure 9.2.1.1-7). The reasons delta smelt are believed to permanently occupy this part of the estuary are the presence of fresh- to low-salinity water year around that is comparatively turbid and of a tolerable water temperature year around. These appropriate water quality conditions overlap an underwater landscape featuring variation in depth, tidal current velocities, edge habitats, and food production (Sweetnam 1999; Nobriga *et al.* 2008; Feyrer *et al.* 2011; Murphy and Hamilton 2013; Hammock *et al.* 2015; Bever *et al.* 2016). Field observations are increasingly being supported by laboratory research that explains how delta smelt respond physiologically to variation in salinity, turbidity, water temperature, and other aspects of their habitat that can vary with changes in climate, freshwater flow and estuarine bathymetry (Hasenbein *et al.* 2014; 2016; Komoroske *et al.* 2014; 2016).

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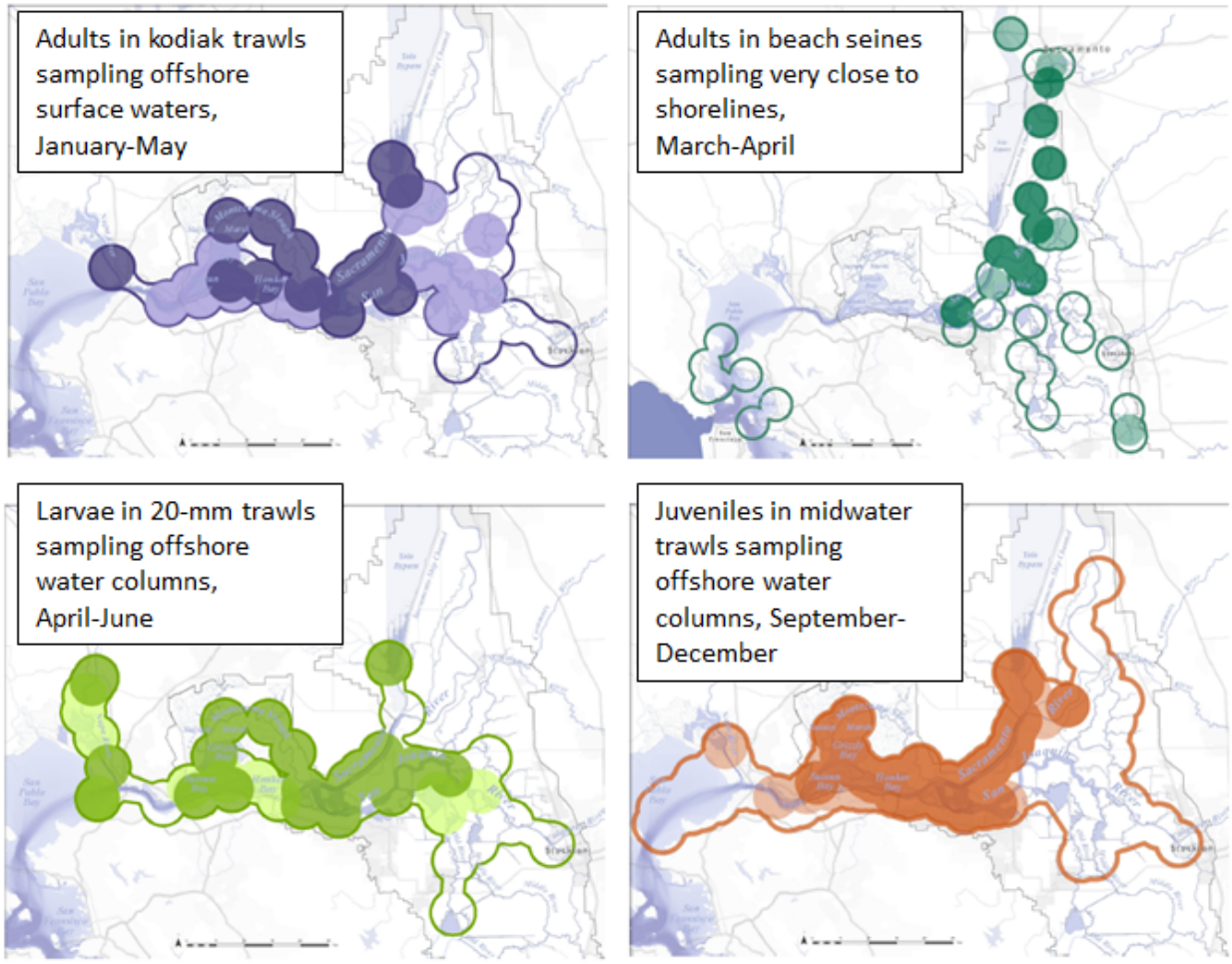

Figure 9.2.1.1-7. Maps of multi-year average distributions of delta smelt collected in four monitoring programs. The sampling regions covered by each survey are outlined. The areas with dark shading surround sampling stations in which 90 percent of the delta smelt collections occurred, the areas with light shading surround sampling stations in which the next 9 percent of delta smelt collections occurred. Source: Murphy and Hamilton (2013).

Each year, the distribution of delta smelt seasonally expands when adults disperse in response to winter flow increases that also coincide with seasonal increases in turbidity and decreases in water temperature (Figure 9.2.1.1-7). The annual range expansion of adult delta smelt extends up the Sacramento River to about Garcia Bend in the Pocket neighborhood of Sacramento, up the San Joaquin River from Antioch to areas near Stockton, up the lower Mokelumne River system, and west throughout Suisun Bay and marsh. Some delta smelt seasonally and transiently occupy Old and Middle rivers in the south Delta each year, but face a high risk of entrainment when they do (Grimaldo *et al.* 2009).

The distribution of delta smelt occasionally expands beyond this area (Figure 9.2.1.1-6). For instance, during high outflow winters, adult delta smelt also disperse west into San Pablo Bay and up into the Napa River (Hobbs *et al.* 2007). Similarly, delta smelt have occasionally been

reported from the Sacramento River north of Garcia Bend up to Knights Landing (*e.g.,* Merz *et al.* 2011; Vincik and Julienne 2012).

The expanded adult distribution initially affects the distribution of the next generation because delta smelt eggs are adhesive and not believed to be highly mobile once they are spawned. The distribution of larvae reflects a combination of where spawning occurred and freshwater flow conditions when the eggs hatched. Variation in Delta outflow affects the spatial distribution of the delta smelt population for most of its life. The ecological condition of the estuary's low-salinity zone has historically been indexed using a statistic called X2, a local name for the geographic location of 2 ppt salinity near the bottom of the water column (Jassby et al. 1995). During spring, larval delta smelt have centers of distribution in freshwater, typically 20-40 km upstream of X2 (Dege and Brown 2004). By July, as water temperatures in the Delta reach annual peaks, post-larval and juvenile delta smelt have centers of distribution very close to X2 (Dege and Brown 2004), but the fish are broadly distributed around that peak (Sweetnam 1999; Nobriga *et al.* 2008). During the fall, subadult delta smelt still have a center of distribution near X2 (Sommer *et al.* 2011), and remain broadly distributed around that peak (Feyrer *et al.* 2007; 2011). During the winter, maturing adult delta smelt disperse in connection with winter storms following the spread of turbid fresh water (Grimaldo *et al.* 2009; Sommer *et al.* 2011; Murphy and Hamilton 2013). After an initial dispersal, recent analyses suggest the delta smelt population's distribution no longer responds strongly to variation in Delta outflow (Polansky *et al.* in review), though some individuals continue to move around in response to flow changes associated with storms (Leo Polansky, unpublished analysis of Early Warning Survey data set).

Food

At all life stages, numerous small crustaceans, especially a group called calanoid copepods, make up most of the delta smelt diet (Nobriga 2002; Slater and Baxter 2014). Small crustaceans are ubiquitously distributed throughout the estuary, but which prey species are present at particular times and locations has changed dramatically over time (Winder and Jassby 2011; Kratina *et al.* 2014). This has likely affected delta smelt feeding success, particularly during Central California's warm summers.

Reproductive Strategy

The reproductive behavior of delta smelt is only known from captive specimens spawned in artificial environments and most of the information has never been published. Spawning likely occurs mainly at night with several males attending a female that broadcasts her eggs onto bottom substrate (Bennett 2005). Although preferred spawning substrate is unknown, spawning habits of delta smelt's closest relative, the Surf smelt (*Hypomesus pretiosus*), as well as unpublished experimental trials, suggest that sand may be the preferred substrate (Bennett 2005, Sommer *et al.* 2013). Hatching success peaks at temperatures of 15-16°C (59-61°F) and decreases at cooler and warmer temperatures. Hatching success nears zero percent as water temperatures exceed 20°C (68°F) (Bennett 2005). Water temperatures suitable for spawning occur most frequently during the months of March-May, but ripe female delta smelt have been observed as early as January and larvae have been collected as late as July.

Delta smelt spawn in the estuary and have one spawning season for each generation, which makes the timing and duration of the spawning season important every year. As stated above, delta smelt are believed to spawn on sandy substrates in fresh and possibly low-salinity water (Bennett 2005). Therefore, freshwater flow affects how much of the estuary is available for delta smelt to spawn (Hobbs *et al.* 2007).

Delta smelt can start spawning when water temperatures reach about 10°C (50°F) and can continue until temperatures reach about 20°C (Bennett 2005). The ideal spawning condition occurs when water temperatures remain cool throughout the spring (*e.g,* March-May). Few delta smelt ≤ 55 mm in length are sexually mature and 50% of delta smelt reach sexual maturity at 60 to 65 mm in length (Rose *et al.* 2013b). Thus, if water temperatures rise much above 10°C in the winter, the "spawning season" can start before most individuals are mature enough to actually spawn. If temperatures continue to warm rapidly toward 20°C in early spring, that can end the spawning season with only a small fraction of 'adult' fish having had an opportunity to spawn. Delta smelt were initially believed to spawn only once before dying (Moyle *et al.* 1992). It has since been confirmed that like many other ecologically similar forage fishes (Winemiller and Rose 1992) individual delta smelt can spawn more than once if water temperatures remain suitable for a long enough time, and if the adults find enough food to support the production of another batch of eggs (Lindberg *et al.* 2013; Kurobe *et al.* 2016). As a result, the longer water temperatures remain cool, the more fish have time to mature and the more times individual fish can spawn.

Although adult delta smelt can spawn more than once, mortality is high during the spawning season and most adults die by May (Polansky *et al.* in review). The egg stage averages about 10 days before the embryos hatch into larvae. The larval stage averages about 30 days. Metamorphosing "post-larvae" appear in monitoring surveys from April into July of most years. By July, most delta smelt have reached the juvenile life stage. Delta smelt collected during the fall are called "subadults", a stage which lasts until the following winter when fish disperse toward spawning habitats. This winter dispersal usually precedes sexual maturity (Sommer *et al.* 2011).

Recovery and Management

Following Moyle *et al.* (1992), the Service (1993) indicated that SWP and CVP exports were the primary factors contributing to the decline of delta smelt due to entrainment of larvae and juveniles and the effects of low flow on the location and function of the estuary mixing zone (now called the low-salinity zone). In addition, prolonged drought during 1987-1992, in-Delta water diversions, reduction in food supplies by nonindigenous aquatic species -specifically overbite clam and nonnative copepods, and toxicity due to agricultural and industrial chemicals were also factors considered to be threatening the delta smelt. In the 2008 Service BiOp, the Service's Reasonable and Prudent Alternative required protection of all life stages from entrainment and augmentation of Delta outflow during the fall of Wet or Above-Normal years as classified by the State of California (Service 2008). The expansion of entrainment protection for delta smelt in the 2008 Service BiOp was in response to large increases in juvenile and adult

salvage in the early 2000s (Kimmerer 2008). The fall X2 requirement was in response to increased fall exports that had resulted in greatly reduced variability in Delta outflow during the fall months (Feyrer *et al.* 2011).

Consistent with the 2008 Service BiOp, the Service's (2010c) recommendation to uplist delta smelt from threatened to endangered included reservoir operations and water diversions upstream of the estuary as mechanisms interacting with exports to restrict the low-salinity zone and concentrate delta smelt with competing fish species. In addition, Brazilian waterweed (*Egeria densa*) and increasing water transparency were considered new detrimental habitat changes. Predation was considered a low-level threat linked to increasing waterweed abundance and increasing water transparency. Additional threats considered potentially significant by the Service in 2010 were entrainment into power plant diversions, contaminants, and reproductive problems that can stem from small population sizes. Conservation recommendations included: establish Delta outflows proportionate to unimpaired flows to set outflow targets as fractions of runoff in the Central Valley watersheds; minimize reverse flows in Old and Middle rivers; and, establish a genetic management plan with the goals of minimizing the loss of genetic diversity and limiting risk of extinction caused by unpredictable catastrophic events. The Service (2012b) recently added climate change to the list of threats to the delta smelt.

Continued protection of the delta smelt from excessive entrainment, improving the estuary's flow regime, suppression of nonnative species, increasing zooplankton abundance, and improving water quality are among the actions needed to recover the delta smelt.

Climate Change

Climate projections for the San Francisco Bay-Delta and its watershed indicate that temperature and precipitation changes will diminish snowpack in the Sierra-Nevada, changing the availability of natural water supplies (Knowles and Cayan 2002; Dettinger 2005). Warming may result in more precipitation falling as rain which will mean less water stored in spring snowpacks. This would increase the frequency of rain-on-snow events and increase winter runoff with an associated decrease in runoff for the remainder of the year (Hayhoe *et al.* 2004). Overall, these and other storm track changes may lead to increased frequency of flood and drought cycles during the 21st century (Dettinger *et al.* 2015). Thus far, the 21st century has been substantially drier than the 20th century (Figure 9.2.1.1-8).

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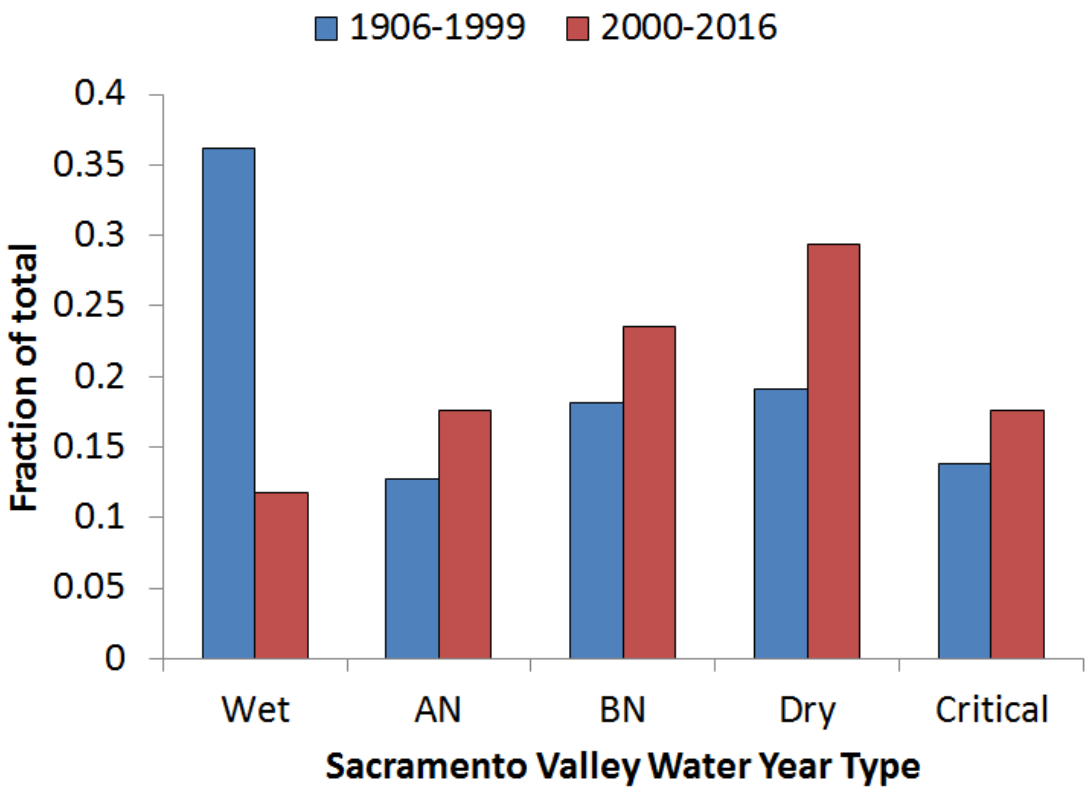

Figure 9.2.1.1-8. Frequency distribution of Sacramento Valley Water Year Types for: blue= 1906-1999 and red= 2000-2016.

Sea level rise is also anticipated as a consequence of a warming global climate and if it is not mitigated, sea level rise will likely influence saltwater intrusion into the Bay-Delta. Salinity within the northern San Francisco Bay is projected to rise by 4.5 ppt by the end of the century (Cloern *et al.* 2011). Elevated salinity could push X2 farther up the estuary if outflows were not increased to compensate. Fall X2 mean values are projected to increase by about 7 km to the area near the City of Antioch approximately 90 km from the Golden Gate Bridge by 2100 (Brown *et al.* 2013). This projected change in the location of X2 in the fall is expected to decrease suitable physical habitat if current levees and channel structures are maintained.

Central California's warm summers are already a source of energetic stress for delta smelt and warm springs already severely compress the duration of their spawning season (Rose *et al.* 2013a,b). Central California's climate is anticipated to get warmer (Dettinger 2005). We expect warmer estuary temperatures to present a significant conservation challenge for delta smelt. Mean annual water temperatures within the Delta are expected to increase steadily during the second half of this century (Cloern *et al.* 2011). Warmer water temperatures could further reduce delta smelt spawning opportunities, decrease juvenile growth during the warmest months, and increase mortality via several food web pathways including: increased vulnerability to predators, increased vulnerability to toxins, and decreased capacity for delta smelt to successfully compete in an estuary that is energetically more optimal for warm water-tolerant fishes.

Recent research into the ecological effects of warming water temperatures suggests that delta smelt, depending on location, may be forced to spawn an average of ten to twenty-five days earlier in the season (Brown *et al.* 2013). The number of high mortality days (cumulative number of days of daily average water temperature >25 °C (77°F)) is expected to increase (Brown *et al.* 2013). The number of physiologically stressful days (cumulative number of days of daily average water temperature >20 °C (68°F)) is expected to be stable or decrease partly because many stressful days will become high mortality days. Thus, current modeling indicates that delta smelt will likely face a shorter maturation window and reduced habitat availability due to increased water temperatures. A shorter maturation window will likely have effects on reproduction (Brown *et al.* 2013). Growth rates have been shown to slow as water temperatures increase above 20 °C (68°F), requiring delta smelt to consume more food to reach growth rates that are normal at lower water temperatures (Rose *et al.* 2013a). Delta smelt are smaller, on average, than in the past (Sweetnam 1999; Bennett 2005) and expected temperature increases due to climate change will likely slow growth rates further.

In summary, the delta smelt is currently at the southern limit of the inland distribution of the family Osmeridae along the Pacific coast of North America. Thus, increased temperatures associated with climate change may present a significant conservation challenge if they result in a Bay-Delta that is outside of the delta smelt's competitive limits. For the time being however, water temperatures are cool enough in the delta smelt's range for the species to complete its life cycle.

Summary of the Status of Delta Smelt

The relative abundance of delta smelt has reached very low numbers for a small forage fish in an ecosystem the size of the San Francisco Estuary. The extremely low recent relative abundance reflects decades of habitat change and marginalization by non-native species that prey on and out-compete delta smelt. The anticipated effects of climate change on the San Francisco Estuary and watershed such as warmer water temperatures, greater salinity intrusion, lower snowpack contribution to spring outflows from the Delta, and the potential for frequent extreme drought, which has been experienced for the 21st century thus far (Figure 9.2.1.1-8) indicate challenges to delta smelt survival will increase. A rebound in relative abundance during the very wet and cool conditions during 2011 indicated that delta smelt retained some population resilience (IEP 2015). However, since 2012, declines to record low population estimates (Table 9.2.1.1-1) have been broadly associated with the remarkably dry hydrology occurring over the past few years.

9.2.1.2 Status of the Species at Proposed Action Area Preconstruction and Construction Sites

The following sections provide additional detail about habitat conditions in specific areas where CWF proposes construction activities. The status of the delta smelt at these proposed construction areas is dependent on the species' range-wide status because the CWF construction is all proposed to occur in seasonally or transiently used habitats that will be occupied and used by fish in general proportion to their overall range-wide abundance.

Sacramento River from I Street Bridge in Sacramento to its Confluence with Cache Slough at Grand Island and the Primary Distributary Channels Steamboat Slough, Georgiana Slough, and the Delta Cross Channel

The adjacent land use along most of this river reach has been urban (Sacramento) or agricultural since the 1860s-1890s (Whipple *et al.* 2012; Figure 9.2.1.2-1). Major changes include deforestation of the natural levees, disconnection of the river from its flanking floodplains, extensive levee reinforcement with rip-rap, and an initial increase in sediment, followed by a long-term decrease that has changed the tidal prism of this river reach. Reclamation constructed the Delta Cross Channel (DCC) in 1944 from the Sacramento River at Walnut Grove to the North Fork Mokelumne River to increase the flow of Sacramento River water across the Delta. When the DCC gates are opened, Sacramento River water flows into the North Fork of the Mokelumne River, which then flows into the San Joaquin River between Bouldin and Andrus islands.

Historically, the Sacramento River and its distributary sloughs had a well-developed riparian corridor along large natural levees that separated this river segment from its flanking floodplains (Whipple *et al.* 2012). The fringing riparian forest varied from several hundred feet wide to about one mile wide depending on location. The river did not meander here. Rather, floodwaters flowed into the Yolo basin at Knights Landing Ridge and into the Sacramento basin at the confluence of the American River. The Sacramento basin connection has been severed to develop and protect the greater Sacramento urban area. The Yolo basin connection has been muted by Fremont and Sacramento weirs, and levees that separate the Yolo Bypass from adjacent land areas, but the connection is not completely severed. The Yolo Bypass continues to route flood flows away from the Sacramento urban area (Sommer *et al.* 2001).

Presently, urban and agricultural land uses encroach to the landside of the existing reinforced levee system and little riparian habitat remains (Figures 9.2.1.2-2 and 9.2.1.2-3). This reach of the Sacramento River also includes a 286 cfs capacity water diversion operated by the Freeport Regional Water Authority, and the outfall for the Sacramento Regional Wastewater Treatment Plant. The positive barrier fish screens on the Freeport diversion preclude post larval fishes from being entrained. Larval fish sampling behind the Freeport fish screens was conducted from 2012-2014; no delta smelt larvae were found, though a small number of wakasagi larvae were collected (CWF BA 2016). The only significant natural habitat area adjacent to this river reach is the Stone Lakes National Wildlife Refuge near the City of Elk Grove. However, even the refuge has no natural connection to the river and therefore provides no habitat value to delta smelt. Hydraulic mining made this reach of the Sacramento River much shallower (and non-tidal) during the late 19th and early 20th centuries, but the sediment has dispersed over time and the river has regained its tidal influence (Whipple *et al.* 2012). Although under tidal influence, this reach of the Sacramento River is a major CVP and SWP water conveyance channel. Thus flows are almost always high enough such that net flow is downstream even during flood tides (CWF BA 2016). The sediment supply carried into the estuary via the Sacramento River declined by 50% from the latter 1950s to the early 2000s (Wright and Schoellhamer 2004). Most of the sediment currently delivered to the estuary from this and other sources occurs during periods of

high flow because sediment delivery rates steepen as inflows increase (Wright and Schoellhamer 2005).

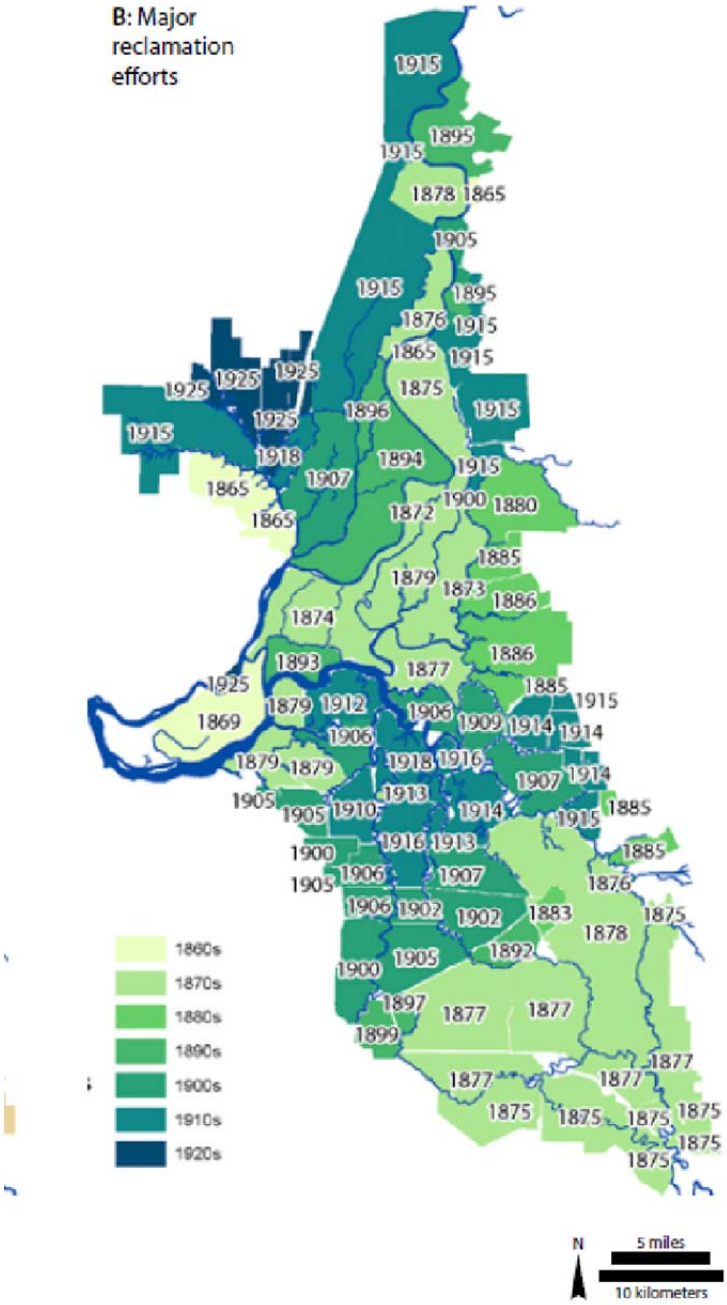

Figure 9.2.1.2-1. Map of the Delta showing dates of island conversion to agriculture. Taken from Whipple *et al.* (2012).

Figure 9.2.1.2-2. Google Earth image of the Sacramento River in the vicinity of Isleton.

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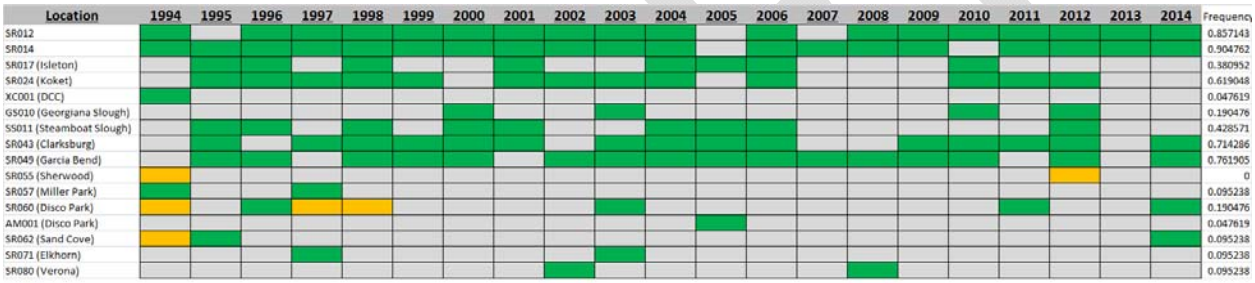
Figure 9.2.1.2-3. Google Earth image of the Sacramento River in the vicinity of Garcia Bend.

Food web: The Sacramento River from Sacramento to Isleton and its primary distributaries are low productivity channels and have been for several decades (Orsi and Mecum 1986). This may be due to the canal shape of these channels and the rapid conveyance of river water into the Delta. However, there are also water chemistry-related reasons for this area's low productivity. For instance, chlorophyll concentrations in the Sacramento River decline rapidly as it flows past the City of Sacramento, suggesting a toxic effect on primary productivity (Parker *et al.* 2012). Parker *et al.* (2012) proposed ammonium inhibition of phytoplankton growth as the mechanism generating this pattern. In addition, toxicity to invertebrates related to urban pesticide runoff has been observed in the American River, which flows into the Sacramento River in the city limits (Weston *et al.* 2012). Thus, this river reach is not presently a major source of immediately available zooplankton production for delta smelt to prey on.

Adult migration and spawning: The results of DSM-2 PTM modeling show that there is no measurable probability tide-surfing particles intended to represent dispersing adult delta smelt could ascend the Sacramento River to the proposed NDD sites using only open off-channel habitats (CWF BA 2016). This makes intuitive sense for two reasons. First, the tidal energy extending up into Cache Slough is much greater than the tidal energy extending into the comparatively narrow mainstem channel of the Sacramento River so most particles that can move upstream move into Cache Slough. Second, both flood and ebb tide flows are usually

moving downstream in the Sacramento River where the proposed NDDs would be built. Once the tides stop flowing in two directions, the standard tide-surfing mechanisms, vertical and lateral changes in distribution during flood versus ebb tides, would no longer work to move fish upstream. However, adult delta smelt do ascend the Sacramento River (Merz *et al.* 2011), in one robustly documented instance, even reaching Knight's Landing, which is well beyond the reach of tidal influence (Vincik and Julienne 2012). The most parsimonious explanation for how delta smelt can accomplish this against water velocities that exceed their sustained swimming speeds in mid-channel is to do something they do less frequently further downstream – remain near the shoreline throughout the tidal cycle because near the shoreline, water velocities are slower.

If this hypothesis about migration tactics is correct, then we would expect to see low catches in trawls from this reach of the Sacramento River and relatively higher catches in nearshore beach seines. The available data support this hypothesis. The estimated densities of adult delta smelt in this river reach based on the CDFW SKT are zero. In contrast, detection frequencies based on the Service's Delta Juvenile Fishes Monitoring Program beach seine surveys are fairly high (Table 9.2.1.2-1).



Location	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Frequency
SR012																						0.857143
SR014																						0.904762
SR017 (Isleton)																						0.380952
SR024 (Koket)																						0.619048
XC001 (DCC)																						0.047619
GS010 (Georgiana Slough)																						0.190476
SS011 (Steamboat Slough)																						0.428571
SR043 (Clarksburg)																						0.714286
SR049 (Garcia Bend)																						0.761905
SR055 (Sherwood)																						0
SR057 (Miller Park)																						0.095238
SR060 (Disco Park)																						0.190476
AM001 (Disco Park)																						0.047619
SR062 (Sand Cove)																						0.095238
SR071 (Elkhorn)																						0.095238
SR080 (Verona)																						0.095238

Table 9.2.1.2-1. Summary of adult delta smelt detections at sixteen sites along a transect of the Sacramento River and its primary distributaries from Decker Island to Verona. The sites SR012 and SR014 are downstream of the Sacramento River confluence with Cache Slough and reflect a permanently occupied baseline or background detection rate for this sampling program (86 to 90 percent; see far right column). The other sampling sites are seasonally or transiently occupied habitats that can be compared against SR012 and SR014. Green cells represent detections during January-June, gray cells represent non-detections, yellow cells represent autumn detections, which were only reported a few times in relatively upstream locations and thus may represent misidentified wakasagi. Data source: Delta Juvenile Fishes Monitoring Program, 1994-2014 (https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm).

The beach seine data suggest that delta smelt use the Sacramento River between Isleton and Sacramento, and its primary distributaries, as a migratory corridor and spawning habitat. We conclude this because the vast majority of individuals collected are adult-sized fish during February-May (Figure 9.2.1.2-4). These recent observations of timing and location are consistent with a somewhat older study by Stevens (1963): "Evidently freshwater smelt leave the Courtland-Freeport area soon after their spawning period. Most specimens present in the stomachs of bass caught in this area had ripe ovaries or testes and only three were found after June 25."

Larval transport and juvenile rearing: Delta Smelt larvae that hatch in the Sacramento River above its confluence with Cache Slough typically encounter swift downstream currents that would rapidly transport them below the confluence with Cache Slough into larger channels with tidal flows that move upstream and downstream twice a day. Larvae can use this stronger tidal influence to help them maintain position in the estuary (Bennett *et al.* 2002). Larvae that hatch in Steamboat and Georgiana sloughs would likewise be rapidly moved downstream; however, larvae that hatch in Steamboat Slough would be transported to the same areas as larvae hatched in the Sacramento River whereas larvae hatching in Georgiana Slough would be transported to the San Joaquin River.

Juvenile delta smelt catches along the Sacramento River and its distributaries are rare above Cache Slough. During 1994-2014, only three were collected from Courtland and Garcia Bend, the two sampling sites nearest the proposed NDD locations (Figure 9.2.1.2-4). Thus, this part of the Action Area is for the most part, not a juvenile rearing habitat.

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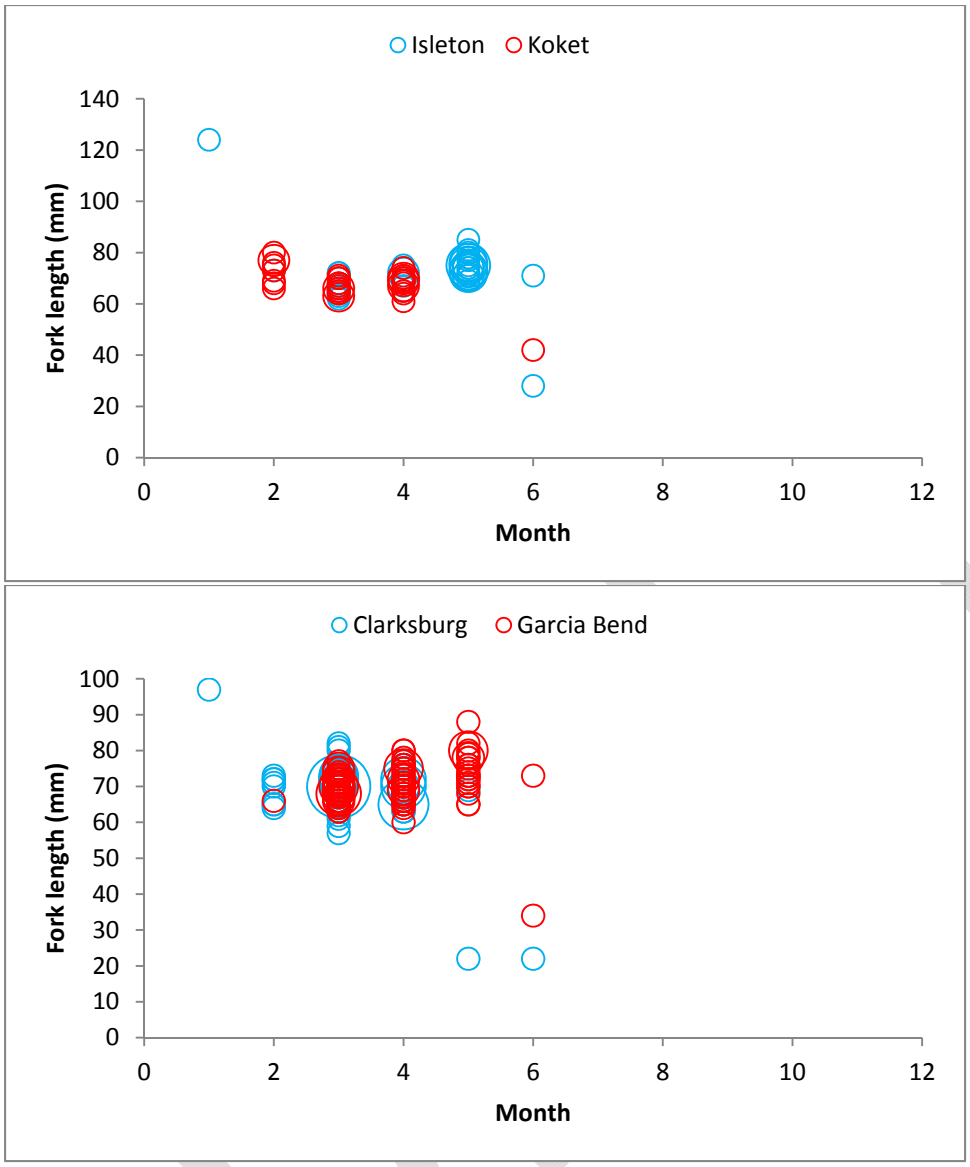

Figure 9.2.1.2-4. Scatterplots of delta smelt size by month for the locations listed in the captions. Delta smelt larger than 50 mm in length are adults. The smallest data points reflect one fish collected the plotted length; the larger the data point, the more fish of that the plotted length were collected. Data source: Delta Juvenile Fishes Monitoring Program beach seine survey, 1994-2014.

Waterways to the east of the Sacramento River in the vicinity of Locke and Walnut Grove: Snodgrass Slough, Lost Slough, the lower Cosumnes River, and the North and South forks of the Mokelumne River adjacent to Staten Island

The adjacent land use along most of this river reach was converted to agriculture around 1915 (Whipple *et al.* 2012; Figure 9.2.1.2-1). Before reclamation, the region was largely riverine

though it was under tidal influence as it is today (Florsheim and Mount 2002). Major changes include deforestation of the natural levees, channelization and disconnection of the river from its flanking floodplains and extensive levee reinforcement with rip-rap. Presently, agriculture is the dominant adjacent land use; however, there are a few natural habitat areas including stands of riparian forest and parcels of freshwater wetlands that are more frequently separated from the river channels by levees than not (Figure 9.2.1.2-5). Since the 1990s, there has been some restoration of the Cosumnes River floodplain at the edge of the Delta's tidal influence (Swenson *et al.* 2003).

Routine trawl-based monitoring programs by CDFW that sample this part of the Delta like the FMWT and the SKT have seldom collected delta smelt (< 1 percent of the catch; Murphy and Hamilton 2013). The Service's beach seine monitoring program has occasionally collected delta smelt (57 individuals in 21 years) from the few sampling sites it has in this region (Figure 9.2.1.2-6). All 57 collections were adults; similar to the Sacramento River, the collections occurred during the spawning season with observations as late in the year as June 1 in 1999 (Table 9.2.1.2-2). Delta smelt have occasionally been collected from several other locations within this area and up the Mokelumne River as far as Woodbridge Dam (Merz *et al.* 2011; Figure 9.2.1.1-6). No delta smelt were collected during a three-year study of fishes in the Cosumnes River basin during 1999-2001 (Moyle *et al.* 2003). Furthermore, no delta smelt larvae were collected during larval fish surveys of the Cosumnes floodplain restoration areas (Crain *et al.* 2004). The Service concludes this is a transiently used spawning habitat area for delta smelt.

Figure 9.2.1.2-5. Google Earth image of the Delta east of Walnut Grove showing the Mokelumne River system from the Delta Cross Channel to the Cosumnes River floodplain.

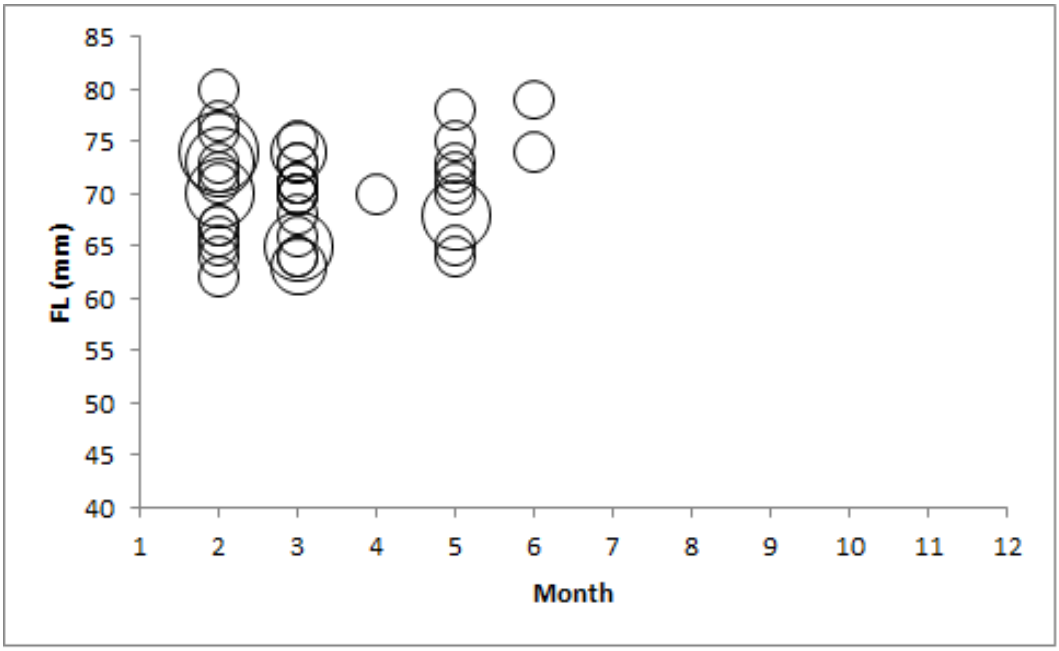

Figure 9.2.1.2-6. Timing and fork lengths of delta smelt collected by Service beach seine surveys at Mokelumne River sites. Delta smelt larger than 50 mm in length are adults, so only adults have been collected in these surveys. The smallest data points reflect one fish collected the plotted length; the larger the data point, the more fish of that the plotted length were collected. Data source: Delta Juvenile Fishes Monitoring Program beach seine survey, 1994-2014.

Location	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Frequency
SF014E (Wimpy's)					■	■	■			■			■				■					0.285714
LP003E (Terminous)					■		■				■		■									0.190476
MK004W (B&W Marina)																						0

Table 9.2.1.2-2. Years in which beach seine surveys conducted by the Service's Lodi Fish and Wildlife Office have collected delta smelt from Mokelumne River sites.

Waterways near Prisoners Point

The forks of the Mokelumne River and Georgiana Slough flow into the San Joaquin River along the north and west sides of Bouldin Island. The proposed tunnel alignment crosses under the San Joaquin River at Venice Island just east of Prisoners Point (CWF BA 2016). Historically, this reach of the San Joaquin River system was part of the central Delta's vast 300,000-acre tidal marsh system with a complex, sinuous channel network (Whipple *et al.* 2012). The historical vegetation was dominated by tules. The surrounding landscape was converted to agriculture between 1906 and 1916 (Figure 9.2.1.2-1).

Figure 9.2.1.2-7. Google Earth image of the central Delta including the San Joaquin River region around Prisoners Point.

The major landscape change in this region is the disconnection of the Delta islands from the river channel network and the conversion of the tule marsh plains into agriculture (Whipple *et al.* 2012). The tule peat was burned and otherwise oxidized away over the previous 100 years, leaving the surrounding islands well below sea level (Mount and Twiss 2005). These subsided islands are protected from flooding by rip-rapped levees. Generally the levees along the north bank of the San Joaquin River are extensively rip-rapped and as a consequence, largely denuded of vegetation, while the southern bank retains greater amounts of riparian and marsh vegetation.

There are numerous in-channel islands in Potato Slough along the north side of Venice Island and in the San Joaquin River upstream of Prisoners Point (Figure 9.2.1.2-7). The channel edges and remnant wetland complexes in this reach are heavily infested with submerged aquatic vegetation (Durand *et al.* 2016) and slow moving sloughs and smaller channels can have seasonal infestations of water hyacinth as well (Toft *et al.* 2003). These aquatic plants, largely comprised of invasive species, create highly productive microhabitats (Lucas *et al.* 2002; Nobriga *et al.* 2005; Grimaldo *et al.* 2009), but they degrade habitat quality for delta smelt by increasing water transparency (Nobriga *et al.* 2008; Hestir *et al.* 2016) and harboring predatory fishes (Ferrari *et al.* 2014; Conrad *et al.* 2016).

Unlike the proposed construction areas to the north, this region has been monitored more intensively and has been a region of significant fish biological research as well (*e.g.,* Toft *et al.* 2003; Grimaldo *et al.* 2004; Nobriga *et al.* 2005; 2008; Grimaldo *et al.* 2009; 2012). Thus, delta smelt's use of the area is more mechanistically understood here. Each winter, some delta smelt move up the San Joaquin River to spawn. This has been confirmed over the past decade and a half by the CDFW's SKT Survey (http://www.dfg.ca.gov/delta/data/skt/DisplayMaps.asp) and more recently, the Service's Early Warning Surveys (https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm). These fish presumably find spawning habitats along sandy beach areas. Grimaldo *et al.* (2004) generally found higher densities of delta smelt larvae in the river channels around Venice Island than the remnant marshes associated with the in-channel islands. The CDFW's 20-mm Survey, which samples channel habitats, has collected larval and small juvenile delta smelt from this region every year of its 21-year history (http://www.dfg.ca.gov/delta/data/20mm/CPUE_map3.asp). However, larvae collected in the San Joaquin River could have either been spawned in the San Joaquin River or have been transported from the Sacramento and Mokelumne systems, which are hydrodynamically connected to the San Joaquin River near Prisoners Point (Kimmerer and Nobriga 2008). The abundance of larval delta smelt in the central Delta usually drops below 20-mm survey detection limits by the end of June and below south Delta diversion (SDD) fish facilities detection limits about a month later (Figure 9.2.1.2-8). As abundance has decreased, these detection thresholds have shifted earlier in the year because both trawl nets and the fish facilities have minimum densities of fish they can reliably detect, and perhaps because water operations changes initiated under the Service and NMFS biological opinions have better enabled larval delta smelt to move seaward during the spring.

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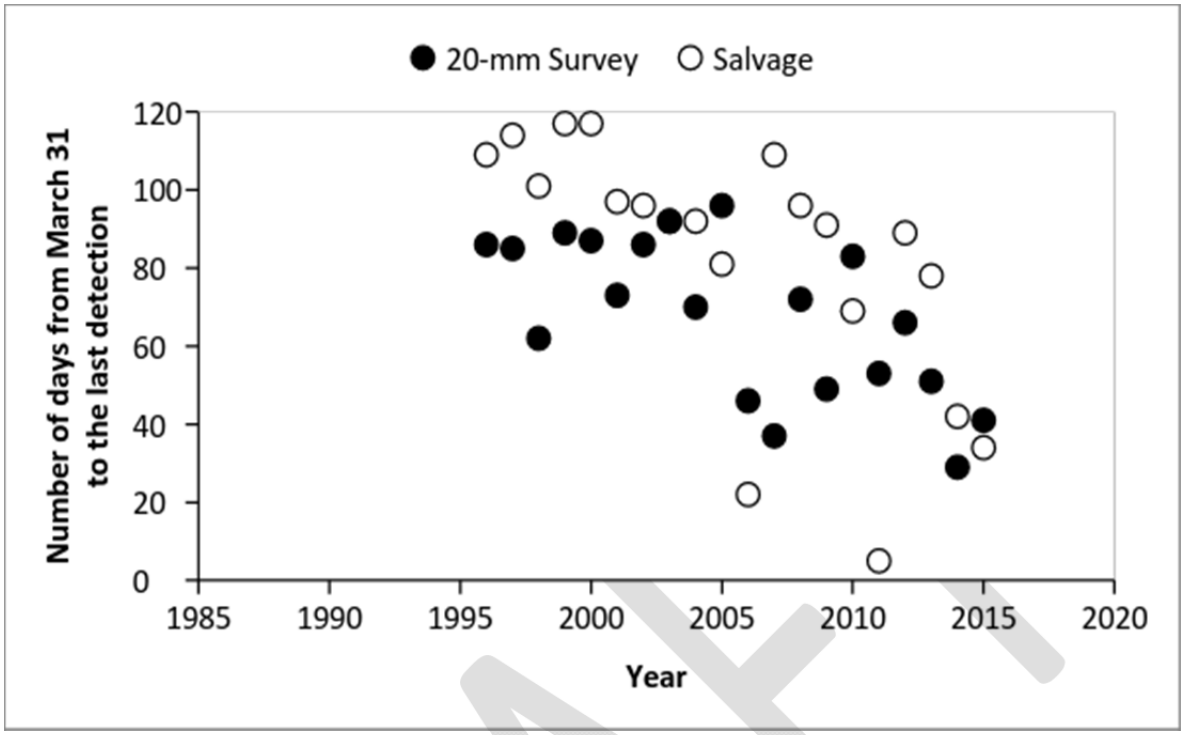

Figure 9.2.1.2-8. Time series of the day of last detection of delta smelt upstream of Jersey Point in the 20-mm Survey and at the CVP or SWP fish facilities. On the y-axis, day 1 is April 1, and day 120 is July 29.

Head of Old River and Other Waterways along the Proposed Tunnel Alignment South of the San Joaquin River Main Stem

The CDFW's striped bass and delta smelt monitoring surveys do not sample in the San Joaquin River upstream of Rough and Ready Island in Stockton (Figure 9.2.1.1-7). Delta smelt have been collected as far up the San Joaquin River as Mossdale (Figure 9.2.1.1-6) and the Service's DJFMP beach seine program has occasionally collected delta smelt in the vicinity of the head of Old River (Figure 9.2.1.1.7). The Service considers delta smelt that ascend this far up the San Joaquin River to be entrained and as such not functionally contributing to the next generation of fish. Not all entrained delta smelt die in water diversions because many are eaten by predators in the poor quality habitats of the southern Delta's flooded islands (Franks Tract, Mildred Island) and canals with net reverse flows (Old and Middle rivers) before they reach the fish facilities. Some of these 'entrained' fish may even have the opportunity to spawn, but PTM shows their larvae would seldom have a hydrodynamic opportunity to escape the south Delta (Kimmerer and Nobriga 2008). In addition, most delta smelt that reach the CVP and SWP intakes are eaten by predators before they can be salvaged (Castillo *et al.* 2012). Delta smelt are seldom collected anywhere in the southern Delta beyond June due to entrainment, increasing water temperature (Kimmerer 2008; Service 2008), and increasing sensitivity to high transparency water as they metamorphose into juveniles (Nobriga *et al.* 2008).

9.2.1.3 Status of the Critical Habitat

Legal Status

The Service designated critical habitat for the delta smelt on December 19, 1994 (Service 1994). The geographic area encompassed by the designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (Service 1994). The entire designated critical habitat for delta smelt is encompassed by the Action Area for the proposed action. Therefore, we combined the *Status of Critical Habitat* and the *Environmental Baseline/Status of Critical Habitat in the Action Area* into one section.

Conservation Role of Delta Smelt Critical Habitat

The Service's primary objective in designating critical habitat was to identify the key components of delta smelt habitat that support successful completion of the life cycle, including spawning, larval and juvenile transport, rearing, and adult migration back to spawning sites. Delta smelt are endemic to the Bay-Delta and the vast majority only live one year. Thus, regardless of annual hydrology, the Bay-Delta estuary must provide suitable habitat all year, every year. The primary constituent elements essential to the conservation of the delta smelt are physical habitat, water, river flow, and salinity concentrations required to maintain delta smelt habitat for spawning, larval and juvenile transport, rearing, and adult migration (Service 1994). The Service recommended in its designation of critical habitat for the delta smelt that salinity in Suisun Bay should vary according to WY type. For the months of February through June, this element was codified by the State Water Resources Control Board's "X2 standard" described in D-1641 and the Board's current Water Quality Control Plan.

Description of the Primary Constituent Elements

The original descriptions of the primary constituent elements are compared and contrasted with current scientific understanding in Table 9.2.1.3-1.

Table 9.2.1.3-1. Comparison of delta smelt primary constituent elements of critical habitat between the 1994 publication of the rule and the present.

Primary Constituent Element	1994 critical habitat rule	2016 state of scientific understanding
Spawning Habitat	Shallow fresh or slightly brackish edgewaters	No change
	Backwater sloughs	Possible, never confirmed. Most likely spawning sites have sandy substrates and need not occur in sloughs. Backwater sloughs in particular tend to have silty substrates that would suffocate eggs.
	Low concentrations of pollutants	No change
	Submerged tree roots, branches, emergent vegetation (tules)	Not likely. Unpublished observations of spawning by captive delta smelt suggest spawning on substrates oriented horizontally and a preference for gravel or sand that is more consistent with observations of other osmerid fishes.
	Key spawning locations: Sacramento River "in the Delta", Barker Slough, Lindsey Slough, Cache Slough, Prospect Slough, Georgiana Slough, Beaver Slough, Hog Slough, Sycamore Slough, Suisun Marsh	All of the locations listed in 1994 may be suitable for spawning, but based on better monitoring from the Spring Kodiak Trawl Survey, most adult fish have since been observed to aggregate around Grizzly Island, Sherman Island, and in the Cache Slough complex including the subsequently flooded Liberty Island.
	Adults could spawn from December-July.	Adults are virtually never fully ripe and ready to spawn before February and most spawning is completed by May (warm years) or June (cool years).

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Larval and juvenile transport	Larvae require adequate river flows to transport them from spawning habitats in backwater sloughs to rearing habitats in the open waters of the low-salinity zone	Not likely. Most delta smelt that survive to the juvenile life stage do eventually inhabitat water that is in the 0.5 to 6 ppt range, due to either or both of downstream movement or decreasing outflow. However, delta smelt larvae can feed in the same habitats they were hatched in and juvenile fish can rear in water less than 0.5 ppt salinity.
	Larvae require adequate flow to prevent entrainment	No change
	Larval and juvenile transport needs to be protected from physical disturbances like sand and gravel mining, diking, dredging, rip-rapping	No change, but seems likely to have more impact on spawning habitat than larval transport
	2 ppt isohaline (X2) must be west of the Sacramento-San Joaquin River confluence to support sufficient larval and juvenile transport	Generally is during February-June due to State Water Resources Control Board X2 standard; however, the standard does have a drought off-ramp
	Maturation must not be impaired by pollutant concentrations	No change
	Additional flows might be required in the July-August period to protect delta smelt that were present in the south and central Delta from being entrained in export pumps.	July-August outflow augmentations may be helpful, but not to mitigate entrainment. Habitat changes in the central and south Delta have rendered it seasonally unsuitable to delta smelt during the summer; entrainment is seldom observed past June and the 2008 Service BiOp RPA has a 25 degree Celsius off-ramp that usually triggers in June.

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Rearing habitat	2 ppt isohaline (X2) should remain between Carquinez Strait in the west, Three-Mile Slough on the Sacramento River and Big Break on the San Joaquin River in the east. This was determined to be a historical range for 2 ppt salinity (including its tidal time scale excursion into the Delta).	Generally is during February-June due to State Water Resources Control Board X2 standard; however the standard does have a drought off-ramp. Most juvenile delta smelt still rear in this area but it is now recognized that a few remain in the Cache Slough complex as well.
Adult migration	Adults require unrestricted access to spawning habitat from December-July	Adults disperse faster than was recognized in 1994; most of it is finished by the time Spring Kodiak Trawls start in January, though local movements and possibly rapid longer distance dispersal occurs throughout the spawning season, which as mentioned above is usually February-June or a subset of those months.
	Unrestricted access results from adequate flow, suitable water quality, and protection from physical disturbance	No change

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Primary Constituent Element 1: "Physical habitat" is defined as the structural components of habitat (Service 1994). The ancestral Delta was a large tidal marsh-floodplain habitat totaling approximately 300,000 acres. During the late 1800's and early 1900's, most of the wetlands were diked and reclaimed for agriculture or other human use (Figure 9.2.1.2-1). The physical habitat modifications of the Delta and Suisun Bay were mostly due to land reclamation and urbanization. Water conveyance projects and river channelization have had some influence on the regional physical habitat by armoring levees with riprap, building conveyance channels like the Delta Cross Channel, storage reservoirs like Clifton Court Forebay, and by building and operating temporary barriers in the south Delta and permanent gates and water distribution systems in Suisun Marsh.

During the 1930's to 1960's, the shipping channels were dredged deeper (~12 m) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the Sacramento-San Joaquin River confluence region as the largest and most depth-varying places in the typical range of the low-salinity zone. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995). However, the deeper landscape created to support shipping and flood control requires more freshwater outflow to maintain the low-salinity zone in the large Suisun Bay/river confluence region than was once required. The shipping itself has historically provided a source of non-native organisms, that along with depleted flows and deep channelization, have contributed to the changing ecology of the upper estuary (Winder *et al.* 2011; Kratina *et al.* 2014).

Although the delta smelt is a generally pelagic or open-water fish, depth variation of open-water habitats is an important habitat attribute (Moyle *et al.* 1992; Hobbs *et al.* 2006). In the wild, delta smelt are most frequently collected in water that is somewhat shallow (4-15 ft deep) where turbidity is often elevated and tidal currents exist, but are not excessive (Moyle *et al.* 1992; Bever *et al.* 2016). In Suisun Bay, the deep shipping channels are poor quality habitat because tidal velocity is very high (Bever *et al.* 2016), but in the north Delta where tidal velocity is slower, the Sacramento Deepwater Shipping Channel is used to a greater extent, particularly for spawning and by larval fish (CDFW unpublished data). Adult delta smelt also use edge habitats as tidal current refuges and corridors to spawning habitats (Bennett and Burau 2015).

Primary Constituent Element 2: "Water" is defined as water of suitable quality to support various delta smelt life stages that allow for survival and reproduction (Service 1994). Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for delta smelt and are discussed in detail below. Contaminant exposure can degrade this primary constituent element even when the basic habitat components of water quality are otherwise suitable (Hammock *et al.* 2015).

Turbidity: Delta smelt require turbidity. Even in captivity, clear water is a source of physiological stress (Lindberg *et al.* 2013; Hasenbein *et al.* 2016). The small plankton that delta smelt larvae eat are nearly invisible in clear water. The sediment (or algal) particles that make turbid water turbid, provide a dark background that helps delta smelt larvae see their translucent prey (Baskerville-Bridges *et al.* 2004). Older delta smelt are less reliant on turbidity to see their prey, but older fish still feed more effectively in water of moderate turbidity (Hasenbein *et al.*

2013; 2016) and probably need turbid water to help disguise themselves from predators (Ferrari *et al.* 2014). The turbidity of the Delta and Suisun Bay has been declining for a long time due to dams and rip-rapped levees, both of which cut off sources of sediment from rivers flowing into the estuary (Arthur *et al.* 1996; Wright and Schoellhamer 2004), and due to the spread of Brazilian waterweed (Hestir *et al.* 2015) which filters the water, increasing clarity. Water exports from the south Delta may also have contributed to the trend toward clearer water by removing resuspended sediment in the exported water (Arthur *et al.* 1996). The primary turbid areas that remain in the upper estuary are the semi-shallow embayments in northern Suisun Bay (Bever *et al.* 2016) and the lower Yolo Bypass region that includes Liberty Island and the upper reach of the Sacramento Deepwater Shipping Channel (Morgan-King and Schoellhamer 2013). Both tidal and river flows, as well as wind speed, affect turbidity in these locations. Many of the estuary's deeper channels tend to have somewhat lower turbidity because water velocity and wind cannot resuspend sediment that sinks into deep water (Ruhl and Schoellhamer 2004).

Water temperature: Water temperature is the primary driver of the timing and duration of the delta smelt spawning season (Bennett 2005). Water temperature also affects delta smelt's growth rate which in turn can affect their readiness to spawn (Rose *et al.* 2013a). Water temperature is not strongly affected by variation in Delta outflow; the primary driver of water temperature variation in the delta smelt critical habitat is air temperature (Wagner *et al.* 2011). Very high flows can transiently cool the upper estuary (*e.g.,* flows in the upper 10th percentile, Kimmerer 2004), but the system rapidly re-equilibrates once air temperatures begin to warm.

Older laboratory based research suggested an upper water temperature limit for delta smelt of about 25°C, or 77°F (Swanson *et al.* 2000). Newer laboratory research suggests delta smelt temperature tolerance decreases as the fish age, but is a little higher than previously reported, up to 28°C or 82°F in the juvenile life stage (Komoroske *et al.* 2014). It should be kept in mind that these are upper *acute* water temperature limits meaning temperatures in this range will kill, on the average, one of every two fish.

In the laboratory and the wild, delta smelt appear to have a physiological optimum temperature near 20°C or 68°F (Nobriga *et al.* 2008; Rose *et al.* 2013a; Jeffries *et al.* 2016); most of the upper estuary exceeds this water temperature from June through September (Wagner *et al.* 2011). Thus, many parts of the estuary are energetically costly and stress delta smelt. Generally speaking, spring and summer water temperatures are cooler to the west and warmer to the east due to the differences in overlying air temperatures between the Bay Area and the warmer Central Valley (Kimmerer 2004). In addition, there is a strong water temperature gradient across the Delta with cooler water in the north and warmer water in the south. The higher flows from the Sacramento River probably explain this north-south gradient. Note that water temperatures in the north Delta near Liberty Island and the lower Yolo Bypass are also typically warmer than they are along the Sacramento River (Sommer *et al.* 2001; Nobriga *et al.* 2005).

Food: Food and water temperature are strongly interacting components of delta smelt health and habitat because the warmer the water, the more food delta smelt require (Rose *et al.* 2013a). If the water gets too warm, then no amount of food is sufficient. The more food delta smelt eat (or must try to eat) the more they will be exposed to predators and contaminants. Water exports can limit the flux of phytoplankton production from the Delta into Suisun Bay (Jassby and Cloern

2000), but the effect of water exports on phytoplankton production appears to be lower than grazing by clams (Jassby *et al.* 2002) and ammonium inhibition of phytoplankton growth from Sacramento's urban wastewater inputs (Dugdale *et al.* 2012).

Historically, prey production occurred when the low-salinity zone was positioned over the shoals of Suisun Bay during late spring through the summer, but this function has been depleted due to grazing by overbite clams (Kimmerer and Thompson 2014), high ammonium concentrations in critical habitat (Dugdale *et al.* 2012; 2016), and water diversions (Jassby and Cloern 2000). Recent research suggests delta smelt occupying Suisun Bay may experience poor nutritional health (Hammock *et al.* 2015). Delta smelt occupying the Cache Slough region in the north Delta are in better nutritional health, but have shown evidence of relatively high contaminant impacts. The southern Delta is among the more productive areas remaining in the upper estuary (Nobriga *et al.* 2005), but delta smelt cannot remain in this habitat during the warmer months of the year (Nobriga *et al.* 2008) and may face a high risk of entrainment when they occupy it during cooler months (Kimmerer 2008; Grimaldo *et al.* 2009). Extensive blooms of the toxin-producing cyanobacteria *Microcystis* in the central and southern Delta became abundant around 1999 and depending on flow, and temperature, blooms can extend westward into the low-salinity zone where rearing delta smelt (Brooks *et al.* 2011). However, in general delta smelt that occupy Suisun Marsh fare better both in terms of nutrition and in experiencing lower level of contaminant impact (Hammock *et al.* 2015).

