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Acronyms and Abbreviations

AFRP	Anadromous Fish Restoration Program
Basin Plan	water quality control plan
BCDP	Bay Delta Conservation Plan
BMPs	best management practices
BiOp	Biological Opinion
BOD	biochemical oxygen demand
CALFED	CALFED Bay-Delta Program
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CM	conservation measure
CNDDB	California Natural Diversiyty Database
CVP	Central Valley Project
Centra Valley Water Board	Central Valley Regional Water Quality Control Board
D-1641	State Water Resources Control Board water right Decision 1641
DBEEP	Delta-Bay Enhanced Enforcement Project
DCC	Delta Cross Channel
Delta	Sacramento–San Joaquin River Delta
DO	dissolved oxygen
DOM	dissolved organic matter
DPS	distinct population segment
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DWR	California Department of Water Resources
EBC	existing biological conditions
EC	electrical conductivity, salinity
EFH	Essential Fish Habitat
EHW	extreme high water
EIR/EIS	environmental impact report/environmental impact statement
ELT	early long-term
ERP	Ecosystem Restoration Program
ESA	federal Endangered Species Act
ESU	evolutionarily significant unit
FAV	floating aquatic vegetation
fps	feet per second
FR	Federal Register
HSI	habitat suitability index
HUs	habitat units
IAV	invasive aquatic vegetation
IEP	Interagency Ecological Program
LLT	late long-term

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LSZ	low salinity zone
mg/L	milligrams per liter
MHHW	mean higher high water
MLLW	mean lower low water
NBA	North Bay Aqueduct
NCCPA	Natural Communities Conservation Planning Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOP	Notice of Preparation
NT	near-term conditions
OCAP	operating criteria and plan
OMR	Old and Middle River
POM	particulate organic matter
ppt	parts per thousand
PP	preliminary proposal
ROAs	Restoration Opportunity Areas
RPA	Reasonable and Prudent Alternative
SAV	submerged aquatic vegetation
SL	standard length
SR	State Route
State Water Board	State Water Resources Control Board
SWP	State Water Project
TAF	thousand acre-feet
TL	total length
UC Davis	University of California, Davis
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VSP	viable salmonid population
WDRs	waste discharge requirements
WWTP	Wastewater Treatment Plant
YOY	young-of-year

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Chapter 5
Effects Analysis

5.1 Introduction and Summary of Conclusions

This chapter describes how the Bay Delta Conservation Plan (BCDP or Plan) would affect ecosystems, natural communities, and covered species, and presents conclusions regarding expected outcomes from implementing the conservation strategy (described in Chapter 3, *Conservation Strategy*) and covered activities (described in Chapter 4, *Covered Activities*). Those conclusions are reached through a systematic, scientific evaluation of the potential adverse, beneficial, and net effects of the Plan on ecosystems, natural communities, and covered species.

The effects analysis also provides the fish and wildlife agencies with the information that they will need to issue incidental take permits and authorizations for the BDCP, to prepare findings regarding the contribution that the BDCP will make to the recovery of covered species and natural communities, and in certain other ways to comply with regulatory requirements that are described below (Section 5.1.1, *Regulatory Scope*) and detailed in Section 1.3, *Regulatory Context*.

The overall goal of the BDCP is to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework. This chapter documents how implementing the BDCP will meet the ecosystem health portion of that goal by providing for the conservation of each of the natural communities and covered species. For an evaluation of how the BDCP will meet the goal of protecting and restoring water supply and water quality, see the Environmental Impact Report/Environmental Impact Statement (EIR/EIS). The BDCP would contribute to the restoration of Sacramento–San Joaquin River Delta (Delta) ecosystems largely by addressing ecological functions and processes on a broad landscape scale. Proposed actions would result in fundamental, systemic, long-term physical changes to the Delta. These changes include substantial alterations to water conveyance and management and extensive restoration of tidal, floodplain, and terrestrial natural communities. Addressing such fundamental and large-scale change has required the development of new analytical tools and new ways of looking at Delta ecosystems and species.

5.1.1 Basis for Evaluation

The effects analysis is built on and reflects an extensive body of monitoring data, scientific investigation, and analysis of the Delta compiled over several decades (well summarized in Healey et al. 2008), including the results and findings of numerous studies initiated under the CALFED Bay-Delta Science Program, the long-term monitoring programs conducted by the Interagency Ecological Program (IEP), research and monitoring conducted by state and federal resource agencies, and research contributions of academic investigators.

To ensure that the BDCP would be based on the best scientific and commercial data available, the California Department of Water Resources (DWR) undertook a rigorous process to develop new and updated information and to evaluate a wide variety of issues and approaches as it formulated a cohesive, comprehensive conservation strategy. This effort included an evaluation in early 2009, conducted by multiple teams of experts, of BDCP conservation options using the CALFED Bay-Delta Program (CALFED) Ecosystem Restoration Program's (ERP's) Delta Regional Ecosystem Restoration

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Implementation Plan (DRERIP) evaluation process. Implementation of the DRERIP evaluation process brought together a large group of scientific experts on various aspects of the Delta ecosystem and its species. The information generated from this process provided some of the most advanced thinking on the effects of conservation actions (as proposed at that time) on key ecological stressors. Results of the 2009 DRERIP evaluation were used, as applicable, to add support to various parts of the BDCP effects analysis and are detailed by Essex Partnership (2009). The analysis also benefited from two reviews published by the National Research Council (2010, 2011) and from independent scientific reviews that are described in Chapter 10, *Integration of Independent Science in BDCP Development*.

The analysis presented in this chapter is lengthy and complex. The complexity is inevitable because of the large size of the Plan Area, the large number of natural communities and covered species addressed by the Plan, the scale of the covered activities, the long time horizon of the Plan, the intrinsic and often highly variable properties of the Bay-Delta environment (e.g., salinity gradients, hydrology, projected effects of climate change), and the confounding effects that climate change may have on ecosystems and species in the Plan Area. Despite its length, this chapter is intended to be a summary of all technical analyses, and presents the key technical results and methods needed to meet permit issuance criteria. Conclusions and summaries in this chapter are written to minimize jargon, literature citations, and technical data. The full technical description of all methods and results is provided in a number of appendices, which are cited in this chapter as appropriate. In many cases a reader will have to refer to the appendices to fully understand the methods used or other technical detail underlying conclusions and summaries presented in this chapter. The appendices supporting the analyses in this chapter include:

- Appendix 2.A, *Covered Species Accounts*
- Appendix 2.C, *Climate Change Implications and Assumptions*
- Appendix 5.B, *Entrainment*
- Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*
- Appendix 5.D, *Contaminants*
- Appendix 5.E, *Habitat Restoration*
- Appendix 5.F, *Biological Stressors on Covered Fish*
- Appendix 5.G, *Fish Life Cycle Models*
- Appendix 5.H, *Aquatic Construction Effects*
- Appendix 5.J, *Scenario 6 Comparison*
- Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*

This chapter begins with a summary description of analytical methods (Section 5.2). It then describes effects on aquatic ecosystems in general (Section 5.3), focusing on ecosystem stressors that determine, to a large degree, the mechanisms by which the BDCP would affect covered species. Section 5.4 provides an overview of how natural communities would be affected. Section 5.5 describes the net effects of the Plan on each covered fish species. Finally, Section 5.6 presents the comparable analysis for each terrestrial covered species (amphibians, reptiles, birds, mammals, and plants).

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The remainder of this introduction describes the relationship of the effects analysis to other components of the Plan, the regulatory scope of the BDCP, a summary of the actions evaluated, i.e. the conservation strategy, and a summary of effects on each covered species.