<u>Primary Constituent Element 3</u>: "River flow" was originally defined as transport flow to facilitate spawning migrations and transport offspring to low-salinity zone rearing habitats (Service 1994). River flow includes both "inflow to" and "outflow from" the Delta, both of which influence the movement of migrating adult, larval, and juvenile delta smelt. Inflows, outflows, and Old and Middle River flows influence the vulnerability of delta smelt larvae, juveniles, and adults to entrainment at the Banks and Jones facilities (Grimaldo *et al.* 2009).

The spawning microhabitats of delta smelt are not really known, but whatever they are, it is likely there are more suitable spawning habitats when Delta outflow is high during spawning than when it is low because more of the estuary is covered in fresh- and low-salinity water when outflow is high (Jassby *et al.* 1995). Most spawning occurs between February and May. Delta outflow during February through May is mainly driven by the climatic effect on the amount and form of precipitation in the watershed, the storage and diversion of water upstream of the Delta, and CVP and SWP water operations in the Delta (Jassby *et al.* 1995; Kimmerer 2002b). Thus far, the 21st century has tended to be pretty dry (Figure 9.2.1.1-8) and that could have resulted in some chronic reduction in spawning habitat availability or suitability.

<u>Primary Constituent Element 4</u>: "Salinity" helps define nursery habitat (Service 1994). Older laboratory research suggested that delta smelt have an upper acute salinity tolerance of about 20 ppt (Swanson *et al.* 2000) which is about 60% of seawater's salt concentration of 32-33 ppt. Newer laboratory-based research suggests that some individuals can acclimate to seawater, but that comes at a high energetic cost that is lethal to about one in four individuals (Komoroske *et al.* 2014; 2016). In the wild, delta smelt are nearly always collected at very low salinities which recent laboratory research has confirmed is nearer to the physiological optimum (Komoroske *et al.* 2016). Few individuals are collected at salinities higher than 6 ppt (about 20% of seawater

salt concentration) and very few are collected at salinities higher than 10 ppt (about 30% of seawater salt concentration) (Bennett 2005). This well documented association with fresh to low salinity water is a reason for the scientific emphasis on X2 as a delta smelt habitat indicator (Dege and Brown 2004; Feyrer *et al.* 2011). Recent research combining long-term monitoring data with three-dimensional hydrodynamic modeling shows that the spatial overlap of several of the key habitat attributes described above increases as Delta outflow increases (Bever *et al.* 2016). This means that higher outflow, which lowers the salinity of Suisun Bay and marsh, increases the suitability of habitat in the estuary by increasing the overlap of some, but not necessarily all, needed elements. Lower outflows provide less overlap and in fewer places.

Summary of Status of Delta Smelt Critical Habitat

The Service's primary objective in designating critical habitat was to identify the key components of delta smelt habitat that support successful completion of the life cycle, including spawning, larval and juvenile transport, rearing, and adult migration back to spawning sites. Since the implementation of the RPA in the Service's 2008 BiOp, there has been much lower likelihood of water operations that are highly detrimental to the spawning migration of adult delta smelt, the spawners themselves, or larval transport. Further, recent research suggests that the movement of adult delta smelt to nominal spawning locations is quite similar among years (Polansky *et al.* in review).

The delta smelt's critical habitat, which is synonymous with the downstream waters of the CWF Action Area, is currently doing a poor job of serving its intended conservation role and function because there are very few locations that consistently provide all the needed habitat attributes for larval and juvenile rearing at the same times and in the same places (Table 9.2.1.3-2; IEP 2015). It is the larval and juvenile rearing Primary Constituent Element that remains most impacted by ecological changes in the estuary since the delta smelt's listing under the Act. As described above, those changes have stemmed from chronic low outflow, species invasions and associated changes in how the upper estuary food web functions, declining prey availability, high water temperatures, declining water turbidity, summertime blooms of *Microcystis aeruginosa*, proliferation of submerged aquatic plants, and localized contaminant accumulation by delta smelt.

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Table 9.2.1.3-2. Summary of habitat attribute conditions for delta smelt in six regions of the estuary that are permanently or seasonally occupied in most years.

	Landscape	Turbidity	Salinity	Temperature	Food
Montezuma Slough	Appropriate	Appropriate	Appropriate *when outflow is sufficient*	Usually appropriate	Appropriate
Suisun Bay	Appropriate except in shipping channel	Appropriate, but declining	Appropriate *when outflow is sufficient*	Usually appropriate	Depleted
West Delta	Limited area 4 to 15 feet deep	marginal, declining	Appropriate	Can be too high during summer	Depleted
North Delta (Cache Slough region)	Appropriate	Appropriate	Appropriate	Can be too high during summer	Appropriate, but associated with elevated contaminant impacts
Sacramento River near proposed North Delta diversions	Limited area 4 to 15 feet deep; swift currents	Marginal except during high flows, declining	Appropriate	Usually appropriate	Likely low due to swift currents and wastewater inputs
South Delta	Appropriate except too much coverage by submerged plants	Too low	Appropriate	Too high in the summer	Appropriate

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9.2.1.4 Existing Conditions and Previous Consultations in the Action Area

9.2.1.4.1 Consultation of the Coordinated Long-Term Operations of the CVP and SWP

Background

The CVP and SWP are California's two largest water storage and delivery systems. The CVP and SWP include major reservoirs north and south of the Delta; both projects transport water via natural watercourses and canal systems to areas throughout much of California. For both the CVP and the SWP, the primary north to south transfer point is the Delta where water is exported to the south from the C.W. "Bill" Jones and Harvey O. Banks pumping plants into the Delta-Mendota Canal and the California Aqueduct, respectively. CVP water is exported from the Delta via the Contra Costa Water District facilities to the Bay Area and SWP water is exported from the Delta via the Barker Slough Pumping Plant.

The California State Water Resources Control Board (SWRCB) permits the CVP and SWP to store, release, and divert water and to divert natural runoff. The CVP and SWP operate pursuant to water rights permits and licenses issued by the SWRCB. As conditions of their water rights permits and licenses, the SWRCB requires the CVP and SWP to meet specific water quality, quantity, and operational criteria within the Delta. Reclamation and the DWR closely coordinate the CVP and SWP operations to meet these obligations.

2008 Service BiOp on the Coordinated Operations of the CVP and SWP

In July 2004, the Service issued a BiOp addressing *Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operations Criteria and Plan to Address Potential Critical Habitat Issues* (Service file # 1-1-04-F-0140). The Department of the Interior (DOI) was sued on that BiOp on February 15, 2005. On February 16, 2005, the Service reissued a BiOp that concluded the CVP and the SWP were not likely to jeopardize the continued existence of delta smelt or destroy or adversely modify its critical habitat. The Natural Resources Defense Council sued, and in 2007 the BiOp was ruled to be arbitrary and capricious and the court ordered protections for the delta smelt, while the Service revised the BiOp.

In 2008, the Service issued a new BiOp that concluded that the continued long-term operation of the CVP and SWP was likely to jeopardize the continued existence of delta smelt and adversely modify its critical habitat. The Service included a Reasonable and Prudent Alternative (RPA) to avoid jeopardizing the continued existence of the delta smelt and adversely modify its designated critical habitat. Reclamation provisionally accepted the RPA and began implementing the BiOp, including the RPA, in December, 2008. In 2009, Metropolitian Water District, State Water Contractors, Westlands Water District, San Luis and Delta-Mendota Water Authority, Kern County Water Agency, Coalition for Sustainable Delta, California Farm Bureau, Stewart and Jasper Orchards, and King Pistachio Grove challenged the 2008 Service BiOp in Federal court. DWR intervened on behalf of the Plaintiffs. In December of 2010, the court found the BiOp to

be arbitrary and capricious. A new BiOp was required by December 2013. Judge Wanger also required Reclamation to analyze its acceptance and implementation of the BiOp, including the RPA under the National Environmental Policy Act (NEPA). Time extensions were requested to focus on development of a collaborative science process.

In 2014, the Ninth Circuit Court of Appeals reversed the lower court's decision and upheld the 2008 Service BiOp. While they recognized the BiOp to be overwhelming and complex, the Ninth Circuit found the Service had not acted arbitrarily or capriciously.

Key elements of the Service's RPA in the 2008 BiOp are:

RPA Component 1: The objective of Component 1 (comprised of Actions 1 and 2) is to reduce entrainment of pre-spawning adults during December through March by controlling OMR flows during periods of elevated entrainment risk. Action 1 is designed to protect migrating delta smelt. Action 2 is designed to protect adult delta smelt that are residing in the Delta prior to spawning. Overall, RPA Component 1 increases the suitability of spawning habitat for delta smelt by decreasing the amount of Delta habitat affected by the projects' export pumping plants' operations prior to, and during, the critical spawning period (Service 2008; pages 280-282);

RPA Component 2: The objective of Component 2 is to limit entrainment of larval and juvenile delta smelt by reducing net negative flow conditions in the central and south Delta, so that larval and juvenile delta smelt can successfully rear in the Delta and move downstream when appropriate (Service 2008; pages 282);

RPA Component 3: The objective of Component 3 is to improve fall habitat conditions for delta smelt by increasing Delta outflow during fall of Wet and Above-normal years to re-establish variability in habitat conditions during this time of year (Service 2008; pages 282-283);

RPA Component 4: The objective of Component 4 is to restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh to increase prey production for delta smelt (Service 2008; pages 283-284); and

RPA Component 5: Component 5 provides for monitoring and reporting. Reclamation and DWR shall ensure that information is gathered and reported to ensure: (1) proper implementation of the restoration actions, (2) that the physical results of the restoration actions are achieved, and (3) that information is gathered to evaluate the effectiveness of these actions on the targeted life stages of delta smelt so that the actions can be refined, if needed (Service 2008; pages 284-285).

For more information, the 2008 Service BiOp can be found at:
https://www.fws.gov/sfbaydelta/documents/SWP-CVP_OPs_BO_12-15_final_signed.pdf

2009 NMFS BiOp on the Coordinated Operations of the CVP and SWP

NMFS issued its current coordinated operations of the CVP and SWP BiOp on June 4, 2009. The NMFS BiOp covers: Central California Coast steelhead and its critical habitat; Sacramento River

winter-run Chinook salmon; Central Valley spring-run Chinook salmon; Central Valley steelhead; Southern Distinct Population Segment (DPS) of Northern American green sturgeon; and Southern resident killer whales, which rely on Chinook salmon runs for food. NMFS determined that the action was likely to jeopardize these species and adversely modify their critical habitat, except the Central California Coast steelhead, and included an RPA.

Key elements of the NMFS RPA in the 2009 BiOp are:

- A new temperature management program for Shasta Reservoir and the Sacramento River below Keswick Dam;
- Long-term passage prescriptions at Shasta Dam to allow re-introduction of listed salmonids;
- Flow and temperature criteria in Clear Creek below Whiskeytown Dam;
- A new screened pumping plant in Red Bluff to replace the Red Bluff Diversion Dam (completed in 2012);
- Improved juvenile salmonid fish rearing habitat in the lower Sacramento River and Delta;
- Delta Cross Channel gate closure beyond the mandates of D-1641;
- An OMR flow limit of -5000 cfs from January 1 through June 30 with salvage-based triggers that can limit OMR flow to less negative values;
- A limit on the ratio of exports to San Joaquin River inflow during April and May;
- Required studies of acoustic tagged steelhead in the San Joaquin Basin to evaluate the effectiveness of the RPA and refinements as necessary;
- New flow management standard, temperature management plan, additional technological fixes to temperature control structures, and long-term fish passage above Folsom Dam for steelhead on the American River;
- New minimum flow regime for steelhead in the Stanislaus River and long-term fish passage evaluations above Goodwin, Tulloch, and New Melones Dam; and
- A hatchery genetics management plan for Nimbus Hatchery for steelhead and fall-run Chinook salmon (which is an important prey base for listed Southern Resident DPS killer whale).

For more information, the 2009 NMFS BiOp can be found at:
http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/Operations,%20Criteria%20and%20Plan/nmfs_biological_and_conference_opinion_on_the_long-term_operations_of_the_cvp_and_swp.pdf

Existing Water Facilities

Below is a summary of the existing CVP and SWP water facilities. For additional information on CVP and SWP water service contracts, allocations, deliveries, and project facilities operational considerations that the SWP and CVP are obligated to comply with, see the Project Description in the 2008 Service and 2009 NMFS BiOps on the Coordinated Long-Term Operations of the CVP and SWP (Reclamation 2008, Service 2008; NMFS 2009a).

Central Valley Project (CVP) Re-authorization

The CVP is the largest Federal Reclamation project and was originally authorized by the Rivers and Harbors Act of 1935. The CVP was reauthorized by the Rivers and Harbors Act of 1937 for the purposes of "improving navigation, regulating the flow of the San Joaquin River and the Sacramento River, controlling floods, providing for storage and for the delivery of the stored waters thereof, for construction under the provisions of the Federal Reclamation Laws of such distribution systems as the Secretary of the Interior (Secretary) deems necessary in connection with lands for which said stored waters are to be delivered, for the reclamation of arid and semiarid lands and lands of Indian reservations, and other beneficial uses, and for the generation and sale of electric energy as a means of financially aiding and assisting such undertakings and in order to permit the full utilization of the works constructed." This Act provided that the dams and reservoirs of the CVP "shall be used, first, for river regulation, improvement of navigation and flood control; second, for irrigation and domestic uses; and, third, for power." The CVP was reauthorized in 1992 through the Central Valley Project Improvement Act (CVPIA). The CVPIA modified that authorization under Rivers and Harbors Act of 1937 adding mitigation, protection, and restoration of fish and wildlife as a project purpose. Further, the CVPIA specified that the dams and reservoirs of the CVP should now be used "first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses and fish and wildlife mitigation, protection and restoration purposes; and, third, for power and fish and wildlife enhancement."

The CVPIA (Public Law 102-575, Title 34) includes authorization for actions to benefit fish and wildlife. Specifically, Section 3406(b)(1) is implemented through the Anadromous Fish Restoration Program (AFRP). The AFRP objectives, as they relate to operations, are further explained below. CVPIA Section 3406(b)(1) provides for modification of the CVP operations to meet the fishery restoration goals of the CVPIA, so long as the operations are not in conflict with the fulfillment of the Secretary's contractual obligations to provide CVP water for other authorized purposes. The DOI decision on Implementation of Section 3406(b)(2) of the CVPIA, dated May 9, 2003, provides for the dedication and management of 800,000 acre-feet (af) of CVP-water yield annually. This (b)(2) water has been used to augment flows below CVP dams and to reduce CVP exports from the Delta. DOI manages and accounts for (b)(2) water pursuant to its May 9, 2003, decision and the Ninth Circuit's decision in *Bay Institute of San Francisco v. United States*, 66 Fed. Appx. 734 (9th Cir. 2003), as amended, 87 Fed. Appx. 637 (2004). Additionally, DOI is authorized to acquire water to supplement (b)(2) water, pursuant to Section 3406(b)(3).

State Water Project (SWP)

DWR was established in 1956 as the successor to the Department of Public Works for authority over water resources and dams within California. DWR was also given the authority to apply for the appropriation of water on behalf of the state (Stats. 1956, First Ex. Sess., Ch. 52; see also Wat. Code Sec. 123) and currently holds water rights permits use by the SWP. DWR's authority to construct state water facilities or projects is derived from the Central Valley Project Act (CVPA) (Wat. Code Sec. 11100 et seq.), the Burns-Porter Act (California Water Resources

Development Bond Act) (Wat. Code Sec. 12930-12944), the State Contract Act (Pub. Contract Code Sec. 10100 et seq.), the Davis-Dolwig Act (Wat. Code Sec. 11900-11925), and special acts of the State Legislature. The CVPA described specific facilities that have been built by DWR, including the Feather River Project and California Aqueduct (Wat. Code Sec. 11260), Silverwood Lake (Wat. Code Sec. 11261), and the North Bay Aqueduct (Wat. Code Sec. 11270). The Act allows DWR to administratively add other units (Wat. Code Sec. 11290) and develop power facilities (Wat. Code Sec. 11295).

The Burns-Porter Act which was approved by California voters in November 1960 (Wat. Code Sec. 12930-12944), authorized the issuance of bonds for construction of the SWP. The principal facilities of the SWP are Oroville Reservoir and related facilities in the Feather River, the San Luis Dam and related facilities, two pumping plants in the Delta, the California Aqueduct including its terminal reservoirs, and the North and South Bay Aqueducts. DWR is required to plan for recreational and fish and wildlife uses of water in connection with state-constructed water projects and the agency can acquire land for those uses (Wat. Code Sec. 233, 345, 346, 12582). The Davis-Dolwig Act (Wat. Code Sec. 11900-11925) established the policy that preservation of fish and wildlife is part of state costs to be paid by water supply contractors, and recreation and enhancement of fish and wildlife are to be provided by appropriations from the General Fund.

DWR holds contracts with 29 public agencies in northern, central, and southern California for water supplies from the SWP. Water stored in Lake Oroville and the Thermalito Complex along with water available in the Delta (consistent with applicable regulations) is conveyed to SWP contractors via the Barker Slough and Banks Pumping Plants.

The SWP is operated to provide flood control and water for agricultural, municipal, industrial, recreational, and environmental purposes. A large portion of the water stored in Oroville Reservoir is provided to three Feather River area contractors, two contractors served from the North Bay Aqueduct, and 24 contractors south of the Delta. In addition to pumping water released from Oroville Reservoir, both the Barker Slough and Banks Pumping Plants pump water entering the Delta from other managed and unmanaged sources of inflow.

Coordinated Operations of the CVP and SWP

Coordinated Operation Agreement

The Coordinated Operation Agreement (COA) between the United States and the State of California to operate the CVP and SWP was signed in November 1986. Congress, through Public Law 99-546, authorized and directed the Secretary of the Interior to execute and implement the COA. The COA defines the rights and responsibilities of the CVP and SWP with respect to in-basin water needs and project exports and provides a mechanism to account for those rights and responsibilities.

Under the COA, Reclamation and DWR agree to operate the CVP and SWP under balanced conditions in a manner that meets Sacramento Valley and Delta needs while maintaining each

project's annual water supplies. Balanced conditions are defined as periods when the two projects agree that releases from upstream reservoirs, plus unregulated flow, approximately equal water supply needed to meet Sacramento Valley in-basin uses and project exports. Coordination between the CVP and the SWP is facilitated by an accounting procedure based on the sharing principles outlined in the COA. During balanced conditions in the Delta when water must be withdrawn from storage to meet Sacramento Valley and Delta requirements, 75% of the responsibility to withdraw from storage is borne by the CVP and 25% by the SWP. The COA also provides that during balanced conditions when unstored water is available for export, 55% of the sum of stored water and the unstored water for export is allocated to the CVP, and 45% is allocated to the SWP. Although the principles were intended to cover a broad range of conditions, changes made subsequent to the COA, including the 2000 Trinity Record of Decision (ROD), recent BiOps, the SWRCB Water Quality Control Plan (WQCP), and the CVPIA were not specifically addressed by the COA. However, these variances have been addressed by Reclamation and DWR through mutual, informal agreements.

1995 SWRCB Water Quality Control Plan

The SWRCB adopted the 1995 Bay-Delta Water Quality Control Plan (SWRCB 1995) on May 22, 1995, which became the basis of SWRCB Decision 1641 (D-1641) in 2000. The SWRCB continues to hold workshops and receive information regarding processes on specific areas of the 1995 WQCP. The SWRCB amended the WQCP in 2006, but to date, the SWRCB has made no significant changes to the 1995 WQCP framework.

SWRCB Decision 1641 and Revised D-1641

The SWRCB has issued numerous orders and decisions regarding water quality and water right requirements for the Bay-Delta including multiple operational responsibilities on the CVP and SWP to meet the flow objectives in D-1641 (issued December 29, 1999) and its subsequent revision (Revised D-1641, dated March 15, 2000). The SWRCB objectives set forth in the WQCP are intended to protect beneficial uses in the Delta. The SWRCB is currently considering a petition to change points of diversion in support of CWF and an update to the WQCP that could change the operational assumptions reflected in the CWF BA.

The various flow objectives and export limits in D-1641 are designed to protect the estuary ecosystem, in-Delta agriculture and regional municipal water quality. These objectives include salinity requirements throughout the year, and export to inflow ratio limits in February through June. The water quality objectives vary within and among years according to the Sacramento Valley 40-30-30 WY Index: Wet, Above-normal, Below-normal, Dry, and Critically Dry. These flow and water quality objectives are subject to revision per petition process or every 3–5 year revision process set by the SWRCB.

2006 SWRCB Revised Water Quality Control Plan

The SWRCB undertook a proceeding under its water quality authority to amend the WQCP. Prior to commencing this proceeding, the SWRCB conducted a series of workshops in 2004 and

2005 to receive information on specific topics addressed in the WQCP.

The SWRCB adopted a revised WQCP on December 13, 2006. There were no changes to the Beneficial Uses from the 1995 WQCP to the 2006 WQCP, nor were any new water quality objectives adopted in the 2006 WQCP. A number of changes were made for readability. Consistency changes were also made to assure that sections of the 2006 plan reflected the current physical condition of the estuary and regulations existing at that time.

Current Water Quality Control Plan Process

The SWRCB is currently in the process of developing and implementing updates to its 2006 WQCP. The update has been broken into four phases, some of which are proceeding concurrently. Phase 1 of this work, currently in progress, involves updating San Joaquin River flow and southern Delta water quality requirements for inclusion in the WQCP. Phase 2, which is getting underway at this writing, will involve comprehensive changes to the WQCP to protect beneficial uses not addressed in Phase 1, focusing on the Sacramento River basin and the Delta. Phase 3 will involve implementation of Phases 1 and 2 through changes to water rights and other measures. This phase will require a series of hearings to determine the appropriate allocation of responsibility between water rights holders within the scope of the Phase 1 and Phase 2 plans. Phase 4 will involve developing and implementing flow objectives for priority Delta tributaries upstream of the Delta.

Annual/Seasonal Temperature Management Upstream of the Delta

Reclamation is required to control water temperature in the Sacramento River pursuant to SWRCB Order WR 90-5 and Action Suite I.2 of the RPA in the NMFS 2009 BiOp. Reclamation is required to develop and implement an annual Temperature Management Plan by May 15 each year to manage the cold water supply within Shasta Reservoir and make cold water releases from Shasta Reservoir, and Trinity Reservoir through the Spring Creek Tunnel, to provide suitable temperatures for winter-run Chinook salmon, and, when feasible, fall-run Chinook salmon, which supports an important commercial fishery and a prey base for listed Southern Resident DPS killer whale.

NMFS is currently working with Reclamation and other state and Federal agencies to adjust the RPA Action Suite 1.2. The adjustment will be made pursuant to the 2009 NMFS BiOp Section 11.2.1.2. *Research and Adaptive Management*, which states "After completion of the annual review, NMFS may initiate a process to amend specific measures in this RPA to reflect new information, provided that the amendment is consistent with the Opinion's underlying analysis and conclusions and does not limit the effectiveness of the RPA in avoiding jeopardy to listed species or adverse modification of critical habitat." This process is anticipated to conclude in winter 2017 and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation's Shasta operations when the adjustment process is completed. It remains to be seen whether the revised RPA Action Suite 1.2 will affect inflows to

the Delta.

Drought Operations and Management

Drought Contingency Plan and Temporary Urgency Change Petitions

The exceptionally dry conditions in 2014, 2015, and 2016 resulted in low reservoir storages which created a challenge to deliver water supplies, provide adequate cold water for instream fisheries resources, and comply with D-1641 standards. During 2014, 2015 and 2016, Reclamation and DWR petitioned the SWRCB on several occasions to temporarily modify the terms of their water rights permits for operation of the CVP and SWP. The SWRCB Executive Director approved Orders for temporary urgency changes to D-1641 standards to help Reclamation and DWR deliver minimum water supplies. The granted requests and information related to the drought workshops can be found online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/index.shtml.

West False River Temporary Emergency Drought Barrier

An emergency drought barrier was installed at West False River between Jersey and Bradford Islands in 2015. The barrier was installed in May and June to prevent tidal pumping of saltwater into the central Delta during a period of extremely low Delta outflow. Installation of the barrier allowed the CVP and SWP water facilities to meet relaxed salinity standards while conserving very limited water supply in the Projects' reservoirs. Removal of the approximately 750-foot rock barrier began on September 8 and was completed on November 15. About 150,000 tons of large rip-rap rocks were used to build the barrier.

The barrier was installed near the end of the delta smelt's spawning season. The barrier prevented delta smelt from utilizing that corridor as a path for migration or dispersal, possibly increasing the risk of predation if fish were dispersed into Franks Tract.

9.2.1.4.2 Other Existing Conditions and Consultations in the Action Area

The following past and ongoing actions affect the current and future status of delta smelt and its critical habitat in the Action Area.

Contra Costa and Pittsburg Power Plants

NRG Delta LLC (formerly Mirant Delta LLC and Gen On) operates two power-generating plants in Contra Costa County - the Pittsburg Power Plant and Contra Costa Power Plant. During operation, the power plants use once-through cooling systems that take large volumes of Sacramento-San Joaquin Delta water from the adjacent channel and then discharge heated water back into the channel. Power plant operations risk entraining and impinging delta smelt along the traveling screen of their water intakes. The power plants are located along the southern bank of the Sacramento-San Joaquin River confluence. Delta smelt can be found throughout the year at

the locations from which the power plants draw water. In particular, juveniles are present during months of greatest pumping activity. The power plant operations have been substantially reduced since the late 1970s, when high entrainment and impingement were documented (CDFG 2009a).

NRG Delta LLC retired the generators for Contra Costa Power Plant in May of 2013, although some water is still being pumped to the plant for fire suppression systems (50 acre-feet per year). As part of a settlement agreement with the Coalition for a Sustainable Delta, the Corps and NRG Delta agreed to reinitiate consultation with the Service for project effects to delta smelt. The Corps is currently in discussion with the Service regarding reinitiation for the operation and dredging activities associated with the project.

Freeport Regional Water Project

The Freeport Regional Water Project (FRWP) is an on-bank intake with a diversion capacity of 286 cubic feet per second (cfs) and a fish screen of approximately 175 feet in length (http://www.freeportproject.org/nodes/aboutfrwa/). The facility is located along the Sacramento River near Freeport and supplies water to Sacramento County and East Bay Municipal Utility District (EBMUD). EBMUD diverts water pursuant to its amended contract with Reclamation. Sacramento County diverts water pursuant to its water right and its CVP contract. This facility was not in the 1986 COA, so FRWP diversions result in some reduction of Delta export supply for the CVP and SWP contractors south of the Delta. The Service prepared a BiOp for the construction, operation, and maintenance of the facility in 2004 (Service 2004) and the water exports associated with the Freeport Intake Facility were addressed in the 2008 Service BiOp (Service 2008) and previously the 2004 Operations Criteria and Plan (OCAP BiOp) (Service 2004).

Reclamation provides CVP water pursuant to its respective water supply contracts with Sacramento County Water Agency (SCWA) and EBMUD through the FRWP, to areas in central Sacramento County. SCWA is responsible for providing water supplies to areas in central Sacramento County, including the Laguna, Vineyard, Elk Grove, and Mather Field communities, through a capital funding zone known as Zone 40.

The FRWP has a design capacity of 286 cfs (185 millions of gallons per day [mgd]). Up to 132 cfs (85 mgd) is diverted under Sacramento County's existing Reclamation water service contract and other anticipated water entitlements and up to 155 cfs (100 mgd) of water is diverted under EBMUD's amended Reclamation water service contract. Under the terms of its amended contract with Reclamation, EBMUD is able to take Sacramento River water in any year in which EBMUD's March 1 forecast of its October 1 total system storage is less than 500,000 acre feet (AF). When this condition is met, EBMUD can take up to 133,000 AF annually. However, deliveries to EBMUD are subject to curtailment pursuant to CVP shortage conditions and project capacity (100 mgd), and are further limited to no more than 165,000 AF in any 3-consecutive-year period that EBMUD's October 1 storage forecast remains below 500,000 AF. EBMUD diversions at FRWP cannot exceed 100 mgd (112,000 AF per year). Deliveries start at the beginning of the CVP contract year (March 1) or any time afterward. Deliveries cease when EBMUD's CVP allocation for that year is reached, when the 165,000 AF limitations are reached,

or when EBMUD no longer needs the water (whichever comes first). To date, average annual deliveries to EBMUD have been approximately 23,000 AF. Thus far, maximum annual delivery has been approximately 99,000 AF.

The construction footprint for creating the FRWP intake resulted in a loss of 1.03 acres of critical habitat, of which 0.616 acres were considered shallow water spawning habitat for delta smelt. The effects of the loss of shallow water habitat were small and were minimized by the purchase of delta smelt credits at a conservation bank at a 5:1 ratio at a conservation bank. Overall, the project did not contain high quality spawning habitat for delta smelt. The adverse effects of entrainment and impingement on delta smelt were minimized by the construction of a fish screen designed to meet CDFW and NMFS criteria and recommendations provided by the Service. The intake screens were built and operate to a 0.2 feet per second (fps) approach velocity for the protection of delta smelt.

South Delta Temporary Barriers Project

The South Delta Temporary Barriers Project began as a test project in 1991 and was extended for five years in 1996 and again for seven years in 2001. The project was initiated partially in response to a 1982 lawsuit filed by the South Delta Water Agency. The project consists of four rock barriers across South Delta channels (see Figure 9.2.1.4.2-1). Three of the four rock barriers are in place from April 15 to September 30 each year to maintain water levels needed by local irrigators. The fourth, the Head of Old River (HOR) rock barrier, serves as a fish barrier that has been seasonally installed in most years since 1963 between September 15 and November 30. It began to also be installed in the spring between April 15 and May 30 in 1992, and has frequently been installed since. High San Joaquin River flows prohibited its installation in 1993, 1995, 1998, 1999, 2005, and 2006, and 2011. In 2007, a court order designed to protect delta smelt prohibited the installation of the spring HOR rock barrier pending Service actions or further order of the court. Since 2008, the HOR rock barrier has been installed in the spring in 2012, 2014, 2015, and 2016 and fall of 2014 and 2015. None of the four rock barriers were installed in 1998 due to high San Joaquin River flows.

Objectives of the project are to:

- Increase water levels, circulation, and water quality in the southern Delta area for local agricultural diversions, and
- Incentivize salmonid fishes to stay in the mainstem of the San Joaquin River.

The PA proposes to continue the temporary barriers project but to replace the HOR rock barrier with a permanent operable gate, the HORG.

Prior to explicit limits on OMR flows, the installation of the HOR barrier during spring could create rapid changes in south Delta hydrodynamics that were associated with spikes in juvenile delta smelt salvage because the barrier increased net negative flow in Old and Middle rivers if exports were not simultaneously reduced. The OMR flow limits in the Service's 2008 BiOp help minimize the entrainment risk associated with barrier placement.

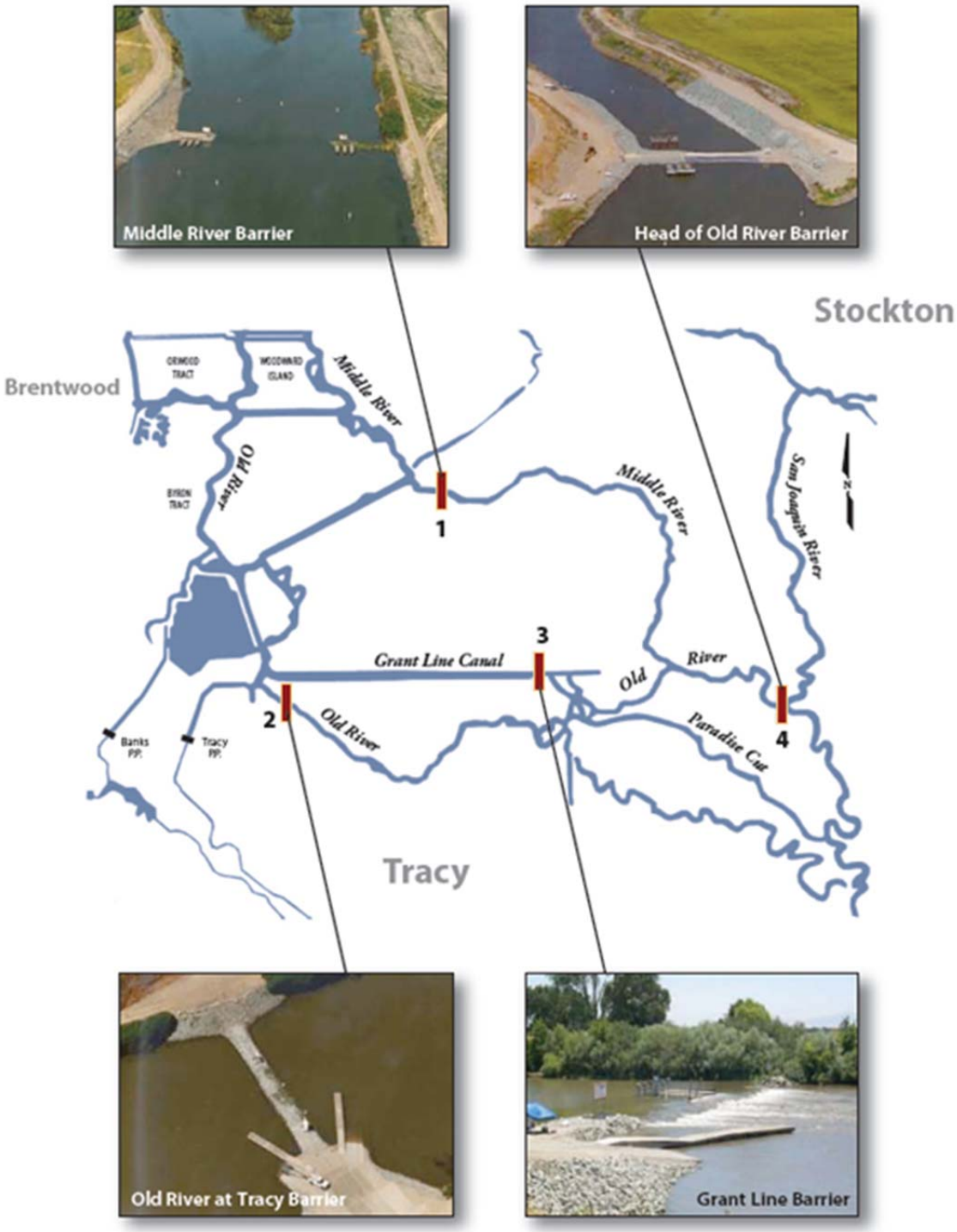

Figure 9.2.1.4.2-1. Location of the South Delta Temporary Barriers Project (Service 2012a).

Maintenance Dredging and Sand-mining

The maintaining of levees, federal navigation channels, and other infrastructure projects throughout the Bay-Delta has resulted in the disturbance and removal of habitat, in addition the harassment or mortality of delta smelt (Service 1993; 1994). The maintenance of these levees and shipping channels reduces nearshore habitat suitability for delta smelt and increases the quantities of freshwater needed to maintain the low-salinity zone in particular locations. The proposed deepening of these channels would worsen these habitat problems.

Suisun Navigation Channel Project

The Corps has consulted with the Service to conduct their annual maintenance dredging in the Suisun Bay Federal Navigation Channels (SBFNC) in the San Francisco Bay-Delta. The SBFNC is composed of several reaches, from west to east: Bulls Head Channel, Suisun Bay Main Channel (comprised of Point Edith Crossing, Preston Point Reach, Roe Island Channel, and Port Chicago Reach) and New York Slough. Maintenance activities have included the use of hydraulic suction dredging and mechanical clamshell dredging equipment. Delta smelt have been entrained with the hydraulic suction dredging. The Corps used clamshell dredging equipment in 2015 and 2016 to minimize effects.

Stockton and Sacramento Deep Water Ship Channel Dredging and Bank Stabilization Project

The Corps has consulted in the past with the Service to conduct its annual operations and maintenance dredging in the Sacramento River Deep Water Ship Channel (SRDWSC) and Stockton Deep Water Ship Channel (SDWSC). The SRDWSC begins in the city of West Sacramento and extends southwest to Collinsville. The SDWSC extends from New York Slough near Pittsburg to Stockton along the San Joaquin River. The SRDWSC varies in width from 200 to 400 feet. The ship channel was proposed to be deepened and widened as authorized under the Water Resources Development Act of 1986 (Public Law 99-662). The channel was proposed to be deepened from 30 feet to 35 feet below mean lower low water (MLLW) along its entire length and widened to bottom widths ranging from 250 to 400 feet. Due to funding and other constraints, the originally proposed project has not been completed. As of the beginning of 2014, only the upstream most 8 miles, river mile (RM) 35 to the turning basin, of the ship channel have been deepened and the only widening that occurred was that necessary to maintain a 1:3 side slope for the deeper channel.

The current shipping channel maintenance projects use a hydraulic cutter head suction dredge for dredging. All sites along the SRDWSC and SDWSC are dredged to maintain the current navigational depths. Dredging activities are limited to areas where MLLW depth is greater than 25 feet, and the cutter head must be kept within 3 feet of the channel bottom while drawing in water. The quantity of material to be dredged is not expected to exceed 500,000 cubic yards, barring any major flood events that redeposit large quantities of sediment in the shipping channels. Delta smelt have been entrained by the dredge equipment (3 in 2016) and captured in

previous year during fish monitoring surveys. The Service requested cessation of the fish monitoring surveys in 2015 to minimize take of delta smelt.

Jerico Products, Hanson Marine Operations, and Suisun Associates Marine Sand-mining Project

Jerico Products, Hanson Marine Operations, and their joint-venture partnership Suisun Associates are commercial sand mining companies that have leases in Suisun Bay and the western Delta to harvest sand for construction-related material using hydraulic dredging methods. This joint venture assures that annual volumes of sand harvested in the estuary are consistent with regulatory limits. The Corps consulted in 2014 on a ten-year marine sand-mining lease project proposal.

The amount and seasonal timing of mining volumes are largely dictated by demand for sand and the weather. Mining volumes could also be limited by the maximum cubic yardage allowed under the respective leases and permits. Generally, sand mining peaks in the summer and early fall when commercial and residential construction is also at its annual peak. Mining activity in the period from July – October historically makes up over 43% of the total annual volume.

The volumes of sand that can be harvested annually from each area of the estuary have been specified in State leases and permits issued by the State Lands Commission (SLC) and Bay Conservation and Development Commission (BCDC) and Federal permits issued by the Corps. The current annual permitted volume of sand that can be harvested from the Middle Ground Shoal Lease is 250,000 cubic yards and the Suisun Associates Lease is 100,000 cubic yards. Jerico shares the Suisun Associates Lease with another sand mining company, Hanson Marine Operations. Jerico's portion of the Suisun Associates Lease is 50,000 cubic yards.

The Middle Ground Shoal Lease and Suisun Associates Lease sand mining typically occurs in waters 15 - 45 feet deep. Due to equipment constraints, such as the barge and tug draft and the suction drag head minimum operation depth (due to pipe length and angle during operation), sand mining cannot occur in shallow water areas. Jerico does not typically mine in areas less than 15 feet deep or greater than 40 feet deep. In addition to equipment constraints, the existing Corps mining permit (and other permits) prohibits sand mining by Jerico within 200 feet of any shoreline. The permits also prohibit sand mining by Jerico within 250 feet of any area having a water depth of 9 feet or less (MLLW). These requirements help protect delta smelt spawning habitat and fringing marsh habitats.

Sand mining is restricted to specific designated lease areas. Mining is not permitted outside of the lease areas. Current sand mining permits require detailed tracking and accounting of the specific locations of each mining event. Bathymetric surveys are also proposed as part of the project to provide a basis for routinely monitoring subtidal conditions within areas where mining takes place and to detect and assess biologically significant changes in subtidal benthic habitat. Monitoring of each individual sand mining event and bathymetric monitoring is required as part of the Corps permit. Tracking mining locations serves to ensure that mining occurs only within

designated lease areas and that mining avoids sensitive subtidal habitat located outside of a lease area.

Suisun Marsh Managed Wetland Operations and Maintenance

The Service issued a BiOp for the *Suisun Marsh Habitat Management, Preservation, and Restoration Plan* on June 10, 2013 for the continued operation and maintenance of managed wetlands in the Suisun Marsh that are an extremely important component of the Pacific Flyway. Also included are: new managed wetland activities; including dredging; installing alternative bank protection; placing new riprap; and installing new fish screens. The BiOp also consisted of a programmatic-level restoration plan for restoring 5,000 to 7,000 acres of natural tidal marsh in the Suisun Marsh (see *Suisun Marsh Habitat Management, Preservation and Restoration Plan (The Suisun Marsh Plan)* in 9.2.1.4.4 *Regional Conservation Efforts* below). Details of the project-level activities associated with the managed wetland activities can be found online at: https://www.fws.gov/sfbaydelta/documents/2012-F-0602-2_Suisun_Marsh_Solano_County_Corps_programmatic.pdf.

Aquatic Weed Control Program

In 1982, California state legislation designated the Division of Boating and Waterways (DBW) as the lead state agency to cooperate with other state, local and federal agencies in controlling water hyacinth in the Delta, its tributaries, and the Suisun Marsh. In addition to water hyacinth, the *Egeria Densa* (Brazilian water weed) control program was authorized by law in 1997 and treatment of this invasive plant began in 2001. DBW also treats curly-leaf pondweed and Spongeplant using mechanical harvesting to control water hyacinth areas. The control programs play a role in controlling these and other invasive plants in the Action Area. Water hyacinth and Brazilian water weed are two South American plants that have negative impacts on the Delta's ecosystem. Both aquatic invasive weeds can form dense mats of vegetation that displace native plants, block light needed for phytoplankton photosynthesis, reduce the amount of dissolved oxygen in the water, and deposit silt and organic matter at several times the normal rate, contributing to increasing water clarity (Hestir *et al.* 2016). These programs are not intended to eradicate the species, but to control their spread. Thus far, they have not been successful. Spraying treatments in the Delta are restricted to March 1 through November 30.

DBW is permitted to treat 3,500 acres of water hyacinth, Brazilian water weed, Spongeplant, and curly-leaf pondweed in the following areas: west up to and including Sherman Island at the confluence of the San Joaquin and Sacramento rivers, north to the confluence of the Sacramento River through the Sacramento Deep Water Channel, plus Lake Natomas, south along the San Joaquin River to Mendota, and all the tributaries to the San Joaquin, Tuolumne, Merced and Stanislaus rivers. For the months between March and November, water hyacinth is chemically treated with glyphosate or 2,4-D. Herbicides are registered for aquatic use with California Environmental Protection Agency and the California Department of Pesticide Regulation. The herbicides are systemic herbicides in liquid form, sprayed directly onto the water hyacinth.

Wallace Weir Modification Project

The Wallace Weir Modification Project is scheduled to begin construction in winter of 2016. Wallace Weir is a permanent, operable structure that provides year-round operational control of the weir's hydraulics. Modifications to the project will replace the seasonal earthen dam with an operable weir. The project will also include a fish rescue facility that would return fish back to the Sacramento River. Wallace Weir has been treated as a common element to the larger habitat restoration and fish passage projects included in the 2009 NMFS BiOp. The project will serve primarily as an anadromous fish passage improvement action that will prevent adult salmonids and sturgeon from getting into the Colusa Basin Drain. Operational control of water levels would also provide greater flexibility for managing water releases for agriculture and managed wetlands. Management and operations of the Yolo bypass have the potential to influence food supply contributions downstream into the Cache Slough Complex and connecting waterways. The Cache Slough Complex has been documented for delta smelt rearing, making food supply availability, quality, and quantity important factors to those rearing individuals.

Sacramento Area Levees

A draft general reevaluation study of the American River Common Features project for the City of Sacramento and surrounding areas was performed in March of 2015, which is one of the most at-risk areas for flooding in the United States due to its location at the confluence of the American and Sacramento rivers. This General Reevaluation Report addresses the flood risk management system for the American and Sacramento Rivers and five other smaller channels. The authorized study is located in the general vicinity of the confluence of the Sacramento and American Rivers, and includes the City of Sacramento and surrounding areas including the American River downstream of Folsom Dam, the Natomas Basin, the east bank of the Sacramento River and areas surrounding five other smaller waterways which are sources of potential flooding. Each area is at risk of flooding from multiple sources.

The authorized project features were developed to work in conjunction with previously authorized Folsom Dam modifications and the increased Folsom reservoir releases that are anticipated. This project will remediate levee seepage problems along approximately 22 miles of the American River. It will also strengthen and raise 12 miles of Sacramento River levee in Natomas. Lastly, the authorization includes seepage remediation and higher levees along four stretches of the American River and 5 miles of the Natomas Cross Canal levee.

Levee creation and on-going stabilization has led substantial shallow-water habitat degradation and substantial disconnection of Delta waterways from surrounding landscapes (Wiens *et al.* 2016). As a result, many of the Delta's nearshore habitats are generally characterized by steep slopes, rip-rapping, and limited shoreline and riparian vegetation.

Small Erosion Repair Program

The Small Erosion Repair Program (SERP) provides a streamlined process for DWR to identify, obtain regulatory authorization for, and construct small levee repairs on levees maintained by

DWR within the Sacramento River Flood Control Project area. The initial focus of SERP covers approximately 300 miles of levees and represents an initial five-year effort. After the first phase, the Interagency Flood Management Collaborative Program Group will evaluate the program's success and, if warranted, SERP may be expanded to include sites repaired by local agencies throughout the Sacramento-San Joaquin drainage. Similar to previous initiatives, these small levee repairs will slowly increase levee rip-rapping along the Sacramento River, further degrading the quality of habitat for delta smelt.

9.2.1.4.4 Existing Monitoring and Research Programs

Monitoring surveys targeting delta smelt and other fishes and invertebrates are conducted throughout the year under the auspices of the Interagency Ecological Program (Hartman pers. comm. 2016; Figure 9.2.1.4.4-1 through 9.2.1.4.4-6). Historically, take in survey collections was low compared to estimated abundances (Bennett 2005); however, given the combination of recent population decline and substantial increase in survey effort, scientific take may be reaching a relevant fraction of the delta smelt population in some seasons. Because of low abundance and a high level of sampling mortality, some survey methods have been modified to limit incidental catches of delta smelt when delta smelt is not the target species (*e.g.*, the Service's Chipps Island trawl, which targets the recapture of tagged Chinook salmon).

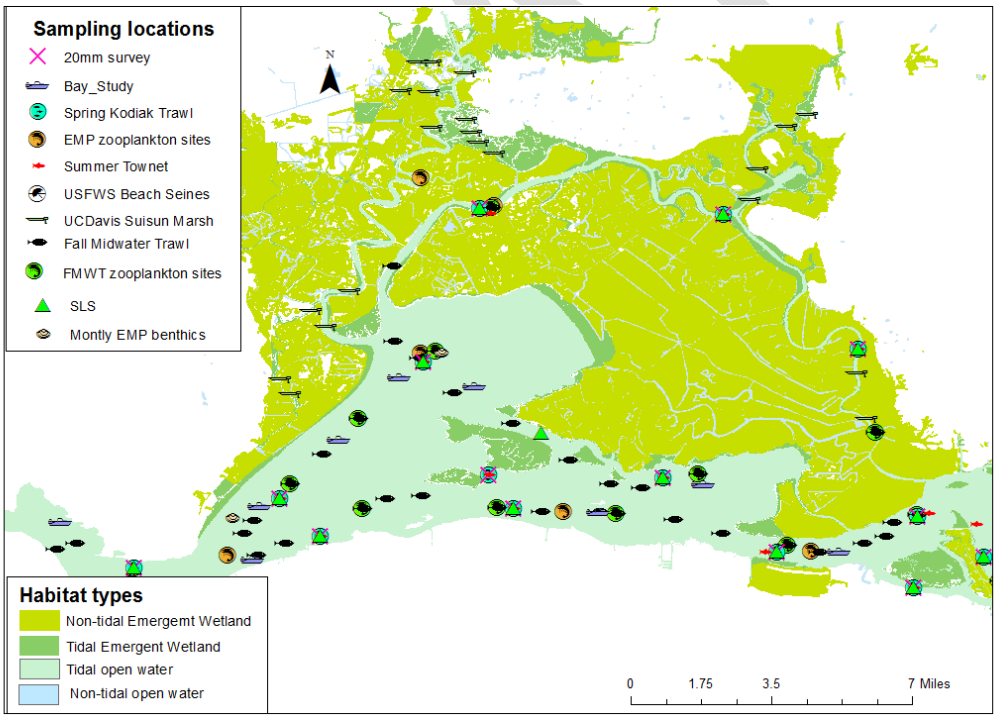

Figure 9.2.1.4.4-1. Sampling locations in the Suisun Marsh for invertebrates and fish.

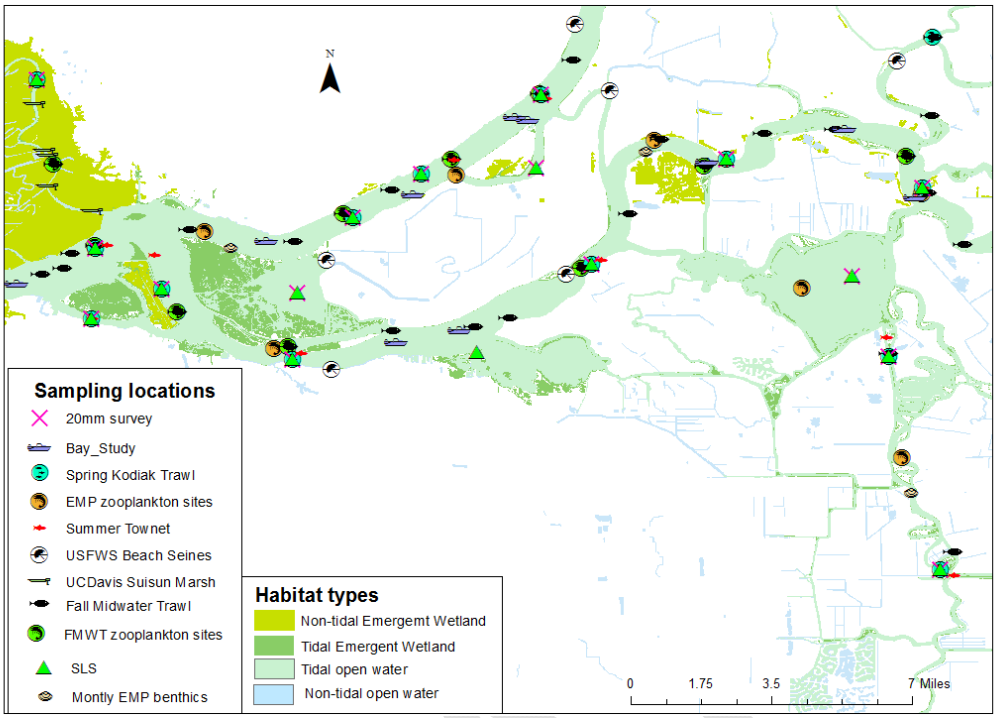

Figure 9.2.1.4.4-2. Sampling locations in the west Delta for invertebrates and fish.

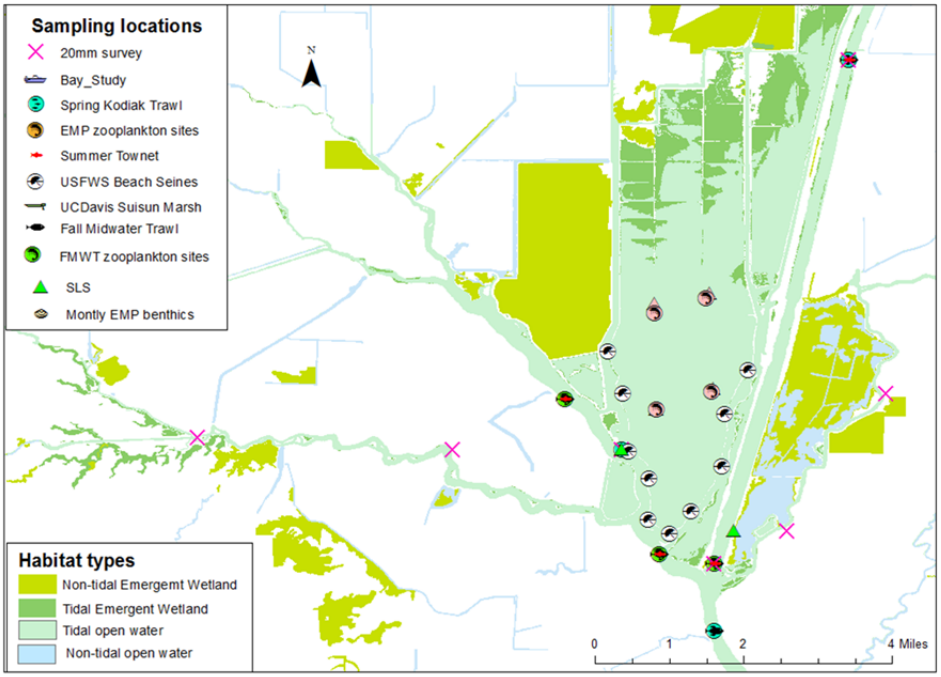

Figure 9.2.1.4.4-3. Sampling locations in the Cache Slough Complex for invertebrates and fish.

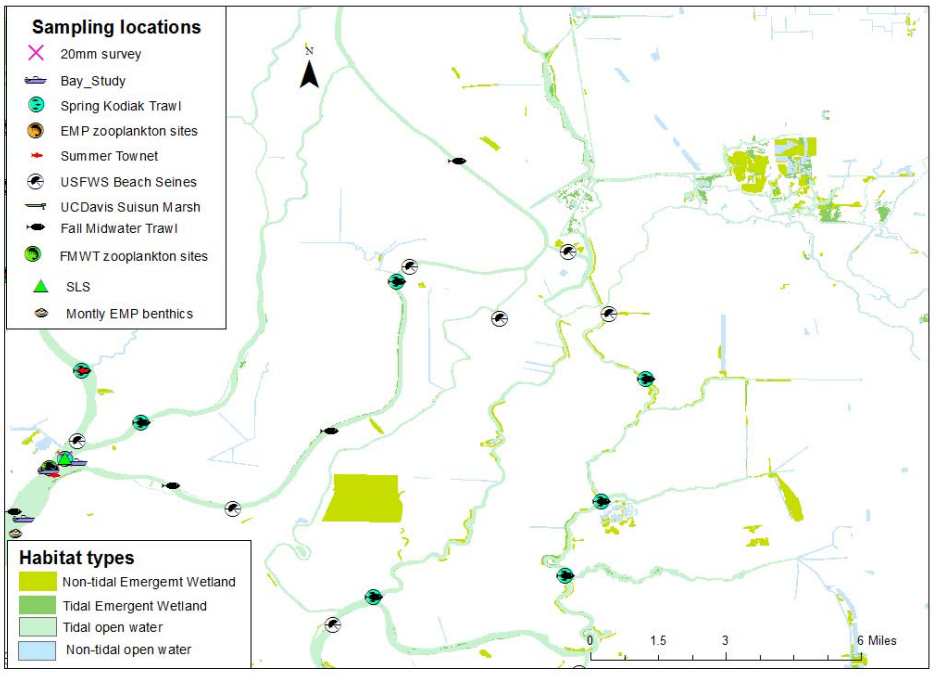

Figure 9.2.1.4.4-4. Sampling locations in the north Delta for invertebrates and fish.

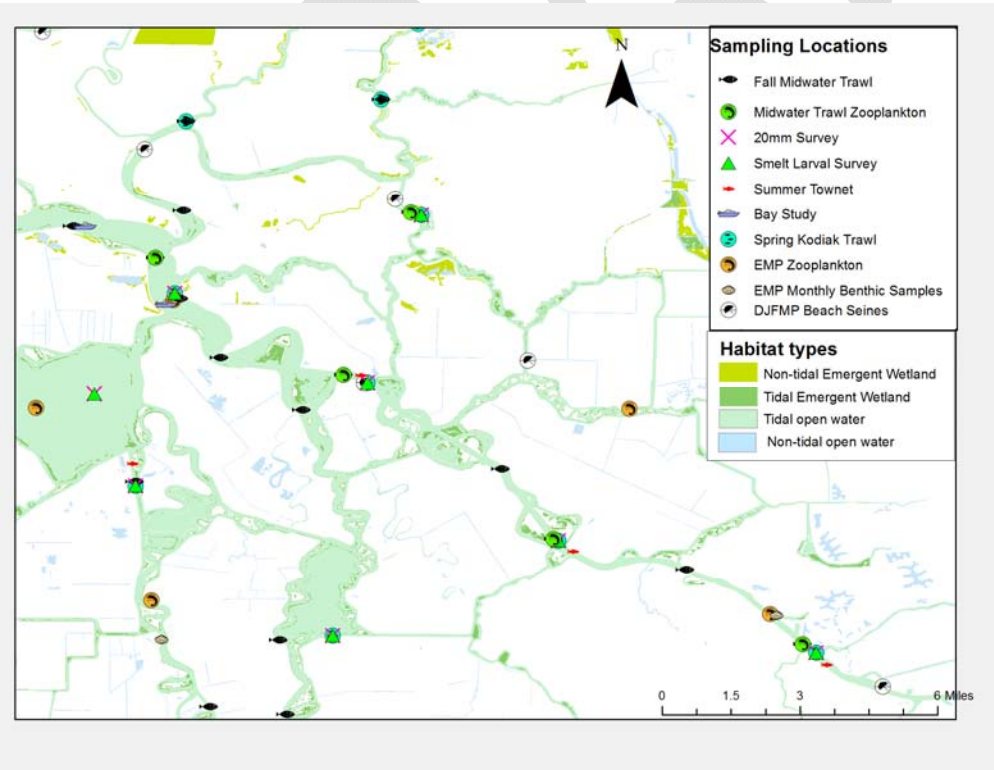

Figure 9.2.1.4.4-5. Sampling locations in the east Delta for invertebrates and fish.

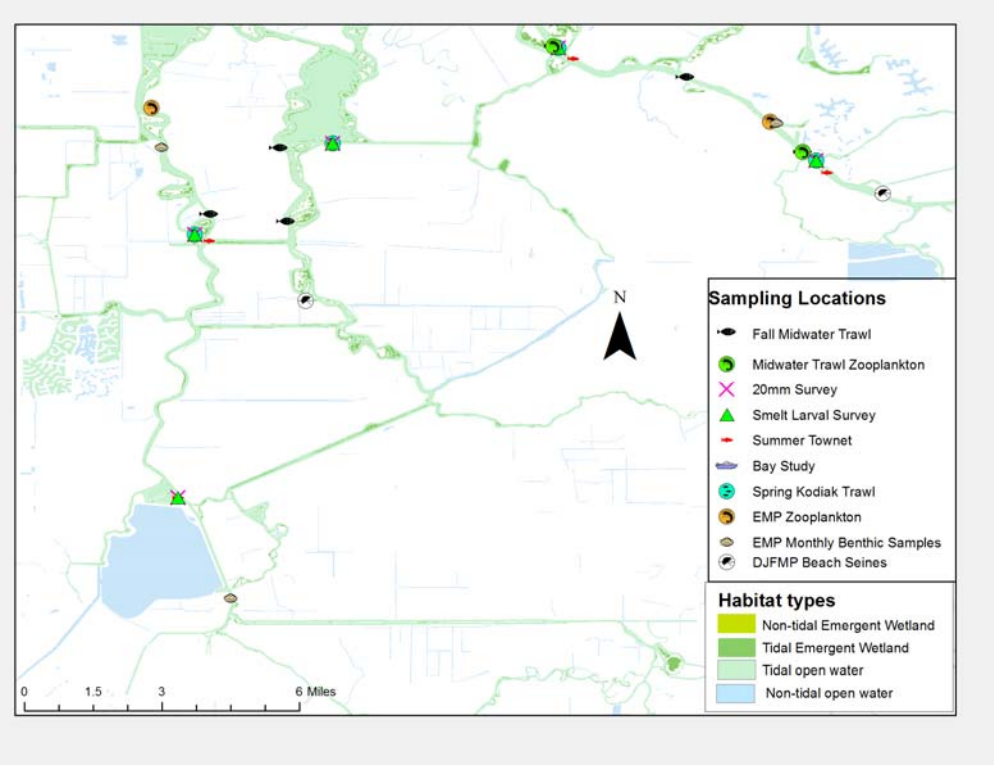

Figure 9.2.1.4.4-6. Sampling locations in the south Delta for invertebrates and fish.

Interagency Ecological Program for the San Francisco Estuary

The mission of the Interagency Ecological Program (IEP) is, in collaboration with others, to provide ecological information and scientific leadership for use in management of the San Francisco Estuary. The goals of IEP are to: Describe the status and trends of aquatic ecological factors of interest in the estuary, develop an understanding of environmental factors that influence observed aquatic ecological status and trends, use knowledge of the above information in a collaboration process to support natural resource planning, management, and regulatory activities in the estuary, continually reassess and enhance long-term monitoring and research activities that demonstrate scientific excellence, and to provide scientific information about the estuary that is accurate, accessible, reliable, and timely manner. Since its inception in 1972, IEP has been the principal entity coordinating ecological investigations, science collaboration and fish monitoring in the Bay-Delta.

Most research and monitoring of fish populations in the Bay-Delta is coordinated through the IEP. The IEP is a cooperative effort led by state and federal agencies with university and private partners (http://www.water.ca.gov/iep/). Several of the IEP's monitoring programs capture delta smelt. However, only four sample efficiently enough for delta smelt to be commonly used to index the species' abundance or distribution, and only three (Spring Kodiak Trawl Survey, 20-mm Survey, and Enhanced Delta Smelt Monitoring) are designed specifically to target delta smelt.

The Service was historically able to derive additional information on delta smelt from fish salvage operations at the Skinner and Tracy fish facilities. These SWP and CVP fish facilities in the south Delta are screened with fish-behavioral louvers designed to salvage young Chinook salmon and striped bass before they reach Banks and Jones pumping plants (Brown *et al.* 1996). In general, the salvage process consists of fish capture, transport, and ultimately release at locations where they are presumed safe from further influence of the Banks and Jones Pumping Plants. However, unlike some species, it is commonly acknowledged that the salvage of delta smelt is extremely inefficient the fish seldom survive the salvage process. Data on the salvage of delta smelt has historically been used to provide an index of entrainment. Delta smelt salvage data in combination with the annual Fall Midwater Trawl index of delta smelt relative abundance have been used to set incidental take for the SWP and CVP since the 2008 Service BiOp.
A summary of the number of individuals that were reported from IEP studies from 2005 through 2016 is presented in Tables 9.2.1.4.4-1, 9.2.1.4.4-2, and 9.2.1.4.4-3.

Table 9.2.1.4.4-1. Number or larvae delta smelt individuals captured from 2005-2016 from IEP studies.

Larvae (<20 mm FL)

Survey	Year											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fall Midwater Trawl	0	0	0	0	10	0	0	0	0	0	0	0
Townet Survey			10	82	49	198	470	246	127	75	0	0
South Delta fish investigations	8		277									
20-mm**	644	978	135	274	435	833	1162	1076	1125	256	94	126
Yolo Bypass	0	0	0	0	0	0	0	0	0	0	0	0
Delta Juvenile Fish Monitoring	14										0	0
Directed Fish Collections			2									
Upper estuary zooplankton			2	17		10	3	3	5	1	0	0
Investigation of Antioch and Pittsburg Power Plants				17	10	1	1					
Spring Kodiak Trawl	26					1		1	2	53	3	26
Morrow Island Distribution			1									
UCD Suisun Marsh										2	0	
Smelt Larva Survey		79	274			6	3	238	118	24	6	8
Mossdale Spring Trawl											0	
Fish Community Monitoring				22								
Pilot Mark-recap to Estimate Pre-screen Loss and Salvage Efficiency					111							
Gear Efficiency Evaluation in Support of Delta Smelt Modeling									85	147	0	
FRP Tidal Wetland Monitoring Study											0	
USGS Early Warning											0	
USGS Physical and Biological Drivers												
TOTAL	692	1057	701	412	615	1049	1639	1564	1462	558	103	160

**20mm Study reports larvae and juveniles together (age-0). Age-1+ reported as adults.

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Table 9.2.1.4.4-2. Number of juvenile and adult delta smelt individuals captured from 2005-2016 for IEP studies.

Juveniles and Adults (>=20 mm FL)

Survey	Year											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fall Midwater Trawl	28	39	27	21	32	54	344	47	21	11	7	
Townet Survey	120	83	45			2	318	28		1	23	6
SF Bay Study	85	21	64	45	20	49	180	95	77	43	51	2
20-mm	15	0	2	1	2	5	8	63	9	1	0	2
Yolo Bypass	4	17	4	26	88	21	30	147	181	61	58	30
Broodstock Collections	2297	2418		70	23	80		2	98			
Delta Juvenile Fish Monitoring	761	954	245	119	136	445	956	710	464	301	245	91
New Technologies and Release Sites, Element 2 (Electrofishing)				2								
Indicators to Predict Adverse Effects to Salvaged Delta Smelt	64											
Fish Predation in the CHTR Phase	19											
Acute Mortality Associated with CHTR		28										
Directed Fish Collections	5	371	4									
Upper estuary zooplankton						1	2	2	0	1	0	
Investigation of Antioch and Pittsburg Power Plants				2	14		0					
Spring Kodiak Trawl	1311	473	708	339	671	659	445	1204	339	356	107	34
Morrow Island Distribution	2	1										
UCD Suisun Marsh	2	1	3	1	4	2	22	10	6	7	3	
Smelt Larva Survey		1			2		2	10	4		2	
Mossdale Spring Trawl						1					0	
Fish Community Monitoring			3	3	8		9					
Effects of Largemouth Bass on Delta Ecosystem						5						
Pilot Mark-recap to Estimate Pre-screen Loss and Salvage Efficiency				189	10							
Smelt Migration Study (AKA First Flush)*						659		822				
Gear Efficiency Evaluation in Support of Delta Smelt Modeling								721	863	890	185	
FRP Tidal Wetland Monitoring Study											0	2
USGS Early Warning											0	
USGS Physical and Biological Drivers												
TOTAL	4713	4407	1105	818	1010	1983	2316	3861	2062	1672	681	167

*Smelt Migration sampling in year 2010 includes one day of sampling in 2011

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Table 9.2-9. Number of adult delta smelt individuals for all life stages reported from 2005-2016 for IEP studies.

All life stages combined

	Year											
Survey	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Fall Midwater Trawl	28	39	27	21	42	54	344	47	21	11	7	0
Townet Survey	120	83	55	82	49	200	788	274	127	76	23	6
SF Bay Study	85	21	64	45	20	49	180	95	77	43	51	2
South Delta Fish Investigations	8	0	277									
20-mm	659	978	137	275	437	838	1170	1139	1134	257	94	128
Yolo Bypass	4	17	4	26	88	21	30	147	181	61	58	30
Broodstock Collections	2297	2418		70	23	80		2	98			
Delta Juvenile Fish Monitoring	775	954	245	119	136	445	956	710	464	301	245	91
New Technologies and Release Sites, Element 2 (Electrofishing)	0			2								
Indicators to Predict Adverse Effects to Salvaged Delta Smelt	64											
Fish Predation in the CHTR Phase	19											
Acute Mortality Associated with CHTR	0	28										
Directed Fish Collections	5	371	6									
Upper estuary zooplankton	0		2	17		11	5	5	5	2	0	0
Investigation of Antioch and Pittsburg Power Plants				19	24	1	1					
Spring Kodiak Trawl	1337	473	708	339	671	660	445	1205	341	409	110	60
Morrow Island Distribution	2	1	1									
UCD Suisun Marsh	2	1	3	1	4	2	22	10	6	9	3	0
Smelt Larva Survey		80	274		2	6	5	248	122	24	8	8
Mossdale Spring Trawl	0					1				0	0	0
Fish Community Monitoring			3	25	8	0	9					
Effects of Largemouth Bass on Delta Ecosystem						5						
Pilot Mark-recap to Estimate Pre-screen Loss and Salvage Efficiency				189	121							
Smelt Migration Experiment (AKA First Flush)						659		822				
Gear Efficiency Evaluation in Support of Delta Smelt Modeling								721	948	1037	185	0
FRP Tidal Wetland Monitoring Study											0	2
USGS Early Warning											0	0
USGS Physical and Biological Drivers												
TOTAL	5405	5464	1806	1230	1625	3032	3955	5425	3524	2230	784	327

Enhanced Delta Smelt Monitoring

The objective of the proposed Enhanced Delta Smelt Monitoring (EDSM) is to provide data for calculating life stage-specific estimates of abundance, spatial distribution, and proportion at risk of entrainment for selected life stages and times of year. The monitoring program aims to collect data that will yield estimates with greater precision and less selection bias than estimates based on catches from existing surveys, namely, the SKTS, 20mm, TNS), and FMWT Surveys. There are three key differences between the proposed monitoring and existing surveys: (1) The most efficient gear for each life stage will be used: to catch larvae and smaller juveniles during the months of May through July 20 mm gear, or a slight modification thereof, will be used and to catch larger juveniles, sub-adults, and adults during the months of August through April a Kodiak trawl will be used. This is in contrast, for example, to the use of a midwater trawl to catch subadults during the months of September through December (the FMWT survey); (2) For each sampling occasion, trawling locations will be chosen at random using a spatially representative selection procedure such as Generalized Random Tesselation Stratified sampling or Balance Acceptance Sampling. Existing surveys have been using the same sampling locations

for every sampling occasion for years and these locations were not selected according to a probability scheme; and (3) Sampling will be done up to four times per week at approximately 24 randomly selected locations throughout the range occupied by the relevant delta smelt life stage, and multiple tows will be taken at each sample location. The minimum number of tows is 2, and the maximum will be 5 or 10 depending upon predicted fish densities. For larger life stages which can be immediately identified at time of capture, a "stopping rule" will be used where sampling ends once at least two tows have been made and at least one delta smelt has been caught, or when the maximum number of tows is reached. The section 10(a)(1)(a) permit to the DJFMP for the Jersey Point Early Warning (see *Jersey Point and Prisoner's Point Early Warning Monitoring*) and Liberty Island (see *Liberty Island*) was renewed in October 2016 to include the EDSM. EDSM will replace the prior Early Warning Monitoring moving forward in 2017. The exempted take allowed for the two projects, Liberty Island and EDSM, annually is up to 1,050 delta smelt for all life stages for 2017.

Other Delta Smelt Research

Liberty Island

In 2009, the Stockton Fish and Wildlife Office (now Lodi Fish and Wildlife Office (LFWO)) served a critical role in developing and facilitating a collaborative interdisciplinary study known as Breach III to assess the effects of restoration on aquatic biota inhabiting the tidally influenced freshwater wetlands at Liberty Island and Little Holland Tract in Yolo County, California. The goals of the Breach III project are to provide a predictive level of understanding about (1) how restoration activities influence local flooding and levee erosion and (2) how abiotic and biotic factors control aquatic vegetation, fish, and wildlife distributions.

The LFWO's DJFMP collaborated with the University of Washington (UW) and Washington State University (WSU) to simultaneously address the macroinvertebrate and fish response portions of the study at Liberty Island. The Service assisted the Universities by providing two boats and three personnel. The sampling, led by WSU, was designed to evaluate the use of a restoring wetland complex by specific life stages of delta smelt, longfin smelt, Chinook salmon, striped bass, threadfin shad, and Sacramento splittail. Adult and juvenile fishes were sampled using gill and fyke nets at six locations to monitor both the relative abundance and diet of fishes (diet information was published by Whitley and Bollens 2014). In addition, the DJFMP sampled larval fishes using trawls to monitor larval fish abundance throughout Liberty Island. The macroinvertebrate sampling, led by the UW, was designed to identify and monitor assemblages associated with the spatial and temporal development of the restoring wetland with emphasis on prey taxa of priority fishes. The UW took benthic core samples, conducted zooplankton trawls, and deployed insect fall-out traps to monitor the abundance of macroinvertebrates under the substrate, within the water column, and on the water's surface, respectively.

This program documented year-around occurrence of delta smelt in Liberty Island and confirmed that some individuals used the tidal marsh edge in northern Liberty Island as a foraging habitat.

This study provided the Service with greater certainty that wetland restoration in this part of the Delta will provide benefits to delta smelt.

The Arc Project: Suisun Marsh, Sherman Lake, and the North Delta

This project aims to provide a better understanding of how land and vegetation in the Delta interact with river flow and tides to create habitat favored by native fishes. Scientists, engineers and resource managers expect to use this information to identify areas and conditions of high potential for habitat improvement throughout the Delta.

The investigation focuses on regions in the north Delta where contemporary fish surveys have shown relatively high populations of native fishes - regions including Suisun Marsh, the flooded Sherman Island and the Cache and Lindsey sloughs. The areas together form an arc, inspiring the project name "North Delta Arc of Native Fishes."

9.2.1.4.4 Regional Conservation Efforts

Fish Conservation and Culture Lab and Livingston Stone National Fish Hatchery Refugial Population

The Fish Conservation and Culture Laboratory (FCCL) has been operated by the University of California, Davis since 1996 within the Biological and Agriculture Engineering Department (FCCL 2016). The effort to culture delta smelt dates back to 1992, when the species was proposed for listing. Dr. Joan Lindberg started the program and the life-cycle of delta smelt was closed around 2004 with the assistance of Dr. Bradd Baskerville-Bridges. Fish reared at the FCCL have been used for numerous research projects and are also used to maintain two refuge populations in captivity as insurance against extinction of the species.

In 2007, CDFW and the Service participated in efforts to culture delta smelt under genetically sound management and began holding the second refuge population at the Service's Livingston Stone National Fish Hatchery (LSNFH). The goal of both refuge populations (FCCL and LSNFH) is to maintain a population in culture that is very close to the wild population both in terms of phenotype and genotype to serve as a safeguard against extinction.

The delta smelt culture techniques have been continuously improved over the years and the survival rate of cultured delta smelt at the FCCL is high (Lindberg *et al.* 2013). Approximately 260-300 families of delta smelt are maintained at the FCCL annually; delta smelt from the wild contribute to each new generation and are currently required to avoid genetic drift (Fisch *et al.* 2012). The FCCL is currently expanding and renovating existing facilities, increasing the capacity for culture and research purposes.

Tidal Marsh Recovery Plan

This California coast-wide, multi-species recovery plan, published in 2013, includes conservation needs for the San Francisco Estuary, with a focus on the following listed plant and

terrestrial species: *Cirsium hydrophilum var. hydrophilum* (Suisun thistle), *Cordylanthus mollis ssp. Mollis* (soft bird's beak), *Suaeda californica* (California sea-blite), California clapper rail (*Rallus longirostris obsoletus*), and salt marsh harvest mouse (*Reithrodontomys raviventris*). The Tidal Marsh Recovery Implementation Team (RIT) was formed in 2015 and has been meeting quarterly. Restoration efforts from this plan are identified in its implementation table online at: https://www.fws.gov/sfbaydelta/es/tidal_marsh_recovery.htm. The RIT is working collaboratively with the San Francisco Bay Joint Venture and other partners to prioritize science, research, and restoration needs. The RIT is also currently developing an action item system by soliciting priorities by species from the clapper rail, salt marsh harvest mouse and plants groups to be presented at the next San Francisco Bay Joint Venture Conservation Delivery Committee meeting. This updated priority list will be used to leverage funding from traditional sources and from recently passed measure AA funding. A portion of tidal marsh restoration actions are to take place in the Suisun Marsh and Bay areas where the delta smelt resides (See Suisun Marsh Habitat Management, Preservation and Restoration Plan below). Actions taken are expected to have ecosystem wide benefits and could positively impact delta smelt habitat.

Suisun Marsh Habitat Management, Preservation and Restoration Plan (The Suisun Marsh Plan)

The Suisun Marsh Plan, signed in 2014, was developed to balance the goals and objectives of the Bay-Delta Program, Suisun Marsh Preservation Agreement and other management and restoration programs within Suisun Marsh. The Plan provides for simultaneous protection and enhancement of Pacific Flyway and existing wildlife values in managed wetlands, endangered species recovery, and water quality. The plan's tidal wetland restoration program could benefit delta smelt via contribution to the Suisun Marsh food web. The first tidal marsh restoration project to fall under the Suisun Marsh Plan was the Tule Red Tidal Restoration Project that started interior construction in late fall of 2016. The project will convert approximately 420 acres of managed wetlands for waterfowl, by breaching a habitat berm allowing for tides to reclaim the land. The project is anticipated to breach in 2017. Once the breach has occurred, food web production is expected to be exported into Grizzly Bay where delta smelt are known to occur.

Ecosystem Restoration Program

The State of California funds several initiatives to improve the estuary for fish and wildlife. The Ecosystem Restoration Program (ERP) was created to improve and increase aquatic and terrestrial habitats and ecological function in the Delta and its tributaries. Additionally, created in 2014, California EcoRestore Prop1 provides funding to facilitate regional water management while reducing reliance on water from the Delta. California EcoRestore also seeks to protect and restore important ecosystems.

The CDFW program seeks to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse plant and animal species. The Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) is one of four regional plans intended to implement the ERP. The DRERIP is an ongoing effort that has produced a series of conceptual models to inform agencies about processes, habitats, species,

and stressors of the Bay-Delta (http://www.dfg.ca.gov/ERP/conceptual_models.asp). CDFW and the DWR are continuing to implement and plan for ecosystem restoration projects begun under the CALFED Bay-Delta Program located in Suisun Marsh, at Dutch Slough, at Cache Slough, in the Yolo Bypass, and at the Cosumnes River Preserve's North Delta project. Between 1994 and 2004, the program expended 700 million dollars on 500 restoration projects in the Estuary and its tributary rivers. This includes enhancement or restoration of over 19 miles of riparian and shaded riverine, instream riverine, saline emergent wetland and freshwater emergent wetland, and in-channel island habitat within delta smelt's range. The program had also funded research on control and prevention of non-native species through the development of an ecological flow tool used to understand the relationship between flow and fish habitat needs in the Estuary. More information on the Ecosystem Restoration Program can be found online at: http://www.dfg.ca.gov/erp/.

California EcoRestore

This initiative by the state of California is implemented in coordination with state and federal agencies to advance the restoration of at least 30,000 acres of Sacramento-San Joaquin Delta (Delta) habitat by 2020. California EcoRestore will pursue habitat restoration projects including tidal wetlands, floodplain, upland, riparian, fish passage improvements and others. Planned restoration projects include the 8,000 acres of tidal habitat required under the 2008 Service BiOp. To date, one tidal marsh restoration project has begun construction: the Tule Red Restoration Project, located in Suisun Marsh, which broke ground in September 2016. The project will restore 420 acres of managed wetlands into tidal and subtidal wetlands designed to provide food web benefits to delta smelt. In addition, the first year of Proposition 1 funds will be providing grant money towards ecosystem restoration and water quality improvement projects which may also provide a benefit to delta smelt. Although projects have been chosen to receive funding, no projects have been completed to date.

Habitat Conservation Plans and National Community Conservation Plans

Under Section 10(a)(1)(B) of the Endangered Species Act, several Habitat Conservation Plans have been completed and are being implemented in the Action Area to provide long-term conservation planning in coordination with human development, while, other Habitat Conservation Plans are still under development and in the planning stage. Of those completed, there is one that has delta smelt as a covered species. The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan was completed in 2000. The HCP allows for urban development and includes compensatory mitigation for the loss of up to 371 acres of shallow water habitat and 3 acres of submerged aquatic habitat at a 3:1 ratio.

Conservation Banks

The Service has approved two delta smelt conservation banks within the Cache Slough Complex: North Delta Fish Conservation Bank and Liberty Island Conservation Bank.

North Delta Fish Conservation Bank

Wildlands worked in partnership with the landowners, The Trust for Public Land and Reclamation District 2093, to establish the 811-acre conservation bank located within the northern portion of Liberty Island and southern end of the Yolo Bypass. The conservation bank will provide habitat benefits to delta smelt and other state and federally listed species. The bank was approved in October 2013 by NMFS, CDFW, and the Service. The conservation bank will enhance 657 acres of tidal marsh wetlands, including emergent marsh, seasonal wetland, riparian, and shallow open water habitats, in addition to 68 acres of tidal channel enhancement, and over 32 acres of tidal emergent marsh creation through the removal of levees and lowering a portion of the existing floodplain habitat.

Liberty Island Conservation Bank

Liberty Island Conservation Bank is a 186-acre habitat restoration project in Yolo County, California. It is a mosaic of tidal aquatic habitats intended to benefit Delta native fish species, such as delta smelt, longfin smelt, and salmonids. The construction included creating open water channels, tidal emergent marsh, seasonally inundated floodplain habitats and removing levees which impeded tidal and flood flow. In all over 190,000 cubic yards of material was moved to complete the project. The conservation bank will preserve 19.3 acres of tidal channel in Liberty Cut and Shag Slough and restore or create 47.9 acres of emergent marsh and tidal channels for delta smelt.

The Delta Smelt Resiliency Strategy

The Delta Smelt Resiliency Strategy (Strategy) was proposed by the State of California in 2016. It proposes to address both immediate and longer term needs of the delta smelt, promote their resilience to drought as well as future variations in habitat conditions caused by climate change, future floods and droughts, CVP and SWP operations, and several other stressors.
The proposed actions in the Strategy include habitat improvement projects like: aquatic weed control; north Delta food web adaptive management projects; outflow augmentation; reoperation of the Suisun Marsh Salinity Control Gates; sediment supplementation in the low-salinity zone; spawning habitat augmentation; Roaring River distribution system food production; and coordinated managed wetland flood and drain operations in Suisun Marsh. It proposes a variety of other actions intended to improve the status of delta smelt including ceasing salvage of nonnative fishes in the summer and fall; planning for improved stormwater discharge management; building the Rio Vista Research Station and Fish Technology Center; accelerating tidal marsh habitat restoration; and exploring the feasibility of restoring Franks Tract into a tidal marsh.

A subset of EcoRestore habitat restoration projects that overlap with the 8,000 acres of tidal marsh and associated subtidal habitat requirement previously described above in 2008 Service BiOp on the Coordinated Operations of the CVP and SWP within RPA Component 4 is also described in the Strategy.

Of the actions proposed, those listed below have occurred and are part of the environmental baseline conditions:

North Delta Food Web Adaptive Management Projects

DWR augmented flow in the Yolo Bypass by closing Knights Landing Outfall Gates and routed water from Colusa Basin into Yolo Bypass in July 2016 to promote food production and export into areas where delta smelt are known to occur.

Roaring River Distribution System Food Production

DWR will install drain gates on the western end of the Roaring River Distribution System that can be used for most months of the year to drain food-rich water from the canal into Grizzly Bay to augment delta smelt food supplies in that area. This area is also adjacent to the Tule Red Restoration Project, which began construction in 2016. In addition to new drain gates, DWR will repair the existing outfall gate on Montezuma Slough which, in addition to a new gate onto Grizzly Bay, would further increase operational flexibility to maximize export of zooplankton to adjacent open water habitat used by delta smelt.

Summary of Environmental Baseline

Much of the Action Area has been altered or degraded from its historical state; where coverage of freshwater emergent wetlands decreased from 193,224 to 4,253 ha while open-water habitats increased from 13,772 to 26,530 ha (Grossinger *et al.* 2014). Loss of shallow water edge habitat along the Sacramento River and its tributaries has occurred over time from rip-rapping and will be likely maintained in the future. Historically, the water diversions of the CVP and SWP export facilities have maintained high-levels of pumping; although due to the recent drought there has been a reduction in pumping-levels.

Other sources of injury/mortality to delta smelt and habitat loss include: dredging; sand-mining; wastewater treatment plants; aquatic weed control; managed wetland activities; research and monitoring efforts; and other consultations of much lower effect to delta smelt, such as boat docks. The Service has collaborated with other state, federal, and private entities to significantly reduce monitoring and research efforts that result in lethal take in parallel with the observed change in status of the species. Although greatly reduced, existing monitoring and research programs, like the IEP, still take delta smelt through the form of injury or mortality in the thousands annually across all life stages (see Section 9.2.1.4. *Existing Conditions and Previous Consultations in the Action Area*). In addition to those existing IEP monitoring efforts, additional efforts are anticipated to continue into the near-term, such as the Enhanced Delta Smelt Monitoring that could take up to 1,050 delta smelt in 2017. Although, it is important to recognize that those numbers of individuals may be lower than estimated when implemented due to the rarity of recent delta smelt observations in the wild.

As mentioned previously, loss/degradation of suitable habitat continues to pose the largest threat to delta smelt. Efforts by DWR and Reclamation are currently being made through the Delta

Smelt Resiliency Strategy to improve baseline habitat conditions and therefore abundance of the population (DWR 2016); however, many of the efforts are still in the planning or preliminary stage of implementation and are not expected to occur in the near-term. Other recovery actions being discussed, include the future development of an estuarine research station and fish technology center (*e.g.,* additional genetic, hatchery, and propagation efforts above and beyond those currently being done by the FCCL and the Service), which are also not expected to occur in the near-term.

Forecasted warmer water temperatures and higher salinity in the Delta due to climate change will likely further impair delta smelt habitat in the future. Effects of climate change on the population are likely already affecting delta smelt. Some observations include slightly warmer temperatures, small increases in sea-level rise, reductions in the spawning window, and earlier spawning.

9.2.2.2 Effects to Delta Smelt from the Proposed Action

The PA, as described in *Description of the Proposed Action*, has been deconstructed into individual activities and analyzed for effects to delta smelt. See Figure 9.2.1.5-1 for the deconstruction.

What has been referred to in Figure 9.2.1.5-1 as the NAA, No Action Alternative, has been provided to the Service in the CWF BA as a basis for comparison when discussing effects of implementing the PA, primarily for assessing effects from operations on delta smelt and its habitat. The NAA is intended to represent the projected conditions under existing regulatory requirements without the PA. The NAA is a representation of the base CVP and SWP operations and physical conditions at year 2030. The NAA and the PA simulations include assumptions about climate change including sea level rise, and water demands of a larger human population in California. Refer to CWF BA Appendix 5.A, *CalSim II Modeling and Results*, for more detail on the CalSim II modeling assumptions for the NAA and the PA. The NAA modeling does not fully represent baseline conditions, since only some of the components of the existing conditions were quantified in the computer simulations. Others are discussed qualitatively; for instance, the restoration of 8,000 acres of tidal marsh habitat identified in the 2008 Service BiOp RPA Habitat Component 4 that is required to be completed by 2018, but the locations of most of the restoration have not been chosen, so it was not directly simulated. See *Status of the Species* for delta smelt and *Existing Conditions and Consultations in the Action Area* for more details.

Preconstruction and construction-related activities have been described in the CWF BA at the site-specific level for near-term implementation with no future Federal action required, except for the NDD and HORG construction, which will have subsequent Federal approvals. Information has been provided to the Service in the CWF BA and supplemental documentation (BiOp Resolution Log) to perform a project-level analysis of effects to delta smelt and its critical habitat from NDD and HORG construction. Therefore, effects to delta smelt and its critical habitat for all preconstruction and construction components of the PA have been analyzed herein at a project-level and include an incidental take statement (ITS) and jeopardy/adverse modification analysis. Effects to delta smelt and its critical habitat from operations of the new and existing CVP and SWP water facilities have been analyzed at a programmatic-level based on

the framework programmatic approach of this consultation with a jeopardy/adverse modification analysis for dual conveyance operations. This BiOp includes a mixture of project- and program-level analysis for the different CWF components as described above.

Uncertainties Regarding Operations

In the CWF BA, Reclamation and DWR have described and analyzed one operational scenario under a dual conveyance system. This BiOp analyzes this scenario at a programmatic-level. However, the consultation on the near-term operations of the south Delta water facility has been reinitiated and the State Water Resources Control Board's Water Quality Control Plan process will influence operational standards that the PA will be required to adhere to for the current existing facilities (near-term) and future operations under a dual conveyance system (long-term). Both of these processes will likely result in changes to near-term and long-term operations, and these changes are not reflected in the PA at this time because the operational standards are not yet known. Therefore, the operational scenario that is described in the CWF BA will almost certainly change between now and when the dual conveyance system goes online. The adverse effects associated with operations described within the effects analysis of this consultation may occur under the real-time operations of a future dual conveyance system; however, Reclamation and DWR have committed to propose future actions that will avoid jeopardizing the continued existence of delta smelt and destroying or adversely modifying their designated critical habitat (Reclamation 2016b). Those future actions could include: new or modified operational criteria, minimizing project footprints during the final design phase, conservation efforts to maintain or increase trends in delta smelt abundance, efforts to restore and/or improve habitat conditions that support delta smelt, and other actions to be defined in the future.

The effects to delta smelt and its critical habitat are described within section 9.2.2.1 *Preconstruction and Construction* and 9.2.2.2 *Operations* of the BiOp as DWR has defined the PA in the CWF BA and BiOp Resolution Log. The *Operations* section may describe in some instances significant adverse effects to delta smelt and its critical habitat that will or may potentially occur in the future from the PA operations; however, Reclamation and DWR have committed to proposing future actions that will not jeopardize delta smelt or destroy or adversely modify their designated critical habitat. These future actions will be informed by the State Board process, reinitiation of the 2008 Service BiOp, the Adaptive Management Framework, and other state and federal processes.

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Figure 9.2.1.5-1. Deconstruction of the existing and projected conditions (referred to as the NAA or No Action Alternative above) and PA (Proposed Action).

9.2.2.1 Preconstruction and Construction

Preconstruction activities include land-based and overwater geotechnical exploration. Common construction-related activities among all water facilities construction include: clearing, site work, ground improvements, borrow fill, fill to flood height, dispose soils, dewatering, dredging and rip-rap placement, barge traffic, landscaping and associated activities, drilling, and pile driving. See Figure 9.2.2.1-1 below for the deconstruction.

Some components of the PA do not propose any in-water work (*e.g.,* land-based geotechnical explorations, temporary access and work areas, power supply and grid connections, and IF and conveyance tunnel construction). These components are judged to have no effect to delta smelt or its habitat, except in the event of an accidental spill. Effects to delta smelt and its habitat from accidental spills are addressed below. The remainder of the effects analysis is associated with components of the PA that include in-water work. If the land-based components change as the PA is refined to include in-water work, reinitiation is required to analyze any new effects not analyzed in this opinion.

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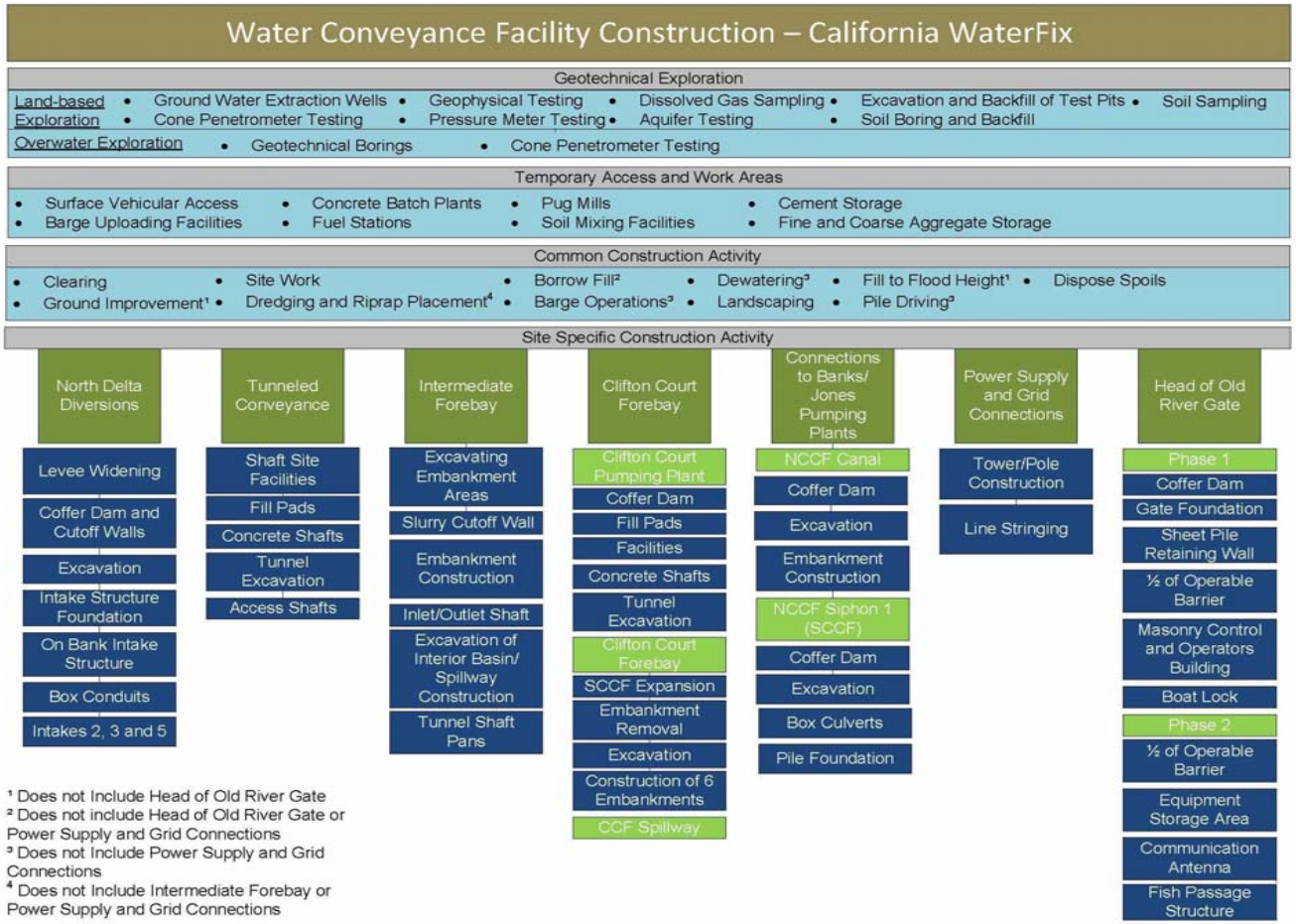

Figure 9.2.2.1-1. Deconstruction of the proposed action (PA) by construction activities, including preconstruction studies (*i.e.*, geotechnical explorations).

Accidental Spills

Land-side proposed construction activities could result in the introduction of chemical contaminants to the waterway and adjacent shorelines. Hazardous materials from construction equipment, barges and towing vessels, and other machinery (heavy equipment) could leach or wash into the water or the soil along the shoreline. Vehicles may leak hazardous substances such as motor oil and antifreeze. A variety of substances could be introduced during accidental spills of materials. Such spills can result from leaks in vehicles, small containers falling off vehicles, or from accidents resulting in loads being spilled.

Accidental spills of contaminants, including oil, fuel, hydraulic fluids, concrete, paint, and other construction-related materials could result in localized water quality degradation and potential adverse effects on delta smelt. Potential effects of contaminants on delta smelt include physical injury and mortality (*e.g.*, damage to gill tissue causing asphyxiation) or delayed effects on growth and survival (*e.g.*, increased stress or reduced feeding), depending on the type of contaminant, extent of the spill, and exposure concentrations. The risk of such effects is highest during in-water construction activities, including cofferdam installation, levee grading and armoring, and barge traffic, because of the proximity of construction equipment to the river. However, implementation of CWF BA Appendix 3.F, *General Avoidance and Minimization Measures,* AMM5, *Spill Prevention, Containment, and Countermeasure Plan*, and AMM14, *Hazardous Materials Management*, is expected to minimize much of the potential for contaminant spills and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (*e.g.,* AMM3, *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to the river from in-water or upland sources will be minimized.

9.2.2.1 Preconstruction Studies (Overwater Geotechnical Explorations)

Effects to Individuals and the Population

Individual-level

Due to the duration of the geotechnical explorations (to occur at one location up to 60 days) and quantity of in-water borings (approximately 100), individual delta smelt are likely to be exposed to in-water work. For delta smelt present during the geotechnical explorations, adverse effects are likely to occur to individuals from contact with heavy equipment or materials, increased turbidity and suspended sediment, exposure to contaminants, disturbance of contaminated sediments, and disturbance or alteration to rearing and spawning habitat.

Adverse effects to delta smelt will be difficult to detect due to their small size, low numbers, and cryptic nature. Any juvenile delta smelt present are likely to be exposed to increased levels of noise which may cause hearing loss or interfere with feeding, sheltering, movement, and foraging behaviors; injury or mortality by machinery; and increased-levels of contaminants leading to sublethal or lethal effects.

To minimize the adverse effects to the delta smelt, conservation measures in the form of work windows have been identified. The in-water work window is established to allow in-water work when the delta smelt are least likely to occupy the areas. The timing of the in-water construction activities (August 1 – October 31) will avoid the adult migration, spawning, incubation (i.e., eggs/embryos), and larval transport phases. Overwater geotechnical explorations are scheduled to occur (August 1–October 31) when juvenile delta smelt will be rearing in the Action Area during the summer and fall months (approximately July – December).

Increased Turbidity and Suspended Sediment

Delta smelt are adapted to turbid waters, where they presumably benefit from increased feeding efficiency and avoidance of sight-feeding predators. Laboratory experiments suggest that if turbidity gets higher than 250 NTU, then there is the potential for a strong decline in feeding (Hasenbein *et al.* 2013). However, the geotechnical explorations are not expected to create turbidity that reaches this threshold.

Exposure to Contaminants and Disturbance of Contaminated Sediment

Delta smelt using these areas could be exposed to contaminants that are present at the site. Exposure pathways could include respiration, dermal contact, direct ingestion, or ingestion of contaminated prey. Exposure to contaminants could lethal or sublethal effects, possibly resulting in reduced productivity or mortality of exposed indivduals. Carcinogenic substances could cause genetic or organ damage resulting in sterility, reduced productivity, or reduced fitness among progeny. Little information is available on the effects of contaminants on delta smelt (Brooks *et al.* 2012) and the effects may be difficult to detect. DWR proposes to minimize risks by implementing BMPs and a Spill Response Plan as stated in the AMMs.

Underwater Noise and Vibrations

Construction noise, vibration, and increased human activity may interfere with normal behavior, including feeding, sheltering, and other essential behaviors of delta smelt. Intolerable levels of disturbance may force individuals from suitable habitat cover and subject them to predation that otherwise would not occur. However, given the delta smelt's seasonal to transient use of the locations where the geotechnical borings will occur, it is expected that rearing juveniles will be in low numbers in the identified areas, resulting in an overall low number of individuals injured or killed.

Disturbance or Alteration to Rearing and Spawning Habitat

Geotechnical exploration activities in open water may affect habitat through suspension and deposition of sediment throughout the water column and onto nearby spawning substrates, primarily when installing and removing the casing. As a result, potential spawning substrates may be buried or altered by suspended sediment. Suspension of sediments and contaminants will alter the localized conditions for rearing juveniles exposed to in-water work activities. However,

as previously mentioned, geotechnical explorations are not expected to create turbidity that reaches the 250 NTU threshold.

It is not known whether any of the geotechnical boring sites will occur over spawning habitat. However, effects to spawning habitat are expected to be low based on the small disturbance footprints and nature of disturbance resulting from installation and removal of the casings, and the general lack of sandy substrates at the proposed geotechnical exploration sites.

Population-level

Due to the anticipated low numbers of individuals that will be exposed to the geotechnical explorations due to the in-water work restrictions and the locations of the sites, it is expected that there will be very low effects to the overall population.

9.2.2.1.2 Barge Landings Construction and Barge Trips

Effects to Individuals and the Population

Individual-level

The overall exposure of delta smelt to activities related to construction of the barge landings is expected to be minimal. Adverse effects to delta smelt will be difficult to detect due to their small size and cryptic nature. Work has been proposed to be conducted during an in-water work window intended to minimize exposure and avoid work during the seasonal and transient use by delta smelt of the locations where the barge landings locations are identified.

Injury or Mortality from Heavy Equipment

To minimize the adverse effects to the delta smelt, the timing of the in-water construction activities, including barge landing construction (August 1 – October 31) will avoid and minimize effects to migratory and spawning adults, incubation (*i.e.*, eggs/embryos), and larval transport phases.

During the in-water work window, juvenile delta smelt will be rearing in the Action Area during the summer and fall months (approximately July – December). However, historical survey data indicate that most of the delta smelt population is distributed near the LSZ during this time. Since juvenile delta smelt typically rear downstream of the proposed barge landing locations in the summer and fall (approximately July – December), it is expected that there will be a low probability of delta smelt being injured or killed by the in-water construction activities, such as pile-driving or rip-rapping. Additionally, there is no scientific evidence that larger delta smelt will be injured or killed by propeller strikes from barge traffic due to their small slender body size and use of various depths within the water column.

Increased Turbidity and Suspended Sediment

Pile driving, barge operations, and levee armoring (rip-rapping) will be the principal sources of turbidity and suspended sediment during construction of the barge landings. These activities will result in disturbance of the channel bed and banks, resulting in periodic increases in turbidity and suspended sediment in the adjacent waterways. In-water vibratory and impact driving of the sheet piles are expected to generate turbidity plumes that could extend beyond the immediate vicinity of the source piles depending on the direction and velocity of tidal flows. Pile driving will be restricted to the in-water construction window (August 1 – October 31) to avoid the primary periods of delta smelt occurrence near the barge landing sites.

DWR proposes to develop and implement AMM7, *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). Other AMMs that are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality effects include AMM1, *Worker Awareness Training*; AMM2, *Construction Best Management Practices and Monitoring*; AMM3, *Stormwater Pollution Prevention Plan;* AMM4, *Erosion and Sediment Control Plan*; AMM5, *Spill Prevention, Containment, and Countermeasure Plan*; AMM14, *Hazardous Material Management Plan*; and AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (CWF BA Appendix 3.F).

Exposure to Contaminants and Disturbance of Contaminated Sediments

Work has been proposed to be conducted during an in-water work window intended to minimize exposure to contaminants. Contaminants may enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. Because the barge landings will be constructed on Delta waterways adjacent to major agricultural islands, these sites are more likely to contain agricultural-related toxins such as copper and organochlorine pesticides. Sediments act as a source of contaminant exposure to delta smelt. The resuspension of contaminated sediments may have adverse effects on delta smelt that encounter sediment plumes or come into contact with deposited or newly exposed sediment from contaminant exposure.

Delta smelt using these areas could be exposed to contaminants that are present at the site. Exposure pathways could include respiration, dermal contact, direct ingestion, or ingestion of contaminated food source. Exposure to contaminants could cause short- or long-term morbidity, possibly resulting in mortality or reduced fitness.. Little information is available on the effects of contaminants on delta smelt and the effects may be difficult to detect (Brooks *et al.* 2012). DWR proposes to minimize these risks by implementing BMPs and a Spill Response Plan as stated in the AMMs.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under CWF BA Appendix 3.F, *General*

Avoidance and Minimization Measures, AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*. These measures include the preparation and implementation of a preconstruction sampling and analysis plan to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (*e.g.*, silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

Underwater Noise and Vibrations

Impact pile driving at the barge landing sites will potentially produce underwater noise levels of sufficient intensity and duration to cause injury to delta smelt. Currently, it is estimated that each barge landing will require vibratory and/or impact driving of 107 steel pipe piles (24-inch diameter) to construct the dock and mooring facilities. Based on the concurrent operation of 4 impact pile drivers at each site and an estimated installation rate of 60 piles per day, pile driving noise is expected to occur over a period of 2 days at each barge landing.

Based on the general timing and abundance of delta smelt in the north, east, and south Delta, restriction of pile driving activities to August 1 - October 31 will essentially eliminate the potential for exposure of delta smelt to pile driving noise during barge landing construction. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9, *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when delta smelt may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (*e.g.*, distances to cumulative noise thresholds) and corrective actions that will be taken should the thresholds be exceeded. These measures will need to be reviewed and approved by the Service to ensure the measures will minimize adverse effects to delta smelt.

Increased Risk of Predation

Larvae, juveniles and adults may be subjected to an elevated risk of predation as they pass the barge landing sites, because of the presence of in-water and overwater structures and the loss of shallow, low-velocity nearshore areas. The presence of in-water and overwater structures (sheet pile wall, floating docks, piles, and vessels) provides shade and cover that may attract certain predatory fish species (*e.g.,* silversides, striped bass, largemouth bass, Sacramento pikeminnow) and increase their ability to ambush prey, such as delta smelt. These structures may also increase predation opportunities on delta smelt for piscivorous birds (*e.g.*, gulls, terns, cormorants) by providing perch sites immediately adjacent to open water.

Loss or Degradation of Habitat

Construction of the barge landings will result in temporary to permanent losses or alteration of aquatic habitat in several locations: Snodgrass Slough north of Twin Cities Road (adjacent to proposed IF), Little Potato Slough (Bouldin Island south), San Joaquin River (Venice Island south), San Joaquin River (Mandeville Island east at junction with Middle River), Middle River (Bacon Island north), Middle River (Victoria Island northwest), and Old River (junction with West Canal at CCF). Permanent effects will occur to shallow water habitat and, depending on exact location, associated riparian and wetland habitats that may be used during adult migration and spawning or by larvae during the spring.

With implementation of the proposed water quality and sound abatement and control AMMs, in-water construction activities will result in temporary, localized increases in turbidity, suspended sediment, noise and vibrations in the vicinity of construction sites, but these parameters are expected to return to baseline levels following cessation of construction activities and will not result in long-term effects on aquatic habitat or water quality. Effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed above. Historical survey data indicates that juveniles rear downstream of the proposed barge landing locations in the summer and fall; therefore juveniles are not expected to be affected by temporary alterations to water quality and noises during construction.

Effects to loss of physical habitat can be measured in acres. The Service has defined the shallow water habitat of delta smelt habitat as all water between Mean High High Water (MHHW) and 3-meters below Mean Low Low Water (MLLW). Construction of the barge landings will result in permanent loss of approximately 22.4 acres of shallow water habitat (approximately 3.2 acres per landing) that are used by delta smelt at various life stages. Because the barge landings will likely be sited in areas with steep, rip-rapped levees and deep nearshore areas, the potential for utilization of these sites by delta smelt for spawning is low. Consequently, permanent losses or alteration of nearshore habitat resulting from construction of the barge landings will not likely have a significant effect on spawning habitat or its use by spawning adults. During construction, and continuing during operation of the barge landings, the channel banks, bed, and waters adjacent to the dock will be periodically disturbed by propeller wash and scour from barges and tidal action, resulting in minor changes to water depths, benthic substrates, and loss of submerged and emergent vegetation. Loss of 22.4 acres of delta smelt habitat will be minimized through on-site and/or off-site mitigation, including the purchase of conservation credits at an approved conservation bank at a ratio of 3:1 prior to the impact.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to minimize effects to delta smelt and its habitat (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore disturbed areas to preconstruction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. To further minimize adverse effects to

aquatic habitat associated with barge traffic, DWR also proposes to implement a *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*).

Population-level

Historical survey data indicate the delta smelt population is distributed near the LSZ during the proposed in-water work window. Thus, we do not expect there to be any population-level effects to delta smelt as a result of exposure to in-water construction activities. Once the barge landings are constructed, there will be a risk of increased predation at the sites that could potentially result in increased mortality of adult delta smelt, although likely low based on the number of delta smelt present near the barge landing locations based on historical survey data.

Summary

Construction of the barge landings will result in permanent effects to approximately 22.4 acres of shallow water habitat that includes the footprint of the docks and mooring structures. Delta smelt exposure to the in-water work activities is avoided with the proposed in-water work window of August 1 – October 31. Based on historical survey data, we expect delta smelt to be distributed near the LSZ during construction. From the start of construction to the completion (approximately 15 years) and until the barge landings are removed, increased predation is likely to occur from in-water structures.

9.2.2.1.3 North Delta Diversions

Construction activities that could potentially affect delta smelt include the following in-water activities: cofferdam installation and removal, levee clearing and grubbing, rip-rap placement, dredging, and barge traffic. In-water construction or work activities are defined here as activities occurring within the active channel of the river, which will be part of, or immediately adjacent to, the river (*e.g.*, at waterline, in water column, on riverbed, or along river shoreline). All other sediment-disturbing activities associated with construction of the NDD and associated facilities, including construction of the sedimentation basins, will be isolated from the Sacramento River and will use appropriate BMPs and AMMs to avoid or minimize the discharge of sediment to the river.

Effects to Individuals and the Population

Individual-level

In-water construction activities (June 1 – October 31) will avoid the adult migration season and minimize exposure to the adult spawning, incubation (*i.e.,* eggs/embryos), and larval transport phases. Infrequent detection of larger juveniles in the fall surveys suggests that the upper Sacramento River serves as a spawning ground and not as a nursery ground (see *Status of the*

Species at Proposed Action Area Preconstruction and Construction Sites). Therefore, since juveniles rear downstream of the proposed intake sites in the summer and fall they are not likely to be exposed to the proposed in-water work activities.

Contact with Heavy Equipment or Materials

Adult Spawners (February – June)

In years when air temperatures are cool during the spring, water temperatures likewise remain cool allowing longer spawning seasons (*e.g.*, June instead of May). Given the in-water work window proposed (June 1 – October 31), spawning may be impaired depending on the conditions when the first year of construction occurs. As previously stated above, very low numbers of delta smelt will be exposed to the in-water work. Although adults are expected to move away from active construction areas, if present, it is assumed there is a potential for injury or mortality whenever heavy equipment or materials are operated or placed in open water.

Eggs and Embryos (Spring: ~ March – June)

Spawning habitat within the footprint of the three intakes is degraded and of low quality. Much of the edge habitat has been rip-rapped and contains only a sparse amount of sandy beaches. Based on the lack of extensive sandy beaches and expected low use and avoidance behavior by spawning adults during in-water construction activities, there is little risk of injury or mortality to eggs or embryos.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

During the first year of construction, there is potential for adult delta smelt to migrate upstream of the proposed construction areas prior to construction. If that occurs, larvae or young juveniles being transported downstream could be exposed to the in-water work activities. Although the potential for exposure is low, delta smelt larvae and young juveniles may be particularly vulnerable to injury or mortality because their small size limits their ability to escape. For the years following the cofferdam installation, the Service anticipates that delta smelt will no longer ascend the river beyond the construction sites. As a result, there should no longer be impacts to offspring. Future Service-approved monitoring studies will investigate the migration barrier effects to delta smelt from the three intake structures, pre- and post- construction through a series of laboratory, field, and modeling investigations.

Increased Turbidity and Suspended Sediment

Construction activities that disturb the riverbed and banks within the footprint of the NDD may temporarily increase turbidity and suspended sediment levels in the Sacramento River. These activities include: cofferdam installation and removal; levee clearing and grading; rip-rap placement; dredging; and barge traffic. These activities will be restricted to the proposed in-water construction window of June 1 through October 31, when delta smelt are least likely to be present in the area. In addition to minimizing effects to delta smelt by limiting activities to

occurring within the in-water work window, additional AMMs are proposed to avoid or minimize effects due to increases in turbidity and suspended sediment levels on water quality and direct and indirect effects to delta smelt resulting from sediment-disturbing activities. Those AMMs include the following: AMM1, *Worker Awareness Training*; AMM2, *Construction Best Management Practices and Monitoring*; AMM3, *Stormwater Pollution Prevention Plan*; AMM4, *Erosion and Sediment Control Plan*; AMM5, *Spill Prevention, Containment, and Countermeasure Plan*; AMM14, *Hazardous Material Management Plan*; AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*; and AMM7, *Barge Operations Plan* (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). Any delta smelt present could be harassed, harmed, or killed by construction equipment, noise, or siltation and impaired water quality. The use of silt trapping devices during all in-water work, where feasible, could minimize the effects on delta smelt caused by siltation and impaired water quality. All other sediment-disturbing activities associated with construction of the NDD, including construction of the sedimentation basins, will be isolated from the Sacramento River and will not result in the discharge of sediment to the river with implementation of the proposed avoidance and minimization measures and BMPs related to off-bank (land-based) construction activities. There is a potential for increased erosion and mobilization of sediment runoff from disturbed levee surfaces; however, with the implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (AMM2, *Construction Best Management Practices and Monitoring*), no adverse water quality effects are anticipated to delta smelt and its habitat from these land-based activities.

<u>Adult Spawners (February – June)</u>

During cofferdam installation, levee clearing and grubbing, rip-rap placement, and barge traffic, turbidity and suspended sediment levels in the river are anticipated to exceed ambient river levels in the immediate vicinity of these activities. Increases in turbidity and suspended sediment levels associated with these activities will be temporary and localized sediment plumes that are unlikely to reach levels causing direct injury or mortality to delta smelt.

During in-water construction activities at the proposed intake sites, turbidity and suspended sediment levels in the river are anticipated to exceed ambient river levels in the immediate vicinity of these activities, creating turbidity plumes that may extend several hundred feet downstream of construction activities. NMFS (2008) reviewed observations of turbidity plumes during installation of rip-rap for bank protection projects along the Sacramento River and concluded that visible plumes are expected to be limited to only a portion of the channel width, extend no more than 1,000 feet downstream, and dissipate within hours of cessation of in-water activities. Based on these observations, NMFS concluded that such activities could result in turbidity levels exceeding 25–75 NTUs. Based on the general association and feeding responses of delta smelt to turbidity, we do not expect these levels to greatly affect delta smelt (Hasenbein *et al.* 2013). However, under the assumption that there could be some effect to the substrate of habitat up to 1,000 feet downstream from each intake, this will result in 1.9 acres of impact to shallow water habitat (which is included in the overall 5.6 acres of shallow water habitat impact from the NDD footprint).

Increases in suspended sediment during in-water construction activities may result in localized sediment deposition in the vicinity of the proposed intakes, degrading potential spawning habitat of delta smelt by burying suitable spawning substrates. The Sacramento River in the vicinity of the proposed intake sites consists of mostly low quality spawning habitat due to levees that are dominated by steep slopes, existing rip-rap, and a lack of sandy substrates. The effects of the permanent loss of downstream shallow water habitat from multiple years of daily in-water construction will be mitigated by the preservation, creation, or restoration of shallow water habitat lost at a 5:1 ratio, prior to impact, in accordance with the proposed conservation measure by DWR (see CWF BA Chapter 3, *Description of the Proposed Action*) and the Service's mitigation policy.

Eggs and Embryos (Spring: ~ March – June)

Delta smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is very low, individual eggs will be subject to burial by the deposition of suspended sediment generated by in-water construction activities. However, only eggs and embryos from late spawners will be subject to burial.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

Delta smelt larvae and young juveniles may still be in the vicinity, as late as June, to be exposed to the levels of turbidity and suspended sediment generated by in-water construction activities at the NDD during their downstream transport. However, implementation of the proposed pollution prevention, erosion and sediment control, and barge traffic AMMs will minimize this risk throughout the construction period.

Exposure to Contaminants and Disturbance of Contaminated Sediments

Contaminants may also enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from the installation and subsequent partial removal of the sheet pile cofferdam. Sediments act as a sink or source of contaminant exposure depending on local hydrologic conditions, habitat type, and frequency of disturbance. Persistent chemicals that have been introduced into the aquatic environment will often bind to sediment particles, with most organic and inorganic anthropogenic chemicals and waste materials accumulating in sediment (Ingersoll 1995). Thus, resuspension of contaminated sediments may impact delta smelt that encounter sediment plumes or come into contact with deposited or newly exposed sediment. Suspended sediment can also adversely affect delta smelt by causing localized increases in chemical oxygen demand in waters in or near plumes. These toxins could have an immediate or delayed lethal or sub-lethal effect on various life stages of delta smelt and may also affect the reproductive success. Submerged aquatic vegetation may also be negatively affected by the persistent herbicides. The use of silt trapping devices during the in-water work, where feasible, will minimize the effects on delta smelt caused by the mobilization of sediments that may contain toxins.

The proposed intake sites are downstream of the City of Sacramento where sediments have been affected by historical and current urban discharges from the city. No information on sediment contaminants at these sites is currently available. Metals, PCBs, and hydrocarbons (typically oil and grease) are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Many of these contaminants readily adhere to sediment particles and tend to settle out of solution relatively close to the primary source of contaminants. PCBs are persistent, adsorb to soil and organic matter, and accumulate in the food web. Lead and other metals also will adhere to particulates and can bioaccumulate to levels sufficient to cause adverse biological effects. Mercury is also present in the Sacramento River system and could be sequestered in riverbed sediments. Hydrocarbons biodegrade over time in an aqueous environment and do not tend to bioaccumulate or persist in aquatic systems.

Dredging has the potential to release contaminants from disturbed sediments into the water column during construction and maintenance dredging at the proposed intakes. Current estimates indicate the total dredging and channel disturbance will affect 12.1 acres of the riverbed adjacent to the cofferdams at the NDD. Measured sediment plumes from hydraulic dredging operations (Hayes *et al.* 2000) suggest that less than 0.1% of disturbed sediments and associated contaminants will likely be re-suspended during cutterhead dredging operations. In sediments, only a small fraction of the total amount of heavy metals and organic contaminants is dissolved. In the case of heavy metals, releases during dredging may be largely due to the resuspension of fine particles from which the contaminants may be desorbed, and in the case of organic contaminants, most of the chemicals released into the dissolved phase will be bound to dissolved organic matter. Therefore, the potential release of contaminants from suspended sediment is expected to be limited, because many of the chemical constituents preferentially adsorb or attach to organically enriched or fine particles of sediment.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*, in Appendix 3.F, *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a preconstruction sampling and analysis plan to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (*e.g.*, silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

<u>Adult Spawners (February – June)</u>

Exposure of delta smelt to contaminants as a result of spills or sediment disturbance can cause effects that range from physiological stress, potentially resulting in delayed effects on growth, survival, and reproductive success, to direct mortality (acute toxicity) depending on the

concentration, toxicity, solubility, bioavailability, and duration of exposure, as well as the sensitivity of the exposed organisms. For example, delta smelt are highly sensitive to sublethal levels of pyrethrin which causes neurological damage and results in impaired swimming ability and potential effects on chemosensory abilities (Connon *et al.* 2009). Such impairments may affect the ability of delta smelt to swim against tides or water currents, increasing their susceptibility to predation and lowering their ability to find food (Connon *et al.* 2009). Chemosensory impairment may also affect the ability of delta smelt to detect pheromones and find mates (Connon *et al.* 2009). In addition, contaminants can enter the aquatic food web and accumulate in fish through their diet, leading to adverse effects on behavior, tissues and organs, reproduction, growth, and immune system (Connon *et al.* 2009).
Based on the timing of in-water construction activities (June 1 – October 31), late spawning adults in the vicinity of the NDD in June will be subject to direct exposure from a potential contaminant spill or sediment-borne contaminants (*i.e.,* through exposure to turbidity plumes). However, implementation of the proposed pollution prevention and erosion and sediment control AMMs will minimize this risk.

<u>Eggs and Embryos (Spring: ~ March – June)</u>

Delta smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although exposure of eggs or embryos is expected to be minimal, individual eggs could be damaged or die if directly exposed to contaminant spills or sediment-borne contaminants during construction. Implementation of the proposed pollution prevention and erosion and sediment control AMMs will minimize this risk throughout the construction period.

<u>Transport of Larvae and Young Juveniles (Spring: ~ March – June)</u>

Individual larvae and young juveniles may be injured or killed by direct exposure to contaminant spills or sediment-borne contaminants during construction of the intakes during the downstream migration. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs will minimize this risk throughout the construction period.

Underwater Noise and Vibrations

During construction of the NDD, activities that are likely to generate underwater noise include pile driving, rip-rap placement, dredging, and barge traffic. Pile driving poses the greatest risk to delta smelt, because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as rip-rap placement, dredging, and barge traffic generally produce more continuous, lower energy sounds below the thresholds associated with direct injury, but may cause avoidance behavior (*i.e.,* cause delta smelt to detour from the area) or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

During NDD construction, underwater noise levels of sufficient intensity to cause direct injury or mortality of fish could occur over a period of 12-42 days during the proposed in-water work period (June 1-October 31) for up to 2 years at each intake location. Restriction of pile driving activities in or near open water in the Sacramento River from June 1 through October 31 will minimize the exposure of delta smelt to potentially harmful underwater noise. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (see CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9, *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory methods or other non-impact driving methods (*e.g.*, drill-shaft methods) to install the cofferdam sheet piles and foundation piles. The degree to which vibratory and non-impact driving methods can be performed is uncertain at this time (due to uncertain geologic conditions at the proposed intake sites) although reasonable assumptions are applied to sheet pile installation in the following analysis. If impact pile driving is required, DWR, in coordination with the Service, NMFS, and CDFW, will evaluate the feasibility of other protective measures including dewatering, physical devices (*e.g.*, bubble curtains), and operational measures (*e.g.*, restricting pile driving to specific times of the day) to limit the intensity and duration of underwater noise levels when delta smelt and/or other listed fish species may be present. Coordination, implementation, and monitoring of these measures will be performed in accordance with the underwater sound control and abatement plan, which includes hydroacoustic monitoring to determine compliance with established objectives (*e.g.*, distances to cumulative noise thresholds) and corrective actions to be taken should the thresholds be exceeded. These measures may include additional physical or operational measures to further limit the magnitude and/or duration of underwater noise levels.

<u>Adult Spawners (February – June)</u>

Restricting pile driving to June 1 – October 31 will avoid most of the delta smelt spawning season, although potential for exposure of late spawning adults could occur. In general, the effects of pile driving noise on fish may include behavioral responses, physiological stress, temporary and permanent hearing loss, tissue damage (auditory and non-auditory), and mortality. Factors that influence the magnitude of effects include species, life stage, and size of fish; type and size of pile and hammer; frequency and duration of pile driving; site characteristics (*e.g.*, depth); and distance of fish from the source. In delta smelt and most other teleost fish, the presence of a swim bladder to maintain buoyancy increases their vulnerability to underwater noise (Hastings and Popper 2005). Sublethal effects of elevated noise include damage to hearing organs that may temporarily affect a delta smelt's swimming ability and hearing sensitivity, which in turn may reduce their ability to detect predators. Non-injurious levels of underwater noise may also cause behavioral effects (*e.g.*, startle or avoidance responses) that can disrupt or alter normal activities (*e.g.*, migration, holding, or feeding), potentially increasing an individual's vulnerability to predation or if exposed for longer time periods, elevated noise could reduce growth which can affect subsequent survival and fecundity (egg production).

To quantify the level of sound expected to cause harassment and harm, the Fisheries Hydroacoustic Working Group, an interagency working group that includes the Service, has

established interim criteria for evaluating underwater noise effects from pile driving on fish. These criteria are defined in the document entitled "*Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities*", dated June 12, 2008 (Fisheries Hydroacoustic Working Group 2008). This agreement identifies dual interim criteria that represent the acoustic thresholds associated with the onset of physiological effects in fish that have been established to provide guidance for assessing the potential for injury resulting from pile driving noise (Fisheries Hydroacoustic Working Group 2008). The dual criteria for impact pile driving are (1) 206 decibels (dB) for peak sound pressure level (SPL); and (2) 187 dB for cumulative sound exposure level (SEL) for fish larger than 2 grams, and 183 dB SEL for fish smaller than 2 grams (Table 9.2.2.1.3-1). The peak SPL threshold is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL threshold is considered the total amount of acoustic energy that a fish can receive from single or multiple strikes without injury. The cumulative SEL threshold is based on the total daily exposure of a fish to noise from sources that are discontinuous (in this case, noise that occurs up to 12 hours a day, with 12 hours between exposures). This assumes that a fish is able to recover from any effects during this 12-hour period. These criteria relate to impact pile driving only. Vibratory pile driving is generally accepted as an effective measure for minimizing or eliminating the potential for injury of fish from pile driving operations. Although there has been no formal agreement on a "behavioral" threshold, National Marine Fisheries Service (NMFS) uses 150 dB-root mean square (rms) as the threshold for adverse behavioral effects (NMFS 2009b).

Table 9.2.2.1.3-1. Interim criteria for injury to fish from pile driving activities.

Interim Criteria	Agreement in Principle
Peak Sound Pressure Level (SPL)	206 dB re: 1μPa (for all sizes of fish)
Cumulative Sound Exposure Level (SEL)	187 dB re: 1μPa^2-sec—for fish size ≥ 2 grams 183 dB re: 1μPa^2-sec—for fish size < 2 grams

Fish smaller than 2 grams are more sensitive to underwater noise than larger individuals, and may experience injury at 183 dB (Fisheries Hydroacoustic Working Group 2008). Larvae and young juvenile delta smelt are generally smaller than 2 grams, while adults average 2 to 3 grams (Foott and Bigelow 2010). Because some adults are less than the 2 grams, the lower injury threshold (183 dB) applies to this life stage as well. The interim criteria were set to be conservatively protective of delta smelt and NMFS species.

The potential for injury of fish from exposure to pile driving sounds was evaluated using a spreadsheet model developed by NMFS to calculate the distances from a pile that sound attenuates to the peak or cumulative criteria. These distances define the area in which the criteria are expected to be exceeded as a result of impact pile driving. The NMFS spreadsheet calculates these distances based on estimates of the single-strike sound levels for each pile type (measured at 10 meters from the pile) and the rate at which sound attenuates with distance. In the following analysis, the standard sound attenuation rate of 4.5 dB per doubling of distance was used in the absence of other data. To account for the exposure of fish to multiple pile driving strikes, the model computes a cumulative SEL for multiple strikes based on the single-strike SEL and the

number of strikes per day or pile driving event. The NMFS spreadsheet also employs the concept of "effective quiet". This assumes that cumulative exposure of fish to pile driving sounds of less than 150 dB SEL does not result in injury.

Other sources of in-water noise include generator and engine vibration transmitted through the hulls of work barges and associated vessels, and dredge equipment. Noise levels produced by these sources typically are less than those associated with vibratory pile driving and are likely to be comparable to ambient noise conditions in the vicinity of the intakes caused by traffic, boats, water skiers, etc. For routine vessel traffic, these noise levels typically range from peak levels of 160 to 190 dB at a range of 10 meters, depending on vessel size (Thomsen *et al.* 2009). Dredge equipment noise will vary depending on equipment type. For example, a hydraulic cutterhead dredge working in the SDWSC produced noise levels of around 152 to 157 dB at 1 meter from the source (Reine and Dickerson 2014). Removal of pilings or other underwater structures could involve use of vibratory methods. This could generate sounds that could cause avoidance behavior of any delta smelt present. However, the noise levels generated by vibratory driving do not approach the peak or cumulative sound criteria outlined above.

Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper *et al*. 2006). NMFS generally assumes that a noise level of 150 dB root mean square (RMS) is an appropriate threshold for behavioral effects. NMFS acknowledges this uncertainty in other BiOps but believes this noise level is appropriate for identifying the potential for behavioral effects of pile driving sound on fish until new information indicates otherwise.

Table 9.2.2.1.3-2 represents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds based on application of the NMFS spreadsheet model and the assumptions presented in CWF BA Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*. This analysis considers only those pile driving activities that could generate noise levels sufficient to exceed the interim injury thresholds in the Sacramento River or other waters potentially supporting delta smelt. These activities include impact pile driving in open water, in cofferdams adjacent to open water, or on land within 200 feet of open water. For cofferdam sheet piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement. For the intake structure foundation piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible (no dewatering or other forms of attenuation). All computed distances over which pile driving sounds are expected to exceed the injury and behavioral thresholds assume an unimpeded sound propagation path. However, site conditions such as major channel bends and other in-water structures can reduce these distances by impeding the propagation of underwater sound waves.

Table 9.2.2.1.3-2. Extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds from NDD construction-related activities.

Facility or Structure	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Construction Season	Timing of Pile Driving	Duration of Pile Driving (days)
Intake 2						
Cofferdam	30	2,814	13,058	Year 8	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 9	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 9	June-Oct	19
Intake 3						
Cofferdam	30	2,814	13,058	Year 7	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 8	Jun–Oct	14
Foundation (with attenuation)	20	1,522	15,226	Year 8	June-Oct	14
Intake 5						
Cofferdam	30	2,814	13,058	Year 5	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 6	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 6	June-Oct	19

[1] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance.

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 feet of the cofferdam sheet piles and 20-46 feet of the intake foundation piles, depending on whether cofferdams can be dewatered (Table 9.2.2.1.3-2).

Based on a cumulative (daily) threshold of 187 dB SEL, the risk of injury is calculated to extend up to 5,628 feet (2,814 x 2[15]) during installation of the cofferdams and 6,560 feet (3,280 x 2[1]) during installation of the foundation piles (3,044 feet if the cofferdams can be dewatered) assuming an unimpeded propagation path.[16] The predictions in Table 9.2.2.1.3-2 apply to one intake location; the current construction schedule indicates that pile driving in a given year will occur at one intake only with the exception of Year 8 in which cofferdam installation at Intake 2 may coincide with foundation pile installation at intake 3 (CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*). In this case, there will be no overlap in the potential noise impact areas although delta smelt moving through the Action Area could be potentially exposed to pile driving noise over two reaches totaling 12,188 feet. Based on the duration of pile driving activities, such conditions could occur for up to 14 days based on the duration of foundation pile installation.

The potential for behavioral effects will exist beyond the distances associated with potential injury. Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend up to 13,058 feet away during cofferdam sheet pile installation, and 32,800 feet away during intake foundation pile installation (15,226 feet away if the cofferdams can be dewatered) assuming an unimpeded propagation path. However, the extent of noise levels exceeding the injury and behavioral thresholds will be constrained to varying degrees by major channel bends that range from approximately 1,500 to 12,000 feet away from each intake facility.

For each intake facility, the current construction schedule indicates that cofferdam sheet piles will be installed over a period of 42 days at each intake location within the in-water construction season (June 1 – October 31 or August 1 – September 30, if feasible) followed by installation of the intake foundation piles over a period of 14 –19 days during the following season.

<u>Eggs and Embryos (Spring: ~ March – June)</u>

Delta smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). There is limited research on effects of noise on delta smelt eggs; however, the potential for exposure is low due to the work window. Prolonged exposure to pile driving noise may reduce survival, development, or viability of any individual eggs in the vicinity of the intake sites.

<u>Transport of Larvae and Young Juveniles (Spring: ~ March – June)</u>

During June of the first year of construction, delta smelt larvae and young juveniles originating from upstream spawning areas may encounter pile driving noise during downstream movement to estuarine rearing areas. Although the exposure potential is low, any larval delta smelt passing the intakes during impact pile driving will be unable to avoid exposure to pile driving noise and

[15] The radius was doubled to determine the diameter of noise effects to delta smelt.
[16] Based on the estimated number of pile strikes per day, the computed distances to the injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).

therefore could be injured or killed depending on their proximity to the source piles and the duration of exposure.

Stranding

If present, delta smelt could be harassed, displaced, or die during construction of the rip-rap and sheet pile cofferdam. Installation of cofferdams to isolate the construction areas for the proposed intake sites has the potential to strand delta smelt, resulting in direct mortality from dewatering, dredging, and pile driving within the enclosed areas of the channel. Adults are less at risk than the younger delta smelt that are most vulnerable to stranding due to their limited ability to swim away and are most susceptible to flows to become entrained.

To minimize entrapment risk and the number of delta smelt subject to capture and handling during fish rescue and salvage operations, cofferdam construction will be limited to the proposed in-water construction period (June 1–October 31) to avoid the peak abundance of adults, larvae, and young juveniles in the north Delta. The effect of stranding on delta smelt will be minimized by rescuing/salvaging any delta smelt stranded behind the cofferdam prior to dewatering. DWR will prepare and submit a fish rescue and salvage plan[17] (see CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM8, *Fish Rescue and Salvage Plan*) to the fish and wildlife agencies (NMFS, Service, CDFW) for review and approval prior to implementation. Due to the delta smelt's sensitive nature, it is likely that any delta smelt salvaged from behind the cofferdam will die from the fish capture methods and handling. Therefore, the efficacy of this minimization measure is considered low. The proposed in-water work window will provide the greatest minimization to reduce stranding.

<u>Adult Spawners (February – June)</u>

Although present in very low numbers, spawning adults may be present in the vicinity of the NDD in June and subject to stranding behind the cofferdams. Adults are expected to move away from active construction occurring, but some risk of stranding will exist as long as the interior of the cofferdam is accessible to delta smelt. Fish rescue and salvage activities using typical fish collection methods can result in injury or mortality to delta smelt. Given the appropriate training, some level of survival is possible. However, injury or mortality may still occur because of varying degrees of effectiveness with the collection methods and potential stress and injury associated with various capture and handling methods.

[17] The fish rescue and salvage plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that will apply to all in-water activities with the potential to entrap delta smelt. All fish rescue and salvage operations will be conducted under the guidance of a qualified Service-approved fish biologist. The Service-approved biologist, in consultation with CDFW and NMFS, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if Service-approved.

Eggs and Embryos

Based on the low utilization and expected avoidance of the intake sites by spawning adults, there is low to no risk of stranding delta smelt eggs or embryos.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

Although the potential for exposure is very low, delta smelt larvae and young juveniles may be particularly vulnerable to stranding because of their limited swimming abilities and potential entrainment in open cofferdams. In addition, conventional fish collection methods are less effective and more likely to cause injury or death of these life stages compared to larger juveniles or adults. Therefore, it is likely that most if not all of any larvae and young juveniles present will die as a result of stranding.

Increased Risk of Predation

Changes in hydrology due to the placement of the rock revetment around the new intake could occur. This could cause a shift in delta smelt distribution, altering their normal behavior and migratory patterns. The rip-rap could displace delta smelt and disorient them. Rip-rap and structures like the sheet pile cofferdam are also known to attract and provide habitat for predatory fish that prey upon the delta smelt. The creation of deeper, higher-velocity zones adjacent to the cofferdams and rip-rap could also increase predator habitat, although this will only affect the low numbers of individuals that migrate to the northern portion of their range.

Loss, Alteration, and Restricted Access to Habitat

Larger delta smelt ascending the Sacramento River cannot swim against mid-channel velocities for an extended time and must use low velocity paths to migrate upstream while also avoiding predation (CWF BA 2016). In downstream locations vertical and lateral distribution changes have been observed (Bennett *et al.* 2002; Feyrer *et al.* 2013; Bennett and Burau 2015), but these studies provide no evidence that delta smelt show affinity to one side of the river or the other when they move on and off shore. The Sacramento River makes 6 major bends between Isleton and Freeport shunting the highest velocity parts of the river cross section back and forth across the channel. In addition to this shifting high velocity water, it seems unlikely that delta smelt could keep swimming up one bank of the river from Isleton to areas upstream because they would eventually need to avoid a predator or be displaced off the shoreline at night when they lose visual reference and become less active. Both of these phenomena would tend to mix migrating smelt across the shorelines from day to day. Thus, in-water structures of the length proposed by the PA are likely to delay, impede or entirely block upstream migration as previously discussed in *NDD Construction*.

The CWF BA analysis of the ability of migrating adult delta smelt to pass the most downstream intake if occurring near the left bank suggested that only a very small percentage (4%) of fish would be expected to do so. If successfully passing one intake and remaining near the left bank, the remaining delta smelt would have to pass the two other intakes [with a minimum distance of

one-mile apart from each other], again with a similarly low probability of success. In order for a delta smelt to migrate upstream past the three intakes would depend on their ability to use lower velocity habitat on the west bank of the river, near the channel bottom, or within the refugia along the intakes. Pre-construction studies are expected to further investigate the potential use of the refugia screen panels by delta smelt would not be expected to use a dark area that similarly represents predator habitat (FFTT 2011). In addition, the refugia will allow for small predators (*e.g.,* striped bass, largemouth bass, silversides Baerwald *et al.* 2012) to also use the refugia.

Most spawning seems to occur in Suisun Marsh, the river channels around Sherman Island, and in the Cache Slough/Deepwater Shipping Channel area. Based on historical and recent sampling detections, the reach of the proposed intake locations have consistently seen low observations of delta smelt in shallow water surveys (*e.g.,* beach seines) and even lower for open water methods (*e.g.,* trawls), primarily in the winter, spring, and early summer months during the migration, spawning, and transport phases. The presence of the intake structures will likely prevent migrating adult delta smelt from continuing past the NDD or result in injury or mortality due to impingement if they continue to try and pass them. Few or no individuals may attempt to keep moving upstream along the east bank once they encounter elevated velocities associated with the first diversion. However, delta smelt can currently ascend the river along its east bank. Thus, the loss of low-velocity shoreline and increase in shoreline water velocity along the river's east bank that will occur as a result of installing a cofferdam and constructing the NDD will permanently remove or restrict habitat accessibility because it will alter the capacity of delta smelt to ascend the river along its east bank.

NDD construction will result in permanent loss, alteration, and accessibility of shallow water and open water habitat to migrating and spawning adults, eggs and embryos, and transport of larval and young juveniles. The effects of construction activities on water quality, including turbidity and suspended sediment, and contaminants, were previously discussed above. DWR has proposed to mitigate these effects prior to the impact (see *Description of the Proposed Action*). During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to minimize effects to delta smelt (see CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance to aquatic habitat during construction, and, following construction, to restore temporarily disturbed areas to preconstruction conditions. All construction and site restoration BMPs will be subject to a Service-, CDFW-, and NMFS-approved construction and post-construction monitoring plan to ensure their effectiveness. DWR proposes to offset unavoidable, permanent habitat loss from the construction of the proposed intake sites through yet-to-be developed shallow water habitat mitigation.

The historical range of delta smelt extends north of the City of Sacramento; however, recent monitoring suggests that delta smelt only occasionally migrate beyond the extent of designated critical habitat (I Street Bridge). The CWF BA quantified effects (in number of acres) of the restricted access to habitat to the extent of the designated critical habitat. However, the Service anticipates that construction of the NDD will result in a contraction of the delta smelt's historical range. This will preclude access to habitats upstream of Clarksburg that might otherwise be used for conservation in the future, especially given the potential for salinity intrusion from current

climate change projections or under drought conditions.

Migrating Adults (December – March)

Delta smelt ascending the Sacramento River beyond its confluence with Cache Slough cannot swim against mid-channel velocities for an extended time and thus must use low velocity paths to migrate upstream while also avoiding predation (CWF BA 2016; see *Status of the Species*). In downstream locations vertical and lateral distribution changes have been observed that help fish both move and maintain geographic positions (Bennett *et al.* 2002; Feyrer *et al.* 2013; Bennett and Burau 2015), but these previous studies provide no evidence that delta smelt show affinity to one side of the river or the other when they move on and off shore. The Sacramento River makes 6 major bends between Isleton and Freeport shunting the highest velocity parts of the river cross section back and forth across the channel. In addition to this shifting high velocity water, it seems unlikely that delta smelt could keep swimming up one bank of the river from Isleton to areas upstream because they would eventually need to avoid a predator or be displaced off the shoreline at night when they lose visual reference and become less active. Both of these phenomena would tend to mix migrating smelt across the shorelines from day to day. Thus, in-water structures of the length proposed by the PA are likely to delay, impede or entirely block upstream migration as discussed above.

During the development of the BDCP, it was estimated that there was approximately 3,700 acres of tidal marsh and associated subtidal habitat[18] within the north Delta [primarily the mainstem Sacramento River and its associated waterways] within the total of 100,200 acres of the CWF Action Area (67,900 within the legal Delta and 32,300 acres in Suisun Marsh) (BDCP Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*, 2013). With the construction of the NDD, the project will permanently[19] remove or restrict delta smelt migration for a total of approximately 250.6 acres of shallow water habitat, approximately 0.25% of edgewaters within the Action Area or 6.78% within the north Delta. Table 9.2.2.1.3-3 provides an account of the habitat acres estimated in the CWF BA to be permanently affected. The physical footprint of the intake facilities will permanently remove 5.6 acres of shallow water habitat and result in restricted access to 245 acres of adult migration and spawning habitat.

This BiOp provides a programmatic analysis of the NDD construction, operations, maintenance, monitoring, and adaptive management. Information on the substrate type and vegetation within the footprints are unknown at this time, but is expected to be developed during subsequent consultation at the 2nd Phase of the Corps future permitting when more information on the final siting and design of the NDD is available. As currently provided, the CWF BA does not provide the quantity of sandy substrate within the shallow water habitat footprint, except for the area of

[18] Defined as approximately the MHHW to 6 ft below the MLLW (see BDCP Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*, 2013).

[19] All effects to delta smelt habitat are assumed to be permanent, because they will occur over multiple years, which could affect multiple generations of delta smelt, given that delta smelt are an annual species.

habitat lost to upstream access which only provides an estimate through aerial imagery (due to low vegetation in the area covering the substrate an estimate was feasible) that is expected to be refined when additional information is available to the Service, prior to impact.

DWR has proposed to mitigate these effects to delta smelt habitat at a ratio of 5:1 for the NDD footprint (including downstream disturbances), 3:1 for sandy substrates that have restricted access (*e.g.,* upstream movement), and 1:1 for all other substrate types that have restricted access. DWR has proposed to provide mitigation prior to the impact. The compensatory mitigation will consist of newly created or restored sandy beaches of high quality in areas where delta smelt are known to occur, such as Sherman Island, Cache Slough, North Delta, or other areas approved by the Service and CDFW. Mitigation sites within or upstream of the NDD will not be considered appropriate for mitigating effects to habitat. DWR proposes to provide 273 acres of shallow water habitat (of which 108 acres will be sandy spawning habitat) that will be of higher quality and in areas closer to core areas of occurrence (*i.e.,* the 'North Arc'). The sandy beaches will have appropriate water velocities and depths to maintain the habitat and be accessible to delta smelt for direct use. Water quality conditions must also be suitable for delta smelt (*e.g.,* lack aquatic invasives that could serve as predator habitat, non-lethal levels of contaminants, and suitable salinity levels).

During the in-water construction period, a total of approximately 5.6 acres of shallow water habitat will be permanently removed within the NDD construction footprint. These effects include 0.4 acres that will be altered by dredging and barge traffic through changes in channel depths, benthic habitat, cover, and temporary in-water and overwater structure (barges, spud piles) within active work areas adjacent to the proposed intake structure and levee slope. The footprint of the three intake structures, transition walls, and bank protection will result in the permanent loss of approximately 3.2 acres of shallow water habitat. In addition, the 5.6-acre estimate includes potential suspended sediment effects to habitat 1,000 feet downstream of each intake (a total of 1.9 acres of shallow water habitat). The effects to shallow water habitat will be mitigated at a 5:1 ratio, for a total of 28 acres (see CWF BA Chapter 3, *Description of the Proposed Action*). Permanent modifications of nearshore habitat due to the presence of these structures will encompass a total of 5,367 feet of shoreline. At each intake, between 1.6 and 3.1 acres of open water habitat will be located within the cofferdams during construction. Overall, these changes to the Sacramento River in the vicinity of the proposed intakes will preclude adult passage, elevate risk of predation from an increase in predator habitat, and constrain the width of the channel with the cofferdam construction.

Table 9.2.2.1.3-3. Quantity of habitat acres calculated to be permanently lost from removal, alteration, or restricted access by delta smelt from NDD construction.

Activity	Habitat Acres of Permanent Loss, Alteration, or Restricted Access		
	Shallow Water Habitat (mitigation ratio)		
	Sandy Substrate	**Other Vegetated or Non-vegetated Substrates (*e.g.*, rip-rap, tules, riparian)**	**Shallow Water Habitat Total**
Three Intake Structures and associated features[20]	3.2 (5:1)		5.6[21]
Dredging and Barge Traffic	0.4 (5:1)		
Downstream sediment disturbance	1.9 (5:1)		
Restricted upstream access to habitat along the Sacramento River and adjoining waterways[22]	36 (3:1)	209 (1:1)	245
		Total Mitigation Acreage	273 (of which 108 acres will be sandy beach spawning habitat)
		Total Acreage Effects	250.6

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Adult Spawners (February – June)

[20] This includes the intake structure (*e.g.*, fish screen and refugia panels), transition walls, and bank protection.

[21] Due to rounding of digits not represented in this table, the total for the three intake structures and associated features, dredging and barge operations, and downstream disturbance is 5.6 acres.

[22] The CWF BA provided a quantitative loss of acreage from the southernmost intake to the extent of the I Street Bridge. Although, this BiOp qualitatively recognizes the loss of their historical range beyond the I Street Bridge.

Within the footprint of the proposed intake locations, there appears to be little or no sandy substrates that are thought to be preferred by delta smelt for spawning habitat (see *Status of the Species at Proposed Action Area Preconstruction and Construction Sites*). During the site selection process, DWR minimized the placement of the proposed intakes to avoid, where feasible, large stands of riparian shaded riverine habitat for NMFS species and spawning substrates for delta smelt (BDCP 2013). The proposed intake locations are dominated by steep levee slopes, existing rip-rap and low quantities of riparian and aquatic vegetation. The permanent loss of nearshore habitat will preclude access to upstream sandy beaches and remove low quality spawning habitat. As a result, delta smelt may suitable spawning habitats downstream but this is speculative. It is unknown if there will be an effect to the spawning success of those individuals that migrate up the Sacramento River and have to redistribute to avoid the construction areas. Predation rates are strongly linked to distance travelled. Spawning habitat is not thought to be a limiting factor for delta smelt within the Action Area, although spawning habitat is limited along the Sacramento River due to historical habitat conversions (*e.g.,* rip-rapping). These reductions in spawning habitat and changes to spawning behavior will result in approximately 15 river miles of edgewater with intermittent spawning habitat, typically thought to be areas with sandy substrates with suitable water velocities, from just below the southernmost diversion to the I Street Bridge. Restriction of habitat beyond the I Street Bridge has not been quantified, but is recognized in this BiOp that the three permanent structures will redefine the northern limit of the delta smelt spawning distribution, reducing the northern extent of its historical range (see *Status of the Species* Figure 9.2.1.1-6. Delta smelt range map).As stated above, NDD construction will preclude access to 36 acres of spawning habitat from the lowermost NDD to the northern extent of its range along the Sacramento River and its tributaries (see Table 9.2.2.1.3-3 above).

<u>Eggs and Embryos (Spring: ~ March – June)</u>

Available data suggest few individuals utilize the habitats in the vicinity of the proposed NDD for spawning. It is unknown if there will be an effect to the spawning success of delta smelt that migrate up the Sacramento River to spawn and had to use other nearby downstream habitat. With the expected low use near the intakes by spawning adults and low contribution to the overall spawning habitat available, there is a low risk on egg and embryo production or survival.

<u>Transport of Larvae and Young Juveniles (Spring: ~ March – June)</u>

At this life stage, delta smelt are subject to predation along the intake sites where construction is proposed to occur. Once installation of the three cofferdams has occurred, it is expected that delta smelt will experience restricted access to areas above the cofferdams to spawn. With the reduction in delta smelt spawning north of the cofferdams, it is expected that in those areas larvae and juvenile offspring will no longer be there to migrate downstream to rearing habitat. Overall, there will be a loss in edge water and open water habitat available to larvae and young juveniles for transport in these areas, similarly as it is for migrating adults, adult spawners, and eggs and embryos.

<u>Rearing Juveniles (Summer/Fall: ~ July – December)</u>

Juvenile delta smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be affected by losses or alteration of habitat in the vicinity of the Sacramento River where the proposed intakes are located.

Population-level

Historical survey data indicate that most of the delta smelt population is distributed downstream of the proposed intake sites. Adults and larvae have been reported to occur in the north Delta and farther upstream (Vincik and Julienne 2012), but the results from various surveys and general life history information suggest that the proportion of the population occupying the area affected from the construction of the NDD is low and most likely occur during the primary winter and spring migration and spawning periods, rather than during the proposed in-water work period. For example, the mean densities of delta smelt larvae collected in the vicinity of the proposed intakes during the 1991-1994 egg and larval surveys was 4-6% of the mean densities collected downstream of these locations during April and May. The estimated low proportion of migrating adults that occur near the proposed intake sites during construction of these facilities is also supported by the low catch data observed in the DJFMP beach seine historical data.

Due to current low population estimates and record low detections of delta smelt in recent survey efforts, the individuals remaining in the population are more vulnerable and susceptible to further reductions in the population. It is possible that the reduction in available migratory and spawning habitat from loss and restricted upstream access will have effects to the overall viable population size. However, there are limitations with the analyses provided to the Service in the CWF BA and with available information related to the effects of restricted access on the success of adult spawning and recruitment. Implementation of the proposed future Service-approved monitoring plan as described in the CWF BA and the Adaptive Management Framework may provide information to better assess restricted upstream passage from NDD construction (CWF BA 2016; Adaptive Management Framework for the California WaterFix and 2008/2009 Biological Opinions on the combined operations of the Central Valley Project and State Water Project 2016).

Summary

Delta smelt presence has been established in these upper reaches of the Sacramento River where construction is proposed to occur; however, the likelihood of a delta smelt being exposed to the in-water work activities is low. Our conclusion is based on the post- 2001 DJFMP beach seine observations that indicate there have been only 3 adult delta smelt observed during the in-water work window of June 1 through October 3, thus supporting the conclusion that there is a low likelihood of presence and exposure to in-water work activities.

DWR will be constructing cofferdams to minimize effects to delta smelt by isolating work areas from fish in the river and allow for work on the intake screens to be conducted in the dry, as feasible. However, the cofferdams will reduce the width of the river channel and eliminate some of the already limited amount of shallow, low-velocity nearshore zone along the east bank of the river. If cofferdams are not feasible to construct, the consultation will need to be reinitated. Once

the intakes are constructed, each intake will be a permanent vertical wall extending 1,030-1,404 feet along the east bank of the Sacramento River (see CWF BA Chapter 3, *Description of the Proposed Action*).

During February-May, few adult delta smelt are routinely collected along the river reach where the NDD will be constructed (see *Status of the Species at Proposed Action Area Preconstruction and Construction Sites).* The PTM modeling in the CWF BA suggests that these migrating adults could not ascend the Sacramento River this far changing only their depth in the water column (CWF BA 2016). Therefore, these individuals must consistently remain in lower velocity water near the shore. The anticipated water velocities along the cofferdam faces, and later the fish screens, will be faster than delta smelt can swim against for extended periods of time. Without an immediately adjacent shoreline to provide a velocity refuge, the Service believes this will create a barrier that will prevent individuals from migrating beyond the NDD.

Using December – June Freeport velocity data, the probability that an individual migrating adult delta smelt will successfully pass the lowermost cofferdam or intake structure was estimated to range from 0.071 to 0.072 (CWF BA Appendix 6A.2). The probability that an individual will pass all three intakes is estimated to be 0.0004[23]. This analysis suggests that river velocities will almost always be too high for delta smelt to swim the required distance upstream (see *Status of the Species at Proposed Action Area Preconstruction and Construction Sites*).

If present during the first year of construction of the cofferdam, individual delta smelt (adults, eggs/embryos, larvae, and young juveniles) may experience: direct physical injury or mortality from rip-rapping and sheet piling; increases in turbidity and suspended sediment; exposure to contaminants from accidental spills and disturbed contaminated sediments; underwater noise and vibrations from dredging, pile-driving, and hammering; stranding behind the cofferdam; increased risk of predation; and loss, alteration or restricted access to habitat. Once the installation of the cofferdams has been completed, the altered hydrology will impair the upstream migration of delta smelt to upstream spawning habitat, constricting their overall historical range.

9.2.2.1.4 Head of Old River Gate

Effects to Individuals and the Population

Individual-level

The timing of the in-water HORG construction activities (August 1 – October 31) will avoid adverse effects to migratory and spawning adults, incubation (*i.e.,* eggs/embryos), and larval transport phases because these life stages do not occur during this time of year. HORG construction is scheduled to occur (August 1–October 31) during juvenile delta smelt rearing (approximately July – December). However, conditions at the HORG are not suitable for

[23] If the probability of passing one intake is approximately 0.07, then the probability of passing all three intakes is 0.0004 (0.07*0.07*0.07).

juvenile rearing at this time of the year because the water is too warm so we do not expect any individuals to be present at the construction site during the work window. Water temperature will cool during the work window, but delta smelt will not re-occupy this site until after the first winter rains occur in December or January. This seasonal change in the distribution of delta smelt is also conveyed in RPA Component 2 of the 2008 Service BiOp, where the action ends June 30th or when the 3-day mean water temperature at CCF reaches 25 degrees Celsius, whichever occurs earlier (Service 2008; see *Status of the Species* and *Status of the Species at Proposed Action Area Preconstruction and Construction Sites*). Therefore, we do not expect there to be any exposure to delta smelt from in-water work activities occurring at the HORG during August 1-October 31.

Increased Risk of Predation

As analyzed in the 2008 Service BiOp, delta smelt and their offspring that migrate into the south Delta within the entrainment footprint are functionally lost to the population due to reverse flows, entrainment and salvage, predation, and degraded habitat conditions. With the installation of the HORG, there will be an increased risk of predation during the earlier months of the year when delta smelt are present. The cofferdam will constrict the flow to half the channel's width which will increase water velocities. The presence of in-channel cofferdams and the HORG may increase the amount of predatory fish habitat and create hydraulic conditions that improve a predator's ability to prey on delta smelt as they migrate past the site. In its current state, the south Delta almost always has an annual installation of a temporary spring and sometimes fall HOR rock barrier, which poses similar predation concerns. However, the HORG will be a permanent in-water structure.

Loss or Alteration of Habitat

Construction of the HORG will result in permanent impacts to approximately 2.9 acres of shallow water habitat including the footprint of the gate and the channel segments upstream and downstream of the structure that will be affected by dredging. DWR proposes to mitigate unavoidable impacts to delta smelt habitat at a ratio of 3:1 prior to impact.

<u>Migrating Adults (December – March)</u>

Historically, delta smelt more frequently utilized portions of the San Joaquin River upstream as far south as Mossdale; however, they no longer occur in large numbers at the HOR due primarily to high entrainment risk and perhaps high predation risk associated with the aquatic weed infestations present throughout much of the south Delta. We base this conclusion on the recent lack of detections in the Mossdale Kodiak trawls, nearby DJFMP beach seines, annual on-going disturbance from installing a temporary HOR rock barrier, rip-rapped levees, and denuded habitat.

DWR has proposed to mitigate effects to shallow water habitat at a 3:1 ratio. Location of the mitigation is important to the function of the habitat for delta smelt. DWR has proposed to mitigate in areas such as, Sherman Island, Cache Slough, or the north Delta, where we observe

higher abundances of delta smelt. The habitat will have the appropriate water velocities and depths to maintain the habitat and be accessible to delta smelt for direct use. In addition, it will have the appropriate water quality conditions in order to be suitable for delta smelt (*e.g.,* lack of man-made predator habitat, non-lethal levels of contaminants, and suitable salinity levels). Given the degraded condition of the habitat within the area of the HORG footprint, habitat being mitigated for at a 3:1 ratio, in areas that are of higher value and quality to delta smelt, will provide an overall greater conservation value to delta smelt in comparison to the habitat that will be disturbed or removed during HORG construction.

Adult Spawners (February – June)

Loss or alteration of aquatic habitat within the footprints of the cofferdams, rip-rapped banks, and dredged channel areas may reduce the amount of shallow water habitat potentially available to spawning adults. However, this portion of the Old River channel is frequently disturbed by the annual installation of a temporary rock barrier and is dominated by steep levee slopes, rip-rap, and low quantities of sandy substrates, riparian, and aquatic vegetation (see *Existing Conditions and Previous Consultations in the Action Area*).

Eggs and Embryos (Spring: ~ March – June)

Based on the lack of spawning habitat for delta smelt, the potential for injury or mortality of eggs and embryos is negligible. The footprint of the HORG has experienced annual disturbances since the conception of the rock barriers in 1963 (see *Existing Conditions and Previous Consultations in the Action Area*) and lacks suitable habitat for spawning adults and their spawn.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

The Service believes that any delta smelt larvae that hatch in the area surrounding the proposed HORG will be entrained or eaten and thus will not contribute to the population. This conclusion is based on extensive hydrodynamics modeling that shows extremely low probability of water and by extension, planktonic animals like fish larvae, being transported away from the south Delta export pumps.

Rearing Juveniles (Summer/Fall: ~ July – December)

The southern Delta does not support delta smelt rearing during the summer. Delta smelt densities decline below 20-mm Survey detection limits by the end of June and typically fall below the much more sensitive detection limits of the south Delta fish facilities during June or July.

Population-level

Delta smelt have been found as far upstream on the San Joaquin River as Mossdale, which is upstream of the HOR, but smelt that migrate into the south Delta are faced with high risk of entrainment and predation. As a result, most of the delta smelt population is distributed downstream of the proposed HORG. Available monitoring data suggest that adult delta smelt occur in very low numbers near the HORG. Over 2,300 beach seine samples in the San Joaquin River between Dos Reis (RM 51) and Weatherbee (RM 58) between 1994 and 2016 yielded four delta smelt (all in February–April) (Service 2016). Nearly 30,000 trawl samples at Mossdale from 1994 to 2016 resulted in the capture of 44 delta smelt, principally in March-June (Service 2016).

The low abundance of delta smelt and low quality of potential spawning habitat in the vicinity of the HORG indicates that impacts from construction will have undetectable population-level effects. Based on the low abundance of delta smelt in the San Joaquin River in the vicinity of HORG, potential adverse effects on migration and survival of migrating adults will likely be limited to a small proportion of the population.

Summary

Due to the distribution of delta smelt during August 1 – October 31, the proposed HORG construction work window will avoid take of delta smelt. Habitat within the footprint of the HORG has become heavily altered and disturbed with the annual installation of the temporary HORB that is installed most years in the spring and fall (see *Existing Conditions and Previous Consultations in the Action Area*). By permanently installing an operable gate within that footprint there will be a loss of 2.9 acres of shallow water habitat that is proposed to be mitigated at a 3:1 ratio.

9.2.2.1.5 Clifton Court Forebay, Clifton Court Forebay Pumping Plant, and Connections to Banks and Jones Pumping Plants

Effects to Individuals and the Population

Individual-level

Construction activities at CCF that may affect delta smelt include expansion and dredging of SCCF, construction of divider wall and east/west embankments, dewatering and excavation of NCCF, construction of NCCF outlet canals and siphons, and construction of a SSCF intake structure and NCCF emergency spillway. Of those identified activities, effects to delta smelt and its critical habitat have previously been addressed for some components of the PA in prior consultation with the Service in the 2008 Service BiOp. Delta smelt exposure and loss of habitat within the existing CCF have previously been accounted for in the 2008 Service BiOp. Delta smelt can only occur within the CCF (entrainment) by operation of the SWP. This BiOp addresses those additional affects to delta smelt and its critical habitat outside of the previously analyzed footprint in the 2008 Service BiOp.

Construction within and nearby the CCF may alter (increase or decrease) the number of delta smelt salvaged at the existing CVP and SWP pumping facilities. There are limitations to the delta smelt effects analyses based on the information provided to the Service in the CWF BA and best available information; it is too speculative to determine how salvage estimates of the existing CVP and SWP pumping facilities will be affected by the implementation of the PA. Effects to individuals from exposure to in-water work activities at CCF are described below.

Contact with Heavy Equipment or Material

Delta smelt could be injured or killed by contact with equipment or materials during in-water construction activities in CCF and the adjacent Old River channel. In addition to the proposed in-water work window, DWR proposes to implement a number of AMMs to minimize the potential for impacts on delta smelt, including AMM1, *Worker Awareness Training*; AMM4, *Erosion and Sediment Control Plan*; AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*; AMM7, *Barge Operations Plan*; AMM9, *Underwater Sound Control and Abatement Plan*; and AMM8, *Fish Rescue and Salvage Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*).

Increased Turbidity and Suspended Sediment

In-water construction activities at CCF will result in elevated turbidity and suspended sediment levels in CCF and Old River. The principal sources of increased turbidity and suspended sediment are dredging and cofferdam construction (sheet pile installation and removal). Minor increases in turbidity and suspended sediment in CCF and Old River are also expected during construction of the CCPP, outlet canals and siphons, SSCF intake structure, and North CCF (NCCF) emergency spillway. All other sediment-disturbing activities within cofferdams, upland areas, or forebays pose little or no risk to water quality.

The potential for elevated turbidity and suspended sediment to affect delta smelt will be minimized by restricting all in-water construction activities to July 1-November 30 (when delta smelt are least likely to be entrained by operations), limiting the duration of these activities to the extent practicable, and implementing the AMMs described in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*.

Dredging could cause extensive, long-term effects on turbidity and suspended sediment within CCF. Potential secondary effects include potential increases in chemical and biological oxygen demand associated with the decomposition of vegetation and organic material in disturbed sediments. In addition to implementing the AMMs listed above, DWR proposes to limit the potential exposure of listed species to water quality impacts by restricting the timing, extent, and frequency of major sediment-disturbing events. For example, DWR proposes to limit the extent of dredging impacts in CCF by restricting daily operations to two dredges operating for 10-hour periods (daylight hours) within 200-acre cells enclosed by silt curtains (representing approximately 10% of total surface area of CCF). In addition, dredging will be monitored and regulated through the implementation of the *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan*, which includes preparation of a sampling and analysis

plan, compliance with NPDES and SWRCB water quality requirements during dredging activities, and compliance with proposed in-water work windows.

Exposure to Contaminants and Disturbance of Contaminated Sediments

Contaminated sediments can adversely affect fish through direct exposure from mobilized sediment or indirect exposure through accumulation of contaminants in the food web. Consequently, dredging, excavation, and expansion of CCF pose a substantial short-term and long-term risk of exposure of delta smelt and other aquatic organisms to elevated concentrations of contaminants. Current estimates indicate the dredging will affect up to 1,932 acres of CCF while expansion of the SCCF will create an additional 590 acres of newly exposed sediment. The proximity of the south Delta to agricultural, industrial, and municipal sources indicates that a broad range of contaminants that are toxic to fish and other aquatic biota, including metals (*e.g.*, copper, mercury), hydrocarbons, pesticides, and ammonia, could be present. Mud and silt in south Delta waterways have been shown to contain elevated concentrations of contaminants, including mercury, pesticides (chlorpyrifos, diazinon, DDT), and other toxic substances (California State Water Resources Control Board 2010). Impairments in Delta waterways also include heavy metals such as selenium, cadmium, and nickel (G. Fred Lee & Associates 2004). Thus, exposure and resuspension of sediments during in-water construction could lead to degradation of water quality and adverse effects on fish or their food resources in the Action Area.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*, in Appendix 3.F, *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a preconstruction sampling and analysis plan to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (*e.g.*, silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

Underwater Noise and Vibrations

During construction of the CCF water conveyance facilities, activities that are likely to generate underwater noise include in-water pile driving, rip-rap placement, dredging, and barge traffic. Pile driving conducted in or near open water poses the greatest risk to delta smelt because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as rip-rap placement, dredging, and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause harm and harassment to individuals resulting in avoidance behavior or

temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

Pile driving conducted in or near open water can produce underwater noise of sufficient intensity to injure or kill fish within a certain radius of the source piles. Pile driving information for CCF is available for the embankments, divider wall, siphon at NCCF outlet, and siphon at Byron Highway (CWF BA Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*). Pile driving operations include the installation of an estimated 19,294 temporary sheet piles to construct the cofferdams for the embankments and divider wall, and 2,160 14-inch diameter concrete or steel pipe piles to construct the siphon at the NCCF outlet. Pile driving for the siphon under Byron Highway is not addressed in the following analysis because all pile driving will be conducted on land and more than 200 feet from water potentially containing listed fish species. A total of 4 construction seasons will likely be required to complete pile driving operations based on the estimated duration of pile installation (CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*).

DWR proposes to minimize the potential exposure of delta smelt to pile driving noise by conducting all in-water construction activities between July 1 and November 30 (when delta smelt are least likely to be entrained by operations). In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9, *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when delta smelt may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (*e.g.*, distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

Table 9.2.2.1.5-1 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds during installation of cofferdam sheet piles for the embankments and divider wall, and the structural piles for the NCCF siphon based on application of the NMFS spreadsheet model and the assumptions presented in CWF BA Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*. For cofferdam sheet piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement. For the NFFC siphon piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible.

Table 9.2.2.1.5-1. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at CCF.

Facility	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Number and Timing of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving (days)
Clifton Court Forebay						
Embankment Cofferdams	30	2,814	13,058	1 (Year 5)	Jul–Nov	85
Divider Wall	30	2,814	13,058	1 (Year 4)	Jul–Nov	86
NCCF Siphon (no attenuation)	46	1,774	9,607	2 (Years 2-3)	Jul–Nov	72
NCCF Siphon (with attenuation)	20	823	4,458	2 (Years 2-3)	Jul–Nov	72

[1] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance.

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 feet of the cofferdam sheet piles and 20-46 feet of the NCCF siphon piles (Table X). Based on a cumulative (daily) threshold of 187 dB, the risk of injury is calculated to extend 2,814 feet away from the source piles during installation of cofferdam sheet piles and 1,774 feet during installation of the NCCF siphon piles (823 feet if the cofferdams can be dewatered).[24] Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend 13,058 and 9,607 feet (4,458 if the cofferdams can be dewatered), respectively. Such exposures will occur over a period of up to 72 days (36 days per season) during installation of the NCCF siphon piles (second and third years of construction activities at CCF), 86 days during cofferdam construction for the divider wall (year 4), and 85 days during cofferdam construction for the embankments (year 5).

Stranding

Installation of cofferdams to isolate construction areas in CCF and the adjacent Old River channel has the potential to strand fish, resulting in direct injury and mortality of fish that become trapped inside the cofferdams. To minimize potential stranding losses, DWR will implement a fish rescue and salvage plan (CWF BA Appendix 3.F, *General Avoidance and*

[24] In this case, the distance to the injury thresholds are governed by the distance to "effective quiet" (150 cB SEL).

Minimization Measures, AMM8, *Fish Rescue and Salvage Plan*[25]). This plan will be submitted to the fish and wildlife agencies (NMFS, Service, CDFW) for review and approval prior to implementation.

Disturbance and Alteration to Habitat

Construction of the new water conveyance facilities at CCF will result in temporary and permanent losses or alteration of aquatic habitat in CCF and, near the new SCCF intake and the NCCF emergency spillway, in the Old River. Effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. The following analysis focuses on permanent impacts on physical habitat associated with construction activities. Cofferdam installation, dredging, embankment construction, and construction of CCPP, NCCF emergency spillway, and SCCF intake, and NCCF canal and siphons will affect an estimated 1,932 acres of shallow water habitat (see CWF CWF BA Mapbook M3.A) through changes in water depths, vegetation, and substrate. Permanent impacts on aquatic habitat encompass an estimated 258 acres of shallow water habitat in CCF that will be replaced by permanent fill and structures associated with the new CCPP, embankments, canals and siphons, and intake structure and spillway.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore any disturbed areas to preconstruction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. DWR is not proposing to mitigate for permanent effects to aquatic habitat in CCF due to the unfavorable conditions within the forebay as previously analyzed and characterized in the 2008 Service BiOp (see *Status of the Species at Proposed Action Area Preconstruction and Construction Sites* and *Existing Conditions and Previous Consultations in the Action Area*).

<u>Population-level</u>

[25] The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that will apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a Service-approved fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing as approved by the Service, CDFW, and NMFS.

Delta smelt within the CCF have been entrained and been effectively lost to population in terms of successful reproduction and contribution to future generations previously analyzed in the 2008 Service BiOp. Construction within and near the CCF may alter the number of delta smelt salvaged at the existing CVP and SWP pumping facilities. It is too speculative to determine how delta smelt salvage within the existing CVP and SWP pumping facilities will be affected by the implementation of the PA. However, the construction in-water work window is scheduled to occur when typically low salvage is observed. Salvage records indicate that adults and larvae may be present in June and July but abundance is low and declining in these months, especially in July as water temperatures typically exceed the upper tolerance levels for successful reproduction. This is recognized in the RPA Component 2 of the 2008 Service BiOp, where the action ends June 30th or when the 3-day mean water temperature at CCF reaches 25 degrees Celsius, whichever occurs earlier (Service 2008).

Summary

Construction within CCF will result in changes to 258 acres of shallow water habitat and affect an estimated 1,932 acres of shallow water habitat from cofferdam installation, dredging, embankment construction, and construction of CCPP, NCCF emergency spillway, and SCCF intake, and NCCF canal and siphons. Salvage estimates may be altered from the proposed in-water work activities. Given uncertainty and limitations in information provided to the Service within the CWF BA and available information, it is too speculative to determine how those estimates of the existing CVP and SWP pumping facilities will be affected by the implementation of the CWF BA. It is acknowledged that low salvage numbers and detections are expected to occur during the overlap in action RPA Component 2 and the in-water work activities (*i.e.,* during the in-water work window) and therefore may have a small effect to salvage.

9.2.2.1.6 Summary of Preconstruction and Construction-related Effects on Delta Smelt Reproduction, Numbers, and Distribution

Activities associated with the preconstruction, construction, and operations of the water conveyance facilities will pose a potential risk in the reduction of individuals through the form of harassment, injury, and mortality of delta smelt and loss of suitable habitat. Details related to maintenance, monitoring, adaptive management, and implementation of the compensatory mitigation are too speculative to determine take to individuals from implementation of these actions at this time; however, will be assessed during subsequent future consultations (*i.e.,* Phase 2) when information related to final design of the NDD, HORG, restoration locations are available.

Because of the following reasons we expect risk in exposure to individuals (*e.g.,* harassment) and injury or mortality to be low from preconstruction and construction related in-water activities: (1) work has been proposed to be conducted during work restriction windows (Appendix 3.F General Avoidance and Minimization Measures); (2) the record low abundance of the population delta smelt are not likely to be in the construction areas in high numbers; and (3) the

seasonal and transient use of the locations where the in-water work has been identified to occur. Therefore, it is expected that the overall adverse effects to individuals will be low resulting in a minimal reduction in the delta smelt population over the approximately 13 years of proposed in-water construction activities (see CWF BA Appendix 3.D *Assumed Construction Schedule for the Proposed Action*).

The most significant adverse effect to delta smelt from the PA is the permanent constriction/reduction in available habitat to delta smelt, that support the migration, spawning, transport, and rearing processes, that are necessary for reproduction and therefore survival of the species. The construction of the NDD is expected to result in restricted access to all migratory and spawning habitat from the southernmost intake to the northern extent of their range. DWR has proposed to mitigate for the effects to delta smelt from habitat loss through removal, alteration/degradation, or restricted access at the proposed compensatory mitigation ratios identified in the *Description of the Proposed Action* and the CWF BA Chapter 3, with ratios varying from 1:1 to 5:1. This yet-to-be determined mitigation will not minimize the impact from range constriction but improve habitat remaining below the NDD.

9.2.2.2 Operations

Implementation of the PA includes operations of both new and existing water conveyance facilities, once the NDD facilities are completed and have become operational. Prior to the NDD facilities becoming operational, the existing CVP and SWP facilities will continue to be operated consistent with existing regulatory authorizations, including the Service (2008) and NMFS (2009) BiOps or until redefined as part of the 2008 Service BiOp reinitiation process. As stated previously, the CWF BA provided described and analyzed one operational scenario under a dual conveyance system and that processes underway to reinitiate the 2008 BiOp and update the State Water Resources Control Board's Water Quality Control Plan will influence and change operational criteria. It is anticipated that as part of the reinitiation of the 2008 Service BiOp Reclamation and DWR will propose project operations that avoid jeopardizing delta smelt or destroying or adversely modifying its critical habitat and that will ultimately supercede at least some of the operations described in the CWF BA. This section summarizes the effects from operations proposed in the CWF BA that may occur at the programmatic-level with understanding the operations proposed in the CWF BA will be superseded by the reinitiated 2008 BiOp consultation and the updated Water Quality Control Plan.

The proposed suite of operations has been deconstructed into the following sections identified in Figure 9.2.2.2 -1, which interact to form the new and existing CVP and SWP water conveyance facilities operations. These include: NDD; South Delta Water Facilities; HORG; DCC; Suisun Marsh Facilities, including the Suisun Marsh Salinity Control Gates, Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall; NBA Intake; and other facilities, including Contra Costa Water District Facilities, Freeport Intake Facility, and the Clifton Court Forebay Aquatic Weed Control Program.

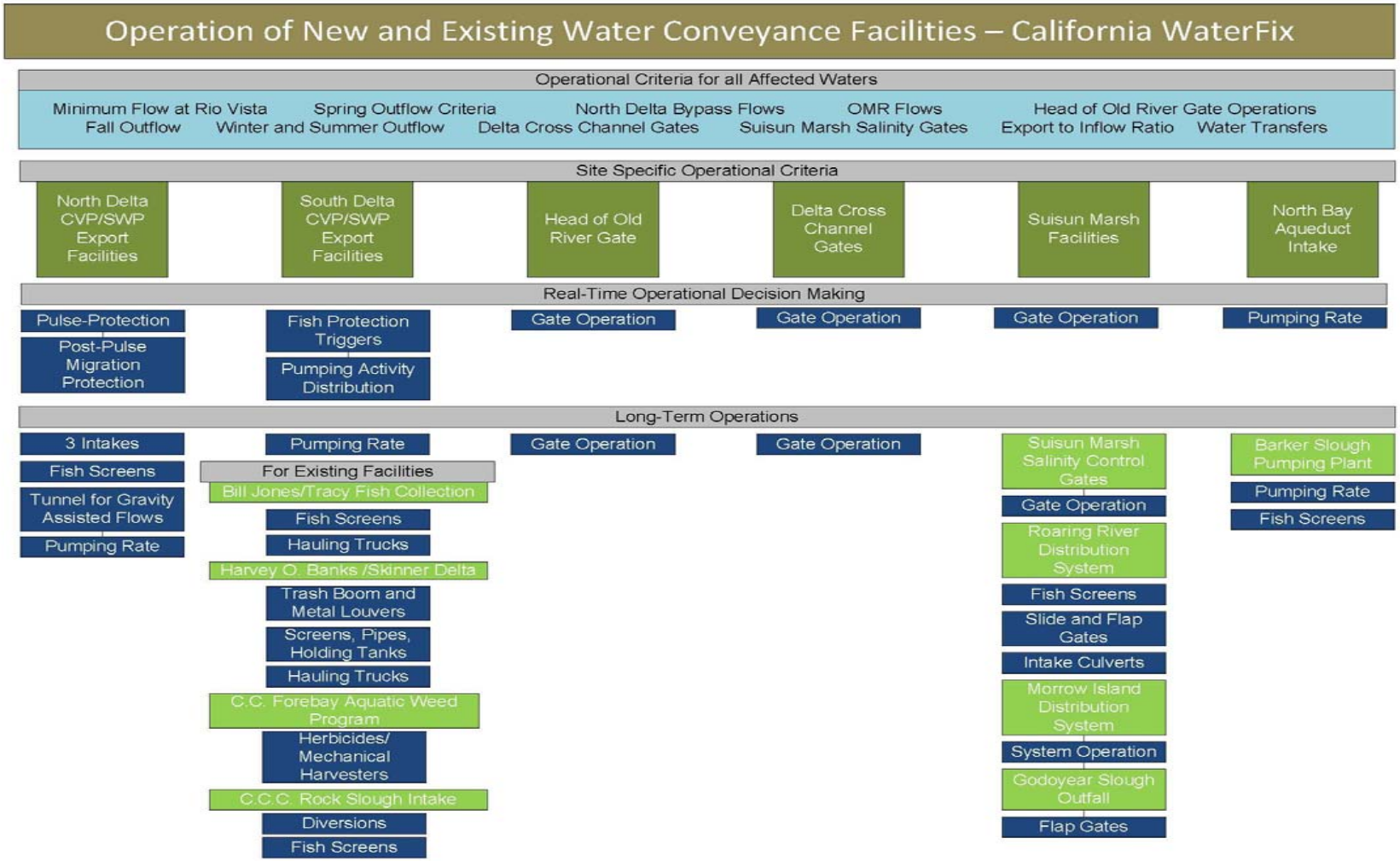


Figure 9.2.2.2 -1. Deconstruction of the new and existing water conveyance facilities.

The following effects analysis addresses the three general categories of potential effects that may be caused by the presence of diversion structures and their operations. The first category of effects are those that can typically result from the operation of large diversions such as salvage, entrainment, impingement, and injury of delta smelt that come in contact with the facility as water is being diverted. The second category includes those impacts that may result from the simple existence of large concrete/steel structures in the river, such as increased predation and loss of shoreline habitat features. The third category of impacts are those associated with the actual diversion of large quantities of water from the river, which can affect flow patterns, hydrodynamics, and habitat features/ecological processes that are dependent on river flows. Entrainment, impingement, and fish screen contract are used to assess effects to delta smelt from diversions. Entrainment and impingement are two sources of potential injury or mortality for delta smelt. Entrainment is can occur whenever delta smelt are present in river water that is diverted (or exported), creating the opportunity for delta smelt and/or their food supply to follow the flow of diverted water and become entrained. Impingement occurs when delta smelt are trapped or pinned by the force of the intake flow against the intake screens at the entrance of a diversion. Screen contact is defined as any contact along the face of the fish screen, similar to impingement.

The analyses of the potential effects of water exports on delta smelt that are presented in the sections below address direct effects of water exports (such as entrainment and impingement) and indirect effects (such as predation and habitat impacts). Effects to habitat from the various CVP and SWP water facilities are combined in the analysis below because those effects cannot be separated out by facility. There is the potential for near-field habitat effects to occur from each water facilities operations, such as adjacent or downstream habitat alterations and localized scouring. However, those habitat alterations are assumed to fall within the habitat acres previously analyzed in the previous construction sections. Future modeling, monitoring, and laboratory studies associated with preconstruction monitoring efforts are expected to inform localized [downstream, upstream, or adjacent] effects from water exports (FFTT 2011). This information will inform final design of the NDD HORG and future project-level consultations.

9.2.2.2.1 North Delta Diversions

Adverse effects from placement of the in-water structures are elevated by operation of the NDD from impingement/screen contact and predation, further worsening conditions for those delta smelt that migrate into the reach of the intakes. Delta smelt may experience a variation in flow velocities along the vertical wall of the fish screen, if attempting to migrate upstream along the east bank, associated with the approach velocity of exporting water from the NDD. In general, larger delta smelt risk impingement/screen contact, while smaller individuals could potentially become entrained based on the proposed fish screen mesh size.
Based on historical and recent sampling detections, the reach of the proposed intake locations have consistently seen few observations of delta smelt in shallow water surveysand fewer from open water sampling methods , primarily in the winter, spring, and early summer months during the migration, spawning, and transport phases.

Entrainment

Based on delta smelt body depth to body length ratios and using the screening effectiveness analysis described in the CWF BA Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.2, the proposed NDD screen mesh of 1.75 mm would prevent delta smelt greater than standard length of around 20-21 mm from being entrained through the fish screens. Therefore, delta smelt older than approximately 90 days (Hobbs *et al.* 2007) could not be entrained through the NDD fish screens. All adult delta smelt exceed 90 days of age and 20-21 mm in length. Based on fish screen exclusion, it is not expected that migrating or spawning adults and juveniles will be entrained by the NDD operations. Additionally, eggs and embryos are demersal (sink) and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Individual eggs would not be subject to entrainment or impingement/screen contact. Therefore, entrainment effects to larvae would be the only life stage that could potentially be at risk of entrainment based on their body size.

The CWF BA provided estimates of entrainment, specifically for larvae, using estimates of the percentage of flow diverted and DSM2-PTM in order to quantity the loss of individuals and the population from NDD operations (CWF BA Chapter 6). However, based on previous results presented in *NDD Construction*, the NDD is expected to impede migration and restrict upstream access to suitable spawning habitat; and therefore, will no longer be available to adult spawners. Larvae are not expected to be within the entrainment/impingement footprint of the NDDs, due to lack of spawning in the area, thus entrainment is expected to have minimal or no population effect.

Impingement and Screen Contact

As described in the construction effects section, the NDD intakes will act as a barrier to migration and spawning above the intakes. Migrating adults are most at risk of impingement if they are able migrate up the Sacramento River.

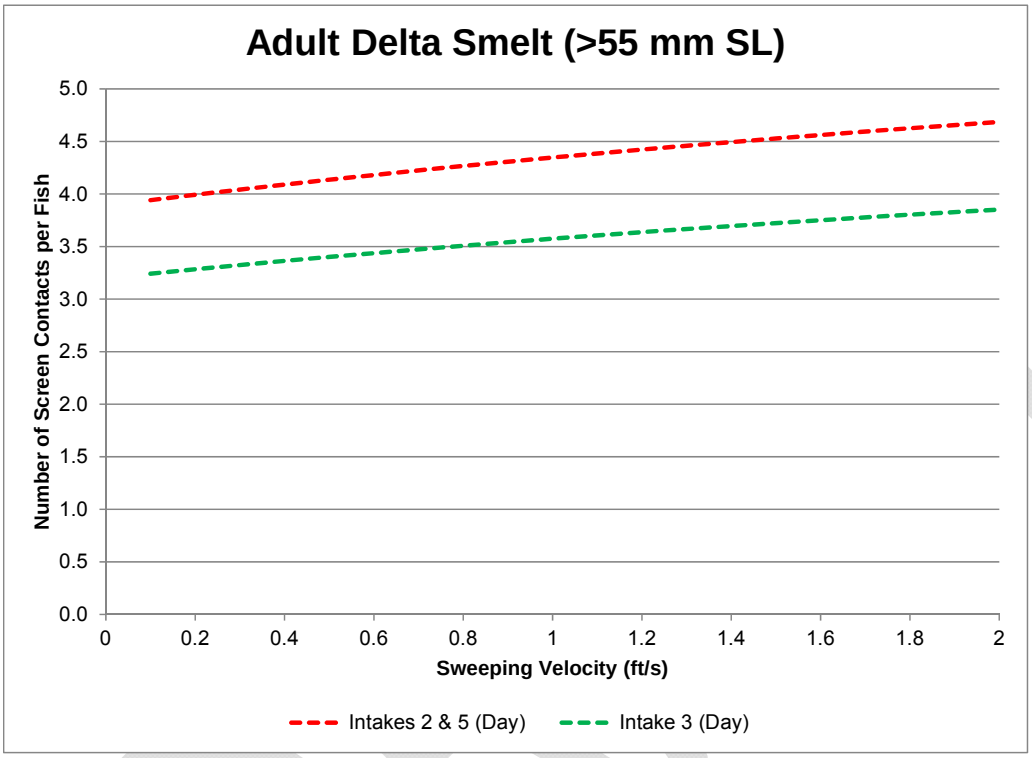
As noted in CWF BA Chapter 3, *Description of the Proposed Action* and *Description of the Proposed Action*, the NDD would be operated such that approach velocity would be limited to 0.2 fps as a minimization measure for delta smelt. It is expected that the FFTT, as part of the final design process, will investigate and assess various approach and sweeping velocity operational criteria intended to minimize effects of screened water exports on delta smelt. There remains the potential that delta smelt larger than the minimum screenable size of approximately 20-21 mm could contact the NDD screens and be injured or die. This potential exists for several reasons: (1) even at 0.2-fps approach velocity, delta smelt were injured from screen contact in an experimental flume (White *et al.* 2007), (2) the sweeping flow velocity at which it was assumed that NDD diversions could commence (0.4 fps; see Section 5.A.5.2.4.9, *North Delta Diversion Bypass Flows*, in CWF BA Appendix 5.A *CALSIM Methods and Results*, and Section 5.B.2.3.5, *North Delta Diversion Operations*, in CWF BA Appendix 5.B *DSM2 Modeling and Results*) is within the velocity range at which captive delta smelt switched swimming modes from a non-continuous stroke and glide behavior to continuous swimming, resulting in swimming failure because of inability to swim steadily (Swanson *et al.* 1998), and (3) the proposed fish screens are

long (fish screens the length of 1,350 feet at intakes 2 and 5 and 1,110 feet at intake 3) requiring that delta smelt will need to swim continuously against strong current for lengthy periods of time. The behavior-based PTM analysis (see Section 6.1.3.2.2.1.2, *Population-Level Effects* of the CWF BA) supports the hypothesis that adult delta smelt migrating upstream in the vicinity of the NDD need to use the lower velocity periphery of the channel to swim upstream against unidirectional flow during periods when the NDD would be operating (*i.e.,* the typical tidal surfing behavioral conceptual model [Bennett and Burau 2015] would not move fish this far upstream). As a result, individuals that do migrate this far upstream may face a higher risk of contact with the screens if they migrated along the left bank of the river where the NDD would be located. Injury and mortality of juveniles and adults have been found to occur following screen contact in laboratory experiments conducted at the UC Davis Fish Treadmill Facility (Swanson *et al.* 2005; White *et al.* 2007), and stress (measured as plasma cortisol) is positively correlated with screen contact in adult delta smelt (Young *et al.* 2010).

The published studies on delta smelt from the UC Davis Fish Treadmill Facility were used to assess the potential for screen contact, screen passage, and mortality. As described in CWF BA Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.3, two of the methods (CWF BA Section 6.A.2.3.1.1 *Adult Delta Smelt (Number of Screen Contacts)*; Section 6.A.2.3.1.2 *Juvenile and Adult Delta Smelt (Percentage Mortality)*) were based on an assessment methodology undertaken as part of the BDCP Fish Facilities Technical Team (FFTT) planning effort. From these analyses, it is estimated the adult delta smelt passing one of the NDD screens—moving against the flow in an upstream direction, based on the laboratory studies—would contact the screen 3 to 5 times, and that there would be little variation in this estimate across a wide range of sweeping velocity (Figure 9.2.2.2.1-1). In addition, application of the relationships from the laboratory studies show that mortality is estimated to be 1% or less for fish encountering one of the intakes when sweeping velocity is low (0.2–0.3 fps), possibly increasing to 4–6% at sweeping velocity above 1.5 fps if encountered at night (Figure X). A third analysis (CWF BA Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)*) was adapted from an analysis provided by the Service. This analysis focuses on the ability of delta smelt moving upstream near the left bank of the river to pass the lowermost NDD fish screen, given historic Sacramento River at Freeport water velocity, and also examined potential survival of those successfully passing the screen. Using December-June Freeport velocity information, the probability that an individual adult delta smelt would successfully pass the lowermost NDD fish screen was estimated to range from 7.3% to 7.5% (or 0.04% probability past three intakes[26]). When the data were restricted to the more likely December-March period, the estimate was 4.0% (3.98% to 4.05%). The survival estimates for fish that actually pass the screen were relatively high and had low variability: mean ± standard deviation = 0.916 ± 0.0079, but the survival estimates had little influence on passage (*P*) because river velocity is almost always too high for delta smelt to swim the required distance upstream. As described in the CWF BA Section 3.2.2.2, *Fish Screen Design*, 22-foot-wide refugia could be provided between each of the six screen bay groups at the three intakes, which, if effective, could provide resting areas and

[26] The estimated chance of passing one diversion is approximately 7.3%, so the chance of passing all three is 7.3% times 7.3% times 7.3% = 0.04%.

refuge from predators for salmonids occurring near the intakes in order to meet NMFS fish screen exposure time criteria. However, the efficacy of the refugia to provide cover and protection to delta smelt is uncertain. Given that the refugia are still in the conceptual design phase and there is uncertainty as to their effectiveness for delta smelt, the analyses presented above only accounted for the refugia by excluding the refugia length from the estimates of overall screen length at each intake.



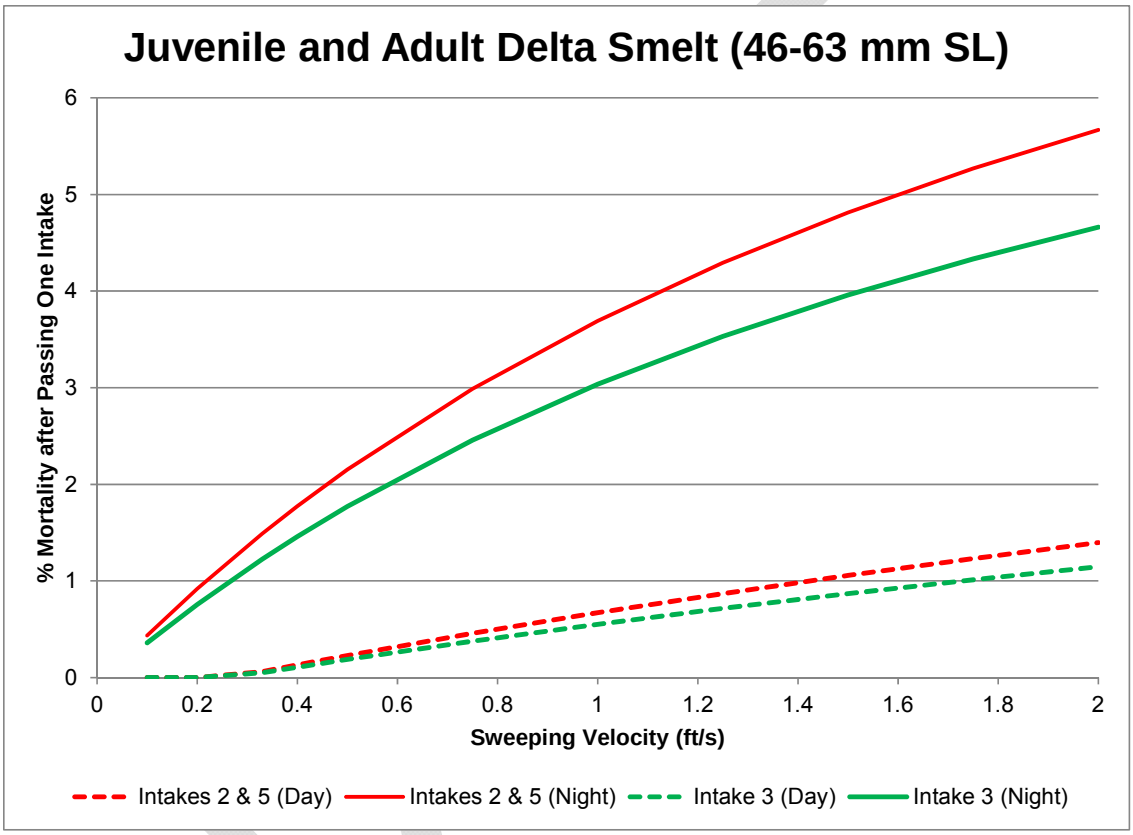
Note: This plot is only relevant to the delta smelt occurring in the reach of the Sacramento River where the proposed NDD would be situated, and of those, only the ones encountering the intake screens at the river margins where the on-bank intakes would be sited. Plot only includes mean responses and does not consider model uncertainty.