5.1.2 Structure of the BDCP

The structure of the BDCP includes four elements: the biological goals and objectives, the conservation measures, the effects analysis, and the adaptive management and monitoring program. The relationship between these elements is described in Section 5.2, *Methods*. Briefly, the biological goals and objectives reflect the anticipated outcomes of the BDCP with regard to minimizing, and mitigating for incidental take, and contributing to the recovery of covered species and natural communities. The conservation measures define the actions that will be implemented under the BDCP in order to achieve the goals and objectives. The effects analysis describes what the conservation measures are expected to achieve at certain time steps during BDCP implementation, based on the best available information. The adaptive management and monitoring program will guide the BDCP during implementation and will provide a means of revising the conservation strategy in response to new and updated information in order to help advance the goals and objectives for the plan. These four elements work together to ensure that the BDCP ultimately will achieve its biological goals and objectives.

5.1.3 Regulatory Scope

The regulatory scope of the BDCP is detailed in Chapter 1, *Introduction*. Table 5.1-1 briefly summarizes the compliance requirements for each state and federal permitting agency under the federal Endangered Species Act (ESA), the Natural Communities Conservation Planning Act (NCCPA), California Environmental Quality Act (CEQA), and National Environmental Policy Act (NEPA)and the trigger for each compliance action. These actions are directly related to the BDCP and its endangered species authorizations. Additional regulatory authorizations are required to implement many BDCP conservation measures as described in Chapter 6, *Implementation*, and the EIR/EIS.

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Table 5.1-1. Environmental Regulation Requirements for Each BDCP State and Federal Agency

Agency	Required Regulation Compliance	Trigger for Compliance
California Department of Water Resources	ESA (Section 10, incidental take permit application) NCCPA (incidental take permit application) CEQA	Potential for take of federally listed species from covered activities requires permit from USFWS and NMFS; potential for take of state-listed species required permit from DFG; DWR adoption of the BDCP and incorporation into the SWP
California Department of Fish and Game	NCCPA (NCCP permit decision) CEQA	DWR submits NCCP and requests take permit for covered species under Fish and Game Code Section 2835. DFG issuance of take authorization and approval of NCCP (CESA 2081 permit not required if NCCP permit issued for state-listed species) is subject to CEQA compliance
Bureau of Reclamation	ESA (Section 7 consultation with USFWS and NMFS) NEPA	Adoption of the BDCP and its incorporation into the CVP; potential to adversely affect federally listed species
U.S. Fish and Wildlife Service	ESA (Section 10 permit decision, internal Section 7 consultation) NEPA	Receipt from DWR of an application for a Section 10 permit; internal Section 7 consultation within agency; request for formal consultation by Reclamation and receipt of biological assessment
National Marine Fisheries Service	ESA (Section 10 permit decision, internal Section 7 consultation) NEPA	Receipt from DWR of an application for a Section 10 permit; internal Section 7 consultation within agency; request for formal consultation by Reclamation and receipt of biological assessment

Notes:
CESA = California Endangered Species Act; ESA = Endangered Species Act; NCCPA = Natural Community Conservation Planning Act; CEQA = California Environmental Quality Act; SWP = State Water Project; NEPA = National Environmental Policy Act; CVP = Central Valley Project; Reclamation = Bureau of Reclamation; NCCP = natural community conservation plan.

5.1.3.1 Other Federal Regulatory Analyses

The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) require additional information to support the federal decision-making process. These analyses include an Essential Fish Habitat (EFH) assessment, an analyses of critical habitat, and an analysis of effects on southern resident killer whale. The EFH assessment is required because the BDCP is a federal action subject to review and approval under the Magnuson-Stevens Fishery Management and Conservation Act (62 Federal Register [FR] 244, December 19, 1997). The EFH assessment would support decisions by NMFS. The critical habitat evaluation and southern resident killer whale analysis are required because Reclamation activities and permit issuance both are federal actions subject to review under Section 7 of the ESA. Covered species under the jurisdiction of both USFWS and NMFS have designated critical habitat, so this assessment provides information for both federal regulatory agencies. Killer whales are under the jurisdiction of NMFS. These other federal regulatory analyses are found in Appendix 5.I with conclusions summarized in Section 5.7.

[***Note to Reader:*** *First drafts of these evaluations were provided to the fish and wildlife agencies in February 2010. They will be updated and revised and provided for review in the coming months.*]

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5.1.4 Actions Evaluated

The effects analysis evaluates the effects of implementing BDCP covered activities, including all conservation measures (see Chapter 4, *Covered Activities*, and Section 3.4, *Conservation Measures*). There are 22 conservation measures (CMs), and they are here briefly summarized:

- *CM 1 Water Facilities and Operation* is intended to meet or contribute to a variety of biological goals and objectives that are expressed mostly at the landscape scale and are related to flow. Many of the conservation actions proposed under CM1 constitute a continuation of existing activities being implemented under the biological opinions (BiOps) (Section 1.3.7, *Relationship to Existing Biological Opinions*) that currently constrain State Water Project (SWP)/Central Valley Project (CVP) operations.
- *CM2 Yolo Bypass Fisheries Enhancement* describes how the BDCP Implementation Office will modify the Yolo Bypass to increase the frequency, duration, and magnitude of floodplain inundation. These actions will improve passage and habitat conditions for Sacramento splittail, Chinook salmon, green and white sturgeon, lamprey, and possibly steelhead.
- *CM3 Natural Communities Protection and Restoration* describes how the BDCP Implementation Office will provide the mechanism and guidance to establish a system of conservation lands in the Plan Area, called a reserve system, by acquiring lands for protection and restoration. Such a system is needed to meet natural community and species habitat protection goals and objectives.
- *CM4 Tidal Natural Communities Restoration* describes how the BDCP Implementation Office will provide for the restoration of tidal perennial aquatic, tidal mudflat, tidal freshwater emergent wetland, and tidal brackish emergent wetland natural communities in the BDCP Restoration Opportunity Areas (ROAs). Tidal natural communities will be restored along a contiguous gradient encompassing shallow subtidal aquatic, tidal mudflat, tidal marsh plain, and adjoining transitional upland natural communities. The transitional upland areas will accommodate approximately 3 feet of sea level rise in topographic settings and can function as tidal marsh plain at some future time, if necessary.
- *CM5 Seasonally Inundated Floodplain Restoration* describes how the BDCP Implementation Office will set back river levees and restore seasonally inundated floodplains that historically existed in the Plan Area but have been lost as a result of flood control and channelization.
- *CM6 Channel Margin Enhancement* describes how the BDCP Implementation Office will restore channel margin habitat by improving channel geometry and restoring riparian, marsh, and mudflat habitats on the inboard side of levees.
- *CM7 Riparian Natural Community Restoration* describes how the BDCP Implementation Office will restore riparian forest and scrub in association with restoration of tidal and floodplain areas (CM4 and CM5, respectively) and channel margin enhancements (CM6). Riparian forest and scrub will be restored to include the range of conditions necessary to support habitat for each of the riparian-associated covered species.
- *CM8 Grassland Natural Community Restoration* describes how the BDCP Implementation Office will restore grassland natural community in Conservation Zones 1, 8, and/or 11.