Figure 9.2.2.2.1-1. Estimated number of screen contacts of adult delta smelt encountering fish screens the length of intakes 2 and 5 (1,350 feet) and intake 3 (1,110 feet) at an approach velocity of 0.2 fps during the day.

Overall, the UC Davis Fish Treadmill studies indicate that there is potential for lethal and non-lethal effects to juvenile and adult delta smelt from screen contact and impingement, for the subset of the population occurring in the reach of the river where the NDD would be located (Figure 9.2.2.2.1-2). Although shorter and smaller in size, we can infer from the Freeport intake facility potential lessons learned and extent by which the NDD might cause similar effects to delta smelt from their operations at a larger scale. Monitoring efforts conducted at the Freeport intake to evaluate impingement impacts using sonar cameras and diver surveys did not reveal any impinged fish (eggs, larvae, or later life stages) in 2014 (or in 2011–2013), and there was no significant debris accumulation on screen panels (which can affect screen performance). A hydraulic evaluation of the Freeport intake in 2014 showed that approach velocity ranged from

0.09 fps to 0.27 fps and that 70% of approach velocity measurements did not exceed the target design approach velocity of 0.2 fps, although the facility was operating at 85% of capacity (ICF International 2015b).

It is expected that the FFTT, as part of the final design process, will assess various techniques to measuring approach and sweeping velocities in an attempt to get velocity readings that represent the face of the screen where a delta smelt could occur. This will allow for operators to respond to changes in approach and sweeping velocities in real-time in order to be more protective of delta smelt when present.



Note: This plot is only relevant to the delta smelt occurring in the reach of the Sacramento River where the proposed NDD would be situated, and of those, only the ones encountering the intake screens at the river margins where the on-bank intakes would be sited. Plot only includes mean responses and does not consider model uncertainty.

Figure 9.2.2.2.1-2. Estimated 48-hour mortality of juvenile and adult delta smelt encountering fish screens the length of intakes 2 and 5 (1,350 feet) and intake 3 (1,110 feet) at an approach velocity of 0.2 fps during the day and night.

Predation Risk

It is uncertain to what extent the predation rate in front of an operable fish screen will differ from the predation rate that would otherwise occur in this reach without the NDD present because there are no data available to estimate predation rates on delta smelt in this reach. A

hydroacoustic survey as part of Freeport intake monitoring in 2014 (when diversions were over 130 cfs) found that predator-sized fish (*i.e.,* 12 inches long [305 mm long] and larger) density at the intake was similar or less than the density in upstream and downstream control reaches (ICF International 2015a), although only four surveys were undertaken[27]. As discussed in the CWF BA Section 6.1.1.3, *Water Facilities Construction*, rip-rap used in association with the intakes could result in increased predator habitat and predation risk. Various substrates and material types will be assessed for inclusion as part ofconvening the FFTT in the future to develop a final design and minimize effects to delta smelt from predation. In addition, the implementation of localized predatory fish reduction under the PA may limit predation risk (CWF BA Chapter 3, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities*), but there is uncertainty in the effectiveness of this measure given that the area is open to immigration and emigration of predators and turnover may be appreciable in a relatively short period of time (Cavallo *et al.* 2013). The efficacy of this minimization measure will be researched during the pre-construction phase, when the predator baseline is established as part of the pre-construction studies that have been identified during the FFTT.

9.2.2.2.2 South Delta Water Facilities

The entrainment of delta smelt into the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. Salvage is used as an indicator of fish loss resulting from CVP and SWP export operations from the south Delta. Salvage estimates are defined as the number of fish entering a salvage facility and subsequently returned to the Delta through a truck and release operation. See Brown *et al.* (1996) for a description of fish salvage operations from which delta smelt entrainment estimates have historically been derived (*e.g.*, Kimmerer 2008).

The salvage estimates are indices - most entrained fish are not observed (Table 9.2.2.2.2-1), so most of the fish are not salvaged and do not survive. Bennett (2005) suggested that many, if not most, of the delta smelt that do reach the fish facilities likely die due to handling stress and predation; however, recent studies suggest there may be relatively high survival of adult delta smelt during collection, handling, transport, and release when they are salvaged during cool temperature conditions (Morinaka 2013). There is no data on the survival on these fish post release. Pre-screen loss due to predation near and within the CVP and SWP fish facilities is an additional cause of mortality for delta smelt. Pre-screen loss of captive-reared delta smelt released into CCF ranged from about 90% to 100% for adults and nearly 100% for juveniles (Castillo *et al.* 2012).

Under a dual conveyance system, south Delta exports are reduced from baseline conditions under existing regulatory conditions. This is due to the flexibility to utilize the dual conveyance system. Observed reductions in south Delta water exports thereby reduce the entrainment risk of individuals in the south Delta during the spawning migration and larval transport phases and will

[27] NMFS also has been conducting hydroacoustic surveys of predator-sized fish near the Freeport intake; these data were not yet available for inclusion in this effects analysis.

increase the potential for delta smelt to use the San Joaquin River for spawning and their offspring to escape entrainment.

Delta smelt exposure to increased predation within the existing CCF was analyzed in the 2008 Service BiOp. There are no data available to suggest that increased levels of predation beyond what occurs at the SWP and CVP facilities will occur post-construction when the new facilities are in operation. Decreases in entrainment should translate into lower number of individuals dying from predation.

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Table 9.2.2.2.2-1. Factors affecting delta smelt entrainment and salvage.

Factor	Adults	Larvae < 20 mm	Larvae >20 mm and Juveniles	Source
Pre-screen loss (predation prior to encountering fish salvage facilities)	CVP: unquantified; SWP: 89.9–100%	Unquantified	CVP: unquantified; SWP: 99.9%	SWP: (Castillo *et al.* (2012
Fish facility efficiency	CVP: 13%; SWP: 43–89%	~0%	CVP: likely < 13% at all sizes, << 13% below 30 mm (based on adult data); SWP: 24–30%	CVP (Kimmerer 2008; adults only), SWP: (Castillo *et al.* 2012)
Collection screens efficiency	~100%	~0%	<100% until at least 30 mm	(Service 2011)
Identification protocols	Identified from subsamples, then expanded in salvage estimates	Not identified	Identified from subsamples, then expanded in salvage estimates	(Service 2011)
Collection and handling	48-hour experimental mean survival of 93.5% (not statistically different from control) in 2005; 88.3% in 2006 (significantly less than 99.8% of control)	Unquantified	48-hour experimental mean survival of 61.3% in 2005 and 50.9% in 2006 (both significantly less than mean control survival of 82.0–85.9%)	(Morinaka 2013)
Trucking and release (excluding post-release predation)	No significant additional mortality beyond collection and handling (above)	Unquantified	No significant additional mortality than collection and handling (above), although mean survival was 37.4% in 2005	(Morinaka 2013)

Entrainment and Salvage

Larval, juvenile, and adult delta smelt are entrained into the south Delta export facilities during the spawning, migration, and transport period (Grimaldo *et al.* 2009; Sommer *et al.* 2011). Their spawning migrations occur during the winter when precipitation increases the freshwater flow and turbidity in the Delta. Salvage of adult delta smelt at the south Delta export facilities is an imprecise index of entrainment (IEP 2015). Salvage of adults has mainly occurred from late December through March (Kimmerer 2008; Grimaldo *et al.* 2009). For migrating adults, the risk

of entrainment is influenced by flow cues and turbidity in the south Delta (Grimaldo *et al.* 2009). Old and Middle Rivers are distributary channels of the San Joaquin River. Project pumping (*i.e.,* the export of water from the Delta) can cause the tidally filtered or "net" flows in these channels to move "upstream". This occurs because water removed by Banks and Jones, along with other diversions in the area, is back-filled by tidal and river flows. This phenomenon is mathematically depicted as negative flow. Negative Old and Middle River (OMR) flows and greater turbidity are often associated with adult delta smelt entrainment when delta smelt are present in the zone of entrainment, but no particular OMR flow assures entrainment will or will not occur. The net OMR flows indicate how strongly the tidally averaged flows in these channels are moving toward Banks and Jones pumping plants. It is possible the net flows themselves are the mechanism that increases entrainment risk for delta smelt. However, high exports can also lead to strong tidal asymmetry in Old and Middle Rivers where flood tides toward the pumps become much stronger than the ebb tides away from the pumps (Service 2008), so altered tidal flows are a second, covarying, mechanism that could increase risk of entrainment.

The empirical shape of the associations between estuarine salinity distribution (X2), OMR, turbidity and adult delta smelt salvage normalized by the FMWT is shown in Figure X. Normalized delta smelt salvage is correlated in a nonlinear way with X2. An interpretation of this is that the intermediate river flow or X2 conditions are associated with the highest salvage because flows are sufficient to disperse turbidity around the Delta, but not so high that most delta smelt are distributed seaward of the Delta. Figure X shows that even when X2 and south Delta turbidity are accounted for, there is no OMR flow that assures delta smelt entrainment will or will not occur. The predicted relationship is a smooth, accelerating function with increasing normalized salvage as OMR flow becomes more negative (Figure 9.2.2.2.1-3).

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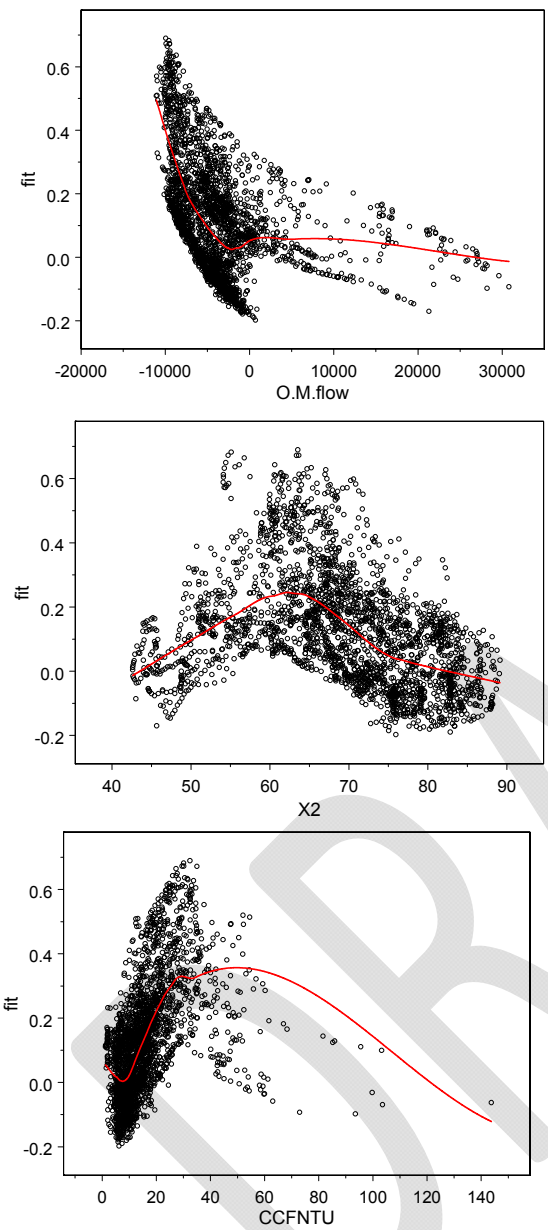

Note: The scatter in each panel is caused by the interacting effects of the other two variables.

Figure 9.2.2.2.1-3. Empirical trends in predictions of adult delta smelt salvage (y-axis) during December–March, 1993–2013, as a function of Old and Middle River flow (O.M. flow, cfs), X2 (km from Golden Gate Bridge), and turbidity at CCF (CCFNTU, NTU).

Freshwater flows in combination with increasing turbidity are cues for adult delta smelt to migrate to spawn in the December through March period (Sommer *et al.* 2011). Exports have the ability to directly alter river flows and can interfere with tidal and upstream migration of delta smelt resulting in entrainment. South Delta exports will draw turbid Sacramento River water into the central and south Delta, furthering the migration of adult delta smelt into the south and east

Delta, making them and their offspring vulnerable to entrainment. The association of adult delta smelt with turbid water can lead to greater entrainment by the south Delta export facilities when turbid conditions occur in the regions that are under the hydraulic influence of the export facilities (Grimaldo *et al.* 2009).

Adult entrainment risk, related to exports from the south Delta, is expected to decrease as a result of the shift in exports to the NDD during the migration period. For the south Delta, OMR flows more positive than -2000 are expected to be protective of a high fraction of migrating adults because Sacramento River water flowing into the mainstem of the San Joaquin River is not being rapidly drawn into Old and Middle rivers. In the PA, OMR flows are less negative during adult migration in all months except December, in which flows will be similar to projected conditions under existing regulations without the PA (CWF BA 2016).

During adult spawning migration, OMR flows in the PA are expected to be more positive than -2000 cfs 40% of the time during January, 50% of the time in February and 60% of the time during March (CWF BA 2016). OMR flow under current conditions is always more negative than -2000 cfs in December unless Action 1 of the 2008 Service BiOp is in effect. The PA represents a reduced risk of entrainment by OMR flows for delta smelt during adult migration when compared to projected conditions under existing regulations without the PA (CWF BA 2016).

As described in CWF BA Section 3.3.2.2 *Operational Criteria for South Delta CVP/SWP Export Facilities*, the OMR flow requirements would be governed by the existing 2008 Service BiOp and 2009 NMFS BiOp (near-term), or reinitiation thereafter, until the NDD becomes operational for dual conveyance (long-term). As described in the CWF BA, the proposed operational criteria would generally improve OMR flows in wetter years compared to the existing BiOps (CWF BA 2016). Real-time management of entrainment risk would also occur, as needed, in a manner similar to the existing determination process or may be modified in the reinitiation process (see *Existing Conditions and Previous Consultations in the Action Area*).

Under the PA, south Delta exports are reduced from the projected conditions under existing regulations without the PA. This is due to the flexibility to utilize the dual conveyance system. Observed reductions in south Delta water exports thereby reduce the entrainment risk of individuals in the south Delta during the spawning migration and larval transport phases and will increase the potential for delta smelt to use the San Joaquin River for spawning and their offspring to escape entrainment.

Predation Risk

Predation probably kills a large proportion of adult delta smelt before they reach the fish facilities or the export pumps (Castillo *et al.* 2012) reducing the number of delta smelt salvaged at the facilities. To the extent that the localized reduction of predatory fishes through electrofishing (discussed further in CWF BA Section 6.1.4.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities)* reduces predator abundance in CCF, predation risk to adult delta smelt could be reduced under the PA.

However, there is uncertainty in the efficacy of localized reduction of predatory fishes, given that previous efforts did not yield measurable changes in predator population size within the Forebay (Brown *et al.* 1996). Predatory removal in CCF has the potential for more entrained fish to show up in salvage.

Operations of the new facilities within and near the CCF may increase or decrease the number of delta smelt salvaged at the existing CVP and SWP pumping facilities by way of changes in predation rates in the CCF. There are limitations to this delta smelt effects analysis based on the information provided to the Service in the CWF BA, along with best available scientific information not being sufficient to determine how salvage estimates or predation rates in the CCF of the existing CVP and SWP pumping facilities will be affected by the implementation of the PA.

9.2.2.2.3 Head of Old River Gate

HORG operations will be managed in real-time to achieve an increase in water levels, quality and circulation patterns in the south Delta for local agricultural diversions, and increase operational flexibility of the CVP SWP to improve conditions for federally-listed species. The HORG will replace the annual installation and removal of the rock barriers used to guide the emigration of salmon and steelhead. Depending on timing of the operations, there is the potential to influence entrainment based on the opening and closure of the gates, but this effect will be minimized by the OMR flows described in the BA (2016). The potential effects of the HORG are similar to effects analyzed previously by the Service for the south Delta Temporary Barriers Project. Unlike the rock barrier, HORG operations would occur in the context of real-time changes in both gate position and management of north and south Delta exports to limit the potential for adverse hydraulic effects to adult delta smelt during their spawning migration phase and the transport of their offspring back downstream. In particular, careful management of OMR flows in consideration of fish distribution and turbidity cues (among other factors), would be undertaken to limit adverse effects to delta smelt. Careful management of OMR flows and HORG operations will limit movement of adult, larval, and young juvenile delta smelt into the south Delta where they would be subject to high entrainment risk and impact mechanisms directly associated with the presence and operation of the HORG.

Entrainment and Predation Risk

As previously noted by the Service (2008), there is potential for negative effects to delta smelt from operation of the HORG. A HOR barrier or gate does not alter total Delta outflow, or the position of X2. However, it would cause changes in the hydraulics of the interior Delta, which may affect delta smelt. The barrier/gate prevents San Joaquin River water from flowing into Old River at the HOR junction. This increases the flow toward Banks and Jones from Turner and Columbia cuts, which can result in more negative OMR and increase the predicted entrainment risk for particles (simulating larvae) in the East and Central Delta by up to about 10 percent (Kimmerer and Nobriga 2008). The directional flow towards Banks and Jones increases the

vulnerability of delta smelt to entrainment. Larval and juvenile delta smelt are especially susceptible to these flow changes.

There is the potential for the HORG to result in short-term negative effects to delta smelt by influencing the hydraulics of Old and Middle Rivers (Service 2008). However, the general improvements to OMR flows resulting from lower proposed south Delta exports, combined with the flexibility to manage the proposed HORG in real time would limit the potential for adverse effects. If necessary, opening and closing of the HORG could be done in consideration of fish distribution and simulation (*e.g.,* PTM) modeling; adjustments to south Delta exports could then avoid short-term increases in entrainment.

In addition to broad-scale effects of the HORG on south Delta hydrodynamics, there may be localized effects on migrating adult delta smelt. Studies of the rock barrier installed at the HOR in 2012 suggested the structure created eddies that could have resulted in elevated predation on juvenile salmonids (DWR 2015a); we deduce that similar effects could also occur to delta smelt as a result of HORG operations.

9.2.2.2.4 Delta Cross Channel

No changes to the operational criteria as identified in the 2008 Service BiOp and 2009 NMFS BiOp and D-1641 (see *Description of the Proposed Action*) are proposed. The DCC is closed for fishery (*e.g.,* salmonid) protection as described in the *Description of the Proposed Action* during a majority of the time period when delta smelt have been historically observed to be present in the vicinity of the DCC. DCC gate operations are not expected to change from current operations; therefore, conditions under the PA would be similar to existing conditions that were analyzed in the 2008 Service BiOp.

Entrainment and Predation Risk

Given that the main effect of DCC operations would be to change the quantity of Sacramento River flow entering the interior Delta (central/south Delta), there will be minimal effects to delta smelt when present due to the proposed gate closure schedule for fishery protection. Closures of the DCC for juvenile salmonid protection are likely to create more natural hydrologies in the Delta, by keeping Sacramento River flows in the Sacramento River and Georgiana Slough, which provide flow cues for migrating adult delta smelt (Service 2008). Closure of the DCC would occur during most, if not all, of the December-March upstream migration period of adult delta smelt, and essentially would not differ between the projected conditions under existing regulations and the PA (see Table 5.A.6-31 in CWF BA Appendix 5.A *CALSIM Methods and Results*).

The effects of the DCC on Delta hydrodynamics are included in the CalSim II modeling results and are discussed through the *Effects to Habitat*. In the fall, the DCC may be open somewhat more often under the PA (see Section 6.1.3.3.1.4, *Larvae/Young Juveniles (Spring: March-June*)). This is because of several operational criteria described in Section 5.A.5.1.4.2 of the

CWF BA Appendix 5.A *CALSIM Methods and Results*. The CalSim II modeling showed that in September, in approximately 20% of years, sufficient water was exported by the NDD and the 25,000-cfs threshold for closure of the DCC is not exceeded, whereas it is exceeded under the NAA in the same years and results in closure of the DCC more than under PA (see Table 5.A.6-31 in CWF BA Appendix 5.A). Additionally, in October-November, reservoir releases later in the year under the NAA triggered the 7,500-cfs Sacramento River at Wilkins Slough threshold assumed to coincide with juvenile salmon migration into the Delta, which resulted in a greater number of days with DCC closed under NAA. Last, the DCC may also have been open more under the PA to maintain water quality conditions per D-1641 (Rock Slough salinity standard). However, given that most juvenile delta smelt would be expected to be in the low-salinity zone or in the Cache Slough area during this time period, any effects are expected to be limited; the extent and location of the low-salinity zone would not differ between projected conditions under existing regulations and the PA during September-December, as shown in the analysis of abiotic habitat for juvenile delta smelt (see CWF BA Section 6.1.3.5.1.1, *Juveniles (Fall: September-December*).

Larval and juvenile delta smelt are probably not strongly affected by the DCC if it is closed or open (Service 2008). Previous PTM modeling done for the SWG has shown that having the DCC open or closed does not significantly affect flows in the central Delta (Kimmerer and Nobriga 2008). There could be times, however, when the DCC closure affects larval/juvenile delta smelt by generating flows that draw them into the South Delta. Those effects are captured in the PTM modeling that was undertaken for the south Delta water facilities above to report entrainment effects. There would be little to no difference in the DCC gate openings/closures (*i.e.,* operations) between the projected conditions under existing regulations and the PA, with the DCC only being open for an average of 5 days more under PA in wet years (see CWF BA Table 5.A.6-31 in Appendix 5.A *CALSIM Methods and Results*).

9.2.2.2.5 Suisun Marsh Facilities

The Suisun Marsh Facilities are the Suisun Marsh Salinity Control Gates, Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall.

<u>Suisun Marsh Salinity Control Gates</u>

No changes in gate operational criteria are proposed. Gates will continue to be closed up to 20 days per year from October through May.

Entrainment, Impingement, and Predation Risk

The SMSCG are generally operated, as needed, from September through May to meet State salinity standards in the Suisun Marsh. The number of days the SMSCG are operated in any given year varies. Historically, the SMSCG were operated 60-120 days between October and May (during 1988-2004). However, effectiveness of the operations has resulted in less frequent gate operations. Effects of the gate operations were addressed in the 2008 Service BiOp. No

changes to those operational criteria are proposed. But rather, due to the implementation of the PA, there may be an overall increase in usage in relatively few days (~10-20 days).

Under current operations it is possible for a delta smelt to be entrained behind the SMSCG in Montezuma Slough and Suisun Marsh when the SMSCG is closed, and this would also occur under the PA. As described in the 2008 Service BiOp, fish may enter Montezuma Slough from the Sacramento River when the gates are open to draw freshwater into the marsh and the fish may not be able to move back out when the gates are closed. It is unknown whether this harms delta smelt, but they could be exposed to predators around the SMSCG or they could have an increased risk of exposure to water diversions within the managed marshes (Culberson *et al.* 2004; Service 2008). If delta smelt are entrained into Montezuma Slough and Suisun Marsh they may be more vulnerable to water diversion. The degree to which movement of delta smelt around the LSZ is constrained by opening and closing the SMSCG is unknown.

SMSCG affects the distribution of the LSZ (indexed by X2), causing it to shift eastward (Service 2008). However, operations to meet D-1641 would limit such potential effects; these operations would be undertaken under existing regulations and the PA, and are reflected in there being little meaningful difference between existing conditions and the PA in X2 during December-March (see Table 5.A.6-29 in CWF BA Appendix 5.A, *CALSIM Methods and Results*) (Service 2008).

Spawning adult delta smelt would be less susceptible to the effects of the SMSCG than migrating adult delta smelt because they would not be undertaking the broad-scale movements of migrating adults. Movement may still be restricted, however, and direct near-field effects (*e.g.*, predation) similar to those suggested in the 2008 Service BiOp could occur. Any such effects would be similar for existing conditions and the PA based on the February-June flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in CWF BA Appendix 5.B, *DSM2 Modeling and Results*).

<u>Roaring River Distribution System</u>

The Roaring River Distribution System will continue to operate as identified in the 2008 Service BiOp. There are no operational changes proposed for the RRDS water intake. It is screened and operated to maintain an approach velocity of 0.2 fps to minimize effects to delta smelt from entrainment, impingement, and screen contact. Any effects on larval/young juvenile delta smelt from the RRDS that occur would be expected to be similar between existing conditions and PA, and would represent a continuation of existing operations.

Entrainment, Impingement, and Predation Risk

The Roaring River Distribution System (RRDS)'s water intake (eight 60-inch-diameter culverts) is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 fps to minimize effects to delta smelt from entrainment and impingement, so that any potential adverse effects to individual migrating adult delta smelt would be minimal.

Based on the RRDS screen specifications and applying the methods used for the NDD (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.2), individual larval and young juvenile delta smelt smaller than 30 mm (SL) total length could be susceptible to entrainment by the three RRDS intake culverts. Slightly larger juveniles and large adults could be impinged on the screens.

Any effects on larval/young juvenile delta smelt from the RRDS that occur would be expected to be similar between existing conditions and PA, and would represent a continuation of existing operations. As previously noted, flows in Montezuma Slough as a result of SMSCG operations were similar for existing conditions and the PA. Entrainment risk into RRDS appears limited, given that DSM2-PTM modeling for the DFG (2009b) longfin smelt incidental take permit application did not predict any particles entering RRDS. Therefore, the population-level effect of the RRDS is expected to be minimal.

Morrow Island Distribution System

The Morrow Island Distribution System will continue to operate as identified in the 2008 Service BiOp. No changes in operations are proposed.

Entrainment, Impingement, and Predation Risk

Individual delta smelt could be entrained by the three unscreened 48-inch intakes that form the MIDS intake. However, Enos *et al.* (2007) noted that this would generally only occur in wet years, per Hobbs *et al.* (2005). Enos *et al.* (2007) noted that under normal operations, MIDS is often closed or diversions are small during spring, which may provide some protection of spring-spawning and spring-migrating fish, particularly open-water fish like delta smelt that do not congregate around in-stream structures such as diversions. Enos *et al.* (2007) did not collect any delta smelt during sampling of the MIDS intake in 2004-2006, although they did capture adult delta smelt with purse seines during sampling in the adjacent Goodyear Slough. The population-level effects of the MIDS to adult delta smelt would be minimal, if any, given that entrainment would only be expected to occur in wet years.

As noted by in the 2008 Service BiOp, entrainment into MIDS may be unlikely based on particle tracking studies that have demonstrated low entrainment vulnerability for particles released at random locations throughout Suisun Marsh (3.7 percent), and almost no vulnerability (<0.1 percent) to particles released at Rio Vista (Culberson *et al.* 2004). This suggests t a minimal population-level adverse effect, which would be similar under NAA and PA (see Tables 5.B.5-31, 5.B.5-32, and 5.B.5-33 in Appendix 5.B, *DSM2 Modeling and Results*).

Goodyear Slough Outfall

Gates will continue to be closed up to 20 days per year from October through May. No changes in gate operations are proposed.

Entrainment, Impingement, and Predation Risk

Opening of the Goodyear Slough outfall culvert flap-gates results in a small southern net flow, with fresher water from Suisun Slough being drawn into Goodyear Slough. Although this may increase the possibility of entry of delta smelt into Goodyear Slough, and therefore increases the potential for entrainment by the MIDS intakes (as previously discussed), operation of the flap-gates also improves circulation and therefore may reduce effects to habitat conditions.

As discussed previously for MIDS, the available sampling data in the area suggest that migrating adult delta smelt would only be susceptible to effects from the Goodyear Slough outfall in wet years (Enos *et al.* 2007), and a minimal population-level effect would therefore be likely to occur, with this effect being common to NAA and PA based on similar flows in Goodyear Slough (see Table 5.B.5-34 in Appendix 5.B, *DSM2 Modeling and Results*).

9.2.2.2.6 North Bay Aqueduct Intake at Barker Slough

No changes in operational criteria are proposed. Operations will continue as identified in the 2008 Service BiOp.

Entrainment, Impingement, and Predation Risk

The Barker Slough Pumping Plant diverts water from Barker Slough into the NBA for delivery in Napa and Solano Counties. Maximum pumping capacity is 175 cfs (pipeline capacity). Past daily pumping rates have ranged between 0 and 140 cfs (Service 2008). The NBA Intake is located approximately 10 miles from the mainstem Sacramento River at the end of Barker Slough. Each of the ten NBA pump bays is individually screened with a positive fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch. This configuration is designed to exclude delta smelt larger than 25 mm and as such is expected to exclude migrating adult delta smelt from being entrained by the NBA (Service 2008). The bays tied to the two smaller units have an approach velocity of about 0.2 fps, minimizing entrainment of larvae and impingement of larger delta smelt through implementation of the operational criteria (Service 2008).

Historical catch data indicate that delta smelt in Barker Slough has been consistently very low, indicating that a relatively small portion of the delta smelt population in this region is susceptible to NBA diversions. NBA diversions do not appear to have had a substantial effect on delta smelt (Service 2008). Pumping rates at the NBA Barker Slough Intake generally would be similar to what was described in the 2008 Service BiOp, so the potential risk of entrainment, impingement, and predation above what has already been analyzed will be minimal. It is expected that the effects to delta smelt will continue to be relatively low under the PA.

9.2.2.2.7 Other Facilities (*i.e.*, Contra Costa Water District Facilities, Freeport Intake Facility, and Clifton Court Forebay Aquatic Weed Control Program)

The CWF BA describes other facilities as: the Contra Costa Water District Facilities, Freeport Intake Facility, and the Clifton Court Forebay Aquatic Weed Control Program.

9.2.2.2.7.1 Contra Costa Canal Rock Slough Intake

Water exports for the Contra Costa Water District Facilities are represented in the hydrologic modeling of the PA and included in the baseline conditions (reflected as the NAA in the CWF BA). No changes in operational criteria are proposed to the facilities in the PA. Operations will continue as identified in the 2008 Service BiOp.

Entrainment, Impingement, and Predation Risk

The 1.75-mm-opening, 0.2 fps-approach-velocity fish screen installed at the Rock Slough intake is intended to prevent entrainment of delta smelt into the Contra Costa Canal. However, the 4 mechanical rakes making up the screen cleaning system are unable to handle the large amount of aquatic vegetation on the fish screen, leading to operation of the fish screen only during ebb tides. At these times, migrating adult delta smelt could be susceptible to entrainment. The operational issues with the fish screen have led Reclamation to test alternative technology (a prototype rake) to improve vegetation removal, an action that NMFS (2015a) concluded would improve fish protection (*i.e.,* screen efficiency) by minimizing the chance a listed fish would be entrained or impinged on the fish screen. In addition, mechanical removal of aquatic weeds within Rock Slough in 2015 to facilitate testing of the new rake design was expected by NMFS (2015b) to improve screen efficiency, reduce predation of listed fish species by vegetation-associated predatory fishes, and reduce fish mortality during screen maintenance.

The 2008 Service BiOp noted that Rock Slough is a dead-end slough with poor habitat for delta smelt, so the numbers of delta smelt using Rock Slough are usually low, as reflected in very few delta smelt having been collected during sampling at the intake. This combined with relatively small diversions that are similar between the PA and projected conditions suggests that any population-level effect of the Rock Slough intake on delta smelt would be minimal.

9.2.2.2.7.2 Freeport Intake Facility

The PA proposes no changes in water diversions associated with the Freeport Intake Facility.

Entrainment, Impingement, and Predation Risk

The 1.75-mm-opening, 0.2 fps-approach-velocity fish screen installed at the Freeport Intake is intended to prevent entrainment of delta smelt from exports. Water diversions are not proposed to change from current operations and would be very similar between the baseline and PA for all life stages. The PA does not propose to change operations of the Freeport Intake Facility. As indicated in the *NDD Construction* and *NDD Operations* related to low numbers of delta smelt in the vicinity of the upper Sacramento River reach, therefore, we expect entrainment of the Freeport Intake Facility to be similar to what is observed in the baseline.

9.2.2.2.7.3 Clifton Court Forebay Aquatic Weed Control Program

DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. Herbicides may include Komeen®, a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and Nautique®, a copper carbonate compound. These products are used to control algal blooms that can degrade drinking water quality through tastes and odors and production of algal toxins. Dense growth of submerged aquatic weeds, predominantly *Egeria densa*, can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of the rooted plant break free and drift into the trashracks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the pumping rate of water to prevent potential equipment damage through cavitation at the pumps. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also reduce the efficiency of fish salvage at the Skinner Fish Facility. Ultimately, this all results in a reduction in the volume of water diverted by the SWP. Herbicide treatments will occur only in July and August on an as needed basis in the CCF, dependent upon the level of vegetation biomass in the enclosure.

Entrainment, Impingement, and Predation Risk

Mechanical removal of aquatic weeds in CCF would occur on an as needed basis and therefore will coincide with the potential presence of delta smelt during the months of July and August. Delta smelt generally would not be expected to found near aquatic weeds (Ferrari *et al.* 2014), but may occur near the weeds if both fish and weeds are concentrated into particular areas by prevailing water movement in the Forebay. Any potential adverse effects to individual delta smelt from mechanical removal of water hyacinth or other aquatic weeds (*e.g.*, injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Delta Fish Protective Facility. There is the potential with increased salvage efficiency to see more delta smelt in salvage.

9.2.2.2.8 Effects to Habitat

Salinity

Conceptually, the freshwater flow regime and its interaction with the system bathymetry and landscape affect the quantity and quality of available habitat (*e.g.*, Peterson 2003). The 2008 BiOp's RPA to increase Delta outflow in the fall following wet and above normal years was based on specific targets for X2, the geographic location of the 2-ppt salinity isohaline in the estuary. This action aimed to restore a greater extent of fall habitat for juvenile delta smelt following wetter years in order to counteract a trend toward lower variability and smaller size of the low-salinity zone during fall of recent years (Feyrer *et al.* 2011; Cloern and Jassby 2012). Feyrer *et al.* (2011) suggested that increased habitat area provides more space for individuals to safely live and reproduce, presumably lessening the likelihood of density-dependent effects (*e.g.*,

food limitation, disease, and predation), and lessening the probability of stochastic events increasing the risk of mortality (*e.g.*, cropping by predators, contaminant events, or the direct/indirect effects of water diversions). The PA includes the fall X2 action of the 2008 Service BiOp RPA.

Research focused on the fall has shown that increases in outflow cause low-salinity water to overlie areas with appropriate tidal current velocity and turbidity improving habitat conditions for delta smelt (Feyrer *et al.* 2011; Bever *et al.* 2016). Defining delta smelt 'habitat' only in terms of salinity is too simple and it is possible that greater habitat quality and quantity contribute to juvenile recruitment or population increases. The flow mechanisms described for the fall would also apply to the summer months.

The quality of habitat for delta smelt is affected by where low-salinity water intersects with the estuary landscape. This is due to the shape of the Delta, which consists mostly of deep canals east of the Sacramento-San Joaquin River confluence. At and west of the confluence, there is much more variable depths particularly where water is just a few meters deep. These semi-shallow areas often have higher turbidity, less submerged vegetation, and more variability in water velocities that delta smelt can exploit. During summer and fall in particular, delta smelt tend to aggregate near X2. Thus, if outflow is high enough to keep the tidal movement of X2 over the semi-shallow Suisun Bay and river confluence region, the intersection of low salinity water with best available bathymetry occurs.

Quality and quantity of habitat in the summer and fall months can contribute to the juvenile recruitment of increasing population size. As described in the 2008 Service BiOp, during the fall (September-December) delta smelt are maturing pre-adults that rely heavily on suitable habitat conditions in the low salinity portion of the estuary. The 2008 Service BiOp briefly defined suitable habitat for delta smelt during this time period as "the abiotic and biotic components of habitat that allow delta smelt to survive and grow to adulthood: biotic components of habitat include suitable amounts of food resources and sufficiently low predation pressures; abiotic components of habitat include the physical characteristics of water quality parameters, especially salinity and turbidity."

When X2 moves eastward into the Delta channels, this intersection occurs much less frequently and delta smelt are harmed by poor habitat conditions (*e.g.*, elevated vulnerability to predators, greater exposure to *Microcystis* blooms, greater temperature stress, etc.). Therefore, for those instances where the PA results in inward movement of X2, we would expect to see population-level effects more adverse than in the baseline conditions from effects of reduced habitat availability (*i.e.,* habitat constriction). As noted by Feyrer *et al.* (2007; 2011), analyses conducted over this rearing phase of the delta smelt life cycle provide support for a population-level effect from degraded fall habitat conditions or negative changes in indicators of those conditions, such as inward movement of X2. In addition, analyses by Miller *et al.* (2012) and Rose *et al.* (2013a, b) suggest that prey density and food supply limitation during this part of the life cycle may also have population-level effects on delta smelt.

On average there are minor changes observed in the location of X2 during the fall; however, by examining hydrological data across WY types on a monthly average for July, August, September, October, November, and December, greater resolution is possible (see Appendix A).

In order for the water pumping facilities to meet the spring outflow criteria and the fall X2 action, water exports are increased during the summer months to meet water export goals (see Appendix A). For context, the location of X2 during summer months under the PA is commensurate with habitat conditions delta smelt are currently experiencing under drought conditions. In September, the PA results in eastward movement of X2 during below normal and critical WY types and maintained in the dry WY type. On average during the wet and above normal WY types, we see no change of the location of X2 due to the inclusion of the Fall X2 action of the 2008 Service BiOp RPA, since the intent of the PA is to maintain baseline habitat conditions during those WY types.

Appendix A provides results of CalSim II modeling for X2 over 82 years for the PA and the projected baseline condition in kilometers for all months. These plots indicate that the PA will further erode juvenile rearing critical habitat by moving X2 further upstream by as much as 4.8 km compared to current conditions. In July, August, and September, the LSZ is consistently predicted to move upstream of current conditions. Under the PA, CalSim II predicts X2 in August will be greater than 84 km 94% of the time (77 of 82 years modelled). The projected baseline, X2 in August will be higher than 84 km 71% of the time (58 of 82 years modelled). The location of the LSZ is important in determining the quality, both extent and suitability, of juvenile rearing habitat. During juvenile rearing from July through December, upstream movement of the LSZ further degrades rearing habitat by decoupling favorable salinity conditions from the food, water depths, and wind-driven turbidity of Suisun Bay. At or above 84 km, the LSZ is upstream of Chipps Island, and entirely out of Suisun Bay and the suitable habitat conditions it provides.

Adults seek fresher water during the migration season (December through March). Under the PA, on average in December through March, there are differences in the location of X2, but no major shifts in the distribution of habitat. The proposed longfin smelt spring outflow criteria will establish target outflow requirements for the months of March, April, and May to maintain outflow levels consistent with existing conditions. The proposed longfin smelt spring outflow criteria determine March outflow targets based on the Eight River Index and achieve the targets with export curtailments down to a minimum of 1,500 cfs exports; the March outflow target is capped at 44,500 cfs at an Eight River Index of 4,217 TAF and greater. April and May outflow targets are based on the San Joaquin River inflow:export ratio included in the NMFS (2009) BiOp, up to a maximum outflow target of 44,500 cfs; this also involves curtailment of exports as necessary.

Water Temperature

Kimmerer (2004) described water temperature in the San Francisco Estuary as depending mainly on air temperature, and that even in the Delta the relationship between air and water temperature is only slightly affected by freshwater inflow. For example, Kimmerer (2004) noted that at

Freeport, high inflow reduces water temperature on warm days, presumably because water reaches the Delta before its temperature equilibrates with air temperature. At Antioch, low inflow increases water temperature on cool days, probably because of the moderating effect of warmer estuarine water moving farther upstream (Kimmerer 2004). Service (2008) suggested, based on Kimmerer (2004) that water temperatures at Freeport can be cooled up to about 3°C by high Sacramento River flows, but only by very high river flows that cannot be sustained by CVP/SWP operations. In general, flow-related effects on Delta water temperature are expected to be minor (Wagner *et al.* 2011). Specifically, Delta water temperatures are primarily driven by air temperatures and the effects from the previous conditions (Wagner *et al.* 2011).

Changes in water temperatures under the PA were investigated in the CWF BA using DSM2-QUAL modeling. DSM2-QUAL modeling was performed to predict water temperatures for the projected baseline conditions and PA scenarios at four locations: Sacramento River at Rio Vista, San Joaquin River at Prisoners Point, Stockton Deep Water Ship Channel, and San Joaquin River at Brandt Bridge. Detailed methods are presented in Attachment 5.B.A.4, *DSM2 Temperature Modeling*, of Appendix 5.B *DSM2 Methods and Results*, with results in Section 5.B.5, *DSM2 Results*, of the same appendix.

The Rio Vista and Prisoners Point stations are of particular relevance to delta smelt. From examination of exceedance plots of Rio Vista mean water temperatures (Figure 5.B.5.40-1 in Appendix 5.B *DSM2 Methods and Results*, Section 5.B.5), the only discernible differences in water temperature were in March, and these were small differences (~0.1°C greater under PA than under projected baseline conditions). At Prisoners Point (Figure 5.B.5.41-1 in Appendix 5.B, Section 5.B.5) differences were evident in January-March, presumably as a result of the HORG retaining a greater proportion of slightly warmer San Joaquin River water in the main stem, combined with less Sacramento River inflow entering the interior Delta. Differences in March were 0.3–0.4°C. Although differences in water temperature between projected baseline conditions and the PA were modeled, these were during a relatively cool part of the year and are not expected to have significant effects on migrating adults in that portion of the Delta.

Delta smelt may begin spawning in the San Joaquin River in February, and spawn during March in most years (see California Department of Fish and Wildlife Spring Kodiak Trawling Data at https://www.wildlife.ca.gov/Conservation/Delta/Spring-Kodiak-Trawl). Previously published modeling studies have indicated that warmer temperatures (caused by climate change) would tend to result in earlier spawning (Wagner *et al.* 2011; Brown *et al.* 2013). Earlier spawning could result in spawning adults being smaller mean size, as they would have had less time to grow to maturity (Brown *et al.* 2013). Migrating adult delta smelt may experience slightly warmer temperatures in the lower San Joaquin River, but these temperatures would be expected to be within the tolerance of the species and are not expected to have any population level impact.

The recent simulation-based life cycle modeling by Rose *et al.* (2013a, b) indicates that egg production has been a major factor affecting delta smelt abundance. Climate change is anticipated to warm Delta water temperatures and could affect the length of time that Delta smelt reach adulthood (Brown *et al.* 2013). If this occurs, it would affect egg production. As described

above, it is uncertain whether the PA will affect water temperature in the Delta. If it does, that effect would be minor and localized.

The slightly greater Prisoners Point water temperature under PA that was estimated by DSM2-QUAL could result in shorter embryo incubation time, as well as slightly lower or higher hatching success, depending on the month. The effects would be limited to the portion of the delta smelt population occurring in the San Joaquin River.

Most delta smelt hatch during March-May. In warm years, hatching can begin in February and in cool years; it can extend at least into June. Bennett (2005) reviewed delta smelt embryo and larval survival data from laboratory studies and found that optimal hatching occurred at 15–17°C. River flows tend to have such a minor influence on water temperatures in the Delta except at the inflowing river margins (Kimmerer 2004; Wagner *et al.* 2011). The general pattern for Prisoners Point in March suggests that the greater water temperature under the PA would be slightly more optimum hatching temperature than under the NAA (Figure 5.B.5.41-1 in Appendix 5.B *DSM2 Methods and Results*, Section 5.B.5), whereas in May, temperatures under PA may be marginally less optimum compared to projected baseline conditions, although these differences were small. Bennett (2005) also noted that incubation time of embryos decreases with increasing water temperature, from around 18 days at 10°C to 9 days at 15°C and 7 days at 20°C. For example, a 0.3°C greater water temperature under PA could result in a 0.5-day shorter incubation time for delta smelt occurring in the lower San Joaquin River.

Bennett's (2005) review of the laboratory studies on water temperature effects on larval delta smelt found that greater water temperature leads to smaller larval length at egg hatching and smaller larval length when first ingesting food. The marginally higher water temperatures estimated under the PA at Prisoners Point could result in delta smelt that are slightly smaller, although the differences between scenarios were small. There could be several effects to delta smelt from smaller size (IEP 2015). First, small size would result in small gape size, which would limit the size of prey items that could be eaten. Second, there may be vulnerability to a wider range of predators. Third, smaller larvae could be more susceptible to hydrodynamic transport toward the south Delta export facilities. Bennett (2005) noted that there is higher mortality of larvae above 20°C. The DSM2-QUAL modeling data for Prisoners Point in June suggested that there could be an increase in the number of days in this range (Figures 5.B.5.41-3 to 5.B.5.41-6 in Appendix 5.B *DSM2 Methods and Results,* Section 5.B.5).

Overall, the DSM2-QUAL analysis suggested that there may be slightly lower larval delta smelt survival in the lower San Joaquin River because of slightly higher water temperature. This would affect the portion of the population occupying this area. Data from the 20-mm surveys indicate that larval delta smelt occur in this area (see Table 7 of Merz *et al.* 2011). An appreciable portion of the population could be subjected to this adverse effect.

Water temperatures above 20°C become increasingly stressful to juvenile Delta smelt up to the lethal range (~25–29°C; Swanson *et al.* 2000; Komoroske *et al.* 2014).The DSM2-QUAL modeling suggested water temperature would be similar or slightly warmer under the PA compared to NAA, at both the Sacramento River at Rio Vista and San Joaquin River at Prisoners

Point during the summer (July–September). The differences that occurred in the warmer 50% of the years indicated about 0.1–0.2°C greater temperature under the PA (Figure 5.B.5.40-1 and Figure 5.B.5.41-1 in Appendix 5.B *DSM2 Methods and Results,* Section 5.B.7).

As reviewed by the IEP (2015), high summer water temperature has a negative effect on the delta smelt population, as it has been linked to delta smelt subadult abundance in the fall (Mac Nally *et al.* 2010) and long-term population dynamics (Maunder and Deriso 2011; Rose *et al.* 2013a, b). The increase in water temperature in the summer could have a small adverse effect on the whole delta smelt population, through mechanisms including reduced habitat extent, increased metabolic requirements (reduced energy intake for growth), and greater susceptibility to disease or the effects of contaminants (IEP 2015).

Turbidity (Sediment Removal and Water Clarity)

Water clarity (turbidity) is an important habitat characteristic for delta smelt and is a significant predictor of larval feeding success (presumably by providing a visual contrast to enable the larvae to locate and ingest prey; Baskerville-Bridges *et al.*2004) and juvenile distribution (Nobriga *et al.* 2008; Feyrer *et al.* 2011) that has been correlated to long-term changes in abundance or survival either by itself or in combination with other factors (Thomson *et al.*2010; Maunder and Deriso 2011). Cloern *et al.* (2011) noted the uncertainty in future turbidity trends in the Delta. It is unclear whether a 40-year average decline in turbidity of 1.6% per year will continue, slow or level off. Should such a trend continue, it presumably will further decrease delta smelt habitat quality (Feyrer *et al.* 2011; Brown *et al.* 2013).

Most sediment entering the Delta comes from the Sacramento River (Wright and Schoellhamer 2004). The NDD is expected to divert a portion of the Sacramento River's sediment load, which could result in higher water clarity downstream because less sediment may over time allow greater erosion and less wind- and velocity-driven resuspension of sediment into the water column. The BDCP public draft included estimates of sediment diverted by the NDD at the late long-term time frame (2060) based on historic sediment load estimates for 1991–2002 (see Section 5C.D.3 in the BDCP public draft, Attachment 5C.D to Appendix 5.C *Upstream Water Temperature Methods and Results*). For the effects analysis of the PA in the CWF BA, very similar analytical methods were used based on sediment load estimates for WYs 1991–2003, matched to CalSim II flow and NDD diversion estimates for the same years. The analysis suggested that a mean of 10% (range: 5–15%) of combined sediment load entering the Delta from combined inflow at Freeport and the Yolo Bypass would be removed by the NDD. Considering only the Sacramento River load at Freeport, it was estimated that a mean of 11% (range: 7–16%) of sediment load would be removed by the NDD. If this sediment, some of which will be collected in the sedimentation basins (described in CWF BA Section 3.2.2 *North Delta Diversions*) is not returned to the system, it is possible that water transparency in the Delta will increase over time due to project operations. However, the extent of increases in water clarity cannot be accurately predicted without application of a full suspended sediment model incorporating the whole estuary; modeling has been noted to be necessary for assessment of the effects of managing regional transport of sediment in the Delta (Schoellhamer *et al.* 2012). Thus, there is uncertainty associated with proportional diversion methods.

The CWF BA analysis did not attempt to provide a quantitative estimate for sediment removal by the south Delta export facilities for the PA; based on the estimates by Wright and Schoellhamer (2005), sediment removal by the south Delta export facilities in 1999-2002 averaged to be around 2% of the sediment entering the Delta at Freeport, *i.e.,* an order of magnitude less than estimated to be removed at the NDD, so the net sediment removal under the PA (NDD exports plus less south Delta exports from existing conditions) would be expected to be appreciably greater than sediment being removed without the project. As described in CWF BA Section 3.2.10.6 *Dispose Spoils*, DWR will collaborate with Service, NMFS, and CDFW to develop and implement a sediment reintroduction plan that minimized effects of sediment removal by the NDD. The proposed sediment reintroduction is expected to require subsequent future approvals from the Corps or Reclamation, in addition to a permit from the Water Control Board. If sediment reintroduction actions proposed by DWR are not implemented, sediment removal may be a long-term, population-level concern for delta smelt and may not be manifested until well into the future. However, population-level effects will likely be limited by factors influencing the timing of higher flows in the system and when suspended sediment concentration often is relatively high.

Increases in water clarity during the latter parts of spring when suspended sediment concentration decreases may result in adverse effects to individual delta smelt eggs/embryos by becoming more visible to predators. Water clarity is related to larval/young juvenile delta smelt feeding success (Baskerville-Bridges *et al.* 2004) and spatial distribution (Sommer and Mejia 2013). As with eggs/embryos and the latter portion of the spawning adult life stage, the occurrence of larval/young juvenile delta smelt bridges the transition between higher flow during winter months and lower flow during summer months, when the suspended sediment concentration in inflowing Sacramento River water decreases and resuspension of sediment delivered in the higher flow months becomes more important.

Occurrence of juvenile delta smelt during the low-flow time of year when suspended sediment concentration in inflow is at a minimum suggests that the NDD's removal of sediment may adversly affect individual juvenile delta smelt by increasing water clarity, given the importance of resuspension of sediment delivered to the estuary by higher flows in winter/early spring.

Entrainment of Food Web Materials

As highlighted by Arthur *et al.* (1996), Jassby and Cloern (2000) and Jassby *et al.* (2002), and the 2008 Service BiOp, CVP and SWP water exports directly entrain phytoplankton and zooplankton which are the base of the food web supporting the production of delta smelt. Water diversions are one source in which the delta smelt food supply and availability have declined over the years. Clam grazing and ammonium inhibition of per capita diatom growth rates are other well documented causes. Entrainment of phytoplankton and zooplankton by the south Delta export facilities generally would be expected to be reduced under the PA, but the NDD would add a new source of loss along the Sacramento River. The impact was examined using an assessment of phytoplankton carbon entrained, based on chlorophyll *a* concentration data for Hood (representing the load of entrained phytoplankton), in relation to the biomass of phytoplankton in the Delta (taken from Antioch chlorophyll *a* data, multiplied up to the volume

of the Delta). The methods are presented in the CWF BA Appendix 6.A *Quantitative Methods for Biological Assessment of Delta smelt*, Section 6A.4.2. This analysis is an approximation of potential entrainment of phytoplankton carbon load that could be entrained by the NDD. Factors that could minimize any potential effects to delta smelt include the in situ productivity of phytoplankton carbon within the Delta, which could be large, and reduced entrainment of phytoplankton carbon by the south Delta export facilities under the PA. These factors are discussed qualitatively.

Based on information provided in the CWF BA, median (50th percentile) estimates of phytoplankton carbon load entrained by the NDD ranged from around 0.2 metric tons/day in April and May (5th to 95th percentile ranges were 0.00–0.02 to ~ 1.8 metric tons/day) to ~ 1.6 metric tons/day in February (5th to 95th percentile range ~ 0.13 to 5.7 metric tons/day). Estimates of phytoplankton carbon biomass in the Delta for 2004–2015 ranged from less than 23 metric tons (December 2011) to more than 230 metric tons (May 2010). Thus, the percentage of Delta phytoplankton carbon biomass estimated to be entrained by the NDD ranged from 0.0% based on the 5th percentile of entrained load estimates at the NDD during several months up to 12% at the 95th percentile load estimate combined with the minimum biomass estimate in December. The median estimates of total fraction of phytoplankton biomass removed by the NDDs ranged from ~ 0.5% to 2% per month when compared to minimum Delta phytoplankton carbon biomass estimates, down to ~ 0.1% to 1% when compared to maximum Delta phytoplankton carbon biomass estimates. On the basis of the 95th percentiles, it appears that the NDD would seldom if ever entrain more than ~5% of the Delta's standing stock of phytoplankton in any given month.

The loss of phytoplankton carbon at the NDD must be considered in the context of all CVP and SWP water diversions because inflows to and exports from the Delta strongly affect the flux of bioavailable carbon into the confluence and Suisun Bay (Arthur *et al.* 1996; Jassby and Cloern 2000). If used as the only source for Delta exports and without any change in total Delta exports, the NDD would increase the export of biological productivity to the western Delta and Suisun Bay because the San Joaquin River is richer in its organic matter load than the Sacramento River (Jassby and Cloern 2000). The PA does not cease exports from the south Delta, but reduces reliance on the south Delta exports generally by greater than 50 percent. The long-term (1922–2003) average reduction when compared to baseline conditions from the CalSim II modeling ranged from 45% less under the PA in January to ~70% less in October. Only in December (12% less under the PA) were the differences less than 50 percent (see CWF BA Appendix 5.A *CALSIM Methods and Results*, Figures 5.A.6-27-1 to 5.A.6-27-19 and Table 5.A.6-27). Jassby *et al.* (2002) estimated that on average during spring through fall, the Delta produces 44 metric tons/day of phytoplankton carbon and another 12 metric tons/day flows into the Delta from its tributaries. Of the total 56 tons/day, the south Delta export facilities remove ~8 metric tons/day or about 14% (Jassby *et al.* 2002)[28]. It is anticipated that the overall long-term ~50% reduction in south Delta exports will increase the loading of relatively productive San Joaquin River water to

[28] An additional ~5 metric tons per day were estimated to be removed by agricultural diversions. Such losses would present under both the projected baseline conditions and PA.

the western Delta and Suisun Bay and therefore will minimize the loss attributable to the NDD, and perhaps could provide a net production.

CalSim II estimates of total Delta exports also provide context for the difference in potential food web productivity between PA and baseline conditions: total Delta exports on average (1922–2003) would be greater under PA (almost 4.9 million acre feet/year) than under baseline conditions (just under 4.7 million acre feet/year). Total Delta exports would be less under PA than baseline conditions in September-November; similar in April-May and August; and generally less under PA than baseline conditions in the remaining months, to varying degrees (see CWF BA Appendix 5.A *CALSIM Methods and Results*, Figures 5.A.6-28-1 to 5.A.6-28-19 and Table 5.A.6-28). If phytoplankton availability was a linear function of CVP and SWP exports, then the annual average change in biomass would be approximately -4%. However, the timing of differences in exports in relation to different life stages is important, and consideration should also be made of the *in situ* productivity that would occur in the Delta, and the relative contribution of this to the delta smelt food web.

The primary mechanisms by which entrainment of planktonic organisms affect individual delta smelt is by temporarily reducing density of zooplankton immediately downstream of the NDDs or by reducing the load of phytoplankton further into the estuary, causing unknown reductions in food for the zooplankton eaten by delta smelt.

At the population level, the effects of entrainment of phytoplankton carbon are likely not important in affecting delta smelt prey abundance. As noted by Baxter *et al.* (2010) and the IEP (2015), there has been little study of prey importance for adult delta smelt, and there is no evidence for food limitation in the adult life stage. However, there may be lower loads of phytoplankton carbon into the estuary because of NDD entrainment could translate into less food for individual delta smelt larvae and young juveniles. It was estimated that a range from less than 0.1% to over 5% of phytoplankton carbon entering the Delta could be entrained by the NDD in March–June. However, the phytoplankton has to be converted into copepod biomass to be prey for larval delta smelt and that process is not always directly related to phytoplankton density as indexed by chlorophyll *a* concentrations in the water (Kimmerer 2002). Given lower south Delta exports when north Delta exports are relatively high, there may be a net increase in phytoplankton carbon production in the Delta due to higher loading from the comparatively productive San Joaquin River that could minimize the loss estimated for the NDD, and perhaps could even provide a net production.

The feeding success of delta smelt larvae appears to be related to prey density (Nobriga 2002). Statistical analyses of delta smelt population dynamics have shown evidence that prey abundance for delta smelt during the larval and early juvenile life stage affects delta smelt abundance (Maunder and Deriso 2011; Miller *et al.* 2012). Other statistical treatments have found less support for this hypothesis (Mac Nally *et al.* 2010; Thomson *et al.* 2010). The hypothesis was also not supported in a recent empirical study of delta smelt feeding ecology and food limitation (Slater and Baxter 2014). In this study, evidence of food limitation was greater for juvenile fish in the late summer than it was for larvae or small juveniles during the late spring. Most likely, food limitation would act as a chronic problem extending across multiple life stages (Rose *et al.*

2013a,b), except possibly for the more mature adults. Less phytoplankton carbon loading to the estuary because of NDD entrainment could reduce the abundance zooplankton. However, the estimates of phytoplankton carbon entrainment were not large (5.4% at the 95th percentile). This, in conjunction with observations that *in situ* production of phytoplankton carbon within the Delta is several times greater than inputs from freshwater inflow (Jassby *et al.* 2002) and that this *in situ* production is the dominant supply to the planktonic food web that includes delta smelt (Sobczak *et al.* 2002), suggests that the entrainment of phytoplankton carbon by the NDD would only have a minor, if any, adverse population-level effect, particularly given the increases in relatively more productive San Joaquin River water during these months.

The empirical evidence for food limitation during the juvenile life stage is generally stronger than it is for other life stages (Slater and Baxter 2014; Hammock *et al.* 2015). Thus, lower phytoplankton carbon load available to the food web (as a result of NDD entrainment) could result in less prey for individual juvenile delta smelt. During July-November, it was estimated that less than 5% of phytoplankton standing stock could be entrained by the NDD (95th percentile for high end estimates). It is possible this loss will be offset by higher loading of phytoplankton from the San Joaquin River.

Microcystis

The toxic cyanobacteria *Microcystis* has been shown to have negative effects on the aquatic foodweb of the Delta (Brooks *et al.* 2012), principally in the south Delta and the middle to upper portions of the west/central Delta near locations such as Antioch, and Franks Tract (Lehman *et al.* 2010). As reviewed by Brooks *et al.* (2012), *Microcystis* could affect delta smelt through direct ingestion, consumption of prey containing high concentrations of toxins, or toxic effects to prey leading to lower prey abundance. *Microcystis* blooms generally occur from June to October, when water temperature is at least 19°C (Lehman *et al.* 2013)[29]. However, this analysis focused on July-November to stay consistent with the general timing of delta smelt juvenile life stage, which co-occurs with *Microcystis* blooms. Lehman *et al.* (2013) suggested that net flows are probably the most important factor maintaining *Microcystis* blooms because low flows with longer residence times allow the slow-growing colonies to accumulate into blooms. Other factors, including nutrients, are also important to *Microcystis* (Lehman *et al.* 2014), but are not readily predictable for comparison of the NAA and PA scenarios, which introduces uncertainty.

The potential effects of PA water operations on *Microcystis* were assessed using two approaches. First, the frequency of flow conditions conducive to *Microcystis* occurrence (as defined by Lehman *et al.* 2013) was assessed in the San Joaquin River past Jersey Point (QWEST) and in the Sacramento River at Rio Vista (QRIO), based on DSM2-HYDRO modeling. Second, DSM2-QUAL water temperature modeling (CWF BA Section 6.1.3.5.2, *Water Temperature*) and DSM2-PTM for estimates of residence time (CWF BA Appendix 6.A *Quantitative Methods for*

[29] During the current drought conditions, *Microcystis* has been detected in appreciable quantities in December, presumably because relatively warm temperatures and low inflow have favored growth beyond the typical period of occurrence.

Biological Assessment of Delta Smelt, Section 6.A.4.3, methods discussion) were used to inform the potential for *Microcystis* occurrence, given the importance of water temperature and the probable importance of residence time (although there are no published relationships between *Microcystis* occurrence and residence time in the Delta). Note that more weight is placed on the analysis based on the published flow conditions at which *Microcystis* occurs (Lehman *et al.* 2013), because there are no published analyses between *Microcystis* occurrence and residence time. Both sets of quantitative analyses (*i.e.,* the flow analysis and the residence time/temperature analysis) focused on the summer/fall (July-November) period because it is during this time of the year that *Microcystis* blooms are likely to occur. Note that other factors including nutrients are also of importance to *Microcystis* (Lehman *et al.* 2014), but these are not readily predictable for comparison of the NAA and PA scenarios, which introduces some uncertainty to the results based only on flow or residence time/temperature.

The first analysis examined the frequency of years during July-November in which mean monthly flows were within the range at which *Microcystis* has been shown to occur, per Lehman *et al.* (2013: 155): -240 to 50 m^3/s (approx. -8,500 to 1,800 cfs) for QWEST, and 100-450 m^3/s (approx. 3,500 to 15,900 cfs) for QRIO[30]. This analysis suggested that flow conditions conducive to *Microcystis* bloom occurrence would tend to occur less frequently under the PA than observed in the projected baseline conditions in the San Joaquin River, based on QWEST. For the baseline conditions, the percentage of years with QWEST within the range for *Microcystis* occurrence ranged from 89% in October to 98% in August, whereas for PA, the range was from 9% of years in October to 99% of years in August. In neither the projected baseline conditions nor the PA scenario were mean monthly flows below the range noted for *Microcystis* occurrence, whereas for PA there were substantially more years above the range than in the baseline. The results reflected greater mean QWEST flows under the NAA compared to PA, with monthly means under the PA ranging from just under 0 m^3/s (-100 cfs) in August (compared to -168 m^3/s or -5,900 cfs under projected baseline conditions) to 245 m^3/s (8,600 cfs) in October (compared to 16 m^3/s or 570 cfs under projected baseline conditions). These results are attributable to less south Delta export pumping under PA than in the baseline.