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- *CM9 Vernal Pool Complex Restoration* describes how the BDCP Implementation Office will restore vernal pool complex in Conservation Zones 1, 8, or 11 to achieve no net loss of vernal pool acreage from BDCP covered activities.
- *CM10 Nontidal Marsh Restoration* describes how the BDCP Implementation Office will restore nontidal freshwater marsh in Conservation Zones 2 and 4.
- *CM11 Natural Communities Enhancement and Management* describes how the BDCP Implementation office will prepare and implement management plans for protected natural communities and for the covered species habitats that are found within those communities throughout the reserve system.
- *CM12 Methylmercury Management* describes how the BDCP Implementation Office will minimize conditions that promote production of methylmercury in restored areas and its subsequent introduction to the foodweb, and to covered species in particular.
- *CM13 Invasive Aquatic Vegetation Control* describes how the BDCP Implementation Office will take actions to control the introduction and spread of invasive aquatic plant species in BDCP aquatic restoration areas that degrade habitat for covered fish species, waterfowl, and rare native plants.
- *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* describes how the BDCP Implementation Office will ensure that the Stockton Deep Water Ship Channel DWR Aeration Facility, which is currently operational, will continue to operate as needed during the BDCP permit term in order to maintain the concentrations of dissolved oxygen (DO) above target levels during the entire BDCP permit term.
- *CM15 Predator Control* describes how the BDCP Implementation Office will reduce the local effects of predators on covered fish species by conducting predator control at "hot spot" locations that have high densities of predators with a disproportionately large adverse effect on covered fish.
- *CM16 Nonphysical Fish Barriers* describes how the BDCP Implementation Office will improve the survival of outmigrating juvenile salmonids by using nonphysical barriers to redirect juvenile fish away from channels and river reaches in which survival is lower than in alternate routes.
- *CM17 Illegal Harvest Reduction* describes how the BDCP Implementation Office will reduce illegal harvest of Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon in the Delta, bays, and upstream waterways by funding enforcement actions.
- *CM18 Conservation Hatcheries* describes how the BDCP Implementation Office will establish new, and expand existing, conservation propagation programs for delta and longfin smelt.
- *CM19 Urban Stormwater Treatment* describes how the BDCP Implementation Office will provide a mechanism for implementing urban stormwater treatment measures that will result in decreased discharge of contaminants to the Delta.
- *CM20 Recreational Users Invasive Species Program*, describes how the BDCP Implementation Office will fund actions to reduce nonnative invasive species within the Plan Area by supporting the California Department of Fish and Game (DFG) Watercraft Inspection Program in the Delta.
- *CM21 Nonproject Diversions* describes how the BDCP Implementation Office will provide funding for actions that will minimize the potential for entrainment of covered fish species associated

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with operation of nonproject diversions (diversions of the natural surface waters in the Plan Area for purposes other than meeting SWP/CVP water supply needs).

- *CM22 Avoidance and Minimization Measures* describes how the BDCP Implementation Office will implement measures to avoid and minimize effects on covered species and natural communities that could result from BDCP covered activities.

5.1.5 Summary of Conservation Measure Effects on Covered Species

Table 5.1-2 provides a summary of the beneficial and adverse effects on each covered fish species as a result of the BDCP. This table provides only a description of the beneficial and adverse effects and does not identify the magnitude of effects to the covered fish species. See the discussion under each covered fish species for details.

Table 5.1-3, Table 5.1-4, Table 5.1-5, and Table 5.1-6, provide an overview of the effects of each conservation measure on each covered wildlife and plant species. This table provides only the *direction* of effects (negative, positive, or both) but do not summarize the *magnitude* of effects. The magnitude of effects varies substantially by covered wildlife or plant species and conservation measure and is quantified in different ways for each species or species group. See the discussions under each natural community or covered species for details.

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Table 5.1-2. Summary of the Beneficial and Adverse Effects on Covered Fish Species

Delta Smelt
Beneficial Effects
• Tidal habitat restoration would substantially increase the amount of tidal habitat in the Plan area, mostly in the Cache Slough and Suisun Marsh subregions, substantially increasing suitable habitat for delta smelt and potentially increasing food for local consumption and export to open-estuary areas. • Overall entrainment of delta smelt under the Plan would remain at or be less than low levels experienced in the recent past. This is because the north Delta diversion operations would reduce reliance on south Delta export facilities, with additional minor benefits from decommissioning of agricultural diversions in restoration areas and implementation of an alternative intake for the North Bay Aqueduct (NBA). Some losses of delta smelt may occur because of entrainment and impingement at the north Delta diversions, but these would be relatively low because much of the population occurs downstream of the diversions. • Plan conservation measures may lower predation of larval, juvenile, and adult delta smelt to a small extent; there is low certainty in this conclusion.
Adverse Effects
• Fall abiotic habitat for juvenile delta smelt in the open-water areas of the Suisun Bay, Suisun Marsh, and West Delta subregions would be lower under the Plan than under existing conditions that include the Fall X2 Reasonable and Prudent Alternative (RPA) because of lower outflow, but would increase relative to existing conditions without the Fall X2 RPA. The decline in fall abiotic habitat conditions in the open estuary is largely offset by tidal marsh habitat restoration when considered across all water year types relative to both EBC1 and EBC2 baselines. • The combination of the movement of X2 and tidal habitat restoration may increase delta smelt exposure to the toxic blue-green alga microcystis and provide additional opportunities for invasive mollusks, including *Corbicula* and *Corbula*, to colonize in delta smelt habitat, affecting delta smelt food availability. • Exposure of delta smelt life stages to contaminants may occur following restoration under the Plan; exposure to agriculture-related contaminants later in the Plan term may decrease because of restoration of agricultural areas. • In-water construction and maintenance effects of the Plan could affect delta smelt but would be minimized with careful management.
Longfin Smelt
Beneficial Effects
• Tidal habitat restoration would substantially increase the amount of tidal habitat in the Plan Area, mostly in the Cache Slough and Suisun Marsh subregions, substantially increasing suitable habitat for longfin smelt and potentially increasing food for local consumption and export to open-estuary areas. • Overall entrainment of longfin smelt under the BDCP conservation strategy would remain at or less than low levels experienced in the recent past, depending on water year type because of north Delta diversion operations reducing reliance on south Delta export facilities. Additional minor benefits are expected from decommissioning of agricultural diversions in restoration areas and implementation of an alternative intake for the NBA. The risk of longfin smelt entrainment and impingement at the north Delta diversions is expected to be very minor based on the implementation of state-of-the-art positive barrier fish screens and the fact that much of the longfin smelt population occurs downstream of the diversions. • Plan conservation measures may lower predation of larval, juvenile, and adult longfin smelt to some small extent; there is low certainty in this conclusion.

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Adverse Effects

- Decreased winter-spring outflows under the BDCP conservation strategy have the potential to contribute to appreciable decreases in longfin smelt abundance as a result of reduced larval transport flows and spring habitat quantity and quality for larval and early juvenile longfin smelt in the Suisun Marsh and West Delta subregions.
- Exposure of longfin smelt to contaminants may occur following restoration under the Plan; exposure to agriculture-related contaminants later in the Plan term may decrease because of restoration of agricultural areas.
- In-water construction and maintenance effects of the Plan could affect longfin smelt but would be minimized with careful management..

Salmonids

Beneficial Effects

- The Plan would greatly expand access to tidal habitat used for juvenile salmonid foraging and would enhance channel margin habitat for foraging and migrating juvenile salmonids.
- Overall entrainment loss of juvenile salmonids under the Plan generally would be appreciably lower than under existing conditions because the north Delta diversion operations reduce reliance on south Delta export facilities. Reduced entrainment occurs in the majority of years under wetter conditions whereas in dry and critical water years overall entrainment is increased relative to that under current conditions.
- The Plan would change the configuration and operation of Fremont Weir and the Yolo Bypass, and restore a considerable extent of south Delta floodplain, which would increase floodplain availability and usage and improve conditions for juvenile and adult salmonids.
- Nonphysical fish barriers (CM16) have the potential to inhibit juvenile salmonids from entering the interior Delta, therefore potentially increasing through-Delta survival.
- The Plan has the potential to reduce predation on juvenile salmonids, with considerable uncertainty to be addressed with monitoring and adaptive management.
- The Plan would help reduce illegal harvest of adult salmonids.
- Juvenile salmonid migration flows in the Feather and American Rivers generally would be greater under the Plan than existing conditions.

Adverse Effects

- Operation of the proposed north Delta diversions under the Plan has the potential to adversely affect juvenile salmonid survival through contact with the screens, predation, and reduced downstream flows.
- Sacramento River attraction flows for migrating adult salmonids would be lower from operations of the north delta diversions under the Plan.
- In-water construction and maintenance effects of the Plan could affect salmonids but would be minimized with careful management.
- The Plan would contribute to a reduction in salmonid exposure to contaminants in the late long-term although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration.
- Winter-run Chinook salmon would have greater potential for redd dewatering and lower-weighted usable spawning area under the Plan; the OBAN life cycle model also suggested adverse effects on winter-run Chinook salmon from upstream effects on flow and water temperature; uncertainty will be addressed with adaptive management.
- Egg mortality for spring-run Chinook salmon in the Sacramento River potentially would be somewhat higher under the Plan relative to existing conditions; refinements to reservoir operations may address this issue.