Implementation of north Delta export pumping under the PA would result in less Sacramento River flow compared to baseline conditions, as reflected in the examination of QRIO. The percentage of years within the range at which *Microcystis* has been noted to occur ranged from 59% in September to 89% in August under the projected baseline, compared to a range from 48% in September to 96% in July for PA. Given that Lehman *et al.* (2013) suggested mechanism for the importance of flow was lower flows leading to sufficiently long residence time to allow *Microcystis* colonies to accumulate into blooms, flows below the range noted for *Microcystis* occurrence by Lehman *et al*. (100-450 m^3/s) could also be favorable for bloom occurrence, whereas flows above the range may reduce residence time sufficiently to limit bloom formation. The percentage of years in which mean monthly flow was above the range that Lehman *et al.* (2013) found for *Microcystis* occurrence was less under PA than NAA in July (0%, compared to

[30] The DSM2-HYDRO output locations used for estimating QWEST were RSAN018 + SLTRM004 + SLDUT007; and for QRIO was RSAC101.

10% under the projected baseline), September (0%, compared to 29% under NAA), and November (10%, compared to 16% under the projected baseline). On the basis of differences in QRIO flow, therefore, there could be greater potential for *Microcystis* occurrence in the lower Sacramento River under the PA than the projected baseline condition. However, this is presently not an area of intense *Microcystis* blooms and if this area remains turbid in the future, it is expected that current conditions will continue.

The results of the DSM2-PTM-based residence time analysis presented here focus only on the particle insertion locations upstream (east) of Suisun Bay and Suisun Marsh, because this is where effects of the proposed action (PA) on hydraulic residence time are highest. The effects of the PA on residence time varied by subregion. As previously described, there has been no published analysis of the relationship between *Microcystis* occurrence and residence time, so there is uncertainty as to what the differences described here may mean in terms of potential for *Microcystis* occurrence. The results showed that regions with short residence times sometimes are predicted to have large proportional changes in residence time (*e.g.*, locations near the NDDs) and regions with comparatively long residence times typically had moderate to low proportional changes in residence time . Differences between NAA and PA ranged from almost no change in the Sacramento River Deepwater Shipping Channel to sometimes substantial increases in predicted residence times (*e.g.*, Disappointment Slough where median predictions ranged from -3.8 to + 11.9 days, Mildred Island where median predictions ranged from + 5.8 to + 16.5 days, and Victoria Canal where median predictions ranged from + 3.0 to + 11.7 days). These results indicate that *Microcystis* may have considerably more opportunity for growth in parts of the southern Delta where water temperatures are relatively high during the summer and present-day blooms are often observed.

Microcystis blooms occur during the mid to late summer and early fall so there will be no effect on adult delta smelt during the spring months. The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for delta smelt is low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm an individual spawning adult or egg/embryo. There is some potential overlap in timing between larval life stages of delta smelt and *Microcystis* blooms.

As previously discussed in the water temperature analysis, climate change is likely to increase summer water temperature but it is not clear whether the PA would change water temperature. The warming climate may increase the length of the viable growing season for *Microcystis* blooms and would interact with PA-related changes in residence time and possibly other conditions (*e.g.*, nutrient loads; Lehman *et al.* 2013) to affect the duration and intensity of blooms. The threshold could be reached earlier in the year under the PA (see previous discussion of timing shifts for spawning Delta smelt), which would increase the length of exposure for Delta smelt and their prey, although air temperature as opposed to flow (operations) is the primary driver of water temperature in the Delta (Wagner *et al.* 2011). Based on the published ranges of flows that support *Microcystis*(Lehman *et al.* 2013), greater flows in the lower San Joaquin River (QWEST) under the PA would be expected to have less potential for *Microcystis* relative to the projected baseline condition. In the PA, a greater percentage of years were above the range of flows at which *Microcystis* has occurred. As summarized in the analysis of residence time

already presented, higher residence time was most evident in predictions for the central/south Delta subregions, but also occurred elsewhere, for instance, in the lower Sacramento River (Chipps Island to Rio Vista) and the Cache Slough/Liberty Island area. With the possibility of longer duration and more intense *Microcystis* blooms resulting from longer residence time, individual juvenile delta smelt may experience a greater likelihood of lethal or sublethal toxicity, or have lessened prey availability (Ger *et al.* 2009; 2010; Lehman *et al.* 2010; Acuña *et al.* 2012; Brooks *et al.* 2012).

Most delta smelt are not in the southern Delta during the summer and fall because the water is too warm and too clear (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Therefore, the delta smelt population does not overlap the peak of the *Microcystis* bloom in space and time. Nonetheless, there is overlap in the low-salinity zone and *Microcystis* can be toxic to copepods. There is potential for more localized higher residence times to intensify blooms that harm or kill delta smelt directly or indirectly by killing their prey or by increasing toxin concentrations in the prey. In the lower San Joaquin River, the analysis based on QWEST flow suggested that generally there would be less potential for *Microcystis* occurrence under the PA. The analysis based on residence time showed that in portions of the south Delta there may be potential for greater *Microcystis* occurrence because of greater residence time, although there are no published relationships between *Microcystis* and residence time to make firm conclusions. There is potential to minimize effects through preferential south Delta export pumping. The modeling currently assumes that in the summer months (July–September), the first 3,000 cfs of exports would be from the south Delta, with any additional allowable exports diverted from either the north or the south Delta, and preference for additional pumping being given to the north Delta (because of higher water quality). It would be possible to shift to additional south Delta pumping as opposed to north Delta pumping in order to reduce water residence time during real-time operations.

Selenium

The selenium concentration in adult delta smelt would be expected to increase during the migration and spawning period. However, the potential to exceed the assumed detrimental threshold of 7.2-µg/g selenium whole-body tissue concentration would be limited spatially (San Joaquin River at Prisoner's Point) and in few years.

Eggs/embryos would not be feeding and exposed to selenium directly. To the extent that selenium is passed from female delta smelt to the eggs, the eggs/embryos would have greater selenium under the PA than baseline conditions. However, as previously described for spawning adults, the incidence of exceedance of the 7.2-µg/g selenium whole-body tissue concentration threshold for spawning adults is limited spatially and temporally, suggesting the likelihood of limited negative effects to eggs/embryos. There is uncertainty in the extent to which selenium could be transferred from female delta smelt to the eggs.

Reflecting the potential for extremely limited individual-level effects, the population-level effects on eggs/embryos would also be limited, although there is uncertainty in the extent to which selenium could be transferred from female delta smelt to the eggs.

The spring months tend to result in the greatest concentrations of selenium in delta smelt tissue, as a result of San Joaquin River inflow to the Delta having the greatest contribution to Delta waters in these months (because of south Delta export restrictions and, in the case of the PA, the HORG). Young juvenile delta smelt (those that are preying on organisms would have a greater risk of accumulating selenium under the PA than otherwise in the baseline. However, as previously described, the risk remains low relative to the rarely exceeded 7.2-µg/g selenium whole-body tissue concentration threshold.

Although the spring months have the greatest risk of potential effects compared to other months, and potential for effects to individual delta smelt, the limited spatial extent of the effect (1 of 5 locations) and frequency of occurrence (very few months of the 82 years that were modeled) suggests little potential for population-level effects. As shown in the Prisoner's Point results broken down by month, the juvenile delta smelt tissue concentration during July–December would be greater under PA than the projected baseline, but well below the 7.2-µg/g selenium whole-body tissue concentration threshold. This indicates the potential for detrimental effects on juvenile delta smelt from selenium during these months is low.

9.2.2.2.9 Summary of Operations-related Effects on Delta Smelt Reproduction, Numbers, and Distribution

By operating the proposed water conveyance facilities, there is potential risk to delta smelt individuals (especially larvae, juveniles, and adults) from entrainment/impingement and increased predation rates. Under a dual conveyance (*i.e.,* South Delta and NDD facilities in operation), there is expected to be reduced entrainment in wet, above normal, below normal, and dry WY Types from baseline. Critical WY types are expected to maintain (or slightly increase) entrainment levels similar to what is experienced in projected baseline conditions. This is likely due to the heavier reliance on the South Delta facilities when North Delta bypass flow criteria limit the use of the NDD in critical years – resulting in similar entrainment levels at the South Delta facilities to those that currently exist. Overall, when analyzing the totality of the operations, there appears to be a reduction from baseline conditions in entrainment levels thereby having a reduced effect on the delta smelt population size from salvage/entrainment.

The PA will result in substantial adverse effects by the constriction/reduction in available habitat to delta smelt that support the migration, spawning, transport, and rearing processes that are necessary for reproduction and therefore survival of the species. The construction of the NDD is expected to result in restricted access to all migratory and spawning habitat from the southernmost intake to the northern extent of their range. Additionally, with exports still continuing in the southern Delta there is still an entrainment footprint that extends into the waterways of the interior Delta toward the west from the south, albeit reduced from baseline conditions due to the reduced reliance on South Delta exports. Generally speaking, the spring outflow criteria will maintain outflow targets in the spring (March, April May), resulting in higher exports under the PA in July, August, and December and Septembers when the Fall X2 component 3 of the 2008 Service BiOp RPA is not triggered and implemented. The PA operations will result in eastward changes in the location of X2 in below normal, dry, and critical WYs, which will constrict rearing habitat.

The PA will result in a constriction of suitable habitat within the historic range of delta smelt from the permanent removal of, and restricted access to, suitable habitat in the Upper Sacramento River, suitable habitat within the risk of entrainment footprint in the southern Delta, and small reductions in habitat from the west from the inward movement of X2 during certain months across WY types. Within that available habitat to delta smelt, we expect to observe: small reductions in available food supply; increased predation rates associated with structures, increased water clarity, residence times, reduced flows, and creation of suitable predator habitat; increased favorable conditions for predators and competitors; slightly modified flow regimes; increased exposure to low levels of contaminants (likely not reaching lethal levels in most cases); reductions in suitable spawning substrates; and the potential for increase in macrophytes and exposure to harmful cyanobacteria blooms. We mostly observe no change or negligible to low-level effects from changes to salinity, water temperature, sediment removal/water clarity, food supply, *Microcystis*, and selenium as a direct result on the reproduction and survival of delta smelt; however, for an annual species, factors affecting habitat conditions throughout its short life span are important to its success or failure especially when baseline conditions are not meeting the needs of the species.

As discussed above under *Uncertainties Regarding Operations*, the CWF operational scenario that has been analyzed above will almost certainly change between now and when the dual conveyance system goes online. Reclamation and DWR have committed to propose future actions that will avoid jeopardizing the delta smelt and destroying or adversely modifying its critical habitat. Those future actions could include: new or modified operational criteria, minimizing project footprints during the final design phase, conservation efforts to maintain or increase trends in delta smelt abundance, efforts to restore and/or improve habitat conditions that support delta smelt, and other actions to be defined in the future. These future actions will be informed by the State Board process, reinitiation of the 2008 Service BiOp, the Adaptive Management Framework, and other state and federal processes.

9.2.2.3 Effects to Recovery

DWR has proposed to minimize the adverse effects of the loss and degradation of habitat by implementing actions to promote the recovery of the delta smelt in a manner where the mitigation is commensurate with the adverse effect. DWR has proposed to restore or create 348.9 acres of habitat to minimize the total loss of individuals predicted for the life of each project. As we stated previously, habitat loss and degradation are contributing factors to the decline of delta smelt. The proposal to create or restore additional migratory and spawning habitat is a reasonable means of minimizing the adverse effects of the loss of individuals, on the species as a whole, and may benefit the recovery of the delta smelt. However, it remains to be seen that the yet-to-be determined mitigation will be able to mitigate the effect of the NDD restricting access to the northern portion of the range.

The Service issued a *Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes* (Recovery Plan) in 1996 (Service 1996). The Service is in the process of revising the Recovery Plan for Delta and Longfin Smelt. In the absence of an updated recovery plan, the Service has

used other available information since the 1996 Recovery Plan to propose what delta smelt need in order to survive and recover. Sources used to develop the needs include, but are not limited to:

- the delta smelt listing and its designated critical habitat on March 5, 1993 (Service 1994);
- the 1996 Recovery Plan;
- the 5-year status review of the delta smelt on March 31, 2004 (Service 2004);
- the 2008 Formal Endangered Species Action Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP) (2008 USFWS BiOp; Service 2008);
- the 5-year status review on September 13, 2010 (Service 2010a);
- 12- month finding on April 7, 2010 (75 FR 17667; Service 2010b);
- Candidate Notice of Review (Service 2016);
- In Draft Recovery Plan for Delta and Longfin Smelt (under development); and
- Other resources available to the Service.

Based on available resources, the Service has proposed that in order to survive and recover, delta smelt need:

Abundance - a substantially more abundant population, which are notably linked to the success of recruitment between life stages. Abundance is affected by entrainment, predation, feeding, competition, demographics/genetics, reproductive success, and fish condition/health.

Entrainment/Impingement Risk

- A reduction in entrainment/impingement of adult, juvenile, and larvae individuals and their food supply at CVP and SWP pumping facilities, over and above reductions achieved under the real-time operations of the 2008 Service BiOp, to increase the abundance of the spawning adult population and the potential for recruitment of larvae and juveniles into the adult population. This can be done through OMR modified actions to increase protection among life stages/processes.
- A reduction in entrainment/impingement from water diversion-related structures within delta smelt critical habitat where delta smelt adults, larvae, or juveniles are known or are likely to be impinged or entrained to increase the adult population and the potential for recruitment of juveniles into the adult population.
- A reduction in entrained food supply from water diversion-related structures and pumping facilities within delta smelt critical habitat.

Predation

- Increased escape cover (*i.e.*, sufficient habitat to reduce/avoid predation from observed increases in water clarity).

- Reduction in predators in the Bay-Delta ecosystem to increase survival of adults, larvae, and juveniles from to an overall increase in relative abundance of predator species system-wide.

Feeding
- Increased food quality, production retention, timing and availability.
- Restoration and enhancement of the food web structure in the Bay-Delta to a condition that more closely mimics the natural environment (*i.e.*, pre-water development) to increase survival of adults and juveniles.

Competition
- Reduction in competition from non-native fish and invertebrates.

Demographic/Genetic
- Maintain or increase genetic diversity within the population and allee effects (e.g., reduced schooling ability, reduced ability to find mates).

Reproductive Success
- Restoration of migratory and spawning cues from reductions in the spawning season window and modification of natural flow regimes.
- Increase the condition of spawning individuals, such as fish size (*e.g.*, weight, length), fat storage, sufficient calorie intake, and lipid energy.
- Improve delta smelt vital rates, including higher growth rates and higher fecundity levels.
- Improve the sex ratio (males to females) – with recognition that there is uncertainty associated with this need and therefore is identified as needing additional research and monitoring.

Fish Body Condition/Health
- Improve physical health through a reduction in contaminants exposure and other pollutants (*e.g.*, metals, pesticides, CEC's [endocrine disruptors], etc.) within its habitat to increase survival of adults, larvae and juveniles.

Habitat - an increase in the quality and quantity of suitable migratory, spawning, and rearing habitat. Improved habitat quality within the Bay-Delta should enhance delta smelt reproduction and allow for recruitment success necessary to the species to survive. Suitable habitat conditions require habitat diversity, water quality, and flow.

Habitat Diversity
- Increase habitat complexity (*e.g.*, reduction in dead end sloughs) and heterogeneity.
- Increase in the quality and quantity of suitable spawning habitat and substrate (*i.e.*, sandy beaches with sufficient water velocities, available for direct use) due to reductions in sandy beaches system-wide.

- Maintain or increase (*i.e.*, protect, restore, create, or enhance) suitable habitat within designated critical habitat (*i.e.*, with PCE's), further preventing reductions in habitat.

Water Quality

- Improve water quality – suitable water quality constituents within optimal range (*i.e.*, turbidity, DO levels, water temperature, pH, salinity).

Flow

- Improve flow conditions – suitable flow conditions (*i.e.*, velocity, [delta] freshwater outflow, salinity, tidal energy, flow suitable for spawning migration, to trigger movement to spawning areas, and egg incubation)

These can be achieved as a result of active or passive management of water and sediment processes in the San Francisco Bay-Delta ecosystem that mimics more natural (*i.e.,* pre-water development) conditions.

Other needs – Other factors that affect delta smelt include climate change, aquatic invasive macrophytes, harmful cyanobacteria blooms (Microcystis), disease, and exposure to in-water work activities.

Climate Change

- Maintain and increase sufficient suitable habitat from threats of ecosystem changes (community and habitat shifts).
- Prevent reductions/shifts in suitable habitat due to sea-level rise and increased droughts and temperatures.
- Maximize delta smelt population resilience in the face of the potential adverse effects of ongoing climate change that are occurring in the Bay-Delta ecosystem.

Aquatic Invasive Macrophytes

- Reduce aquatic invasive macrophytes due to increased predator habitat from changes in water quality as a result of increased water clarity, residence times, and flow reductions.

Harmful Cyanobacteria Blooms (*i.e., Microcystis*)

- Reduce harmful cyanobacteria blooms from increased water residence time/flow reductions and increased anthropogenic nutrient inputs.

Disease

- Reductions in disease to increase survival of adults, larvae, and juveniles.

Risk to Individuals from Exposure to In-water Work Activities (e.g dredging rip-rapping, suction dredging, agricultural diversions)

- Reduce sources of harassment, harm, or mortality to delta smelt individuals, habitat loss, and effects to prey density (*i.e.*, modification of food supply).

Relative to the recovery needs identified above, effects as a result of implementing the PA are likely to:

- Decrease the abundance of delta smelt through:
  - maintained (all WY types) or low increases (in critical WYs) at high entrainment/impingement levels;
  - increase food supply production and availability to delta smelt in the south Delta and decrease in the upper Sacramento River ;
  - increased risk of predation (*i.e.*, associated with structures, increased water clarity, residence times, reduced flows, and creation of suitable predator habitat);
  - maintain or increase favorable conditions for predators and competitors;
  - no improvement toward natural flow regimes;
  - reduce reproductive success from small alterations in the timing, production retention, and availability of food resources; and
  - increase in exposure to low levels of contaminants.
- Decrease in quality and quantity of suitable and available migratory, spawning, and rearing habitat through:
  - reductions in available shallow water habitat available for direct use by migrating adults, spawners, eggs/embryos, larvae, and young juveniles;
  - reductions in suitable sandy substrates, thought to be preferred by delta smelt for spawning;
  - small reductions in juvenile rearing habitat in the summer and fall months;
  - increased water clarity;
  - maintained or reductions in Delta outflow; and
  - constricting suitable habitat within the historic range of delta smelt from permanent removal and restricted access to suitable habitat in the Upper Sacramento River, suitable habitat within the risk of entrainment footprint in the southern Delta, and inward movements of X2 from the west – all within critical habitat.
- Potential for increased aquatic macrophytes due to changes in water clarity, residence times, and flow reductions.
- Increased exposure to potentially harmful cyanobacteria (*Microcystis*) blooms.
- Harassment, harm or mortality to delta smelt individuals, habitat loss, and effects to prey densities from in-water work activities.

Summary of Effects of the PA on Delta Smelt Recovery

Habitat conditions in the Delta are currently not supporting the delta smelt population, as demonstrated by their declining population size. Factors contributing to this decline include:

- the reduction and alteration of the hydrograph
- competition with other organisms for food
- toxins and pollutants that are altering their feeding, breeding, and survival
- decreased turbidity (increased water clarity) in the Delta

With the implementation of the PA, overall baseline habitat conditions are maintained or worsened (*i.e.,* reduction of habitat, water temperature, water clarity, food supply, and exposure to contaminants and dissolved oxygen). The PA is expected to reduce the current level of entrainment by OMR flows for delta smelt, which could increase abundance and recruitment in the south Delta. The PA does little to contribute to recovery overall, although the compensatory mitigation is expected to minimize the effects of lost and degraded habitat as a result of the PA.

9.2.1.1 Effects of the Aggregate Status of the Species/Environmental Baseline, and Proposed Action for Delta Smelt

This section summarizes the aggregate status, baseline, and effects of the PA. As previously noted under *Uncertainties Regarding Operations*, the CWF operational scenario that has been analyzed above will almost certainly change between now and when the dual conveyance system goes online. Reclamation and DWR have committed to propose future actions that will avoid jeopardizing the delta smelt and destroying or adversely modifying its critical habitat.

Summary of the Status of the Species

There has been an overall declining trend in population abundance since the Pelagic Organism Decline (POD). Due to current low population estimates and record low detections of delta smelt in monitoring efforts, the individuals remaining in the population are more vulnerable and susceptible to threats and stressors that threaten even further reductions in the population. As of February 2016, the adult delta smelt population was estimated to be between 6,000 and 28,000 fish with a point estimate of 13,000 individuals. Later that year, June (2016) post-larvae estimates were at 113,882 individuals (SE$\pm$ 47,055). Delta smelt is likely on the brink of extinction (Moyle *et al.* 2016) and like almost all imperiled species the major threat is, in the broadest sense, loss of habitat. And in the case of delta smelt, habitat conditions have been worsened with the historic drought, now in its sixth year.

Summary of the Environmental Baseline and Existing Conditions

Much of the Action Area has been altered or degraded from its historical state; where coverage of freshwater emergent wetlands decreased from 193,224 to 4,253 ha while open-water habitats increased from 13,772 to 26,530 ha (Robinson *et al.* 2014). Much of its historic habitat is no longer available and remaining habitat is increasingly unable to sustain the population (Moyle 2016). Loss of shallow water edge habitat along the Sacramento River and its tributaries has occurred over time from rip-rapping and will be maintained under existing levee erosion repair consultations. Historically, the water diversions of the CVP and SWP export facilities have maintained high-levels of pumping. However, since the implementation of the 2008 Service and

2009 NMFS BiOps, the RPA's have been regulating export levels in the south Delta through negative OMR limits and Inflow:Export ratios, in addition to other regulatory processes, to curtail pumping related effects to delta smelt and other federally listed species. The delta smelt population size has been difficult to monitor due to the low number of individuals remaining. The current population cannot tolerate direct mortality through habitat alterations and entrainment at the current observed levels of south Delta pumping. As previously stated, delta smelt are nearing extinction based on record low numbers observed in monitoring efforts (Moyle 2016).

Other sources of injury/mortality to delta smelt occurring in the Delta ecosystem include: dredging; sand-mining; wastewater treatment plants; aquatic weed control; managed wetland activities; research and monitoring efforts; and other consultations of much lower effect to delta smelt. The Service has collaborated with other state, federal, and private entities to significantly reduce monitoring and research efforts that result in lethal take in parallel with the observed change in status of the species. Although greatly reduced, existing monitoring and research programs, like the IEP, still take delta smelt through the form of injury or mortality in the hundreds annually across all life stages (see *Existing Conditions and Previous Consultations in the Action Area*). In addition to those existing IEP monitoring efforts, additional efforts are anticipated to continue into the future, such as the Enhanced Delta Smelt Monitoring that could take up to 1,050 delta smelt annually. Although, it is important to recognize that those numbers of individuals may be lower than estimated when implemented due to the rarity of recent delta smelt observations in the wild.

As mentioned previously, loss/degradation of suitable habitat continues to pose the largest threat to delta smelt. Efforts by DWR and Reclamation are currently being made through the Delta Smelt Resiliency Strategy to improve baseline habitat conditions and therefore abundance of the population (DWR 2016); however, many of the efforts are still in the planning or preliminary stage of implementation and future implementation is uncertain. Other recovery actions being discussed, include the future development of an estuarine research station and fish technology center (*e.g.*, additional genetic, hatchery, and propagation efforts above and beyond those currently being performed by the FCCL and the Service), which are also uncertain.

Forecasted warmer water temperatures and higher salinity in the Delta due to climate change will likely further impair delta smelt habitat in the future. Effects of climate change on the population are likely already affecting delta smelt. Some observations include slightly warmer temperatures, small increases in sea-level rise, reductions in the spawning window, and earlier spawning.

Summary of the Effects of the PA on the Reproduction, Numbers, and Distribution of Delta Smelt

<u>Reproduction</u>

Construction and pre-construction activities are only expected to result in minor impacts to reproduction of delta smelt. The largest threat to delta smelt from the PA is related to the constriction/reduction in available habitat to delta smelt, that support the migration, spawning,

transport, and rearing processes, that are necessary for reproduction and survival of the species. There will be permanent habitat loss from the construction of the NDD, HORG, new south Delta water facility, and barge landings. The NDD is expected to result in restricted access to all migratory and spawning habitat from the southernmost intake to the northern extent of their historic range. Delta smelt have historically been detected as far north as Knight's Landing. The ability for those adults that migrate up the Sacramento River to spawn in the vicinity of the intakes will be greatly reduced and it is expected that they will be subject to increased risks of injury/mortality from impingement and predation.

Additionally, with continued south Delta pumping there will still be an entrainment footprint that extends into the waterways of the interior Delta toward the west from the south– albeit reduced from baseline conditions due to the reduced reliance on South Delta exports. Habitat conditions will improve along the San Joaquin River, allowing for delta smelt spawning and downstream transport of larvae to occur in areas that may be unsuitable at times due to altered south Delta flow conditions from water exports.

The proposed spring outflow criteria will maintain outflow targets in the spring (March, April May), resulting in increased exports under the PA in July, August, and December and Septembers when the fall X2 component 3 of the RPA is not controlling X2. Therefore, during those times, the PA operations will result in small eastward changes in the location of X2 (*e.g.,* up to approximately 4.8 km) in below normal, dry, and critical years when the Fall X2 component in the RPA is not triggered (above normal and wet) (Appendix A). During the rearing season, these small changes in X2 movement eastward to the interior Delta will result in creating unsuitable salinity conditions in the Suisun area constricting delta smelt to areas that are more channelized. Loss of rearing juveniles and adult spawners from poor habitat conditions will affect survival and recruitment leading into the next generation of delta smelt.

<u>Numbers</u>

Activities associated with the preconstruction, construction, and operations of the water conveyance facilities will adversely affect individuals by harassment, injury, and mortality of delta smelt and loss/degradation of suitable habitat. DWR has proposed to mitigate for the effects to delta smelt individuals and loss of habitat from construction related activities at the proposed compensatory mitigation ratios identified in the *Description of the Proposed Action* and CWF BA *Chapter 3*, with ratios varying from 1:1 to 5:1. Details related to maintenance, monitoring, adaptive management, and implementation of the compensatory mitigation are too speculative to determine take to individuals from implementation of these actions at this time; however, will be assessed during subsequent future consultations (*i.e.,* Phase 2) when information related to final design of the NDD, HORG, restoration locations are available.

By operating the proposed water conveyance facilities, there is potential risk to delta smelt individuals (especially larvae, juveniles, and adults) from entrainment/impingement and increased predation rates. Under a dual conveyance, there is expected to be reduced entrainment at the South Delta facility in all but critical WY types from baseline. Entrainment levels are expected to be maintained, or slightly increased, in critical WY types, similar to what is expected

under projected baseline conditions. This is likely due to the heavier reliance on the South Delta facilities when North Delta bypass flow criteria limit the use of the NDD in critical years – resulting in entrainment levels at the south Delta water facilities similar to what is observed under current regulations. Overall, when analyzing the totality of the operations, in most WY types there will be reductions in entrainment levels from the projected conditions.

The delta smelt population will be most affected by the constriction and reduction in the quantity and quality of available suitable habitat to rearing juveniles and adult spawners. Their habitat size will be greatly reduced from restricted access in the north, altered flows in the south Delta, and interior Delta movements of the LSZ. The quality of habitat will be further degraded by small changes in salinity, water temperature, water clarity, food supply, *Microcystis*, and selenium under the PA. These changes will reduce numbers of delta smelt by: (1) altering their feeding behavior; (2) altering swimming behavior, (3) reducing the quality and availability of food supply, (4) increasing favorable predator habitats, (5) decreasing cover/shelter, and (6) decreasing reproductive success. The PA will provide environmental conditions that will allow for predators and competitors that thrive in stable conditions to persist. Although there is no one single driver of delta smelt population dynamics (Baxter *et al.* 2008), these effects and current threats hinder the ability of the population to recover and maintain higher levels of abundance in the future (Bennett and Moyle 1996; Bennett 2005; Feyrer *et al.* 2007).

The population has been in a declining trend particularly since 2002 and has been almost undetectable in surveys since 2012 (Moyle 2016). The population is thought to be so small that stochastic factors, such as continued drought, the loss of key spawning or rearing sites, or an increase in local abundance of competitors or predators could cause extinction in the wild in the near future (Moyle 2016). Baseline conditions are currently not supporting the need of the species; which for an annual species, factors affecting habitat conditions throughout its short life span are important to its success or failure. It is clear from published research that delta smelt have become increasingly habitat limited over time and that this has contributed to the population declining to their current lowest recorded abundance levels (Bennett 2005; Baxter *et al.* 2008; Feyrer *et al.* 2007, 2008; Nobriga *et al.* 2008). Therefore, the continued loss and constriction of habitat proposed under the PA significantly threatens the ability of a self-sustaining delta smelt population to recover and persist in the Delta ecosystem at abundance levels higher than the current record-lows.

<u>Distribution</u>

The PA will result in a constriction of suitable habitat within the historic range of delta smelt from the permanent removal of, and restricted access to, suitable habitat in the Sacramento River above the NDD and reductions in rearing habitat from the west from the inward movement of X2 during summer months across WY types. The entrainment footprint in the southern Delta is expected to be smaller than current conditions in all but critically dry WYs.

Summary of the Effects of the PA on the Recovery of Delta Smelt

In order to recover delta smelt, they need a hydrograph that more closely resembles historic unimpaired flow conditions and provides optimal X2 habitat conditions. Delta smelt are being out-competed by other organisms for food. A more productive food web is necessary to increase the survival of juvenile and adult delta smelt. The food web must be revived in order for successful survival. Predators and competitors must be removed or controlled to relieve these stressors on delta smelt that are barely surviving in an altered Delta ecosystem. Delta smelt require a reduction in toxins and pollutants that are altering their feeding, reproductive success, health, and fish body condition, in order to increase survival of individuals and the overall population. Increased presence of *Egeria densa* and other invasive aquatic macrophytes, in combination with reductions of sediments in the Delta, have resulted in decreased turbidity (increased water clarity) in the Delta. Delta smelt rely on turbid waters in order to successfully feed and reproduce (*e.g.,* movement and spawning cues).

With the implementation of the PA, overall baseline habitat conditions are maintained or slightly worsened (*i.e.,* water temperature, water clarity, food supply, and exposure to contaminants). Habitat conditions in the Delta are currently not supporting the delta smelt population, as demonstrated by their declining population size.

9.2.3 Effects to Critical Habitat from the Proposed Action

9.2.3.1 Background

The following are the delta smelt critical habitat Primary Constituent Elements (PCEs) as defined in the critical habitat rule (Service 1994):

Primary Constituent Element 1: "Physical habitat" is defined as the structural components of habitat. Because Delta Smelt is a pelagic fish, spawning substrate is the only known important structural component of habitat. It is possible that depth variation is an important structural characteristic of pelagic habitat that helps fish maintain position within the estuary's LSZ (Bennett *et al.*2002; Hobbs *et al.* 2006).

Primary Constituent Element 2: "Water" is defined as water of suitable quality to support various Delta Smelt life stages with the abiotic elements that allow for survival and reproduction. Delta Smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for Delta Smelt. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat.

Primary Constituent Element 3: "River flow" is defined as transport flow to facilitate spawning migrations and transport of offspring to LSZ rearing habitats. River flow includes both inflow to and outflow from the Delta, both of which influence the movement of migrating adult, larval, and juvenile Delta Smelt. Inflow, outflow, and Old and Middle Rivers flow influence the vulnerability of Delta Smelt larvae, juveniles, and adults to entrainment at Banks and Jones

Pumping Plants. River flow interacts with the fourth primary constituent element, salinity, by influencing the extent and location of the highly productive LSZ where Delta Smelt rear.

Primary Constituent Element 4: "Salinity" is defined as the LSZ nursery habitat. The LSZ is where freshwater transitions into brackish water; the LSZ is defined as 0.5–6.0 psu (Kimmerer 2004). The 2 psu isohaline is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby *et al.*1995). By local convention the location of the LSZ is described in terms of the distance from the 2 psu isohaline to the Golden Gate Bridge (X2); X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.*1995; Kimmerer 2002). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X2 has varied from as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km). At all times of year, the location of X2 influences both the area and quality of habitat available for Delta Smelt to successfully complete their life cycle. In general, delta smelt habitat quality and surface area are greater when X2 is located in Suisun Bay. Both habitat quality and quantity diminish the more frequently and further the LSZ moves upstream, toward the confluence.

Due to the interrelationship between the PCEs and the intended conservation role they serve for different delta smelt life stages, some effects are similar and overlap across the PCEs. For instance, Delta outflow determines the extent and location of the LSZ and the areas of physical habitat delta smelt are able to utilize at all times of year. Therefore, many of the effects described below for the PCEs are difficult to separate so some effects are repeated for multiple PCEs.

The PA will affect critical habitat to varying degrees in four ways: 1) the removal of habitat in the construction footprint, 2) the blockage of spawning migration by the NDD intake structures up the Sacramento River beyond Clarksburg, 3) the alteration of water quality, quantity and salinity by water operations of the SDD and NDD, and 4) localized water quality and hydrodynamic effects from construction. Table 9.2.3-1 shows where the effects to critical habitat from the PA are expected to occur for each PCE. Construction will not affect PCEs 3 and 4.

Effects to PCEs were evaluated using various metrics. For PCE 1, we measured acres that would be adversely affected by construction and facility footprint weighed against the compensatory mitigation included as a conservation measure in the Proposed Action. For PCE 2, we used DSM-2 QUAL modeling, DSM-2 hydraulic residence time, DSM-2 PTM, and DSM-2 fingerprinting outputs. For PCE 3 we used CalSim II outputs. For PCE 4, CalSim II outputs of X2 and DSM-2 QUAL salinity outputs were used. The CalSim II model is used by DWR and BOR to simulate the operation of the major CVP/SWP facilities in the Central Valley and generates estimates of river flows, exports, reservoir storage, deliveries, and other parameters. The Delta boundary flows and exports from CalSim II are then used to drive the DSM2 (Delta Simulation Model). DSM2 is a hydrodynamic and water quality model for estimating tidally-based flows, stage, velocity, and salt transport within the estuary. DSM2 also has a particle tracking modeling (PTM) component which uses the velocity fields generated under the

hydrodynamics to emulate movement of particles throughout the Delta system. DSM2 QUAL is used to quantify water quality conditions including salinity, water temperatures and source water fingerprinting.

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Table 9.2.3-1. Effects of the PA on critical habitat by life stage. (Type of effect indicated by cell color: yellow (neutral), and red (negative), brown (mixed effects), grey (not applicable)).

Life stage	*PCE 1: Physical habitat*	*PCE 2: Water [quality]*	*PCE 3: River flow*	*PCE 4: Salinity [LSZ]*
Migrating adults	Restricted access to the Sacramento River above the NDD	No substantive effect.	Improved SJR flows during winter migration improved spawning cues and improved flows reduce entrainment risk. Disruption of migration flows past NDD.	No change in effect.
Spawning adults	Partial to full migration barrier along Sacramento River, small habitat loss from barge landings and HORG; mitigation will reduce effects.	No substantive effect.		No change in effect.
Dispersing larvae and juveniles		No substantive effect.	Improved SJR flows during spring/early summer larval transport out of SJR. Disruption of transport flows past the NDD.	No change in effect.
Rearing larvae and juveniles	No substantive effect on water depths.	Elevated selenium load from SJR, small potential increase in *Microcystis* bloom intensity, potential for elevated zooplankton production; small effect on estuary turbidity.	Lower outflow will increase salinity and limit extent/suitability of western parts of critical habitat and move the LSZ upstream.	Lower outflow will increase salinity and limit extent/suitability of western parts of critical habitat and move the LSZ upstream.

9.2.3.2 Small effects to critical habitat related to PCE 2: Water

The PA will cause minor changes in several components of water quality (PCE 2) needed to support delta smelt at all life stages, but which were found to have small to negligible effects as compared to the current projected baseline condition, either alone or in combination with Conservation Measures proposed as part of the PA. These components include the following:

- **Water temperature:** There is a possibility that the lower Sacramento River inflows to the Delta as a result from export of colder Sacramento River water at the NDD, may result in small water temperature increases in the San Joaquin River. Effects are likely too small (less than 1 ^{o}C) to be modeled with available modeling tools. If realized, this small temperature increase is not anticipated to affect the critical habitat's ability to provide adequate water quality for delta smelt at all life stages.

- **Construction sediment and contaminants:** Potential water quality effects in the vicinity of the NDD, HOR gate, geotechnical borings, and barge landings include elevated noise from pile driving, increased turbidity/suspended sediments and deposition of sediment onto nearby spawning substrates, and potential mobilization of sediment-associated contaminants for installation, operation and removal. Impacts lasting more than one year are considered permanent. Water quality is expected to return to baseline levels following cessation of construction activities (13 years after commencement of construction activities). The potential release of contaminants through spills or sediment disturbance could result in temporary impacts on water quality. With implementation of the proposed pollution prevention, and erosion and sediment control AMMs (Table 3.2-2 Summary of the Avoidance and Minimization Measures detailed in Appendix 3.F, CWF BA 2016), potential adverse effects on spawning habitat downstream of the NDD and near barge landings will not alter water quality (PCE 2) required to support all life stages of delta smelt.

- **Sediment load:** Turbidity produced by suspended sediment provides cover for delta smelt to avoid predators and facilitates larval smelt feeding (Ferrari *et al.* 2014; Baskerville-Bridges *et al.* 2004; Sullivan *et al.* 2016). NDD operations will alter critical habitat by removing Sacramento River suspended sediment which may increase downstream water clarity over time. DWR has committed to reintroduce Sacramento River sediment removed from the water column at the intake sedimentation basins which will minimize the effects to Delta sediment load and turbidity and help to maintain this important aspect of PCE 2.

- **Food entrainment:** Water exports directly entrain aquatic phytoplankton and zooplankton (Arthur *et al.* 1996; Jassby and Cloern 2000). If food web entrainment is a linear function of exports, zooplankton and phytoplankton entering critical habitat from the Sacramento River would be reduced annually by approximately 4%. The NDD could remove up to 5% of phytoplankton standing stock each month (CWF BA 2016). However, the export of plankton at the NDD would be offset by the likely increase in organic matter from the more productive

San Joaquin River water (Cloern and Jassby 2000). San Joaquin River water contribution at Collinsville (on the Sacramento River north of Sherman Island) is expected to increase across all months and all water-year types. It is highly probable that NDD losses will be compensated by San Joaquin River zooplankton production and transport during juvenile rearing. Therefore, it is expected that the PA will not cause a net change in the distribution or availability of food in critical habitat.

- **Microcystis:** Harmful algae blooms, which can produce toxins, are associated with slow-moving, warm, nutrient rich water. Operations under the PA will increase San Joaquin River outflows during summer by reducing SDD pumping. Summer outflow under the PA will reduce the likelihood of San Joaquin River at Jersey Point flow falling within the -240 to 50 m^3/s range that is associated with harmful algal blooms in the Delta (Lehman *et al.* 2013). The same SDD pumping reduction will also cause residence times to increase at Mildred Island and in Middle River. However, should this projected change in residence time increase the frequency of blooms, OMR flows will be negative which will tend to disperse the blooms toward the SDD and into exports rather than toward the critical habitat supporting rearing of juvenile smelt. Thus, the PA may result in a small increased risk of harmful algal bloom frequency, but the PA water operations will result in little to no alteration to water quality in critical habitat.

- **Selenium:** Selenium is a micronutrient needed by all vertebrates however large doses can lead to structural deformities and reproductive failure in fish (Lemly 1993; Lemly 2002). Selenium accumulation at higher trophic levels through dietary exposure can result in deformities and reduced survival. Reductions in SDD exports will cause small increases of selenium loading into the Delta and Suisun Bay. Operations under the PA will result in an increase in the proportion of San Joaquin River water entering the Delta and Suisun Bay by reducing the amount of San Joaquin water exported out of the Estuary via the SDD. By increasing San Joaquin water contribution the PA results in a small degradation in water quality, however there is an extremely small likelihood (less than 1% change) that the PA will alter or degrade selenium concentrations such that water quality (PCE2) will not provide its conservation function for the species (CWF BA 2016).

9.2.3.3 Substantive effects to PCEs by life stage

9.2.3.3.1 Spawning Habitat

PCE 1 – Physical Habitat

Delta smelt require physical habitat (meaning specific water depth and in-water substrates) during spawning because the eggs need to attach to substrates that will not smother them during incubation. The construction of the NDD will remove 5.6 acres of critical habitat that include spawning habitat. The three NDD intakes and fish screen structures, ranging from 1497 to 1969 feet in length, will also create a barrier within critical habitat that will isolate another 245 acres of transiently occupied critical habitat with shorelines that include spawning habitat in the

Sacramento River from RM 36.8 to the I Street Bridge in Sacramento. This barrier will prevent migrating adult delta smelt from using this spawning habitat. Delta smelt are seasonal residents of the Sacramento River from Isleton to Garcia Bend from February-May. The Service expects the NDD will limit the seasonal northward expansion of delta smelt range to about the downstream-most diversion near Clarksburg. See PCE 1 for Adult Migration for a detailed explanation of how the in-water structures block migration. Although not currently preferred by the majority of spawners, the elimination of this habitat in the northern portion of the delta smelt critical habitat reduces the volume and complexity of available spawning habitat including cooler, fresh water which the species may need during drier years and extreme drought. This area of the Sacramento River also provides critical habitat that could have increasing importance due to sea level rise, reductions in precipitation in the northern Sacramento Valley, and increasing water temperatures associated with climate change.

In the PA, DWR has proposed to compensate for spawning habitat loss through compensatory mitigation prior to construction, including, but not limited to, the purchase of conservation credits at an approved conservation bank, at a various ratios depending on location and quality (see Table 3.4-1, CWF BA 2016). Compensatory mitigation in the form of spawning habitat improvements in the Sacramento River from Isleton to Hood may, to some degree, ameliorate the loss of critical habitat from the construction footprint. However, critical habitat and its PCE's from the Sacramento River above Intake 2 (River Mile 4.1) up to the I Street Bridge will remain intact but inaccessible to delta smelt.

Construction of the HORG and barge landings will permanently affect 2.9 acres and 22.4 acres of designated critical habitat respectively. PCEs are present near the HORG but degraded. Physical habitat for spawning is degraded by steep, leveed and riprapped banks. Additionally, transport flows are not appropriate to move larvae and juveniles to rearing habitat (entrainment is probable) and water quality is degraded by agricultural drainage.

9.2.3.3.2 Larval and Juvenile Transport Habitat

PCE 3 – River Flow

The PA will directly influence river flows in the Delta and Suisun Bay, which in turn will affect the quality and quantity of delta smelt critical habitat (Service 1994; Bever *et al.* 2016). Exports have the ability to directly alter river transport flows and can interfere with tidal and downstream transport of larvae and juvenile delta smelt to low-salinity zone rearing habitats, resulting in entrainment. However, the shift in exports from the SDD to the NDD during larval and juvenile transport period is expected to maintain or improve transport flow function and decrease entrainment of larval and juvenile delta smelt at the SDD. For the SDD, OMR flows more positive than -2000 cfs are expected to provide appropriate transport flows for larval and juvenile smelt from spawning locations in the San Joaquin River and eastern Delta to the LSZ. OMR flows more positive than -5000 cfs are expected to provide appropriate transport flows for larvae and juveniles being transported through Three-Mile Slough and the lower San Joaquin River between Antioch and Jersey Point. Modeled OMR flows are more positive for the PA than

modeled projected baseline conditions in March and June and are similar in April and May. OMR will never be more negative than -5000 cfs during the months of March to June.

River flow may be reduced by the water exports at the NDD as transport flows in shallow water along the western stream bank would entrain or impinge eggs and larvae. However, due to the migration barrier presented by the NDD, delta smelt are highly unlikely to be spawned upstream once construction begins.

9.2.3.3.3 Rearing Habitat

PCE 4 – Salinity

The LSZ expands and moves downstream when river flows are high. By exporting river flows, the PA can contribute to upstream movement of the LSZ. Ideal rearing conditions for juvenile delta smelt occur when the location of the LSZ maximizes habitat quantity and quality by providing appropriate salinity, turbidity and food. Figures 9.2.3-1 through 9.2.3-6 show the results of CalSim II modeling for X2 over 82 years for the PA and the current projected baseline condition in kilometers for June through November. The second y-axis shows the difference in X2 between the PA and current conditions in kilometers. These plots indicate that the PA will further erode juvenile rearing critical habitat by moving X2 further upstream by as much as 4.8 km compared to current conditions. In July, August, and September, the LSZ is consistently predicted to move upstream of current conditions. Under the PA, CalSim II predicts X2 in August will be greater than 84 km 94% of the time (77 of 82 years modelled). The current projected baseline, X2 in August will be higher than 84 km 71% of the time (58 of 82 years modelled). The location of the LSZ is important in determining the quality, both extent and suitability, of juvenile rearing habitat. During juvenile rearing from July through December, upstream movement of the LSZ further upstream of the confluence degrades rearing habitat by decoupling favorable salinity conditions from the food, water depths, and wind-driven turbidity of Suisun Bay. At or above 84 km, the LSZ is upstream of Chipps Island, and entirely out of Suisun Bay and the suitable habitat conditions it provides (Figure 9.2.3-7).

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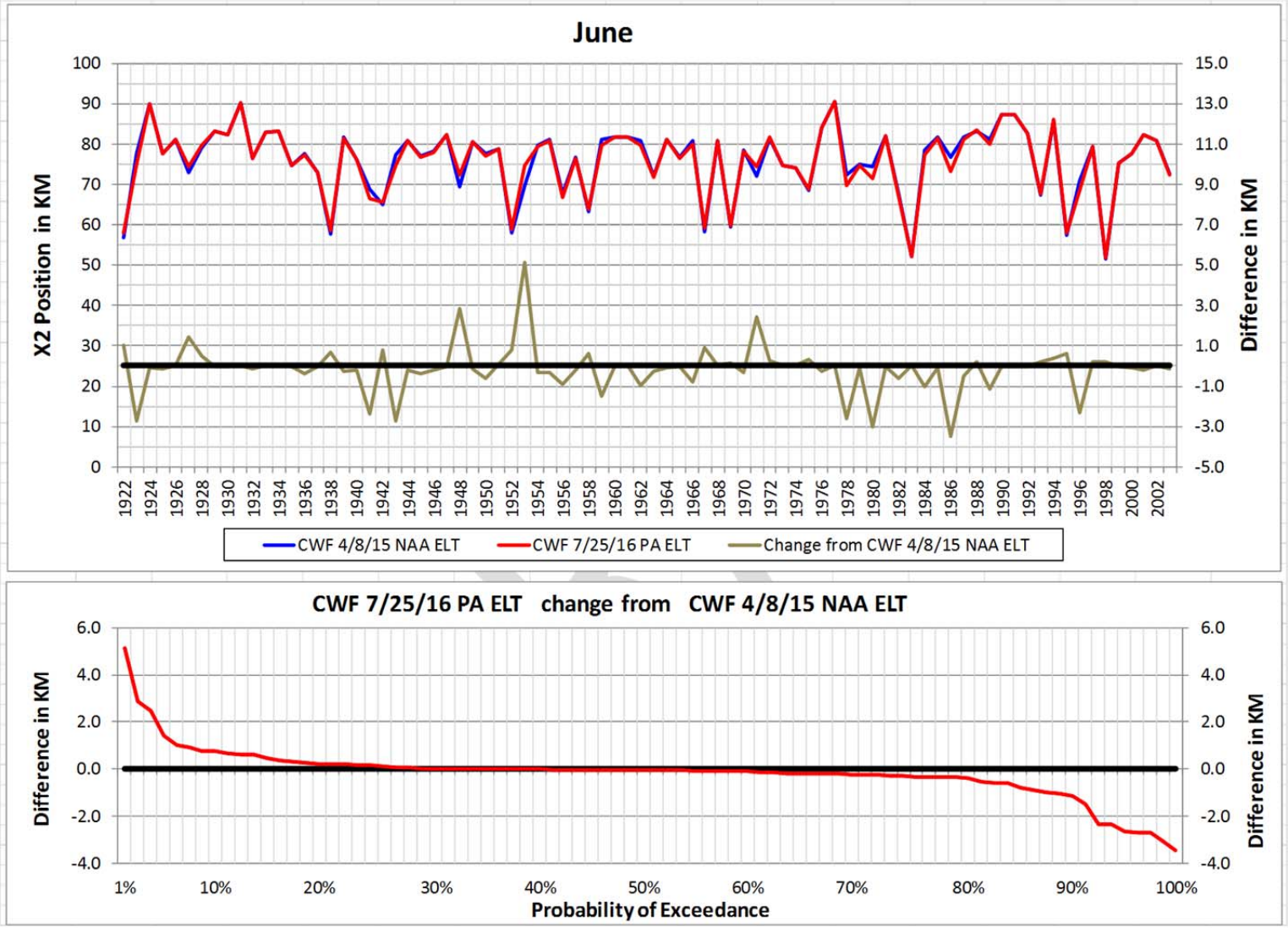

Figure 9.2.3-1. Comparison of 82 years of CalSim II modeling X2 for the PA vs. current projected baseline conditions for June.

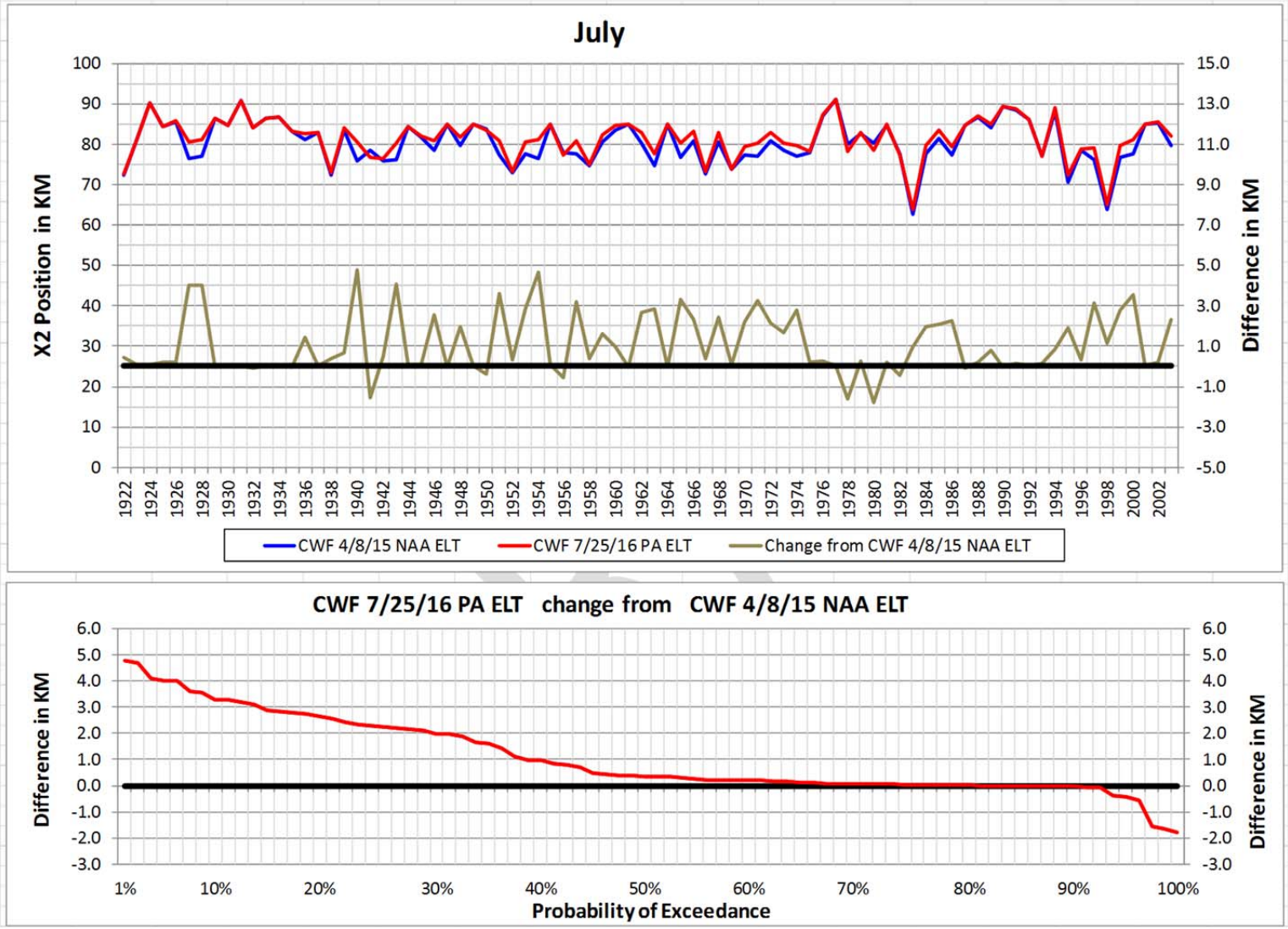

Figure 9.2.3-2. Comparison of 82 years of CalSim II modeling X2 for the PA vs. current projected baseline conditions for July.

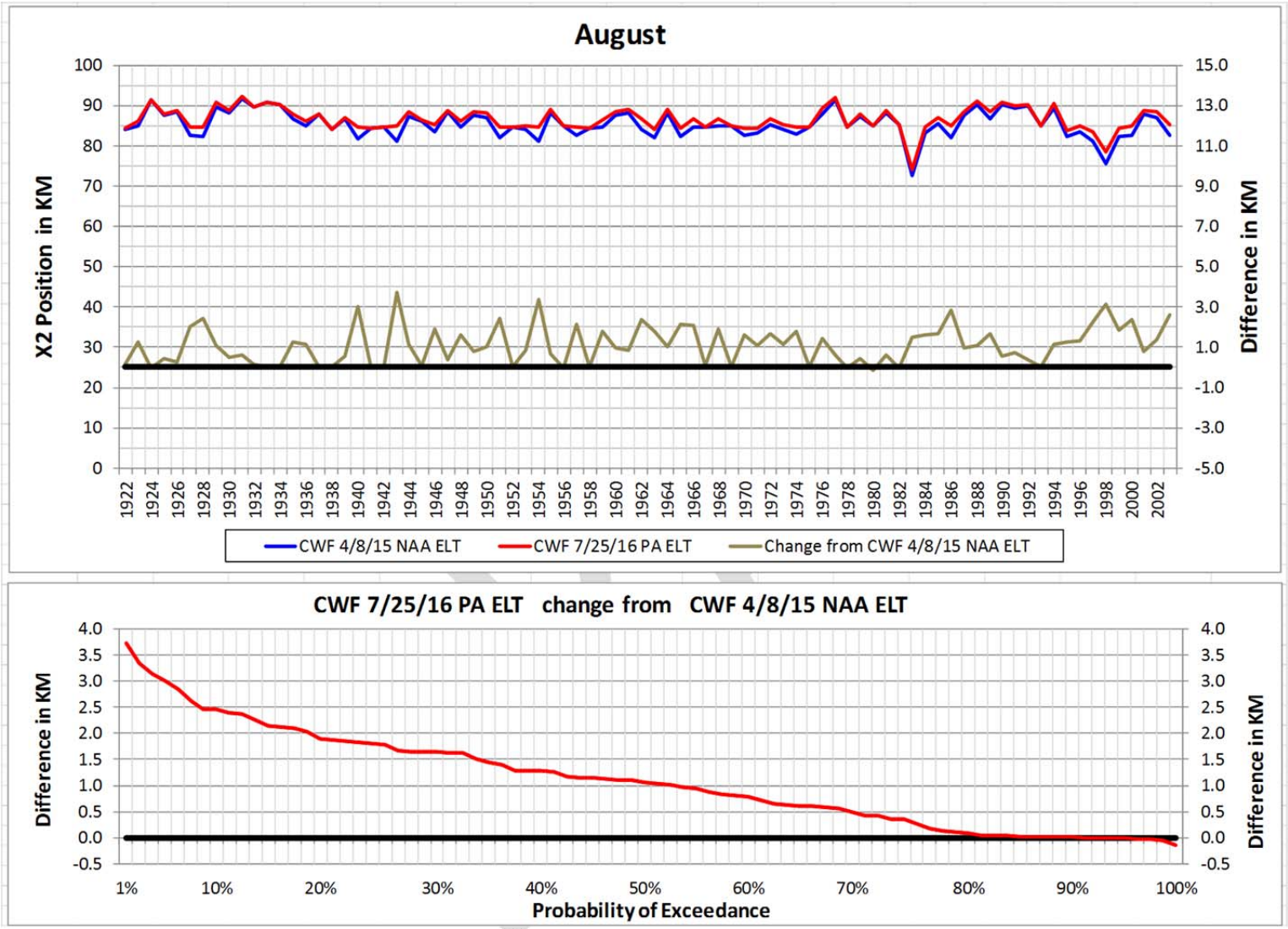

Figure 9.2.3-3. Comparison of 82 years of CalSim II modeling X2 for the PA vs. current projected baseline conditions for August.

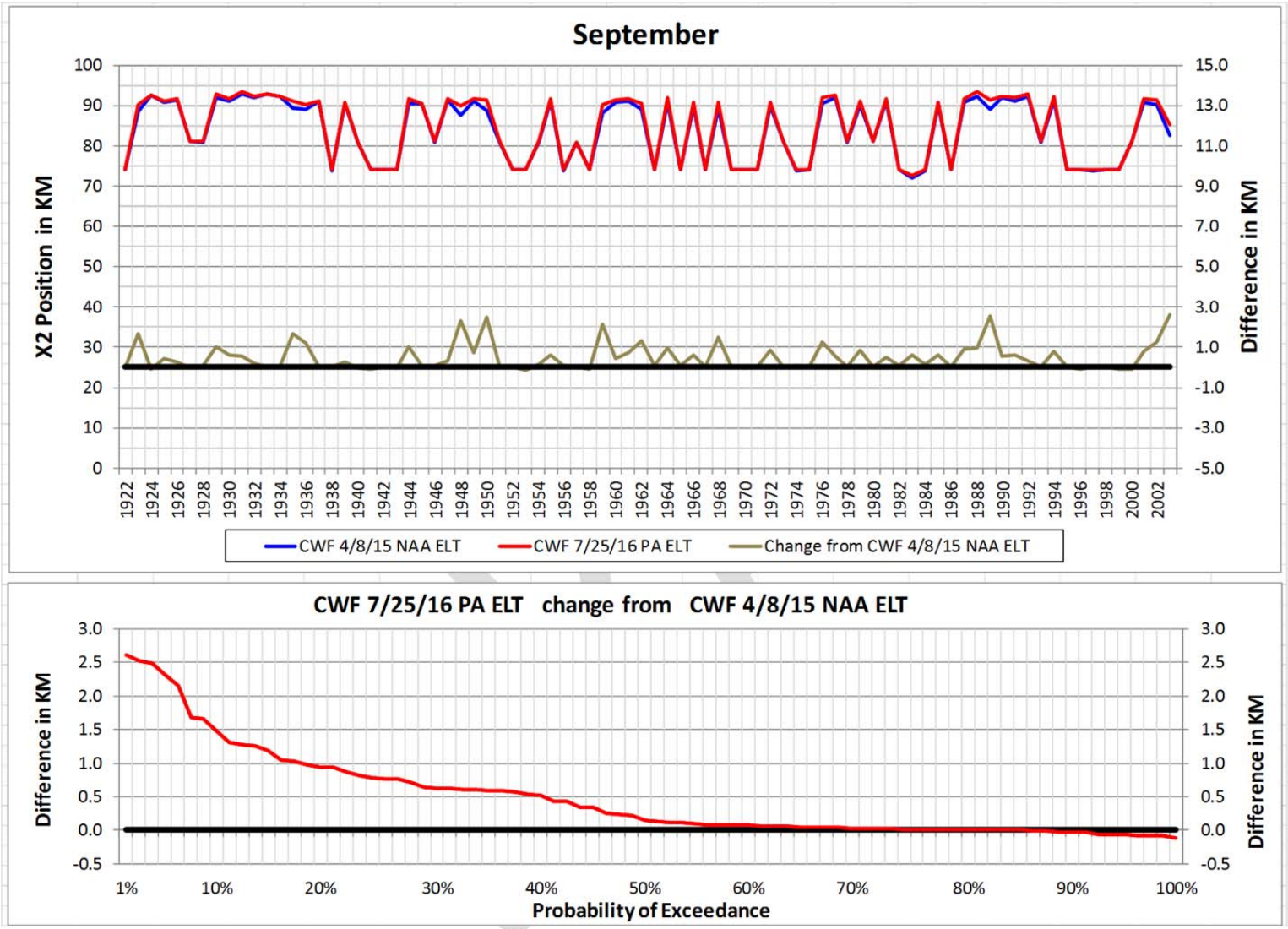

Figure 9.2.3-4. Comparison of 82 years of CalSim II modeling X2 for the PA vs. current projected baseline conditions for September.

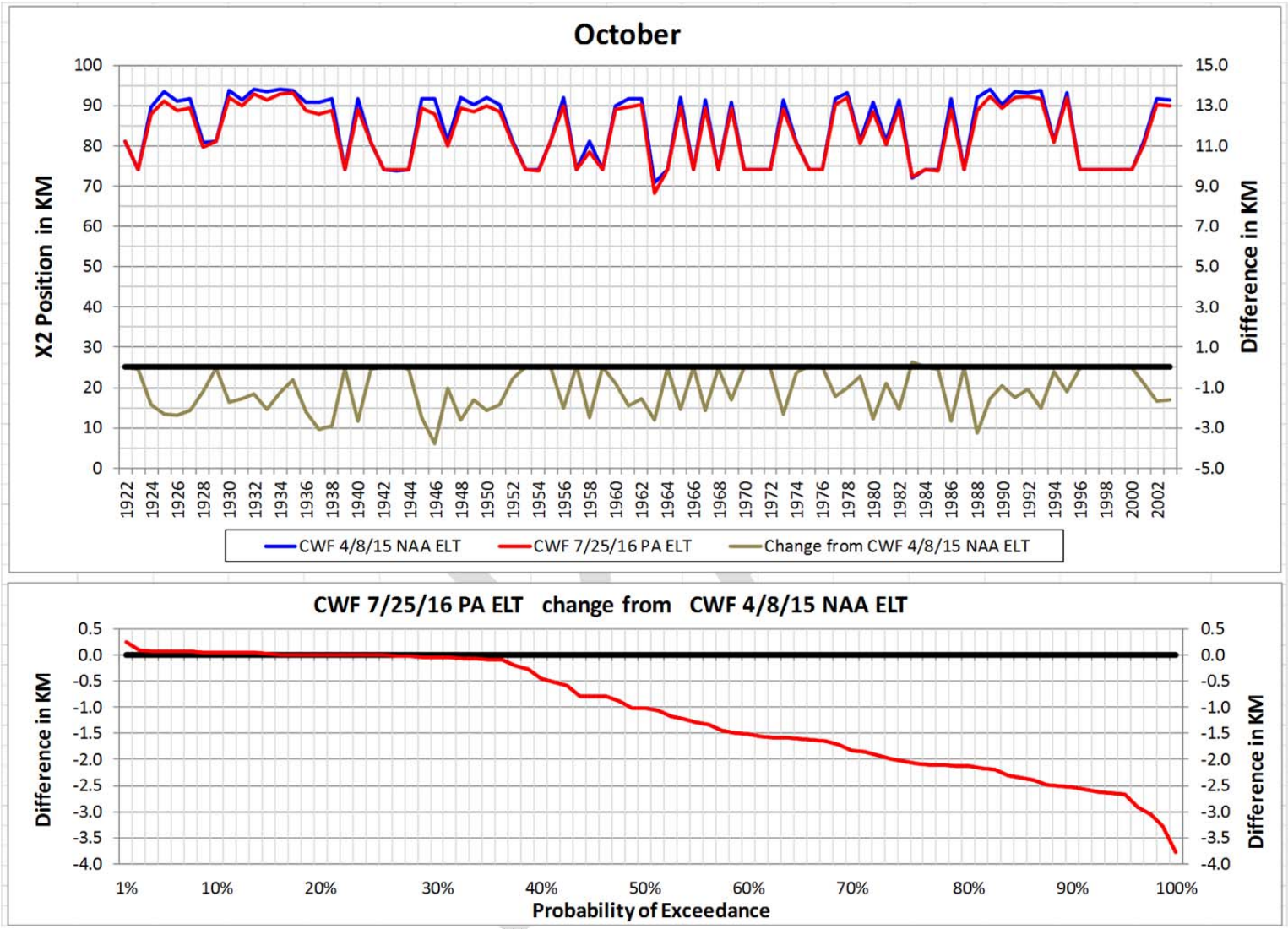

Figure 9.2.3-5. Comparison of 82 years of CalSim II modeling X2 for the PA vs. current projected baseline conditions for October.