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Splittail
Beneficial Effects
• Inundated floodplain habitat enhancement (CM2) and restoration (CM5), and restoration of tidal wetland habitat (CM4) and channel margin habitat (CM6) are expected, with a high degree of certainty, to benefit the Sacramento splittail population. CM2 is expected to increase the frequency, duration, and surface area of Yolo Bypass inundation, resulting in substantial increases in availability of inundated floodplain habitat to splittail, particularly in dry years. CM5 would restore up to 10,000 acres of new seasonally inundated floodplain in wet years. CM4 would increase the amount of tidal habitat in the Plan Area, substantially increasing suitable habitat for juvenile and adult splittail. CM6 would restore and enhance 20 miles of channel margin habitat in the Delta, primarily benefitting juvenile and adult splittail during their migrations. These measures also would increase food resources for local consumption and potentially export surpluses to the Delta. Several factors create uncertainty regarding the potential benefits of the measures, including flows needed to trigger migration of adults to the Yolo Bypass, and potential effects of colonization by predatory fish, invasive aquatic vegetation, and invasive mollusks on habitat value. • Overall entrainment of splittail would be lower under the Plan because of north Delta diversion operations reducing reliance on south Delta export facilities, but entrainment under existing conditions has a minor effect on the splittail population. • Plan conservation measures may lower predation of juvenile and adult splittail to a small extent although the magnitude of this benefit is uncertain.
Adverse Effects
• Increased exposure of splittail to contaminants may occur following habitat restoration and enhancement under the Plan; exposure to some contaminants may decrease later in the Plan term because of reduced agricultural production. • In-water construction and maintenance effects of the Plan could affect splittail but would be minimized with CM 22 and other standard measures.
White and Green Sturgeon
Beneficial Effects
• CM17 Illegal Harvest Reduction is expected to reduce poaching pressure on white and green sturgeon and reduce mortality of reproductive adults. • The Plan is predicted to have positive effects on flow rates during white and green sturgeon egg incubation in the Feather River. • CM2 Yolo Bypass Fisheries Enhancements will substantially improve passage for white and green sturgeon and CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels will improve passage for white sturgeon with smaller benefits to green sturgeon. • Habitat restoration may provide habitat and food benefits to juvenile and adult white and green sturgeon, although there is high uncertainty in this assertion. • CM2 Yolo Bypass Fisheries Enhancement is predicted to provide food downstream in the Delta because of increased flooding frequency and duration. • CM15 Predator Control is expected to provide modest benefits to white and green sturgeon while these species are within vulnerable size ranges. • Entrainment of white and green sturgeon at south Delta pumps under the Plan will be substantially reduced in wetter water years and moderately reduced in drier water years. The negligible reductions in entrainment in agricultural diversions are not expected to affect sturgeon. • CM13 Invasive Aquatic Vegetation Control is predicted to improve the quality and quantity of habitat for important prey resources for white and green sturgeon.

Adverse Effects
• The Plan would reduce April and May Delta outflow, which has been correlated with year class strength of white sturgeon, in some water year types. However, the Plan would maintain upstream spring flows in the Sacramento River, which has been correlated with recruitment of a given year class. • Average transport or migration flows for white sturgeon juveniles and green sturgeon larvae and juveniles in the Sacramento and Feather Rivers are predicted to be lower under the Plan. Flows in the San Joaquin River are not expected to be affected by the Plan.
Pacific and River Lamprey
Beneficial Effects
• Except in the Feather River, upstream river flows are expected to fluctuate such that they dewater redds or strand ammocoetes under the BDCP at a frequency the same as or lower than under existing conditions. • The BDCP is expected to reduce Pacific and river lamprey entrainment at south Delta export facilities and in agricultural diversions. • Pacific and river lamprey macropthalmia and adult passage at the Stockton Deep Water Ship Channel and the Fremont Weir is expected to be considerably improved as a result of BDCP conservation measures. • Upstream adult attraction flows from the San Joaquin River are predicted to increase substantially in the Delta, although there is low certainty that Pacific and river lamprey adults are attracted to chemical cues.
Adverse Effects
• Predation of Pacific and river lamprey macropthalmia at the north Delta intake is expected to increase under the BDCP, although predator control will somewhat offset this increase.

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Table 5.1-3. Summary of the Direction of Conservation Measure Effects on Covered Mammal Species (Not Magnitude of Effects)

Conservation Measure	Covered Wildlife Species					
	Riparian Brush Rabbit	Riparian (San Joaquin Valley) Woodrat	Salt Marsh Harvest Mouse	San Joaquin Kit Fox	Suisun Shrew	Townsend's Big-Eared Bat
CM1 Water Facilities and Operation	●	●	○	●	○	–
CM2 Yolo Bypass Fisheries Enhancement	–	–	–	–	–	–
CM3 Natural Communities Protection and Restoration	⦿	⦿	⦿	⦿	⦿	⦿
CM4 Tidal Natural Communities Restoration	●	●	⦿	–	⦿	⦿
CM5 Seasonally Inundated Floodplain Restoration	⦿	⦿	–	–	–	⦿
CM6 Channel Margin Enhancement	–	–	–	–	–	–
CM7 Riparian Natural Community Restoration	○	○	–	–	–	●
CM8 Grassland Natural Community Restoration	○	○	○	○	○	○
CM9 Vernal Pool Complex Restoration	–	–	–	–	–	–
CM10 Nontidal Marsh Restoration	–	–	–	–	–	–
CM11 Natural Communities Enhancement and Management	⦿	⦿	⦿	⦿	⦿	⦿
CM12 Methylmercury Management	–	–	–	–	–	–
CM13 Invasive Aquatic Vegetation Control	–	–	–	–	–	–
CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels	–	–	–	–	–	–
CM15 Predator Control	–	–	–	–	–	–
CM16 Nonphysical Fish Barriers	–	–	–	–	–	–
CM17 Illegal Harvest Reduction	–	–	–	–	–	–
CM18 Conservation Hatcheries	–	–	–	–	–	–
CM19 Urban Stormwater Treatment	–	–	–	–	–	–
CM20 Recreational Users Invasive Species Program	–	–	–	–	–	–
CM21 Nonproject Diversions						
CM22 Avoidance and Minimization Measures	○	○	○	○	○	○

○	Conservation measure will have beneficial effects to species;
●	Conservation measure will have adverse effects to species;
⦿	Conservation measure will have both beneficial and adverse effects to species.
–	Conservation measure is not applicable to species

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Table 5.1-4. Summary of the Direction of Conservation Measure Effects on Covered Bird Species (Not Magnitude of Effects)

	Covered Bird Species											
Conservation Measure	**California Black Rail**	**California Clapper Rail**	**California Least Tern**	**Greater Sandhill Crane**	**Least Bell's Vireo**	**Suisun Song Sparrow**	**Swainson's Hawk**	**Tricolored Blackbird**	**Western Burrowing Owl**	**Yellow-Billed Cuckoo**	**White-Tailed Kite**	**Yellow-Breasted Chat**
CM1 Water Facilities and Operation	–	–	●	●	●	–	●	●	●	●	●	●
CM2 Yolo Bypass Fisheries Enhancement	–	–	●	–	●	–	●	●	●	●	●	●
CM3 Natural Communities Protection and Restoration	⦿	⦿	○	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿
CM4 Tidal Natural Communities Restoration	⦿	⦿	○	●	●	⦿	●	⦿	●	●	⦿	●
CM5 Seasonally Inundated Floodplain Restoration	–	–	●	–	⦿	–	⦿	⦿	●	⦿	⦿	⦿
CM6 Channel Margin Enhancement	–	–	–	–	–	–	○	–	–	–	○	–
CM7 Riparian Natural Community Restoration	–	–	–	–	○	–	○	⦿	●	○	○	○
CM8 Grassland Natural Community Restoration	○	○	–	–	○	○	⦿	⦿	○	○	⦿	○
CM9 Vernal Pool Complex Restoration	–	–	–	–	–	–	–	–	–	–	–	–
CM10 Nontidal Marsh Restoration	–	–	–	–	–	–	●	⦿	●	–	⦿	–
CM11 Natural Communities Enhancement and Management	⦿	⦿	⦿	●	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿
CM12 Methylmercury Management	○	○	○	–	–	○	–	–	–	–	–	–
CM13 Invasive Aquatic Vegetation Control	–	–	–	–	–	–	–	–	–	–	–	–
CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels	–	–	–	–	–	–	–	–	–	–	–	–
CM15 Predator Control	–	–	–	–	–	–	–	–	–	–	–	–
CM16 Nonphysical Fish Barriers	–	–	–	–	–	–	–	–	–	–	–	–
CM17 Illegal Harvest Reduction	–	–	–	–	–	–	–	–	–	–	–	–
CM18 Conservation Hatcheries	–	–	–	–	–	–	–	–	–	–	–	–
CM19 Urban Stormwater Treatment	–	–	–	–	–	–	–	–	–	–	–	–
CM20 Recreational Users Invasive Species Program	–	–	–	–	–	–	–	–	–	–	–	–
CM21 Nonproject Diversions	–	–	–	–	–	–	–	–	–	–	–	–
CM22 Avoidance and Minimization Measures	○	○	○	○	○	○	○	○	○	○	○	○

○	Conservation measure will have beneficial effects to species;
●	Conservation measure will have adverse effects to species;
⦿	Conservation measure will have both beneficial and adverse effects to species.
–	Conservation measure is not applicable to species

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Table 5.1-5. Summary of the Direction of Conservation Measure Effects on Covered Reptiles, Amphibians, and Invertebrate Species (Not Magnitude of Effects)

	Other Covered Species											
Conservation Measure	**Giant Garter Snake**	**Western Pond Turtle**	**California Red-Legged Frog**	**California Tiger Salamander**	**Western Spadefoot**	**Valley Elderberry Longhorn Beetle**	**California Linderiella**	**Conservancy Fairy Shrimp**	**Longhorn Fairy Shrimp**	**Midvalley Fairy Shrimp**	**Vernal Pool Fairy Shrimp**	**Vernal Pool Tadpole Shrimp**
CM1 Water Facilities and Operation	●	●	●	●	●	●	●	●	●	●	●	●
CM2 Yolo Bypass Fisheries Enhancement	●	●	–	–	–	●	●	●	●	●	●	●
CM3 Natural Communities Protection and Restoration	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉
CM4 Tidal Natural Communities Restoration	◉	◉	–	–	–	●	●	●	●	●	●	●
CM5 Seasonally Inundated Floodplain Restoration	◉	◉	–	–	–	◉	–	–	–	–	–	–
CM6 Channel Margin Enhancement	–	–	–	–	–	–	–	–	–	–	–	–
CM7 Riparian Natural Community Restoration	●	●	–	–	–	○	–	–	–	–	–	–
CM8 Grassland Natural Community Restoration	○	○	○	○	○	○	–	–	–	–	–	–
CM9 Vernal Pool Complex Restoration	–	–	–	–	–	–	○	○	○	○	○	○
CM10 Nontidal Marsh Restoration	○	○	○	○	○	–	–	–	–	–	–	–
CM11 Natural Communities Enhancement and Management	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉
CM12 Methylmercury Management	○	○	○	○	○	–	–	–	–	–	–	–
CM13 Invasive Aquatic Vegetation Control	○	–	–	–	–	–	–	–	–	–	–	–
CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels	–	–	–	–	–	–	–	–	–	–	–	–
CM15 Predator Control	–	–	–	–	–	–	–	–	–	–	–	–
CM16 Nonphysical Fish Barriers	–	–	–	–	–	–	–	–	–	–	–	–
CM17 Illegal Harvest Reduction	–	–	–	–	–	–	–	–	–	–	–	–
CM18 Conservation Hatcheries	–	–	–	–	–	–	–	–	–	–	–	–
CM19 Urban Stormwater Treatment	–	–	–	–	–	–	–	–	–	–	–	–
CM20 Recreational Users Invasive Species Program	–	–	–	–	–	–	–	–	–	–	–	–
CM21 Nonproject Diversions	–	–	–	–	–	–	–	–	–	–	–	–
CM22 Avoidance and Minimization Measures	○	○	○	○	○	○	○	○	○	○	○	○

○	Conservation measure will have beneficial effects to species;
●	Conservation measure will have adverse effects to species;
◉	Conservation measure will have both beneficial and adverse effects to species.
–	Conservation measure is not applicable to species

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Table 5.1-6. Summary of the Direction of Conservation Measure Effects on Covered Plant Species (Not the Magnitude)

Conservation Measure	Covered Plant Species																		
	Alkali Milk Vetch	Bogg's Lake Hedge Hyssop	Brittlescale	Caper-Fruited Tropidocarpum	Carquinez Goldenbush	Delta Button Celery	Delta Mudwort	Delta Tule Pea	Dwarf Downingia	Heartscale	Heckard's Pepper Grass	Legenere	Mason's Lilaeopsis	San Joaquin Spearscale	Side-Flowering Skullcap	Slough Thistle	Soft Bird's Beak	Suisun Marsh Aster	Suisun Thistle
CM1 Water Facilities and Operation	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM2 Yolo Bypass Fisheries Enhancement	●	●	–	–	–	–	–	–	●	–	●	●	–	●	–	–	–	–	–
CM3 Natural Communities Protection and Restoration	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
CM4 Tidal Natural Communities Restoration	–	–	–	–	–	–	⦿	⦿	–	–	–	–	⦿	–	–	○	–	⦿	○
CM5 Seasonally Inundated Floodplain Restoration	–	–	–	–	–	○	–	–	–	–	–	–	–	–	○	○	–	–	–
CM6 Channel Margin Enhancement	–	–	–	–	–	–	○	○	–	–	–	–	○	–	○	–	–	○	–
CM7 Riparian Natural Community Restoration	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	○	–	–	–
CM8 Grassland Natural Community Restoration	○	○	○	–	–	–	–	–	○	–	○	○	–	○	–	–	–	–	V
CM9 Vernal Pool Complex Restoration	○	○	○	–	–	–	–	–	○	–	○	○	–	○	–	–	–	–	–
CM10 Nontidal Marsh Restoration	–	–	–	–	–	–	–	–	–	–			–		–	–	–	–	–
CM11 Natural Communities Enhancement and Management	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
CM12 Methylmercury Management	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM13 Invasive Aquatic Vegetation Control	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	––	–	–	–
CM15 Predator Control	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM16 Nonphysical Fish Barriers	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM17 Illegal Harvest Reduction	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM18 Conservation Hatcheries	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM19 Urban Stormwater Treatment	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM20 Recreational Users Invasive Species Program	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM21 Nonproject Diversions	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CM22 Avoidance and Minimization Measures	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

○	Conservation measure will have beneficial effects to species;
●	Conservation measure will have adverse effects to species;
⦿	Conservation measure will have both beneficial and adverse effects to species.
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Chapter 5
Effects Analysis

5.2 Methods

The methods section presents the qualitative and quantitative methods used to analyze the effects of the BDCP on ecosystems, natural communities, and on all covered species. This section first describes the spatial scope of the effects analysis, the environmental baseline used in the effects analysis, and how climate change was incorporated into the analysis. Finally, the section presents the qualitative and quantitative methods used to analyze the effects analysis for covered aquatic species and covered terrestrial species, and the methods used to analyze the effects on natural communities. The BDCP effects analysis evaluates the effects of BDCP covered activities (including conservation measures) on the Bay-Delta ecosystem, natural communities, and covered species. In most cases, the evaluation of BDCP effects is made by comparing the biological performance of covered species with expected environmental conditions under all BDCP conservation measures at future implementation periods to the baseline environmental conditions. As required by the ESA, the effects analysis also describes the level of take and the effect of that take on each covered species expected from implementation of all BDCP covered activities, including conservation measures.