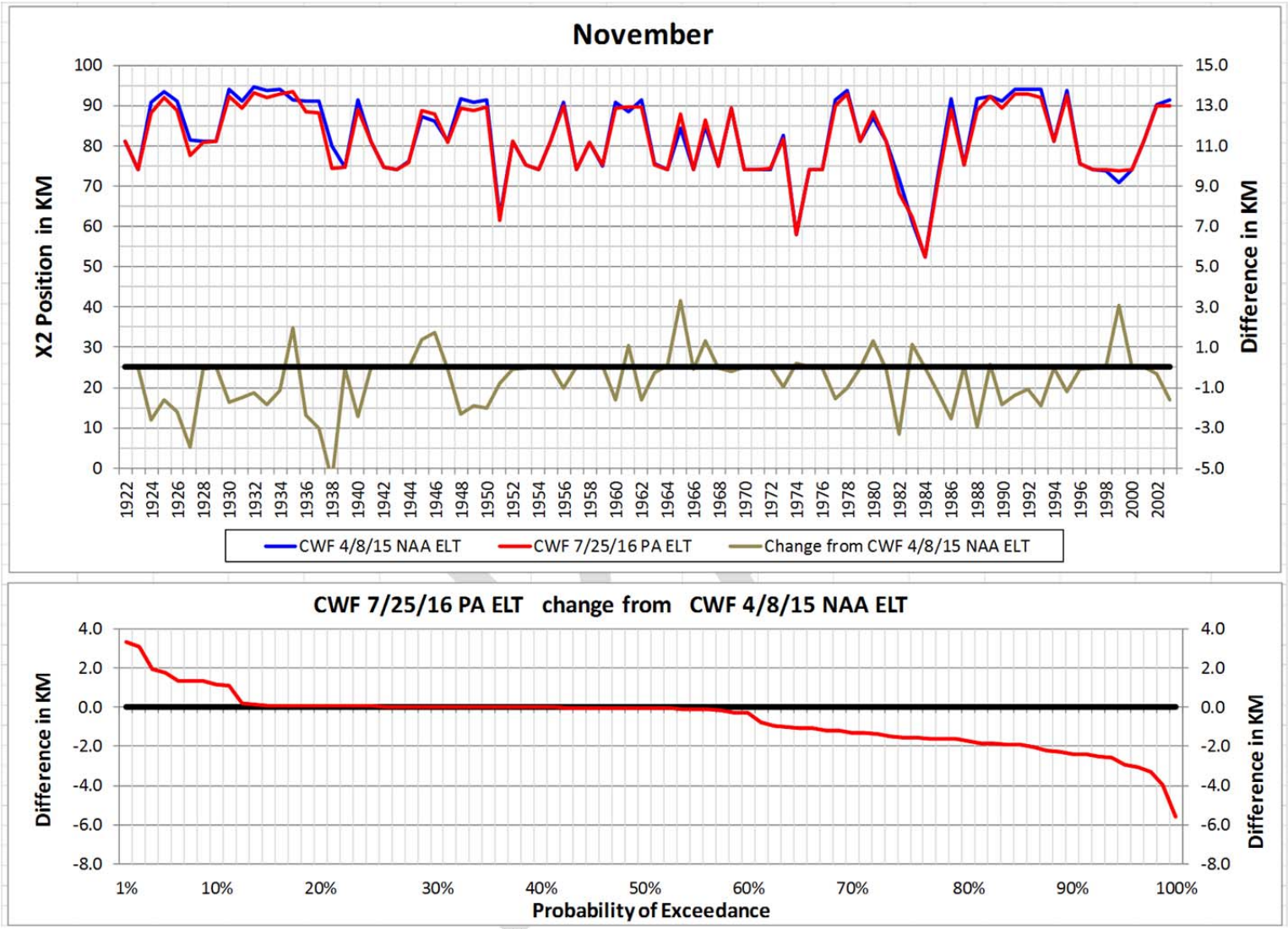

Figure 9.2.3-6. Comparison of 82 years of CalSim II modeling X2 for the PA vs. current projected baseline conditions for November.

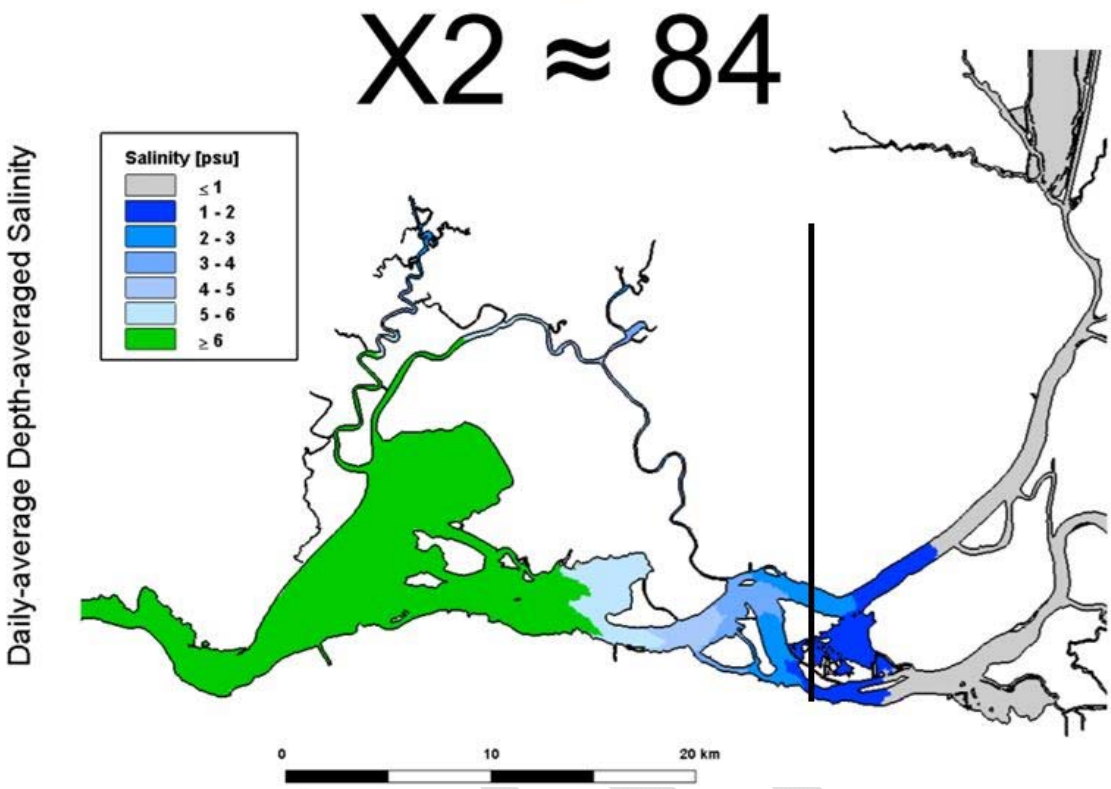

Figure 9.2.3-7. Daily-averaged depth-average salinity between Carquinez Strait and the Western Delta for X2 located at 84 km (DMA 2012). Vertical line at 84 km added for clarity.

An additional consequence of the upstream encroachment of X2 is increased salinity in the western part of designated critical habitat (approximately 10%), as suggested by the DSM-2 QUAL modeling in Montezuma Slough for August and September. This projected salinity increase will further erode juvenile rearing critical habitat for delta smelt. The preferred salinity range for delta smelt is between about 0.5 and 6 ppt (Kimmerer 2004; Komoroske *et al.* 2016). Delta smelt can tolerate higher salinities, but increased osmoregulation comes at an energetic cost that is highly undesirable to a food-limited fish (Hammock *et al.* 2016; Slater and Baxter 2014). In Montezuma Slough at National Steel in eastern Suisun Marsh, salinity in August is currently above 6 ppt 10% of the time. Under the PA, salinity will exceed 6 ppt 20% of the time. In September, salinity conditions favorable for smelt are projected to decrease in frequency from 50% to 40% of the time (CWF BA 2016, Table 5.B.5-28). Thus, the PA will result in favorable salinity for rearing in Montezuma Slough at National Steel in only wet and above normal years. Further west in Montezuma Slough at Beldon's Landing in north-central Suisun Marsh, favorable salinity conditions in August will occur only 40% of the time and only during wet and above normal years (CWF BA 2016, Table 5.B.5-27). September salinity conditions will be favorable 30% of the time and only in wet years. Salinity will improve in October and November but this improvement in critical habitat quality can only be realized by fish that survive through August and September. Suisun March, including Montezuma Slough, is high quality habitat for

delta smelt who exhibit better condition and growth, reduced contaminant exposure (Hammock *et al.* 2015), and no risk of entrainment into the CVP/SWP.

9.2.3.3.4 Adult Migration Habitat

PCE 1 – Physical Habitat

Delta smelt require specified in-water substrates only for spawning, but depth variation is helpful for small fish migrating upstream against net downstream river flows. The in-water structures associated with the NDD construction will act as a barrier within critical habitat, preventing migration by adult delta smelt from the downstream-most diversion near Clarksburg to the northern limit of delta smelt critical habitat. Construction cofferdams and the subsequent three NDD intakes and fish screen structures, ranging from 1497 to 1969 feet in length, will create a permanent barrier to adult fish migration.

Conceptually, delta smelt migrate upstream using the flood tide and use areas of hydrologic refuge (near the bottom or shoreline) to maintain their position in the Estuary during the ebb tide. In the Sacramento River above Georgiana Slough the tide no longer reverses the direction of water flow but slows river velocity. Delta smelt ascending the river cannot swim against mid-channel velocities for an extended time and thus critical habitat must provide low velocity paths to facilitate upstream migration along the Sacramento River while also providing cover to avoid predation (CWF BA 2016). In downstream locations vertical and lateral smelt distribution changes have been observed (Bennett *et al.* 2002; Feyrer *et al.* 2013; Bennett and Burau 2015), but these previous studies provide no evidence that delta smelt show affinity to one side of the river or the other when they move on and off shore.

Once constructed, each of the NDDs will be a vertical wall extending 1,030-1,404 feet at a stretch along the east bank of the Sacramento River extending into the river channel. If adult delta smelt attempt to ascend the east bank of the river, they will no longer have contiguous shoreline and will need to swim against in-channel velocities if they attempt to pass the screens. By virtue of small body size delta smelt are relatively "poor" swimmers (Swanson *et al.* 1998). In addition, they are non-continuous swimmers.

For a delta smelt to swim upstream at all, the river velocity has to be less than their sustainable swimming speed. If the river velocity is higher than the sustainable swimming speed and delta smelt cannot escape the current, then they will be pushed back downstream. Based on the fish screen sweeping velocity, the observed swimming speed of delta smelt in treadmill studies (Swanson *et al.* 1998; Young *et al.* 2010), the NDD fish screen sweeping velocities, and the length of each NDD screen, its seems highly unlikely that a delta smelt would be able to migrate up the east side of the river past a single screen, let alone the length of all three screens, to access the upper Sacramento above Clarksburg.

It is also unlikely that delta smelt could exclusively use the west bank to migrate past the NDDs. The Sacramento River makes 6 major bends between Isleton and Freeport shunting the highest velocity parts of the river cross section back and forth across the channel, requiring fish to

change banks to avoid being swept downstream. In addition to this shifting high velocity water, it seems unlikely that delta smelt could keep swimming up one bank of the river from Isleton to areas upstream because they would eventually need to avoid a predator or be displaced off the shoreline at night when they lose visual reference and become less active. Both of these phenomena would tend to mix migrating smelt across the shorelines from day to day.

Based on observed smelt swimming performance, screen length, screen sweeping velocities and river water velocities during the spring spawning period, it is likely that the NDD in-water structures of the length proposed by the PA will delay, impede or entirely block upstream adult spawning migration. The Service expects that the NDD migration barrier will eliminate the ability of critical habitat at the site of the NDD and upstream (approximately 250 acres) to serve its conservation function for adult migration and spawning. Although not currently preferred by the majority of migrating adults, the elimination of habitat in the northern portion of the delta smelt critical habitat reduces the volume and complexity of available spawning habitat including cooler, fresh water which the species may need during drier years and extreme drought.

PCE 3 – River Flow

Adult delta smelt need unrestricted access to suitable spawning habitat from December to July. Adequate flow must be maintained to attract migrating adults in the Sacramento and San Joaquin River channels, and their associated tributaries, including Cache and Montezuma sloughs and their tributaries. These areas also should be protected from physical disturbance and flow disruption during spawning migration.

Freshwater flows in combination with increasing turbidity are cues for adult delta smelt to migrate to spawning habitat in December through March (Sommer *et al.* 2011). SDD exports alter critical habitat by drawing turbid Sacramento River water into the Central and South Delta, encouraging the migration of adult delta smelt further south and east making them and their offspring vulnerable to entrainment. However, the shift in exports from the SDD to the NDD during the migration period is expected to maintain or improve critical habitat function related to transport flow and decrease the risk of entrainment of adult delta smelt at the SDD. For the SDD, OMR flows more positive than -2000 cfs are expected to be protective of a high fraction of migrating adults because Sacramento River water flowing into the mainstem of the San Joaquin River is not being rapidly drawn into Old and Middle rivers under those conditions. In the PA, OMR flows are less negative for adult migration in all months except December, in which flows will be similar to the current projected baseline conditions. Under the PA, during adult migration, flow conditions in critical habitat are increased and will function appropriately to cue spawning, and reduce entrainment risk in a larger portion of the San Joaquin River from Jersey Point to Prisoners Point.

Small reductions in Delta outflow are predicted during the migration period because total exports will increase. Sacramento River flows will be reduced by small proportions (3-24%) in all months, with the highest flow reductions occurring during the migration period. Flows in the San Joaquin River near Antioch will be reduced in December but increase from January through March. Increased flows in the San Joaquin River during spawning migration will encourage delta

smelt to use the San Joaquin River for spawning. Increased outflow in the San Joaquin River will improve the access to spawning habitat and provide appropriate habitat conditions for adult spawning and migration.

9.2.3.4 Effects of the Aggregate Status of the Critical Habitat/Environmental Baseline, and Proposed Action on PCEs of Critical Habitat for Delta Smelt

The purpose of the aggregate analysis is to evaluate the combined status of critical habitat, the effects of the PA and the cumulative effects of non-federal activities to determine their combined effects to critical habitat, its PCEs and their conservation function and value.

Summary of the Status and Environmental Baseline for Critical Habitat

As discussed in the Status of Critical Habitat section, the status of delta smelt critical habitat is poor (Table 9.2.3-2). The major factors currently limiting the conservation value of critical habitat are:

PCE 1 – Physical habitat
Dredging and shipping channel maintenance increase water depths and increase water supply demands needed to maintain the LSZ in Suisun Bay. Levees are covered in large riprap for erosion protection which over time may have reduced the availability of spawning habitat along channel margins in the Delta.

PCE 2 – Water quality
At the Cache Slough/Liberty Island complex and the upper Sacramento Deepwater Ship Channel where food appears to be adequate, over-summer water temperatures are warm, increasing metabolic rates, and signs of contaminant exposure have been observed, with urban or agricultural pesticide runoff being likely sources. Agricultural drainage and urban stormwater runoff result in the continual presence of low levels of pesticides, fungicides and insecticides throughout critical habitat. Sediment loading from the Sacramento River watershed continues to decline, reducing sediment load available for resuspension and turbid conditions which likely reduces cover from predators and provides light scatter that larvae use to find prey. Food availability at the confluence area is limited to supporting rearing juveniles due to the removal of plankton by the invasive overbite clam.

PCE 3 – River flow
The restricted and narrowly-fixed range of annual and seasonal flows has reduced habitat variability and favored non-native predators and competitors. In summer, the LSZ has been located upstream into the river channels away from the wind-driven turbidity and food resources found in the shallows of Suisun Bay and Marsh. The Delta, particularly since 2011, has seen a proliferation of non-native invasive aquatic vegetation as a consequence of reduced outflow associated with drought. Watershed sediment depletion, in addition to invasive plants and reduced river flows, work together to increased water clarity and favor non-native predatory and competitor fishes. Despite modifications to export operations by the 2008 Service BiOp RPAs,

larval and juvenile transport flows in the San Joaquin, Old and Middle Rivers continue to present entrainment risk to delta smelt at all life stages.

PCE 4 – Salinity

The CVP and SWP's water storage, upstream diversions and in-Delta exports have contributed to a restricted LSZ which, in turn, has impacted the extent and quality of spawning habitat and the suitability of juvenile rearing habitat. Western Suisun Bay, Suisun Marsh and Montezuma Slough salinities are within delta smelt salinity tolerance, but increase in July to September beyond what is optimal for osmoregulation given available food resources.

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Table 9.2.3-2. The baseline condition and effects of the PA for each delta smelt critical habitat PCE.

Primary Constituent Element	Migrating adults		Spawning adults	
	Baseline	**PA**	**Baseline**	**PA**
PCE 1: Physical habitat			Invasive aquatic plant encroachment, dredging altered depths and substrate, channels leveed and riprapped.	Partial to full migration barrier along Sacramento River, habitat loss from footprint.
PCE 2: Water [quality]	Degraded water quality including reduced turbidity, agricultural and urban pesticide and nutrient runoff.	No substantive effect.	Degraded water quality including reduced turbidity, agricultural and urban pesticide and nutrient runoff, warmer water shortening spawning season.	No substantive effect.
PCE 3: River flow	OMR flows create entrainment, risk reduced by OCAP RPA.	Improved SJR flows during winter migration, NDD restricts access above Clarksburg.	OMR flows create entrainment, risk reduced by OCAP RPA.	
PCE 4: Salinity [LSZ]		No change in affect.		No change in effect.
Primary Constituent Element	**Dispersing larvae and juveniles**		**Rearing larvae and juveniles**	
	Baseline	**PA**	**Baseline**	**PA**
PCE 1: Physical habitat			Invasive aquatic plant encroachment, dredging altered depths and substrate, channels leveed and riprapped.	No change in effect on water depths.
PCE 2: Water [quality]	Reduced turbidity.	No substantive effect.		
PCE 3: River flow	OMR flows create entrainment, risk reduced by OCAP RPA.	SJR flows will improve larval/juvenile transport.		Lower outflow will increase salinity, limit extent and suitability of rearing habitat at the LSZ and Montezuma Slough.
PCE 4: Salinity [LSZ]		No change in effect.	LSZ moved upstream away from food supply and turbidity.	Lower outflow will increase salinity and limit extent and suitability of western parts of critical habitat, LSZ located in higher in Estuary with degraded habitat extent and suitability.

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Summary of the Proposed Action

The PA concurrently provides adverse and beneficial effects to delta smelt critical habitat (Table 9.2.3-1). The transfer of exports to the NDD will improve larval and juvenile transport flows in the San Joaquin River from Jersey Point to Prisoners Point thus improving spawning habitat in this reach of the San Joaquin River by reducing entrainment risk for spawning delta smelt, larvae and juveniles. Several water quality factors will have small beneficial effects (food web), small negative changes that are negligible (selenium, *Microcystis*) or have no substantive effect when evaluated with the proposed Conservation Measures (sediment entrainment).

The PA will create a barrier on the Sacramento River within critical habitat and alter adult migration flows that will isolate delta smelt from 250 acres of spawning habitat. Compensatory mitigation in the form of spawning habitat improvements in the Sacramento River from Isleton to Hood may, to some degree, minimize the loss of critical habitat from the construction footprint. Critical habitat and its PCEs above Intake 2 (River Mile 4.1) will remain intact but inaccessible to delta smelt. The PA will further degrade salinity for juvenile rearing in July, August and September by moving X2 upstream as much as 4 km and restrict use of Montezuma Slough for juvenile rearing in all but wet and above normal years.

Summary of Aggregate Effects

The status of the delta smelt population strongly suggests that the current, highly-degraded critical habitat is not supportive of the continued existence of delta smelt. Despite improved larval and juvenile transport flows (PCE 3) for spawning adults, larvae and juveniles provided by the PA that will reduce entrainment risk in the San Joaquin River from Jersey to Prisoners Point, the PA will further alter and contract suitable critical habitat, particularly spawning and rearing habitat.

The PA will result in (1) additional upstream excursion of X2 from already suboptimal locations of the LSZ in summer, further decoupling the LSZ from PCE 2 (food, turbidity, and salinity) for juvenile rearing, (2) further salinity intrusion from the west into Montezuma Slough that will not support rearing delta smelt in three out of five water-year types (critically dry, dry, and normal), (3) improve transport flows (*i.e.,* reduced entrainment) for spawning migration, adult spawning and larval and juvenile transport in the lower San Joaquin River from Jersey Point to Prisoners Point, (4) transport flows from Franks Tract and Mildred Island toward Clifton Court Forebay on the Old and Middle Rivers that remain insufficient to prevent adult, larval and juvenile delta smelt entrainment into the SDD, and (5) a NDD barrier which will restrict access by adult migrants to spawning habitat in the Sacramento River above Clarksburg. The restriction of access to the Sacramento River above Clarksburg by spawning adults excludes delta smelt from the spawning habitat and water quality (cold, fresh water) that will likely have increasing conservation value due to sea level rise, reductions in precipitation in the northern Sacramento Valley, and increasing water temperatures associated with climate change. In addition, the degradation of PCE 3 and 4, and the further spatial contraction of critical habitat erode the habitat diversity and complexity needed for the species to recover and even persist given drought and climate change.

In the aggregate, the current status of delta smelt critical habitat and its PCEs necessary to support all life stages, the effects of the PA on critical habitat, and the current and future cumulative effects, will prevent the ability of delta smelt designated critical habitat to serve its intended conservation role for the species and will preclude the species' recovery.

9.24 Project-level Reinitiation Triggers and Programmatic Approach with Subsequent Consultation

This BiOp uses a programmatic approach to evaluate the elements of the PA that will be subjected to future project-specific consultations because of the need for future Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts to delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of listed species occurring in the Action Area. The remainder of the project elements not addressed programmatically are addressed as a standard, project-level consultation because they are not subject to future Federal approvals. Some project elements and their effects on delta smelt or its critical habitat will change as DWR continues to develop the PA and therefore may require reinitiation for those actions evaluated at a project-level if effects rise above those analyzed herein.

Preconstruction and Construction

Geotechnical Explorations

Some project elements and their effects on delta smelt or its critical habitat will change as the PA is refined (*e.g.,* location or duration of the geotechnical explorations). Therefore, reinitiation is required if additional habitat is affected or more individuals will be exposed based on changes in proposed locations of the borings.

Barge Landings

These barge landing locations represent the general areas for these facilities. Some project elements and their effects on delta smelt or its critical habitat will change as DWR continues to develop the PA and therefore may require reinitiation for those actions. DWR has provided estimates of habitat acreages in the CWF BA that are anticipated to be removed, altered, or degraded from barge landing construction, in the form of shallow water habitat, which encompasses all edgewater substrates including sandy beaches. GIS estimates of the shallow water habitat for the seven barge landing locations were calculated for the CWF BA; however, DWR will ground truth all habitat prior to impact. If the amount of habitat or level of exposure to delta smelt that will be affected by the barge landings changes as a result of refinement of the barge landing locations, reinitiation may be required.

NDD

Within this document, NDD construction has been analyzed at a programmatic level. All in-water work associated with construction of the NDD will require a permit during the 2nd phase of the Corps permitting process and additional consultation under section 7 of the Act. DWR will refine estimates of habitat effects and incidental take, and propose compensation consistent with the conservation measures described in the CWF BA Chapter 3, *Description of the Proposed Action*, in association with these future permits.

It is assumed that once the intakes are completed, the area in front of each intake will be dredged to provide appropriate water depths and hydraulic conditions at each intake. If dredging is required, DWR has proposed to minimize effects to delta smelt by conducting maintenance activities within the in-water work window of June 1 through October 31, when delta smelt are least likely to occur in vicinity. It is also assumed that periodic maintenance dredging will be needed to maintain appropriate flow conditions and will occur as described in the CWF BA Chapter 3, *Description of the Proposed Action*, and subsequent additional information that has been provided to the Service since submitting the CWF BA. NDD maintenance is also described programmatically herein and associated with the 2nd phase of the Corps permitting process; therefore, subsequent consultation with the Service will occur, when additional details on maintenance are available associated with a final NDD design.

CWF BA page 6-22 clarifies that no barge landings are estimated to be constructed along the Sacramento River in the vicinity of the proposed intakes. This was additionally substantiated in subsequent meetings and emails after the CWF BA submittal. Therefore, those calculations are not included in this analysis. If during the course of refining the NDD, there are additional effects not analyzed herein to delta smelt from the need for more than the 7 analyzed barge landings, reinitiation will occur.

This BiOp analyzes a reasonable set of estimates of underwater noise and sediment disturbance effects that is expected to occur from impact pile driving equipment and other methods of cofferdam installation and foundation construction based off of previous projects that have occurred. However, during implementation, DWR will monitor noise and sediment levels created by their heavy construction equipment. If the duration or location of underwater noise or turbidity thresholds extend or peak higher than those analyzed herein, DWR and the action agencies will confer with the Service to determine if project modifications are necessary, and reinitiation of this consultation may be necessary if additional adverse effects are found to occur to delta smelt.

DWR has provided estimates of habitat acreages in the CWF BA that are anticipated to be removed, altered, or restricted from proposed construction activities. Aerial imagery was used to determine these habitat acreages based on the best imagery available at the time of this consultation. DWR will inspect all habitats prior to the impact to confirm the estimates in the Proposed Action. Information on the substrate type and vegetation within the footprints are unknown at this time, but is expected to be developed during subsequent consultation on the 2nd phase of the Corps permitting process when more information on the final siting and design of

the NDD is available. As currently provided, the CWF BA does not quantify the amount of sandy substrate within the shallow water habitat footprint. The area of habitat lost to upstream access is estimated through aerial imagery (an estimate was feasible due to low vegetation in the area covering the substrate) that is expected to be refined when additional information is made available, prior to impact. A future Service-approved monitoring plan is proposed to be developed and could provide details on the monitoring efforts that will be conducted to assess restricted upstream passage from NDD construction and operation.

HORG

The CWF BA provides estimates of shallow water habitat that are anticipated to be removed, altered, and/or degraded from the proposed construction activities. GIS (geographic information system) spatial data provided by DWR was used to determine these habitat acreages. However, DWR will inspect all potential habitats prior to impact to confirm the estimates provided in the CWF BA, consistent with how the Service has defined shallow water habitat. Information on the substrate type and vegetation within the footprints are unknown at this time, but is expected to be developed during subsequent consultation at the 2nd phase of the Corps permitting process when more information on the final siting and design of the HORG is available. If new information reveals the PA may affect delta smelt (or its critical habitat) in a manner or to an extent not analyzed herein, reinitiation will occur.

CCF Forebay Construction, CCF Pumping Plant Construction, and Connections to Banks and Jones Pumping Plants

A future Service-approved monitoring plan is proposed to be developed and could provide details on the monitoring efforts that will be conducted to assess potential changes in salvages estimates from existing CVP and SWP operations of the pumping facilities. Monitoring will inform the refinement of effects in the CCF from construction on salvage.

Operations

NDD

Operational criteria have been identified in the *Description of the Proposed Action* for the NDD, such as approach and sweeping velocity; however, there has not been a final design of the NDD facility. The intake design will be developed in coordination with the Service, NMFS, and CDFW during the continued FFTT identified in the CWF BA. The FFTT will further refine the monitoring, research, operational criteria, and other efforts necessary for a 100% design required for the Corps' 408 process and fall under review during the Adaptive Management Framework. Reinitiation may be required if effects to listed species rise above those analyzed herein for the construction footprint or other project-level components addressed in this consultation. The FFTT will pursue ways to further minimize effects to delta smelt and other federally-listed species that may not necessarily be defined in this BiOp. This BiOp uses a programmatic approach to evaluate elements of the proposed operations that will be subject to future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows

for a broad-scale examination of the potential impacts on delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of delta smelt occurring in the Action Area. As discussed above under *Uncertainties Regarding Operations*, the CWF operational scenario that has been analyzed above will almost certainly change between now and when the dual conveyance system goes online. Reclamation and DWR have committed to propose future actions that will avoid jeopardizing the delta smelt and destroying or adversely modifying its critical habitat. Those future actions could include: new or modified operational criteria, minimizing project footprints during the final design phase, conservation efforts to maintain or increase trends in delta smelt abundance, efforts to restore and/or improve habitat conditions that support delta smelt, and other actions to be defined in the future. These future actions will be informed by the State Board process, reinitiation of the 2008 Service BiOp, the Adaptive Management Framework, and other state and federal processes.

South Delta Water Facilities

Operational criteria have been identified in the *Description of the Proposed Action* for the existing south Delta water facilities, such as those requirements identified in the RPA of the 2008 Service BiOp governing OMR flows and fall X2 location. However, Reclamation and DWR will likely modify existing (and future dual conveyance) operations through the reinitiation process. Once completed, the reinitiation BiOp will supersede the 2008 Service BiOp and the operations portion of this consultation. This BiOp uses a programmatic approach to evaluate elements of the proposed operations that will be subject of future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on listed species and their designated critical habitats, and examines how the parameters of the CWF align with the survival and recovery needs of delta smelt occurring in the Action Area.

HORG

Assumptions have been made on how the HORG will be operated for modeling purposes; however, the HORG operational criteria will be managed in real-time and be considered during the reinitiation process of the 2008 Service BiOp process. The gate design will be developed in coordination with the Service, NMFS, and CDFW during the technical team process identified in the CWF BA. The technical team will further refine the monitoring, research, operational criteria, and other efforts necessary for a 100% design required for the Corps' 408 process and fall under review during the Adaptive Management Framework. Reinitiation may be required if effects to listed species rise above those analyzed herein for the construction footprint or other project-level components addressed in this consultation. The technical team will pursue ways to further minimize effects to delta smelt and other federally-listed species that may not necessarily be defined in this BiOp. This BiOp uses a programmatic approach to evaluate elements of the proposed operations that will be subject of future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of listed species occurring in the Action Area.

DCC, Suisun Marsh Facilities, NBA Intake, and Other Facilities

This BiOp uses a programmatic approach to evaluate elements of the proposed operations that will be subject of future project-specific consultations because of subsequent Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts on delta smelt and its designated critical habitat, and examines how the parameters of the CWF align with the survival and recovery needs of listed species occurring in the Action Area.

9.2.5 Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this BiOp. Future Federal actions that are unrelated to the proposed project are not considered in this section; they require separate consultation pursuant to Section 7 of the Act.

Major human interactions and uses of the landscape within the Action Area include: agricultural practices; recreational uses; urbanization and industrialism - commercial and private; and greenhouse gas emissions.

Agriculture

Farming occurs throughout the Delta adjacent to many waterways used by delta smelt. Levees are reinforced with continual vegetation removal and rip-rapping to stabilize the levees and protect the land within the levees for agricultural purposes. Agricultural practices introduce nitrogen, ammonium, and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman *et al.* 2014); however, wastewater treatment provides the bulk of ammonium loading, for example (Jassby 2008). Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect delta smelt reproductive success and survival rates (Dubrovsky *et al.*1998; Kuivila *et al.*2004; Scholz *et al.* 2012). Discharges occurring outside the Action Area that flow into the Action Area also contribute to cumulative effects of contaminant exposure.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Action Area, and many of them remain unscreened. Most diversions of any reasonable size and cost have been screened, such as new municipal water diversions, are routinely screened per existing BiOps. Private irrigation diversions in the Delta are mostly unscreened, but the total amount of water diverted onto Delta farms has remained stable for decades (Culberson *et al.* 2008) so the cumulative impact should remain similar to baseline. Irrigated agriculture is anticipated to continue into the future, especially for permanent crops that rely on Delta water as a controlled water source for growth. Depending on the size, location, and season of operation, these unscreened diversions have the potential to entrain many life stages of aquatic species, including delta smelt. However, the vast majority of private unscreened diversions in the Action Area are small pipes in large channels that operate intermittently, and

mainly during the spring and summer. As a result, even where they do regularly co-occur with these diversions, delta smelt appear to have low vulnerability to entrainment (Nobriga *et al.* 2004). Nobriga *et al.* (2004) reasoned that the littoral location and small size of these diversions reduced their risk of entraining delta smelt.

Urbanization and Industrialism

The Delta Protection Commission's Economic Sustainability Plan for the Delta reported an urban growth rate of about 54% within the statutory Delta between 1990 and 2010, as compared with a 25% growth rate statewide during the same period (Delta Protection Commission 2012). The report also indicated that population growth had occurred in the Secondary Zone of the Delta but not in the Primary Zone and that population in the central and south Delta areas had decreased since 2000. Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the state as a whole. Total population in the Delta counties is projected to grow at an average annual rate of 1.2% through 2030 (California Department of Finance 2012). Table 9.2.5-1 illustrates past, current, and projected population trends for the five counties in the Delta. As of 2010, the combined population of the Delta counties was approximately 3.8 million. Sacramento County contributed 37.7% of the population of the Delta counties, and Contra Costa County contributed 27.8%. Yolo County had the smallest population (200,849 or 5.3%) of all the Delta counties.

Table 9.2.5-1. Delta counties and California population, 2000–2050.

Area	2000 Population (millions)	2010 Population (millions)	2020 Projected Population (millions)	2025 Projected Population (millions)	2050 Projected Population (millions)
Contra Costa County	0.95	1.05	1.16	1.21	1.50
Sacramento County	1.23	1.42	1.56	1.64	2.09
San Joaquin County	0.57	0.69	0.80	0.86	1.29
Solano County	0.40	0.41	0.45	0.47	0.57
Yolo County	0.17	0.20	0.22	0.24	0.30
Delta Counties	3.32	3.77	4.18	4.42	5.75
California	34.00	37.31	40.82	42.72	51.01
Sources: California Department of Finance 2012.					

Table 9.2.5-2 presents more detailed information on populations of individual communities in the Delta. Growth rates from 2000 to 2010 were generally higher in the smaller communities than in larger cities such as Antioch and Sacramento. This is likely a result of these communities having lower property and housing prices, and their growth being less constrained by geography and adjacent communities.

Table 9.2.5-2. Delta communities population, 2000 and 2010.

Community	2000	2010	Average Annual Growth Rate 2000–2010
Contra Costa County			
Incorporated Cities and Towns			
Antioch	90,532	102,372	1.3%
Brentwood	23,302	51,481	12.1%
Oakley	25,619	35,432	3.8%
Pittsburg	56,769	63,264	1.1%
Small or Unincorporated Communities			
Bay Point	21,415	21,349	-0.0%
Bethel Island	2,252	2,137	-0.5%
Byron	884	1,277	4.5%
Discovery Bay	8,847	13,352	5.1%
Knightsen	861	1,568	8.2%
Sacramento County			
Incorporated Cities and Towns			
Isleton	828	804	-0.3%
Sacramento	407,018	466,488	1.5%
Small or Unincorporated Communities			
Courtland	632	355	-4.4%
Freeport and Hood	467	309[a]	-3.4%
Locke	1,003	Not available	—
Walnut Grove	646	1,542	13.9%
San Joaquin County			
Incorporated Cities and Towns			
Lathrop	10,445	18,023	7.3%
Stockton	243,771	291,707	2.0%
Tracy	56,929	82,922	4.6%
Small or Unincorporated Communities			
Terminous	1,576	381	-7.6%
Solano County			
Incorporated Cities and Towns			
Rio Vista	4,571	7,360	6.1%
Yolo County			

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Incorporated Cities and Towns			
West Sacramento	31,615	48,744	5.4%
Small or Unincorporated Communities			
Clarksburg	681	418	-3.9%
Sources: U.S. Census Bureau 2000; U.S. Census Bureau 2011. [a] Freeport had a population of 38; Hood had a population of 271.			

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require consultation with the Service. State or local levee maintenance may also destroy or adversely affect delta smelt spawning or rearing habitat and interfere with natural, long term spawning habitat-maintaining processes.
Adverse effects on delta smelt and its critical habitat may result from urbanization-induced point and non-point source chemical contaminant discharges within the Action Area. These contaminants include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, pharmaceuticals, and oil and gasoline product discharges. Oil and gasoline product discharges may be introduced into Delta waterways from shipping and boating activities and from urban activities and runoff. Implicated as potential stressors to delta smelt, these contaminants may adversely affect delta smelt reproductive success, survival rates, and food supply.

Contaminants are suspected to be a stressor on delta smelt (Kuivila and Moon 2004; Brooks *et al.* 2012). A study of juvenile delta smelt in five different regions encompassing their range examined delta smelt for signs of contaminants and food limitation. The histopathological analysis of the 244 fish sampled in 2012 and 2013 found an 11-fold increase in gill and liver lesion scores in Cache Slough as compared to Suisun Marsh. Higher lesion scores indicate less healthy tissues and are indicative of contaminant-related stress (Hammock *et al.* 2015).
The largest urban discharger to the Delta is the Sacramento Regional Wastewater Treatment Plant (SRWTP). In order to comply with Central Valley Regional Water Quality Control Board Order no. R5-2013-0124, SRWTP has begun implementing compliance measures to reduce its discharge of ammonia and ammonium. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board, imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board 2013). By May 11, 2021, the SRWTP must reach a final effluent limit of 2.0 milligrams per liter (mg/L total ammonia nitrogen) per day from April to October, and 3.3 mg/L per day from November to March (Central Valley Regional Water Quality Control Board 2013). However, the treatment plant is currently releasing several tons of ammonia in the Sacramento River each day. A study by Werner *et al.* (2008) concluded that ammonia concentrations present in the Sacramento River below the SRWTP are not acutely

toxic to 55-day-old delta smelt. However, based on information provided by EPA (1999) and other related studies, it is possible that concentrations below the SRWTP may be chronically toxic to delta smelt and other sensitive fish species (Werner *et al.* 2010). In 2010, the same group conducted three exposure experiments to measure the effect concentration of SRWTP effluent. No significant effects of effluent on the survival of larval delta smelt were found. More recent studies (which used concentrations of ammonia higher than typically experienced by delta smelt) have shown that delta smelt that are exposed to ammonia exhibit membrane destabilization. This results in increased membrane permeability and increased susceptibility to synergistic effects of multi-contaminant exposures (Connon *et al.* 2009; Hasenbein *et al.* 2014). Results are unclear at this time as to what the effect of ammonia exposure is on delta smelt, and research is ongoing. EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. Studies are ongoing to further determine the adverse effects of ammonia on delta smelt.

In addition to concerns about direct toxicity of ammonia to delta smelt, another important concern is that ammonium inputs have suppressed diatom blooms in the Delta and Suisun Bay, thereby reducing the productivity in the delta smelt food web. The IEP (2015) provided the following summary: "Dugdale *et al.* (2007) and Wilkerson *et al.* (2006) found that high ammonium concentrations prevented the formation of diatom blooms but stimulated flagellate blooms in the lower estuary. They propose that this occurs because diatoms preferentially utilize ammonium in their physiological processes even though it is used less efficiently and at high concentrations ammonium can prevent uptake of nitrate (Dugdale *et al.* 2007). Thus, diatom populations must consume available ammonium before nitrate, which supports higher growth rates, can be utilized or concentrations of ammonium need to be diluted. A recent independent review panel (Reed *et al.* 2014) found that there is good evidence for preferential uptake of ammonium and sequential uptake of first ammonium and then nitrate, but that a large amount of uncertainty remains regarding the growth rates on ammonium relative to nitrate and the role of ammonium in suppressing spring blooms." The IEP (2015) further discussed this issue as follows: "Glibert (2011) analyzed long-term data (from 1975 or 1979 to 2006 depending on the variable considered) from the Delta and Suisun Bay and related changing forms and ratios of nutrients, particularly changes in ammonium, to declines in diatoms and increases in flagellates and cyanobacteria. Similar shifts in species composition were noted by Brown (2009), with loss of diatom species, such as *Thalassiosira* sp., an important food for calanoid copepods, including *Eurytemora affinis* and *Sinocalanus doerri* (Orsi 1995). More recently, Parker *et al.* (2012) found that the region where blooms are suppressed extends upstream into the Sacramento River to the SRWTP, the source of the majority of the ammonium in the river (Jassby 2008). Parker *et al.* (2012) found that at high ambient ammonium concentrations, river phytoplankton cannot efficiently take up any form of nitrogen including ammonium, leading to often extremely low biomass in the river. A study using multiple stable isotope tracers (Lehman *et al.* 2014) found that the cyanobacteria *M. aeruginosa* utilized ammonium, not nitrate, as the primary source of nitrogen in the central and western Delta. In 2009, the ammonia concentration in effluent from SRWTP was reduced by approximately 10%, due to changes in operation (K. Ohlinger, Sacramento Regional County Sanitation District, personal communication). In spring 2010 unusually strong spring diatom blooms were observed in Suisun Bay that co-occurred with low ammonia concentrations (Dugdale *et al.* 2013)."

Ammonia discharge concerns have also been expressed with respect to the City of Stockton Regional Water Quality Control Plant, but its remoteness from the parts of the Estuary frequented by delta smelt and its recent upgrades suggest it is not a significant concern for delta smelt.

Other future, non-federal actions within the Action Area that are likely to occur and may adversely affect delta smelt and their critical habitat include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; and state or local levee maintenance that may also destroy or adversely affect habitat and interfere with natural, long-term habitat-maintaining processes.

Recreational Uses

Increased urbanization also is expected to result in increased recreational activities in the Action Area. Recreational activities, such as the construction and maintenance of golf courses reduce habitat and introduce pesticides and herbicides into the aquatic environment. The Delta, Yolo Bypass, and Suisun Marsh contain numerous parks, extensive public lands, and many interconnected rivers, sloughs, and other waterways that offer diverse recreation opportunities. Privately owned commercial marinas and resorts allow for boating access to the waterways and a variety of other recreational opportunities and services. Private lands also provide several recreational opportunities; particularly hunting.

The Delta is a regional destination for water-based recreationists because of its climatic conditions, variety and abundance of fish, large maze of navigable waterways, and favorable water levels during summer, when most regional reservoirs experience substantial drawdown. Activities in the Delta include cruising, waterskiing, wakeboarding, using personal watercraft, sailing, windsurfing, and kiteboarding, as well as fishing and hunting (from land and by boat). Non-powered boating activities in the Delta include sailing, windsurfing, kiteboarding, canoeing, and kayaking.

Hunting has long been a recreational activity in the Delta, with waterfowl hunting being the primary type. Hunting by boat (typically used as a floating blind) is popular at the larger flooded islands, such as Franks Tract and Sherman Island, because hunters seek open, shallow waters and marsh areas where waterfowl congregate (California Department of Boating and Waterways 2003). Licenses and duck stamps to hunt waterfowl are required by the CDFW and the Service. CDFW manages hunting in California, including the public hunting programs at Sherman Island and other smaller wildlife areas. The California Department of Parks and Recreation (DPR) allow hunting at Franks Tract, designated as Franks Tract State Recreation Area. Boat hunting is also allowed at Big Break, which is managed by the East Bay Regional Park District (EBRPD) (Delta Protection Commission 1997). Late fall through early winter is the designated waterfowl hunting season, with starting and ending dates varying each year by species and by hunting method.

Suisun Marsh has historically been a popular duck hunting location; around 1880, the first private duck clubs were established in the marsh, and by 1930, the primary use of Suisun Marsh was waterfowl hunting (DWR 2000). Duck hunting continues to be a use of Suisun Marsh; with 158 private duck clubs located over 52,000 acres in the marsh. These clubs are managed for waterfowl habitat; the wetlands are flooded to coincide with waterfowl season (DWR 2009a; DWR 2011).

Most of the 370 water diversions operating in Suisun Marsh supply water to waterfowl hunting clubs and are likewise unscreened (Herren and Kawasaki 2001). However the SWP's Roaring River and Morrow Island distribution systems divert most of the water into the marsh; water is subsequently redistributed further by the many smaller diversions. Roaring River is screened while Morrow Island is not; however delta smelt entrainment into the Morrow Island Distribution System is low due to high salinity in western Suisun Marsh (Enos *et al.* 2007).

Greenhouse Gas Emissions

There is an international scientific consensus that most of the warming observed has been caused by human activities (IPCC 2001, 2007a, 2007b; Adger *et al.* 2007), and that it is "very likely" that it is largely due to man-made emissions of carbon dioxide and other greenhouse gases in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Adger *et al.* 2007; Solomon *et al.* 2007; IPCC 2013b). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities. Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon *et al.* 2007; IPCC 2013b; IPCC 2014).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al.* 2007; Ganguly *et al.* 2009). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increasing global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl *et al.* 2007; Ganguly *et al.* 2009; IPCC 2013b).

Ongoing climate change (lnkley *et al.* 2004; Adger *et al.* 2007; Kanter and Revkin 2007) will likely adversely affect delta smelt, since climate change will likely result in sea level changes and overall wet and dry cycles, it may result in changes to availability and distribution of habitat

and prey, and/or increase numbers of predators, parasites, diseases, and non-native competitors. For the endemic delta smelt, a changing climate may result in range shifts precluded by lack of habitat. For additional information on climate change as it relates to delta smelt, see *Status of the Species*.

Summary of the Cumulative Effects to Delta Smelt

Cumulative effects to delta smelt within the Action Area include: agricultural practices; recreational uses; urbanization and industrialism - commercial and private; and greenhouse gas emissions. Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Action Area, and many of them remain unscreened. Most diversions of any substantial size are routinely screened through consultation with the Service. Private irrigation diversions in the Delta are mostly unscreened; however, the vast majority of private unscreened diversions in the Action Area are small pipes in large channels that operate intermittently, and mainly during the spring and summer. As a result, even where they do regularly co-occur with these diversions, delta smelt appear to have low vulnerability to entrainment (Nobriga *et al.* 2004).

With the projected growth rate of 1.2% annually through 2030, we can expect to observe future increases in urbanization and housing developments that may ultimately lead to the destruction or adverse effect of delta smelt spawning or rearing habitat and interfere with natural, long-term spawning habitat-maintaining processes (California Department of Finance 2012).

Delta smelt's exposure to contaminants are inherent in the Delta, ranging in degree of effects. Sources of introduction vary from agricultural use pesticide runoff to urban wastewater treatment discharge, and other potential sources. Implicated as potential stressors to delta smelt, these contaminants may adversely affect delta smelt reproductive success, survival rates, and food supply.

Greenhouse gas emissions leading to climate change and sea-level rise are likely already effecting delta smelt and its habitat. Ongoing climate change as a result of human activities likely imperils delta smelt and the resources necessary for its survival, since climate change threatens to disrupt annual weather patterns, affecting availability and distribution of habitats and/or food base, and/or increase numbers of predators, parasites, diseases, and non-native competitors. In an isolated population such as that of the delta smelt, a changing climate may result in local extinction, with range shifts precluded by lack of habitat.

Summary of the Cumulative Effects to Critical Habitat

Agriculture, urbanization and climate change are most likely to affect critical habitat. PCE 2 (Water Quality) impairment is likely to continue or increase due to agriculture irrigation and municipal waste water discharge which introduces nutrients and pesticides into the watershed. Water temperatures, influenced by warming air temperatures from climate change, are expected to rise. Delta smelt is currently at the southern limit of the inland distribution of the family Osmeridae along the Pacific coast of North America and is living in an environment that is

energetically stressful. Thus, increased water temperatures associated with climate change may present a significant conservation challenge. PCE 3 (River flow) reductions and the associated PCE 4 (Salinity) intrusion will increase as human population growth places additional demands on water resources and less fresh water will available to maintain the LSZ at a suitable location particularly for juvenile rearing habitat. Climate change will also alter the timing and form of precipitation (rain or snow) in the watershed depending on latitude. Sea level rise will likely influence saltwater intrusion into the Bay-Delta. Elevated salinity could push X2 farther up the estuary with mean values increasing by about 7 km by 2100 (Brown *et al*. 2013). The status of critical habitat (PCEs 2, 3, and 4) will likely be degraded by each of these cumulative effects in the early long term.

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Section 9.2.7 Literature Cited

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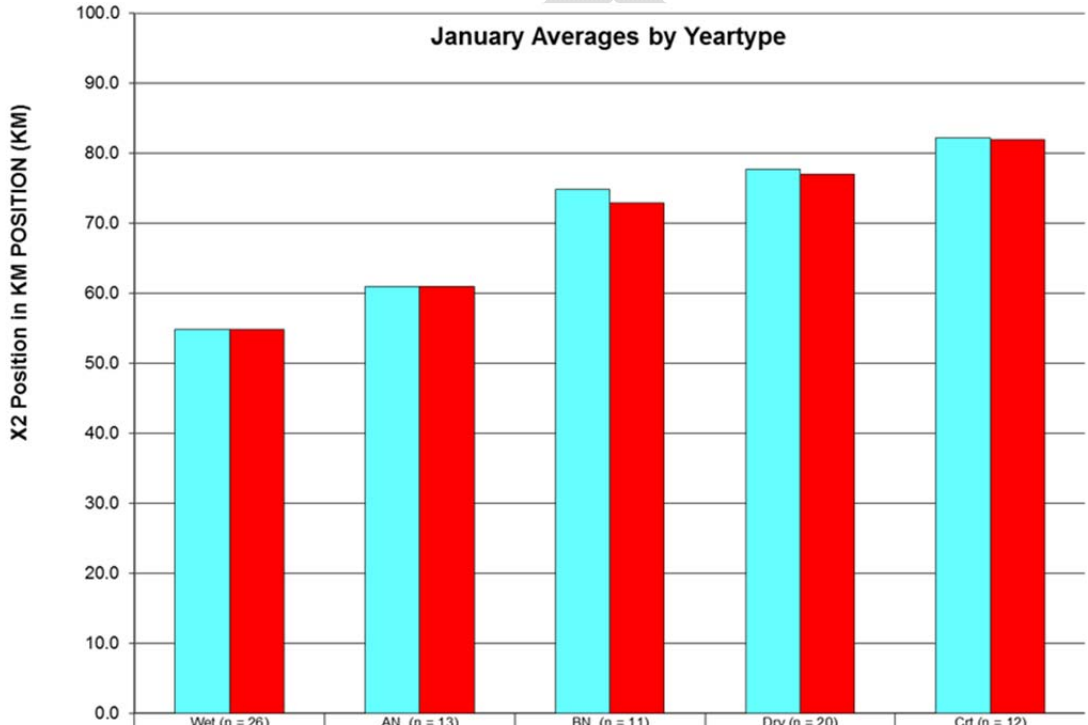
Appendix A. Changes in X2 position.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	55	61	75	78	82
CWF 7/25/16 PA ELT	55	61	73	77	82

Figure A-1. Change in X2 location (in km) for January averages by WY type.

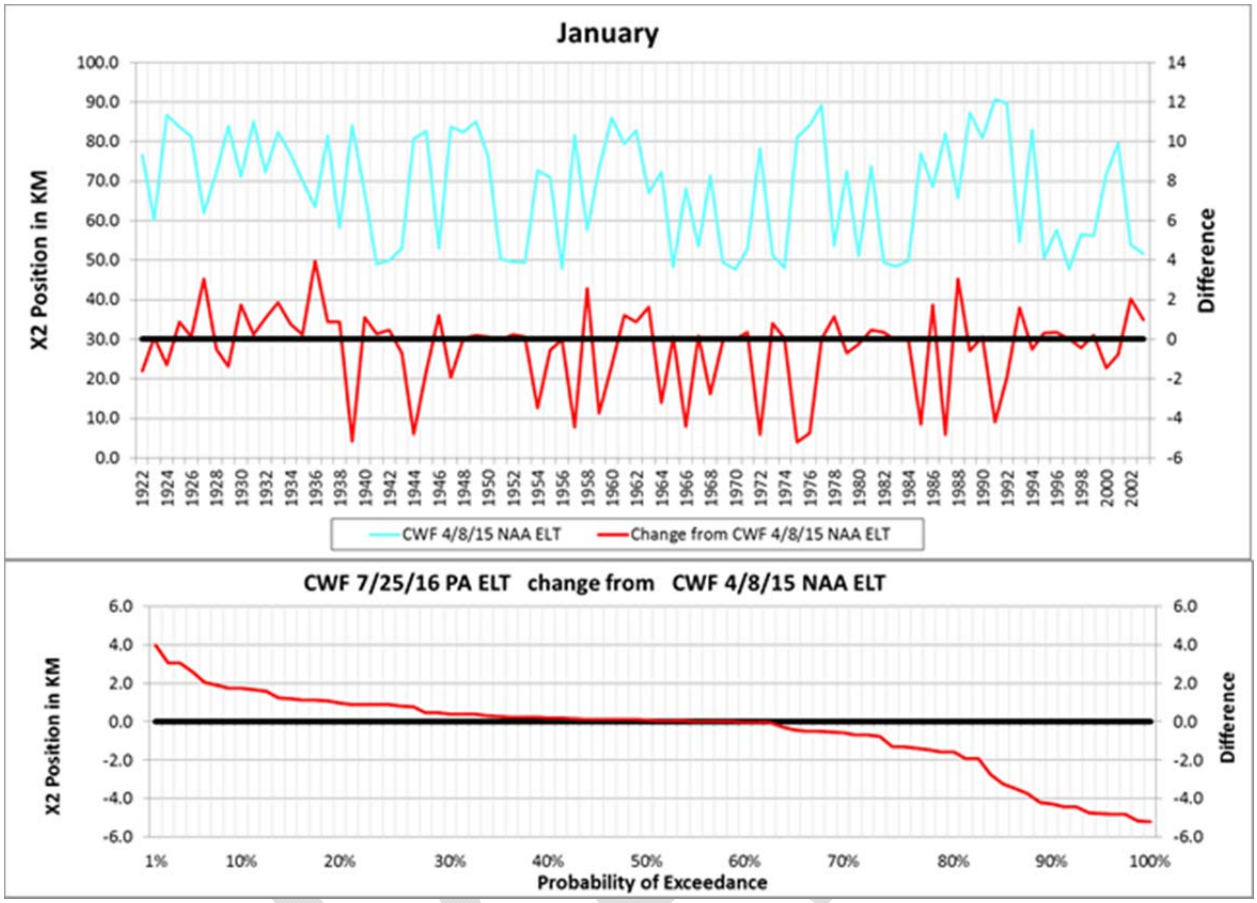
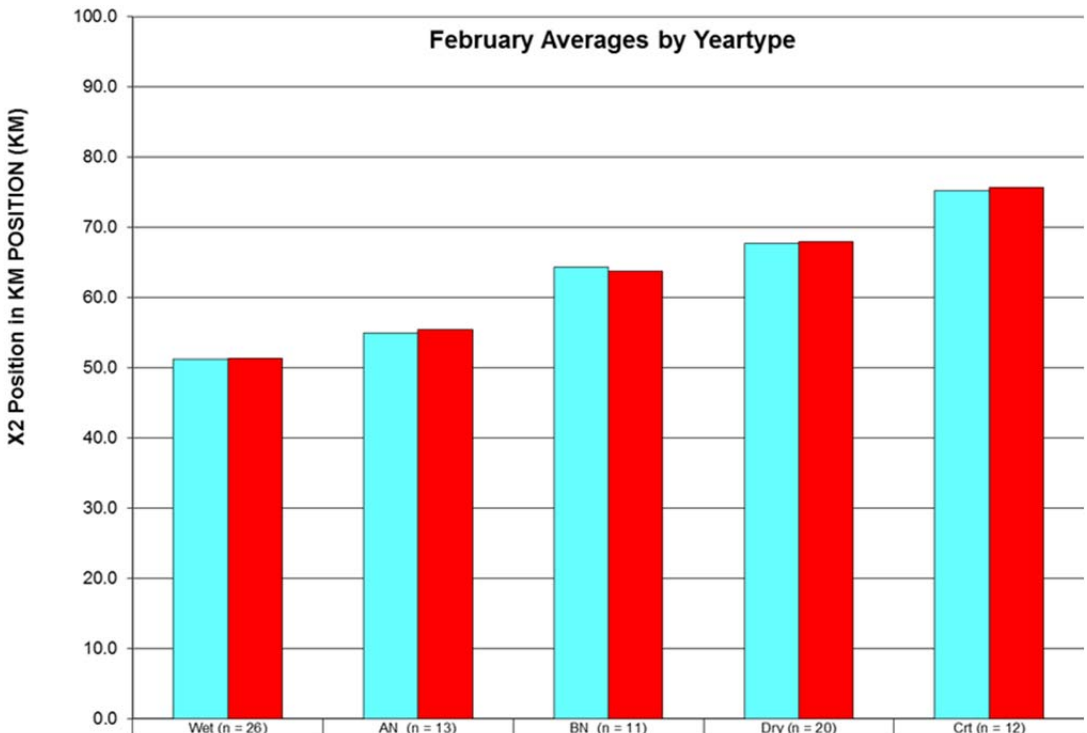


Figure A-2. Change in X2 position (in km) in January with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	51	55	64	68	75
CWF 7/25/16 PA ELT	51	55	64	68	76

Figure A-3. Change in X2 location (in km) for February averages by WY type.

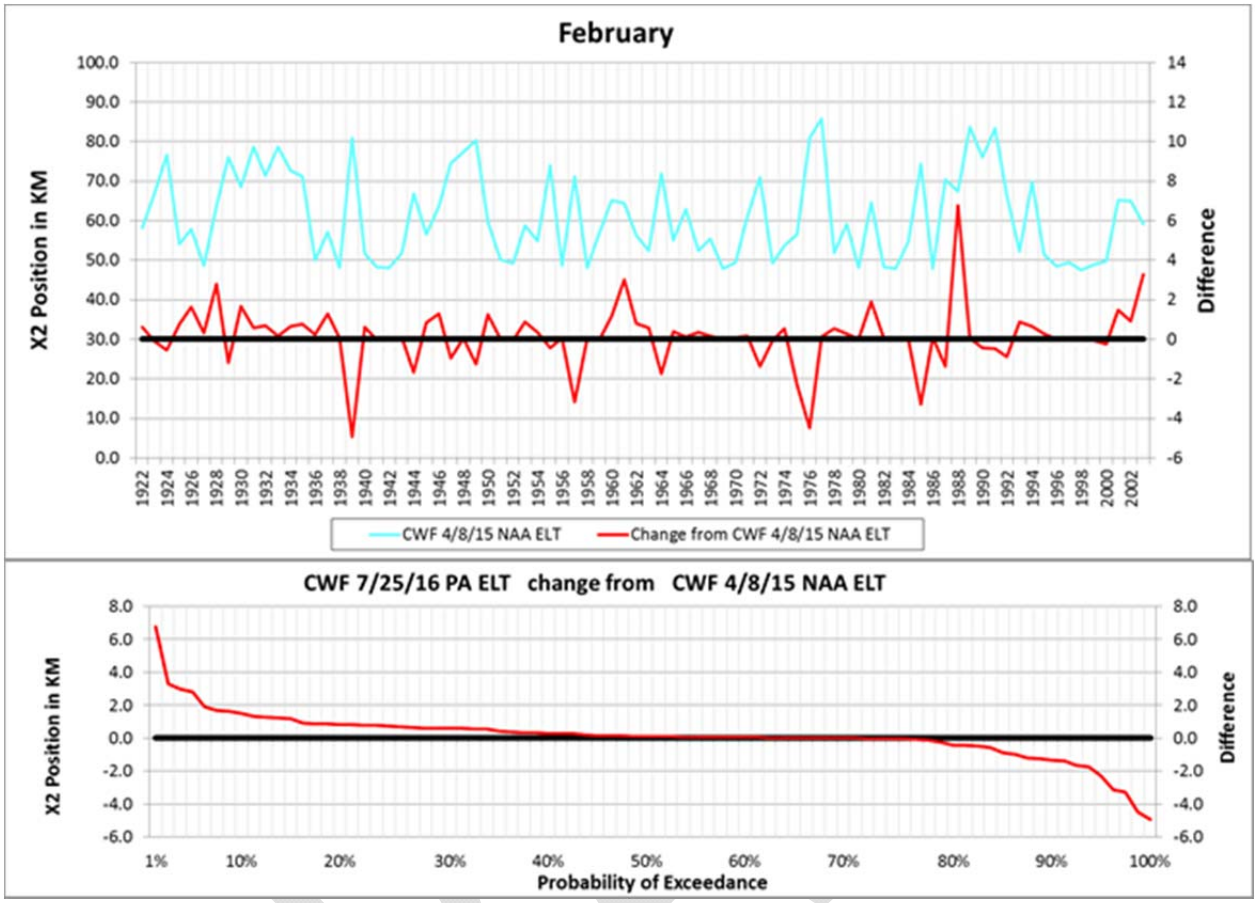


Figure A-4. Change in X2 position (in km) in February with probability of exceedance.