5.2.1 Spatial Scope of the Analysis

The BDCP will affect conditions and species across a wide array of geographies and environments with varying mixes of stressors, environments, and species. Assessment of the effects of individual actions and stressors is enhanced by considering them within a geographic structure that reflects the biogeographical structure of the Delta and its tributaries. Structure and function of ecological systems are often described hierarchically (O'Neill et al. 1986); a hierarchical structure is particularly applicable to estuarine species encompassing a variety of physical and biological features (Peterson 2003). Larger-scale areas can constrain the performance of smaller-scale areas. In turn, the performance at any level reflects the performance of smaller-scale features. A hierarchical structure for the spatial scope of the effects analysis includes the following components.

- **The BDCP Study Area** (Figure 5.2-1). This is the area where physical changes attributable to the BDCP have the potential to affect covered fish species. Included is the Sacramento River upstream to Keswick Dam, the San Joaquin River upstream to the Stanislaus River, tributaries downstream of SWP and CVP dams (Clear Creek, Feather River, American River, and Stanislaus River), and the BDCP Plan Area (see below). The BDCP Study Area is equivalent to the Action Area defined in the EIR/EIS.
- **The BDCP Plan Area** (Figure 5.2-2). This is the area in which all covered activities would occur, including all conservation measures. The effects analysis will focus on the Plan Area. The Plan Area includes the statutory Delta (as defined in California Water Code 12220), Suisun Bay, Suisun Marsh, and the Yolo Bypass south of the Sacramento River.
- **Geographic regions.** These are large-scale areas that can be distinguished hydraulically, ecologically, and geomorphologically. Regions include terrestrial and aquatic environments. The Study Area is divided into three geographic regions: the Sacramento River watershed, the San Joaquin River watershed, and the BDCP Plan Area as described above.

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- **Geographic subregions** (Figure 5.2-2). Subregions are broad geographic and hydrologically distinct areas that are relevant to the life history of Delta fish and wildlife species. Subregions include both terrestrial and aquatic resources. Within the Plan Area, the subregions are based largely on hydrodynamic subregions used by Stoms (2010) that were interpreted from a graphic conceptual model developed by the DRERIP team (Burau pers. comm.). Outside the Plan Area, subregions include tributary reaches below dams that prevent fish passage and that may experience indirect effects from BDCP-related activities such as changed release schedules. Note that geographic subregions are distinct from the Conservation Zones, which are defined for the terrestrial natural communities and covered species (see Figure 3.2-2 and Section 3.2.2, *Identifying Conservation Zones and Restoration Opportunity Areas*).

- **Restoration Opportunity Areas** (Figure 5.2-2). ROAs encompass those locations considered to be the most appropriate for the restoration of tidal habitats within the Plan Area and within which restoration goals for tidal and associated upland natural communities will be achieved. For a description of how ROAs were developed, see Section 3.2.2, *Identifying Conservation Zones and Restoration Opportunity Areas*.

5.2.2 Temporal Scope of the Analysis

The BDCP covered activities, including conservation measures, will be implemented over a 50-year period. Measures will begin at different points over that period, reflecting the implementation schedule in described in Chapter 6, *Implementation* (Tables 6-1 and 6-2). Over the implementation period, climate across the Study Area is expected to change at local, regional, and larger scales. Therefore, evaluations of BDCP conservation measures are made using conditions expected during four periods within the 50-year permit term. Analytical comparisons use all or a subset of these periods as appropriate. Evaluation periods for the BDCP effects analysis are as follows.

- **Current Conditions.** Current conditions exist prior to implementation of the BDCP. See the next section for a definition of the environmental baseline, which is equivalent to current conditions. Current conditions are described in Chapter 2, *Existing Ecological Conditions*.

- **Near-Term Conditions (NT).** NT conditions are expected under the BDCP in the first 10 years of implementation. During this period, the BDCP is expected to address a substantial portion of the planned aquatic and terrestrial restoration with associated improvements in water quality and food production. Benefits will not be immediate but will accumulate as a result of time required for land acquisition and for maturation of habitat restoration actions. During this period, the new water facilities will be constructed but no new operations will occur. Climate conditions in the near term reflect physical analysis of the 2020 conditions.

- **Early Long-Term (ELT) Conditions.** ELT conditions BDCP actions from years 10 through 15. During this period, significant changes in the Delta environment will result from the BDCP. Operation of the new water facility is expected during this period while changes to tidal, floodplain, and terrestrial environments should begin to occur. ELT climate conditions reflect the physical analysis of the 2025 conditions.

- **Late Long-Term (LLT) Conditions.** LLT conditions reflect the full implementation and maturation of BDCP actions from years 15 through 50. All planned habitat restoration will have occurred by year 40 along with full application of the new water facility and full implementation of most other conservation measures. LLC climate conditions reflect the physical analysis of the 2060 conditions.

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5.2.3 Definition of the Environmental Baseline

Biological responses expected to result from the implementation of the BDCP conservation measures have been evaluated in the context of the environmental baseline. The environmental baseline reflects the existing or pre-implementation condition of environment relevant to each conservation measure and covered activity. Regulatory approaches to describing baseline conditions differ between the ESA, CEQA, and NEPA. Differences in the approaches to determining baseline conditions under CEQA and NEPA are addressed in the EIR/EIS for the BDCP by adopting two different baselines conditions.

The BDCP environmental baseline, referred to as the existing biological condition (EBC), reflects the environmental conditions of the Study Area prior to BDCP approval. These include the extent of species habitats, water quality and pollutant inputs, and water temperatures described in Chapter 2, *Existing Ecological Conditions*. The BDCP baseline also reflects the anticipated ecological effects of implementing the operating criteria and plan (OCAP) biological opinions (BiOps) developed by USFWS for delta smelt (2008) and NMFS for salmonids and green sturgeon (2009). These actions were added to the regional water operations structure previously required under D-1641 provisions of the State Water Resources Control Board (State Water Board) (1999), including the Vernalis Adaptive Management Program. The BDCP baseline does not include water operation agreements that are currently being negotiated.

To reflect the differing regulatory directives for determining baseline conditions, two EBCs are included in most analyses (Table 5.2-1). For the BDCP, EBC1 is defined as when the Notice of Preparation (NOP) was revised February 13, 2009[1], and includes provisions of the 2008 and 2009 OCAP BiOps as they have been implemented up to this point. Table 5.2-2 describes the provisions of the 2008 and 2009 BiOps that are not assumed in the baseline condition because their implementation requires additional environmental documentation and in some cases, permitting. Component 3, Action 4 of the USFWS Reasonable and Prudent Action (referred to as fall X2) requires that the X2 position be maintained by increasing Delta outflow during wet and above normal water year types, but this provision has not been triggered due to recent dry hydrologic conditions. In 2009, implementation of the fall X2 provisions was not a requirement of the BiOps (in part, due to ongoing litigation); therefore, the fall X2 are not included in EBC1.

EBC2 captures the requirements of the ESA Section 7 that requires the environmental baseline to include the impacts of all past and present federal, state, and private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects that have undergone Section 7 consultations, and the impacts of state or private actions that are contemporaneous with the consultation in process. Thus, EBC2 assumes that the fall X2 provisions will be implemented. EBC2 also satisfies the NEPA baseline. Under NEPA, the baseline will reflect existing environmental conditions, including the effects of past and ongoing actions that would exist without the proposed action (sometimes referred to as the No Action Alternative conditions) and is typically considered the same as the ESA Section 7 baseline.

In addition to these regulatory considerations for defining baseline conditions, the analysis considers the effects of climate change expected over the implementation period. Because of this,

[1] EBC1 was defined to meet CEQA requirements. Under CEQA, the environmental baseline is defined as the physical conditions that exist at the time the Notice of Preparation is published.

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additional future baseline conditions were defined for ELT and LLT periods. These future baseline conditions are only defined for the EBC2 scenario.

Table 5.2-1. Environmental Baseline Conditions for Evaluation of BDCP Alternatives

Baseline Scenario	Regulatory Basis	Description
EBC1	CEQA	2008 USFWS BiOp and 2009 NMFS BiOp, but without Fall X2
EBC2	ESA Section 7 and NEPA	2008 USFWS BiOp and 2009 NMFS BiOp

Table 5.2-2. Actions Identified under USWFS and NMFS BiOps that are Excluded from Baseline Conditions (EBC1 and EBC2)

Biological Opinion	Program
USFWS	Component 3 (Action 4): Fall X2. X2 position be maintained by increasing Delta outflow during wet and above normal water year types. ***Excluded from EBC1; included in EBC2.***
USFWS	Component 4: Habitat Restoration—Action 6: A program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh shall be implemented. A monitoring program shall be developed to focus on the effectiveness of the restoration program.
NMFS	Action I.3.5. Measures to Compensate for Adverse Effects of Interim Operations on Spring-Run Reclamation shall provide $500,000 for implementation of spring- run passage improvement projects in the Sacramento River.
NMFS	Action I.5. Funding for CVPIA Anadromous Fish Screen Program (AFSP) Reclamation shall screen priority diversions as identified in the CVPIA AFSP.
NMFS	Action I.6.1. Restoration of Floodplain Rearing Habitat In cooperation with DFG, USFWS, NMFS, and USACE, Reclamation and DWR shall, to the maximum extent of their authorities (excluding condemnation authority), provide significantly increased acreage of seasonal floodplain rearing habitat, with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years, depending on water year type.
NMFS	Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass By December 31, 2011, as part of the plan described in Action I.6.1, Reclamation and/or DWR shall submit a plan to NMFS to provide for high quality, reliable migratory passage for Sacramento Basin adult and juvenile anadromous fishes through the Yolo Bypass. By June 30, 2011, Reclamation and/or DWR shall obtain NMFS concurrence and, to the maximum extent of their authorities, and in cooperation with other agencies and funding sources, begin implementation of the plan, including any physical modifications. By September 30, 2009, Reclamation shall request in writing that the USACE take necessary steps to alter Fremont Weir and/or any other facilities or operations requirements of the Sacramento River Flood Control Project or Yolo Bypass facility in order to provide fish passage and shall offer to enter into a Memorandum of Understanding, interagency agreement, or other similar mechanism, to provide technical assistance and funding for the necessary work.
NMFS	Action II.3. Structural Improvements Reclamation shall evaluate physical and structural modifications that may improve temperature management capability [Folsom Dam Temperature Control Device, Cold Water Transport through Lake Natoma, El Dorado Irrigation District Temperature Control Device].

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Biological Opinion	Program
NMFS	Action II.6.1. Preparation of Hatchery Genetic Management Plan (HGMP) for Steelhead Reclamation shall fund DFG to prepare a complete draft HGMP for steelhead production at Nimbus Fish Hatchery, in accordance with current NMFS guidelines, and submit that draft for NMFS review by June 2011. Action II.6.3: Develop and Implement Fall-run Chinook Salmon Hatchery Management Plans for Nimbus and Trinity River Fish Hatcheries By June 2014, develop and begin implementation of Hatchery Management Plans for fall-run production at Nimbus Fish Hatchery and spring-run and fall-run at Trinity River Fish Hatchery. (These actions may have been addressed in recent EIR/EIS).
NMFS	Action IV.4.1 Tracy Fish Collection Facility (TFCF) Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency Reclamation shall undertake the following actions at the TFCF to reduce pre-screen loss and improve screening efficiency: 1) By December 31, 2012, improve the whole facility efficiency for the salvage of Chinook salmon, CV steelhead, and Southern DPS of green sturgeon so that overall survival is greater than 75 percent for each species. a) By December 31, 2011, Reclamation shall complete studies to determine methods for removal of predators in the primary channel, using physical and non-physical removal methods...By December 31, 2012, Reclamation shall implement measures to reduce pre-screen predation in the primary channel to less than ten percent of exposed salmonids. b) By March 31, 2011, Reclamation shall complete studies for the re-design of the secondary channel to enhance the efficiency of screening, fish survival, and reduction of predation within the secondary channel structure and report study findings to NMFS...Reclamation shall initiate the implementation of the study findings by January 31, 2012....
NMFS	Action IV.4.2 Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency DWR shall undertake the following actions at the Skinner Fish Collection Facility: ... a) On or before March 31, 2011, improved predator control methods. Full compliance shall be achieved by March 31, 2014.
NMFS	Action IV.4.3 Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting and Release Survival Rates Reclamation and DWR shall undertake the following actions at the TFCF and the Skinner Fish Collection Facility, respectively. Actions shall commence by October 1, 2009, unless stated otherwise.... 3) Release Site Studies shall be conducted to develop methods to reduce predation at the “end of the pipe” following release of salvaged fish.... 4) By June 15, 2011, predation reduction methods shall be implemented according to analysis in 3.
NMFS	NF 4.1. Adult Fish Collection and Handling Facilities Beginning in 2012, Reclamation...shall design, construct, install, operate and maintain new or rebuilt adult fish collection, handling and transport facilities at the sites listed below. The objective is to provide interim facilities to pass fish above project facilities and reservoirs.
NMFS	NF 4.2. Adult Fish Release Sites above Dams and Juvenile Fish Sites Below Dams Reclamation shall provide for the safe, effective, and timely release of adult fish above dams and juvenile fish below dams. The Fish Passage Plan must identify and release sites. Fish transport and release locations and methods shall follow existing State and Federal protocols. With assistance from the Steering Committee, and in coordination with applicable landowners and stakeholders, Reclamation shall complete construction of all selected sites by March 2012.

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Biological Opinion	Program
NMFS	NF 4.3. Capture, Trapping, and Relocation of Adults By March 2012, Reclamation shall implement upstream fish passage for adults via "trap and transport" facilities while it conducts studies to develop and assess long-term upstream and downstream volitional fish passage alternatives. At least one fish facility must be in place at terminal upstream passage points for each river that is subject to this measure. Facilities to capture adults currently exist at or below Keswick and Nimbus Dams, though these may need to be upgraded.
NMFS	NF 4.4. Interim Downstream Fish Passage through Reservoirs and Dams Beginning in 2012, following the emergence of the first year class of reintroduced fish, and until permanent downstream passage facilities are constructed or operations are established at Project dams, Reclamation shall carry out interim operational measures to pass downstream migrants...
NMFS	NF 4.5. Juvenile Fish Collection Prototype Beginning in January, 2010, with input from the CVP/SWP operations Fish Passage Steering Committee, Reclamation shall plan, design, build, and evaluate a prototype head-of-reservoir juvenile collection facility above Shasta Dam. Construction shall be complete by September 2013.
NMFS	LF 2.1. Long-term Adult and Juvenile Fish Passage Facilities ...Reclamation shall construct long-term fish passage facilities necessary to successfully allow upstream and downstream migration of fish around or through project dams and reservoirs on the Sacramento and American Rivers by 2020, and Stanislaus River depending on results of study provided for in Action NF 4.7.
NMFS	LF 2.2. Supplementation and Management Plan ...Reclamation shall develop and implement a long-term population supplementation plan for each species and fish passage location identified in V. *Fish Passage Program*, with adult recruitment and collection criteria...The plan shall be developed by 2020.
NMFS	LF 2.2. Supplementation and Management Plan ...Reclamation shall develop and implement a long-term population supplementation plan for each species and fish passage location identified in V. *Fish Passage Program*, with adult recruitment and collection criteria...The plan shall be developed by 2020.
Notes: USFWS = U.S. Fish and Wildlife Service; NMFS = National Marine Fisheries Service; AFSP = Anadromous Fish Screen Program; CVPIA = Central Valley Project Improvement Act; DFG = California Department of Fish and Game; USACE = U.S. Army Corps of Engineers; Reclamation = Bureau of Reclamation; DWR = California Department of Water Resources; HGMP = Hatchery Genetic Management Plan; TFCF = Tracy Fish Collection Facility.	