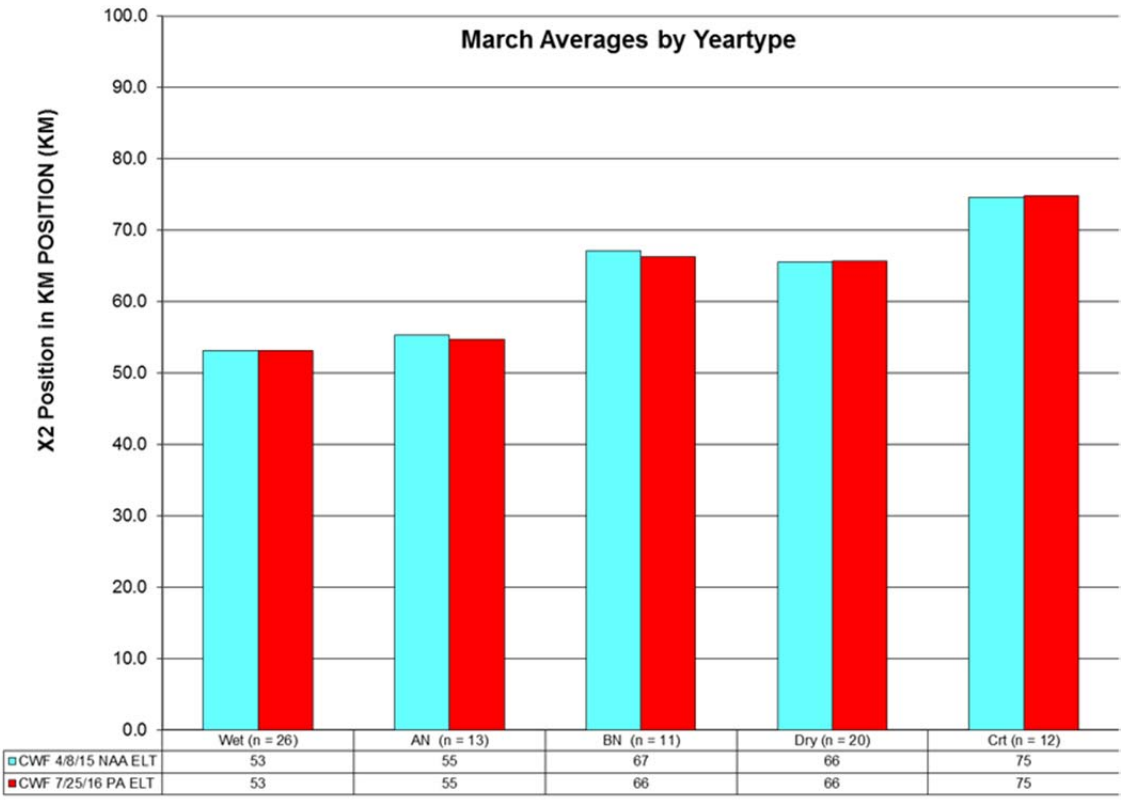


Figure A-5. Change in X2 location (in km) for March averages by WY type.

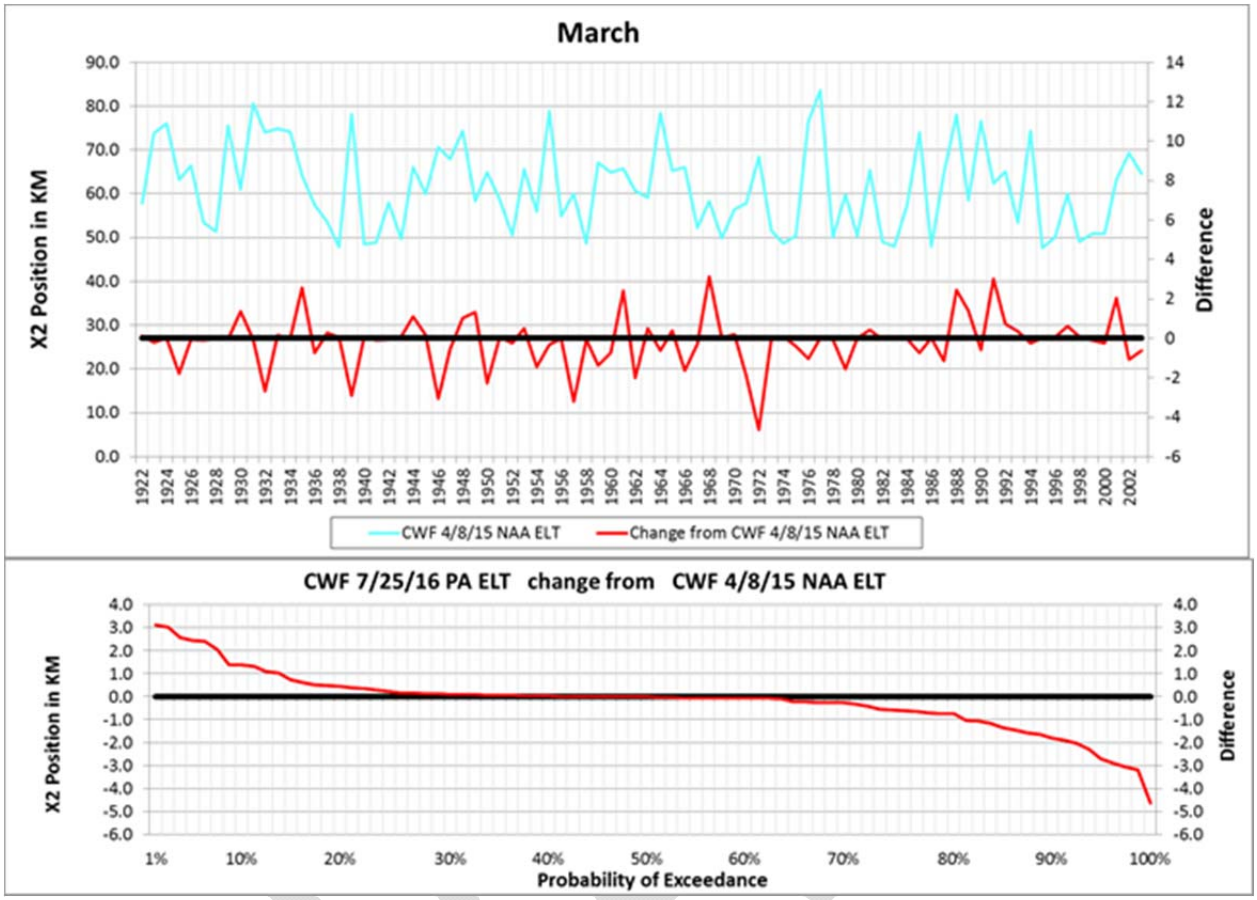


Figure A-6. Change in X2 position (in km) in March with probability of exceedance.

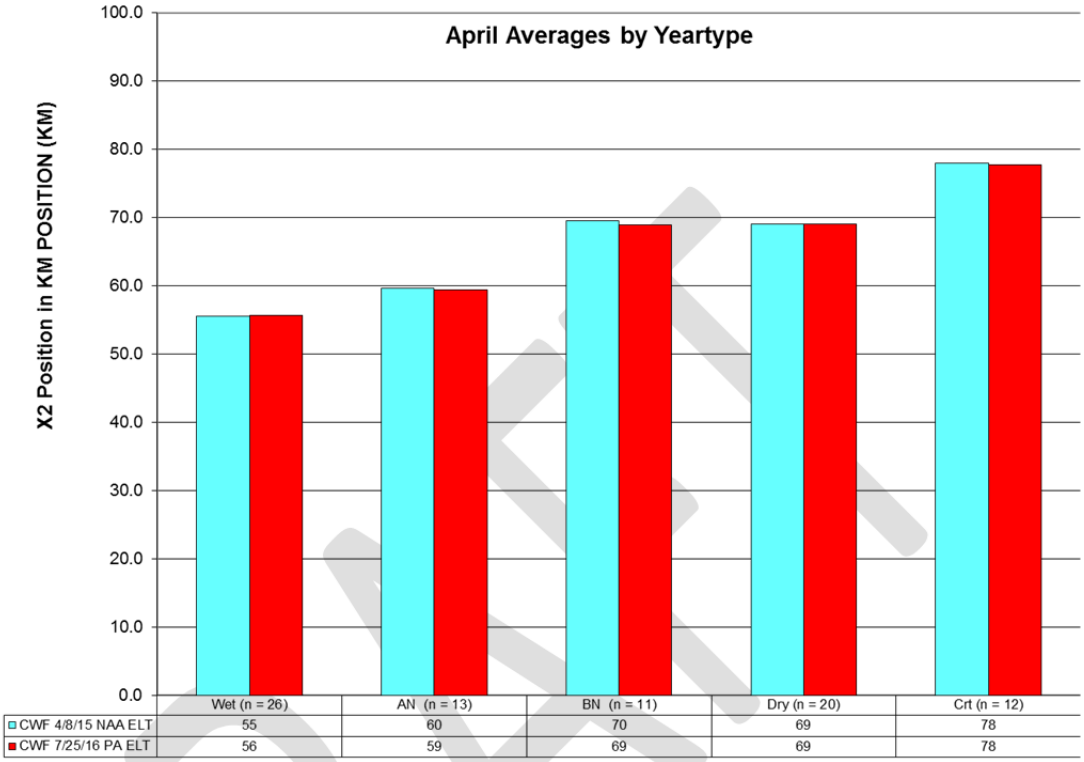


Figure A-7. Change in X2 location (in km) for April averages by WY type.

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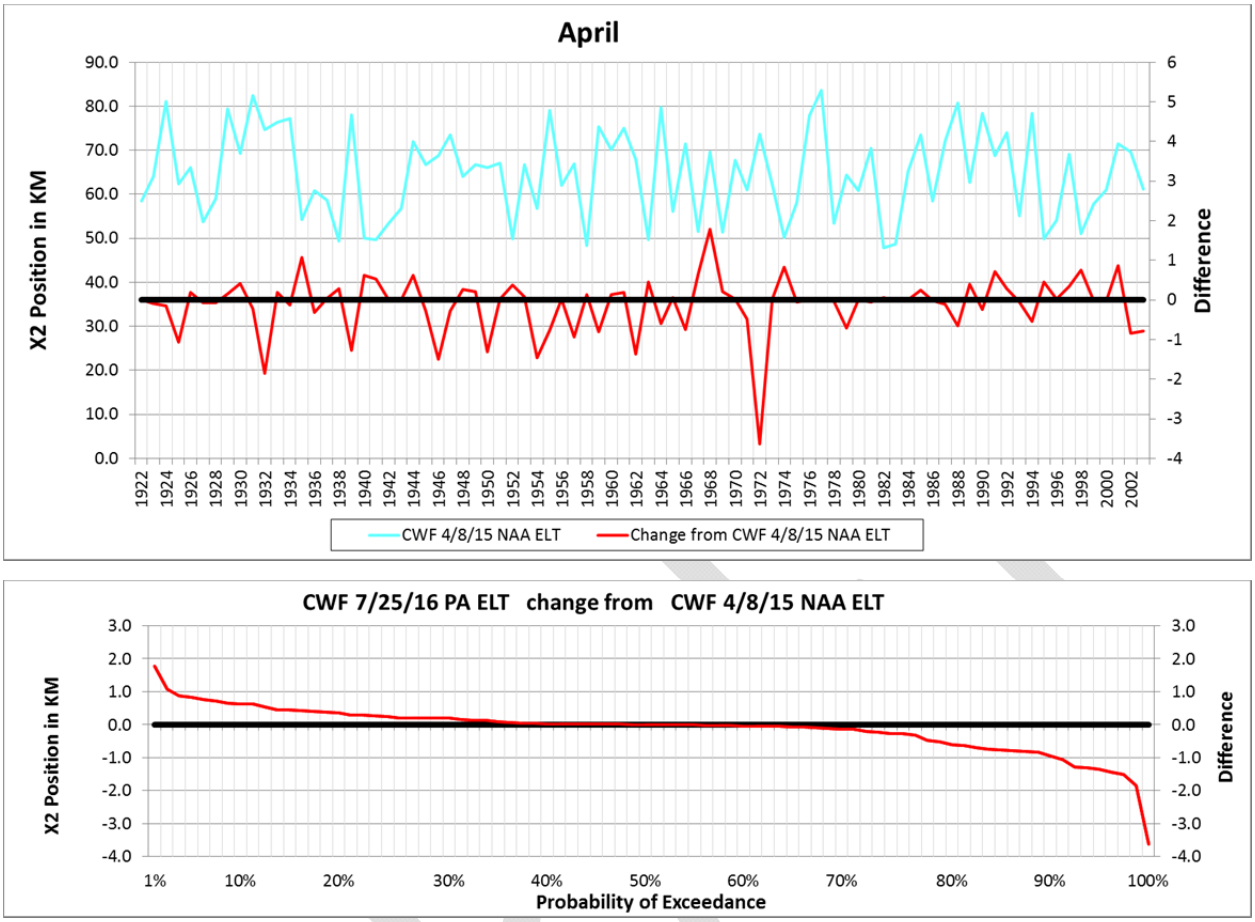
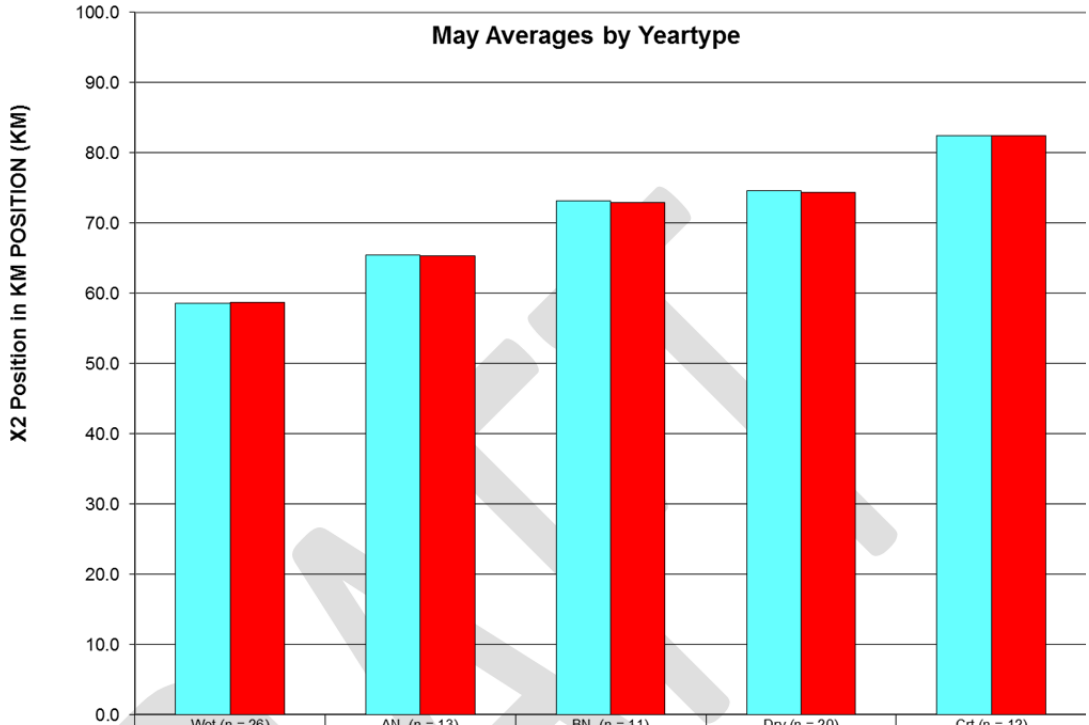


Figure A-8. Change in X2 position (in km) in April with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	59	65	73	75	82
CWF 7/25/16 PA ELT	59	65	73	74	82

Figure A-9. Change in X2 location (in km) for May averages by WY type.

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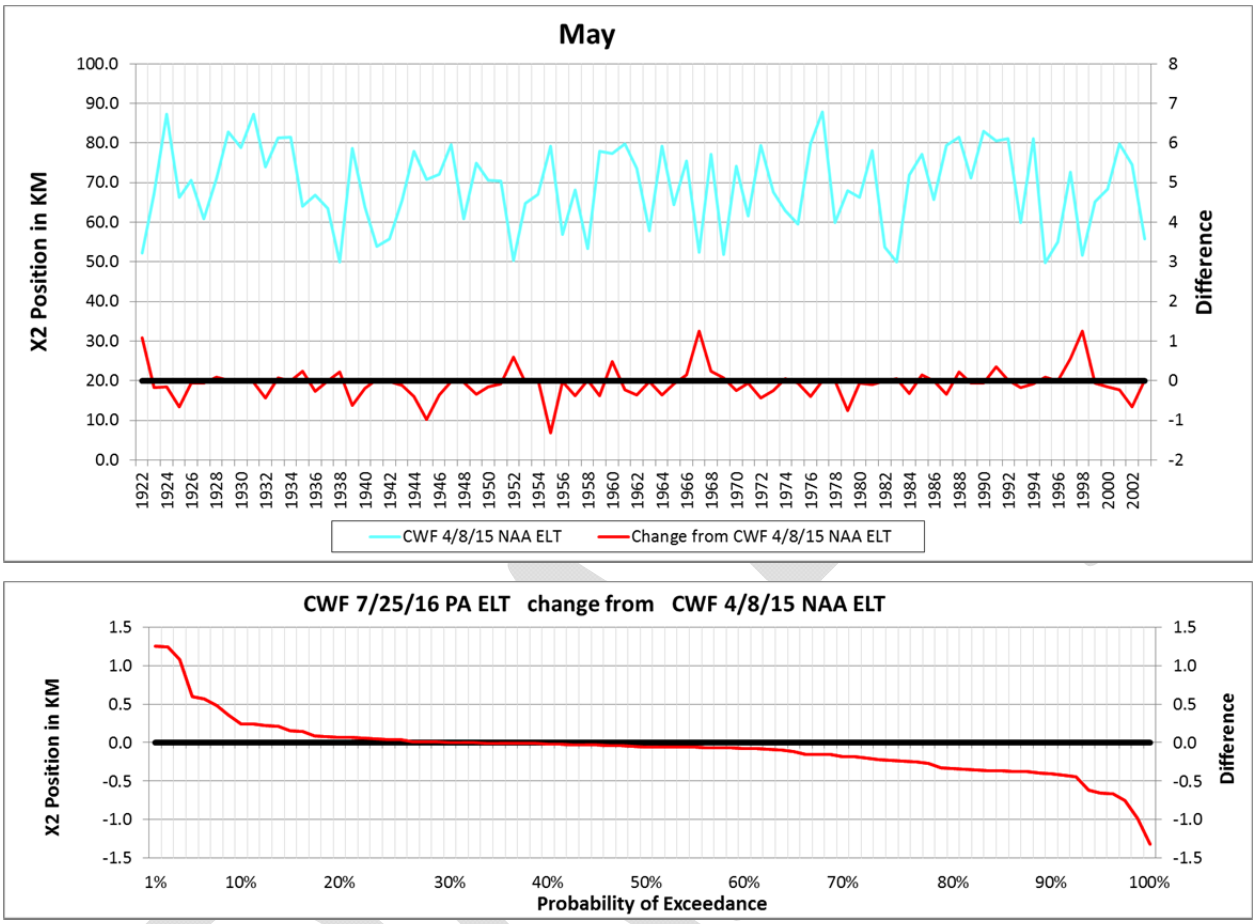
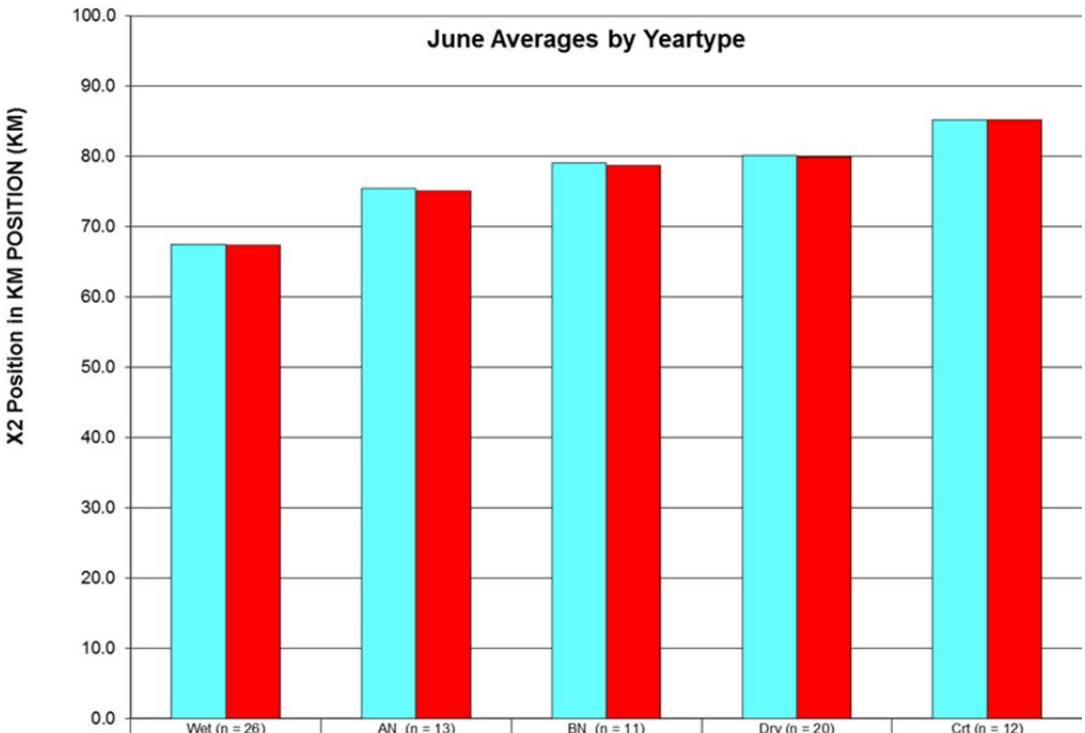


Figure A-10. Change in X2 position (in km) in May with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	67	75	79	80	85
CWF 7/25/16 PA ELT	67	75	79	80	85

Figure A-11. Change in X2 location (in km) for June averages by WY type.

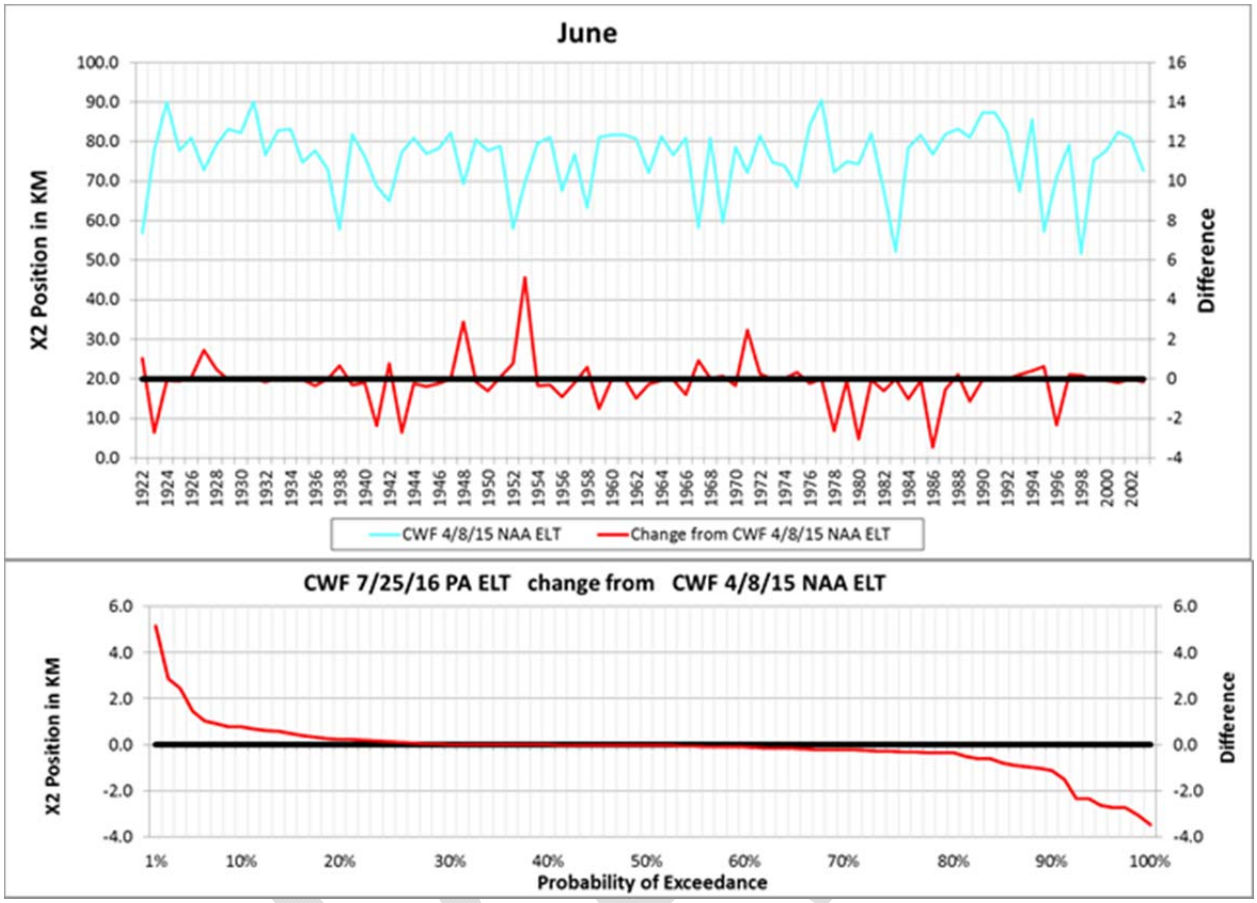
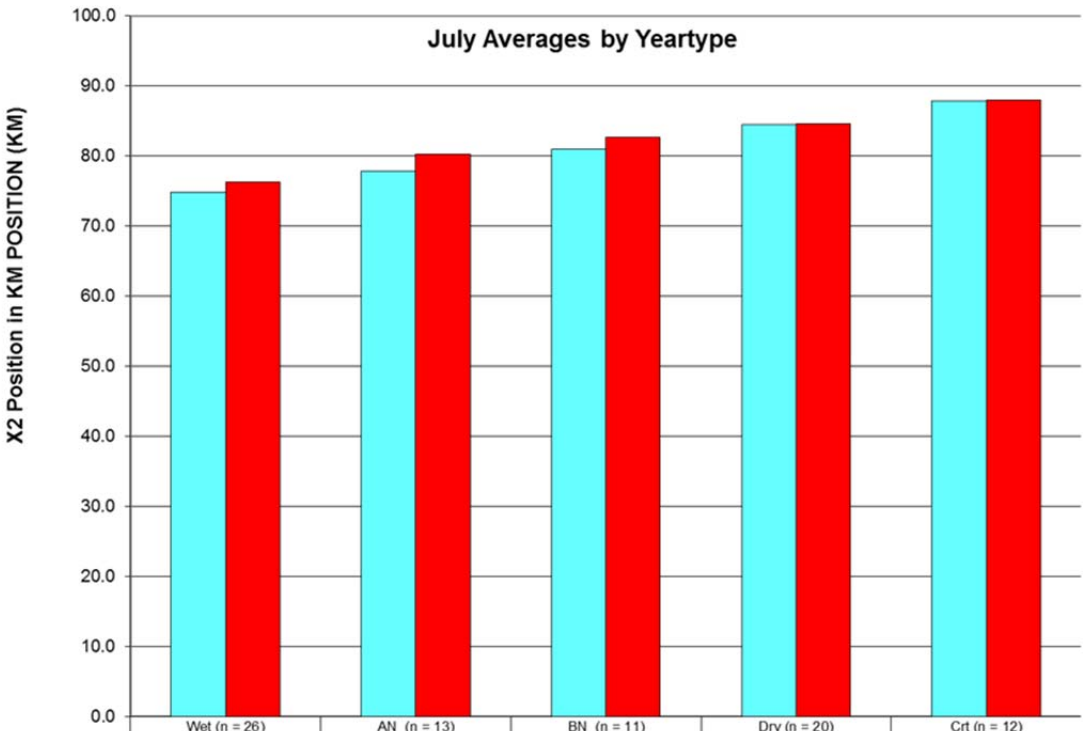


Figure A-12. Change in X2 position (in km) in June with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	75	78	81	84	88
CWF 7/25/16 PA ELT	76	80	83	85	88

Figure A-13. Change in X2 location (in km) for July averages by WY type.

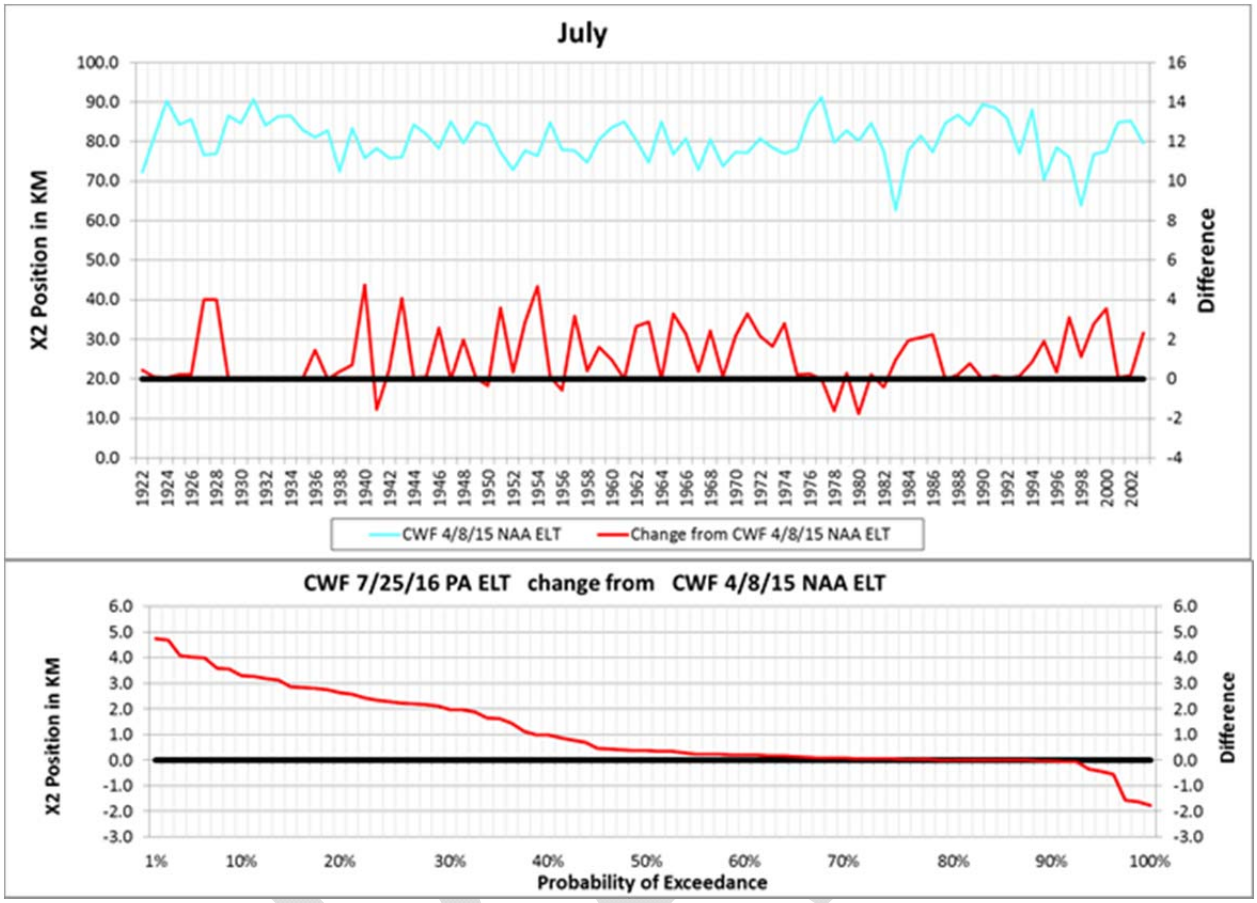
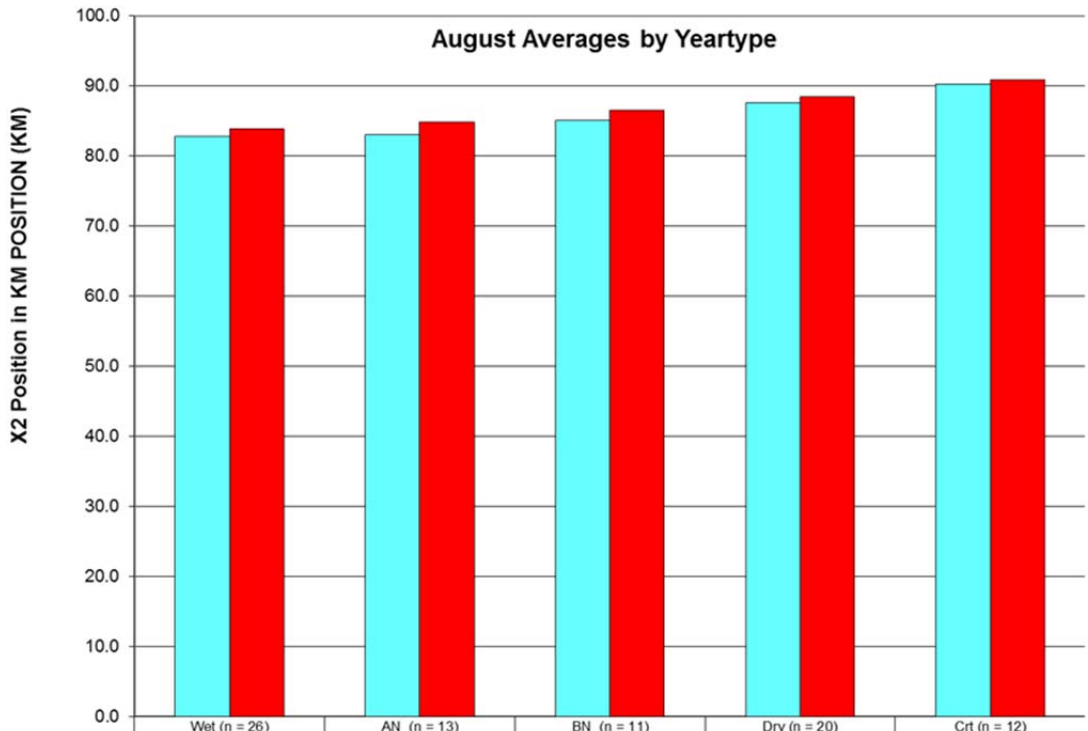


Figure A-14. Change in X2 position (in km) in July with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	83	83	85	88	90
CWF 7/25/16 PA ELT	84	85	87	88	91

Figure A-15. Change in X2 location (in km) for August averages by WY type.

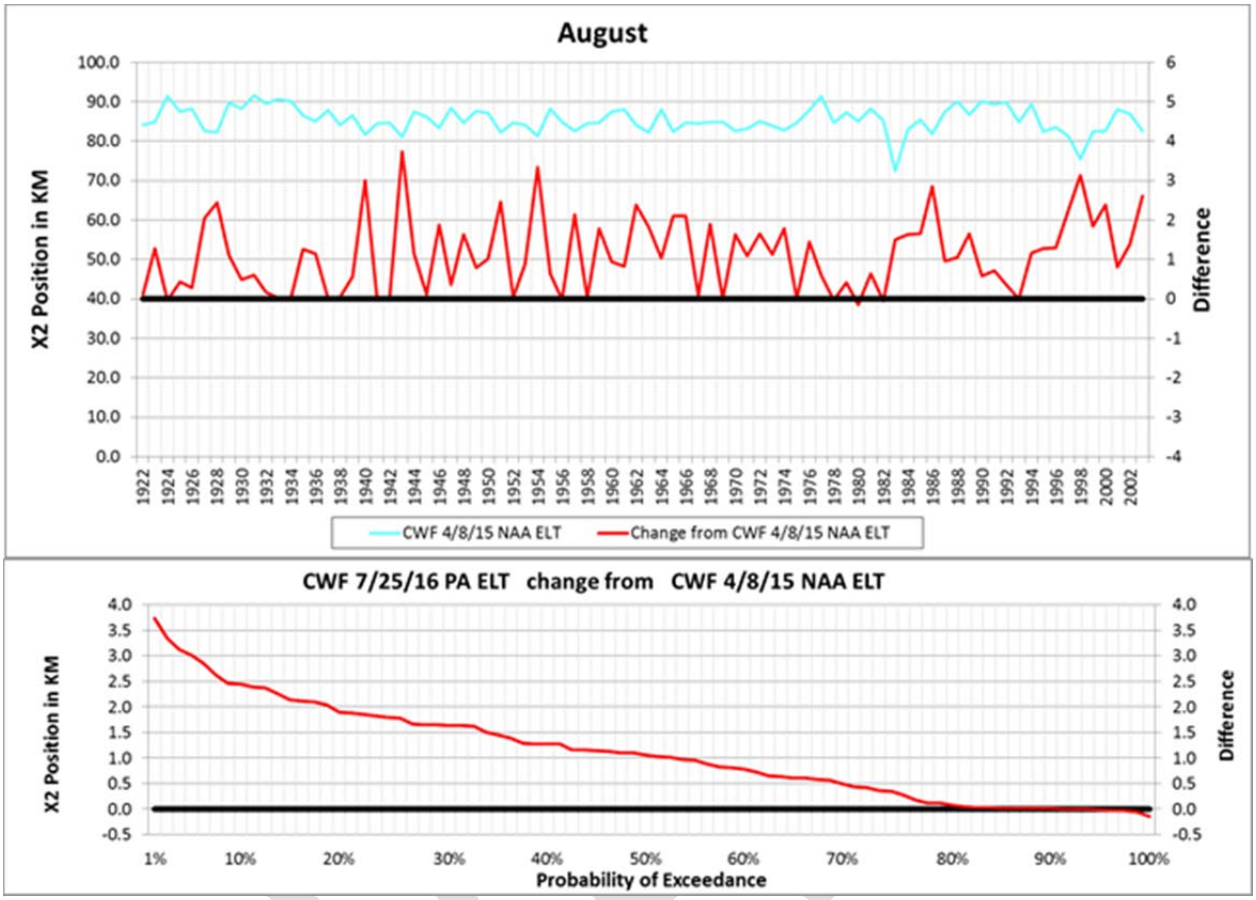
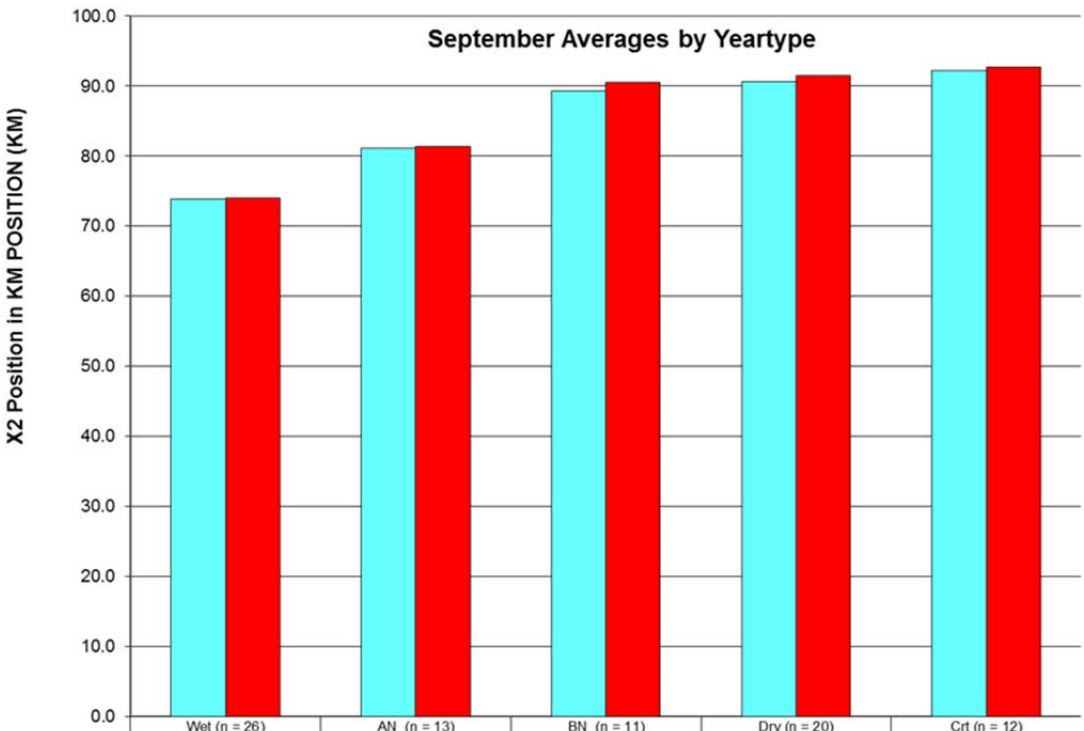


Figure A-16. Change in X2 position (in km) in August with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	74	81	89	91	92
CWF 7/25/16 PA ELT	74	81	90	91	93

Figure A-17. Change in X2 location (in km) for September averages by WY type.

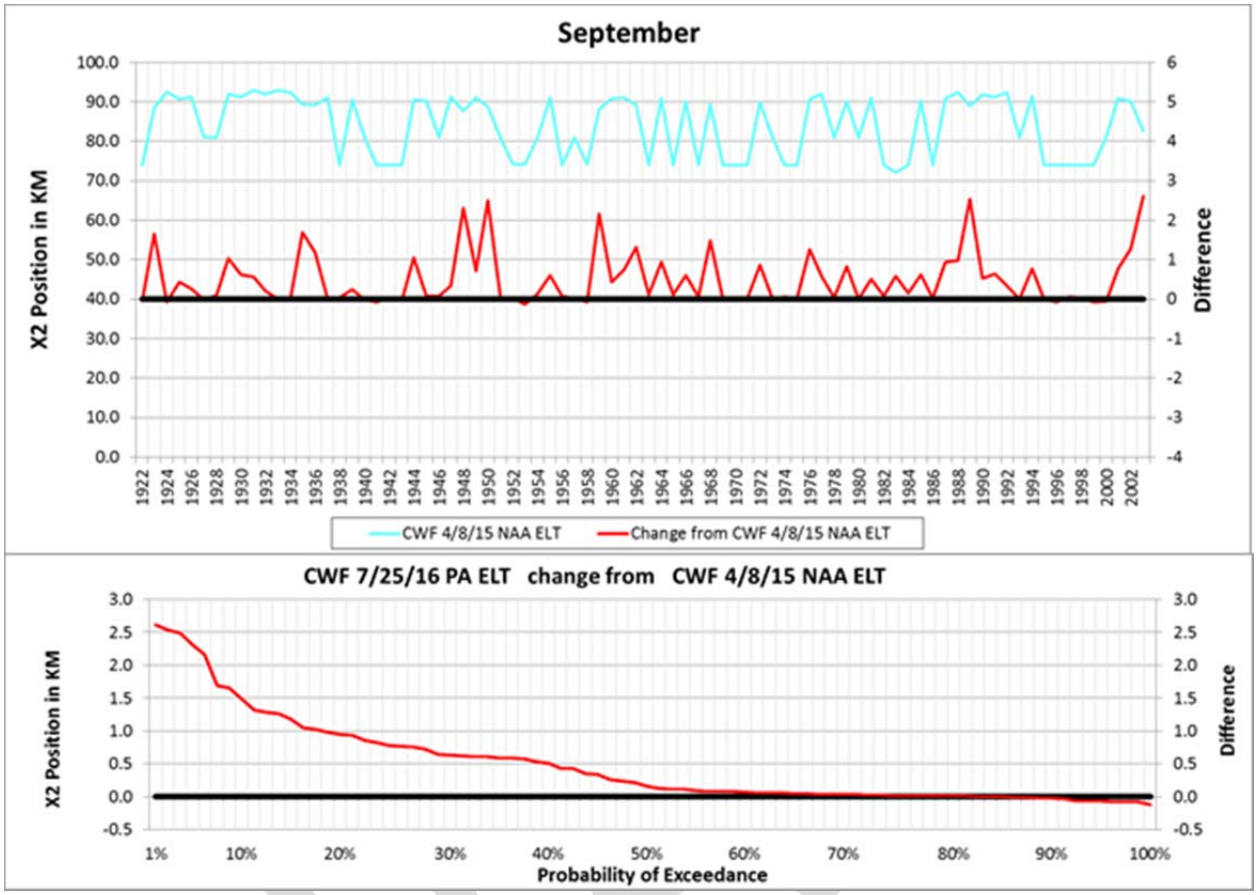
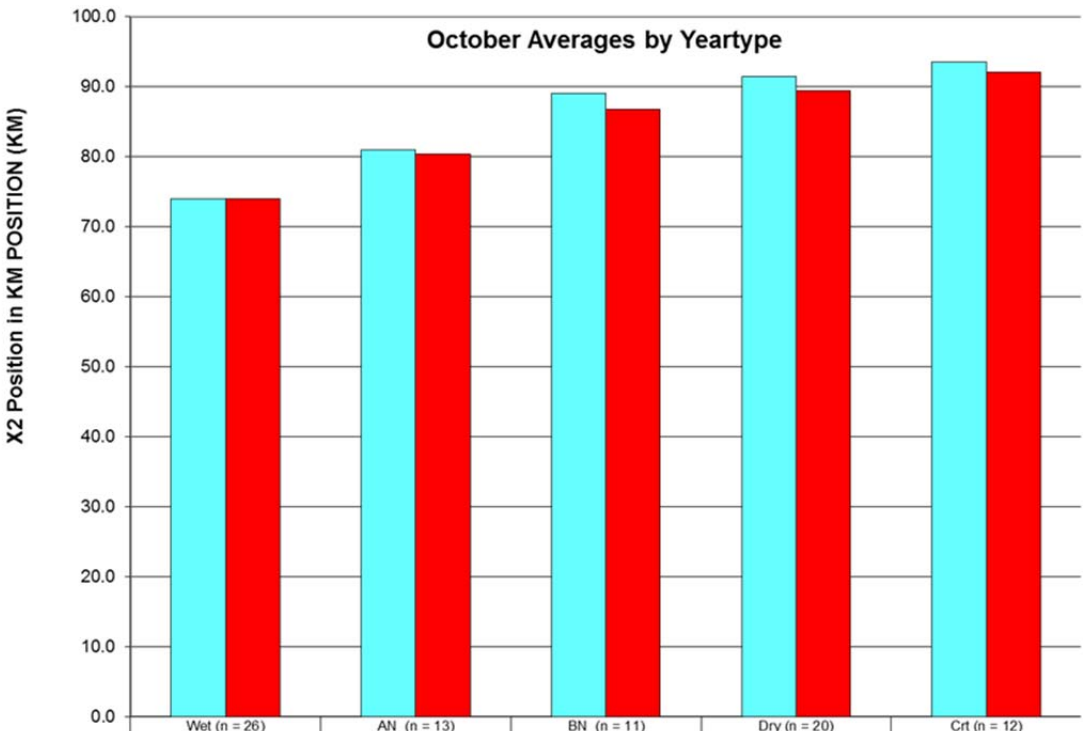


Figure A-18. Change in X2 position (in km) in September with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	74	81	89	91	94
CWF 7/25/16 PA ELT	74	80	87	89	92

Figure A-19. Change in X2 location (in km) for October averages by WY type.

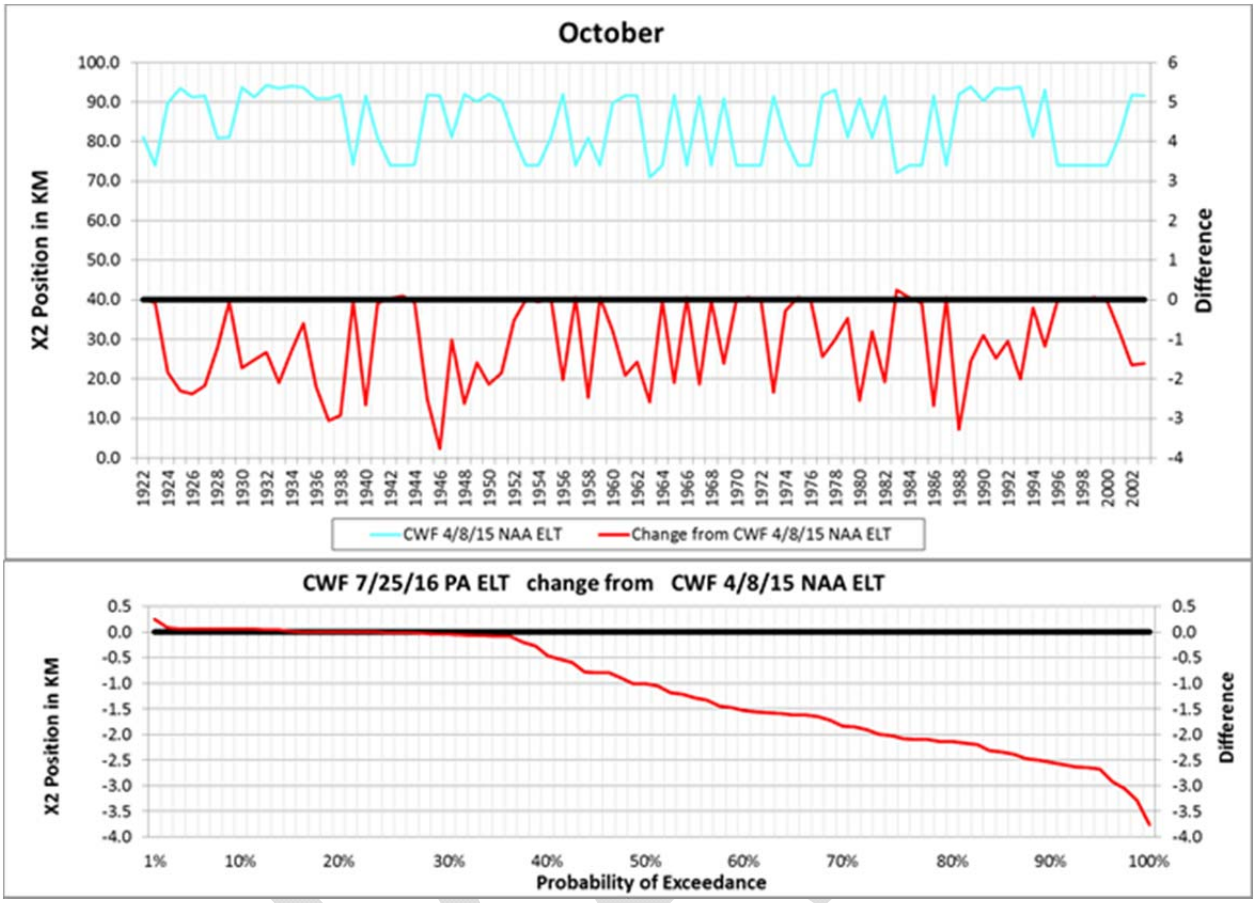
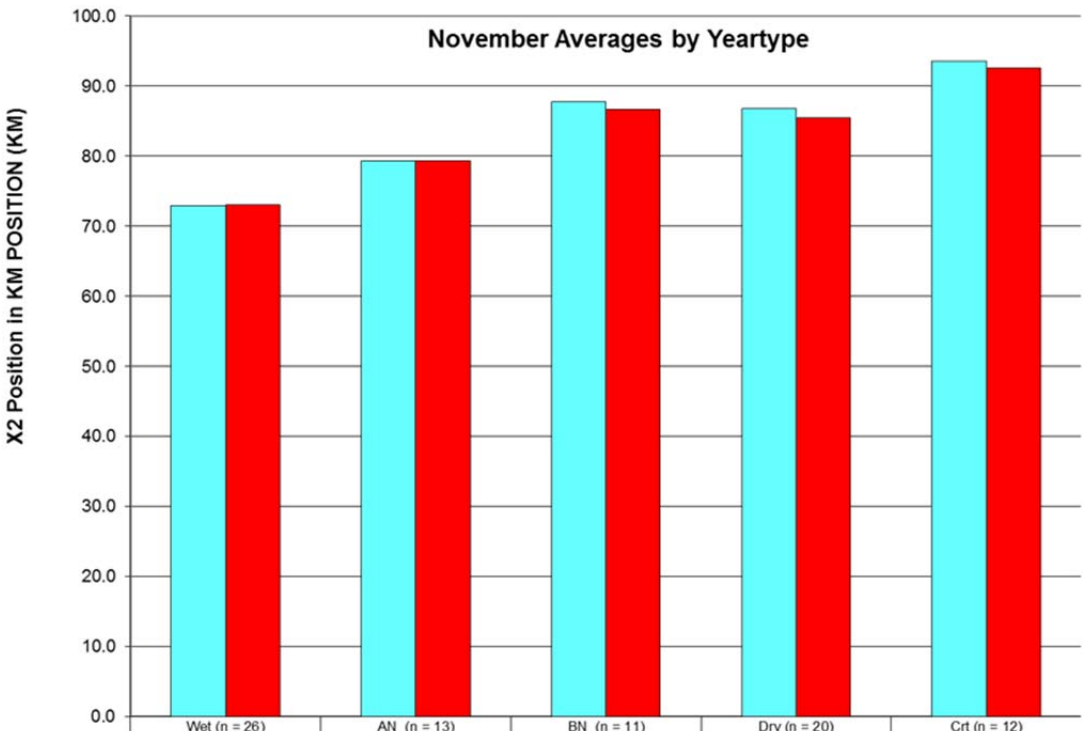


Figure A-20. Change in X2 position (in km) in October with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	73	79	88	87	94
CWF 7/25/16 PA ELT	73	79	87	85	93

Figure A-21. Change in X2 location (in km) for November averages by WY type.

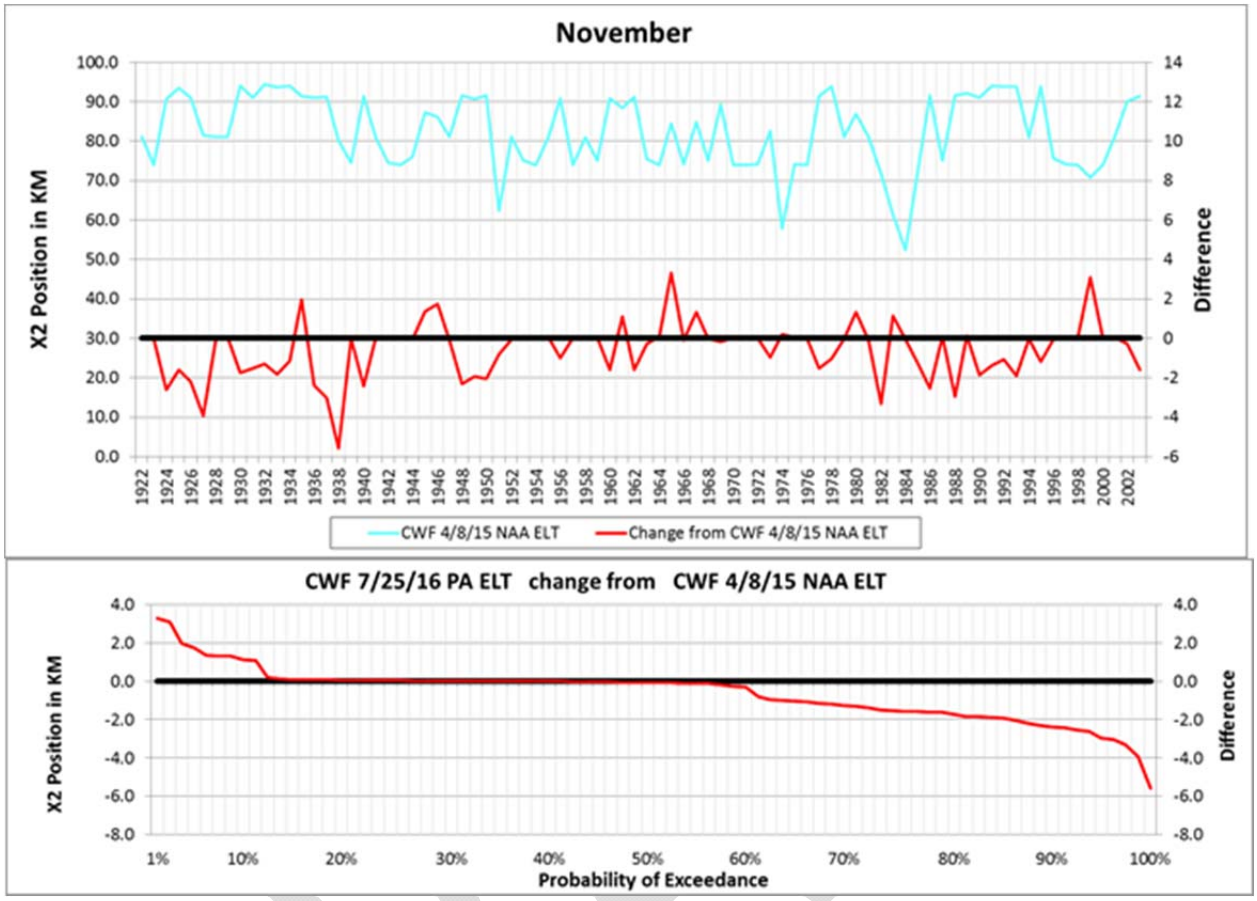
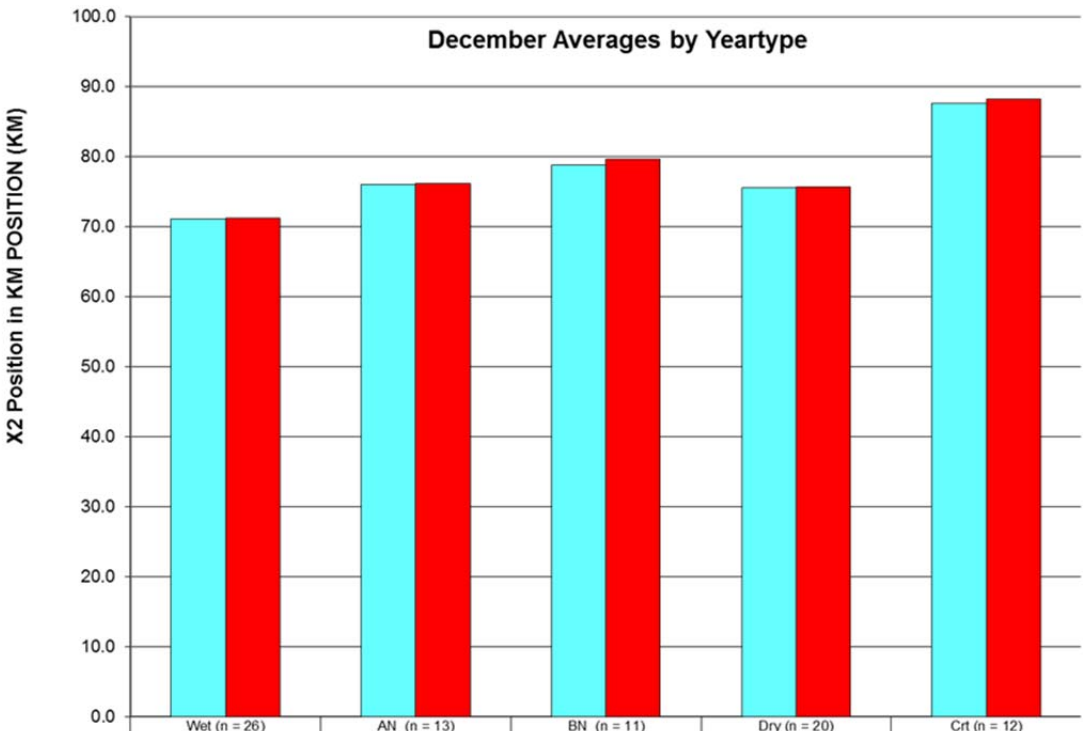


Figure A-22. Change in X2 position (in km) in November with probability of exceedance.



	Wet (n = 26)	AN (n = 13)	BN (n = 11)	Dry (n = 20)	Crt (n = 12)
CWF 4/8/15 NAA ELT	71	76	79	76	88
CWF 7/25/16 PA ELT	71	76	80	76	88

Figure A-23. Change in X2 location (in km) for December averages by WY type.

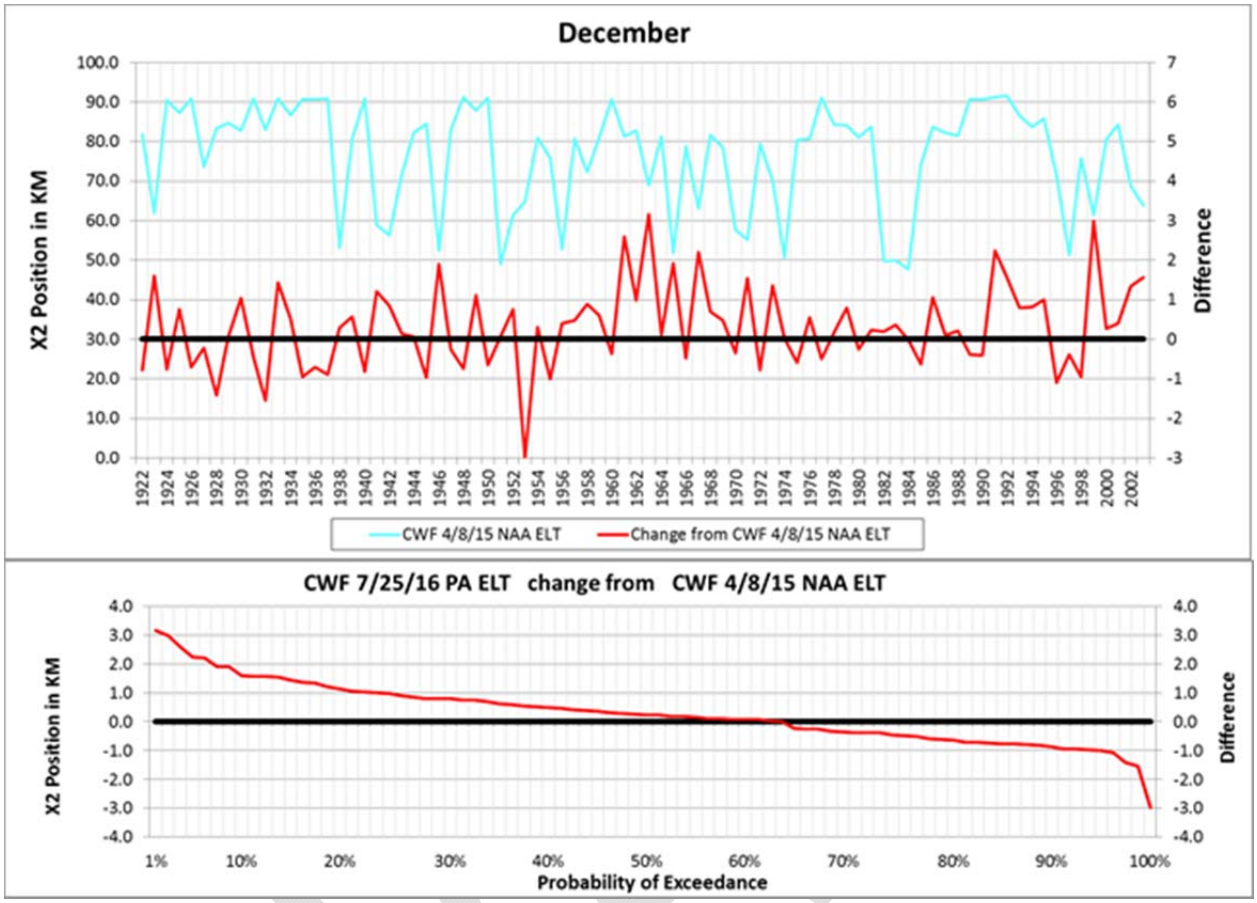


Figure A-24. Change in X2 position (in km) in December with probability of exceedance.