5.2.4 How Climate Change Affects the Analysis

Over the BDCP implementation period, regional climate likely will change in response to global changes in climate (Pachauri and Reisinger 2007). While the expectations of climate change are robust, predictions of changes must depend on model projections which may differ from what actually occurs. In California, climate change is expected to increase air and water temperature, change precipitation patterns, raise sea level, and change salinity patterns across the Study Area (Hayhoe et al. 2004). Climate change will affect hydrologic conditions and water management (Willis et al. 2011) and likely the success of BDCP actions such as habitat restoration (Battin et al. 2007).

Observed climate and hydrologic records indicate that more substantial warming has occurred in the Study Area since the 1970s. Expectations are that warming will continue to increase across the state, with largest changes in spring and summer and larger changes farther away from the coast.

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Annual median temperature increases are projected to be approximately 1.1°C and 2.3°C for 2025 and 2060, respectively, with less warming in winter and higher warming in summer. Summer temperatures may increase by 4°C by 2060 (Moser et al. 2009).

Precipitation in California is characterized by extreme variability over seasonal, annual, and decadal time scales. For this reason, projections of future precipitation are more uncertain than those of temperature. While it is difficult to discern strong trends from the full range of climate projections, the California Climate Action Team analysis generally indicated a drying trend in the 21st century (Cayan et al. 2009). Changes in precipitation address not only total precipitation but also the form of the precipitation and the mix of rain and snowpack accumulation. In general, snowpack is expected to decrease in California, and more of the precipitation will fall as rain (Moser et al. 2009). Even for hydrologic model simulations with mean precipitation virtually unchanged, there were large impacts on snowpack accumulation, runoff, and soil moisture.

Sea levels are projected to increase globally at a more rapid rate as a result of thermal expansion of water in the oceans due to global warming, changes in the freshwater input to the oceans from melting of glaciers and ice sheets, and changes in water storage on land. For the scenarios selected for the California Climate Action Team report, sea level rise in California by 2050 is projected to be 30 to 45 cm (12 to 18 inches) higher than 2000 levels (Rahmstorf 2007) suggests end-of-century sea level rise in the range of 50 to 150 cm (20 to 59 inches).

The types of changes discussed in the preceding paragraphs were incorporated in the effects analysis. For example, sea level was assumed to increase 15 cm (0.5 inch) in the ELT period and by 45 cm (1.48 feet) in the LLT period. Temperature, flow, and salinity were also affected by climate change assumptions. In many cases, the effects of climate change on the environment were greater than the effects of the BDCP. Because of this, the most valid comparisons are between scenarios within a single time period with the same climate change assumption; e.g., EBC2 in the LLT compared to the Plan in the LLT. Comparison of EBC2 current to the Plan in the LLT might show a substantial environmental change but much of it would be due to climate change and the effect of the BDCP would be obscured.

The effect of sea level rise particularly affected the estimate of tidal acres restored under CM4. Rising sea levels will increase the expanse of land flooded beyond that called for under this measure. Potentially restored acres under this measure were estimated by RMA (2010) using a hypothetical restoration scenario assuming existing sea level and a 45 cm rise in sea level in the LLT.

An overview of climate change and more details on the assumptions of climate change made for modeling purposes is found in Appendix 2.C, *Climate Change*.

[***Note to Reviewer:*** *Appendix 2.C,* Climate Change Implications and Assumptions*, is currently under development and will be released in the spring.*]

5.2.5 Effects Analysis for Natural Communities

Adverse effects on natural communities were assessed primarily by quantifying the aerial extent of each natural community permanently or temporarily lost, by overlapping construction footprints and hypothetical restoration footprints with GIS data for existing natural communities. The methods and assumptions used were similar to those used for assessing effects on covered species habitat, and are detailed in Section 5.2.7.2, *Analysis of Adverse Effects*. The effects analysis for natural communities, however, does not provide the level of detail that is provided for species habitat

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effects because there is no regulatory standard for natural communities as there is for species that requires establishment of take limits or findings related to long-term survival or recovery.

Factors considered when assessing the quality of affected natural communities included landscape connectivity, natural community patch size, hydrologic connectivity, native biodiversity, and presence of rare species. Additional factors specific to each natural community were also assessed, as described in the results section for each natural community (Section 5.4, *Effects on Natural Communities*). For natural communities with adverse effects widely dispersed throughout the Plan Area, quality was assessed generally and the areas with the greatest aerial extent of loss were assessed in more detail.

Beneficial effects on natural communities were also evaluated, based on the ecosystem and natural community goals and objectives provided in Section 3.3, *Biological Goals and Objectives*, and implementation of the conservation measures described in Section 3.4, *Conservation Measures*. The net effects on each natural community were then evaluated, taking into consideration the amount lost; the amount restored, protected, and enhanced; and the anticipated quality of the natural communities conserved relative to that lost.

5.2.6 Effects Analysis for Covered Fish

5.2.6.1 Take Assessment

Implementation of covered activities will result in incidental take of covered fish species. To meet regulatory requirements and to ensure adequate mitigation of effects, the amount of take must be discussed and, if possible, quantified. The overall take of covered fish as a result of the conservation measures is not quantifiable. Take was evaluated by determining the mechanism and direction of positive or negative impacts. These determinations were used to establish qualitative ranking of beneficial and adverse effects of the conservation measures. These rankings led to a qualitative determination of overall effects and a set of conclusions regarding take. Effects on fish populations will also be tracked to ensure permit compliance.

The following types of effects could result from covered activities and conservation measures.

- Change in entrainment of fish in water diversions
- Change in predation as a result of new structures
- Modification of river flow
- Increase in habitat
- Increase in food and foraging
- Permanent indirect and other indirect losses

Several of these activities should benefit covered fish species by increasing habitat and food resources. Adverse conditions that could result in take are dependent on flow conditions and are captured in detailed quantitative analysis. A list of covered activities and corresponding conservation measures are summarized in Table 5.2-3. Detailed results from quantitative and qualitative analysis of the covered activities are provided in Appendices A to H.

The effect of construction of the water conveyance facility (CM1) on fish is limited to the construction of the five intake structures on the Sacramento River. Construction impacts are

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discussed in Appendix 5.H *Aquatic Construction Effects* along with proposed actions to minimize impacts on covered fish species. These impacts should be temporary during construction. Operation of the intakes is expected to have minimal impact on covered fish species because of design criteria for screens and operations.

Construction impacts of habitat restoration activities cannot be quantified because designs and locations have not been identified. However, adverse impacts of restoration should be temporary and soon overshadowed by beneficial effects of the restoration. Hypothetical disturbance footprints were developed to estimate maximum change in species habitat resulting from tidal natural community restoration (CM4) and seasonally inundated floodplain restoration. These actions are intended to benefit covered fish species and should not result in take beyond temporary construction impacts. The hypothetical footprints for tidal restoration were developed using outputs of the tidal restoration model (RMA model output) described in Section 5.2.6.2, *Use of Models in the Effects Analysis.* The hypothetical footprint for floodplain restoration was developed by evaluating restoration opportunities and applying assumptions about the most likely locations for floodplain restoration as described in Chapter 3, *Conservation Strategy* (CM5) and Appendix 5.E *Habitat Restoration*.

Table 5.2-3. Covered Activities, Associated Conservation Measures, and Appendices in which Effects on Covered Fish are Evaluated

Covered Activity	Relevant CM	Appendix
Conveyance Facility Construction and Operation		
Conveyance Facility Construction	CM1	5.H
Conveyance Facility Operation	CM1	5.B, 5.C, 5.D, 5.J
Conveyance Facility Maintenance	CM1	5.H
Fremont Weir/Yolo Bypass Improvements		
Fisheries Enhancement Construction	CM2, 5	5.H
Fisheries Enhancement Facility Maintenance	CM2, 5	5.H
Yolo Bypass Operations	CM2, 5	5.C, 5.D, 5.E, 5.F, 5.G
Tidal Natural Communities Restoration		
Grading, levee breaching, and resulting tidal inundation	CM4	5.H, 5.E
Riparian restoration	CM4, CM7	5.E
Floodplain Restoration		
Levee construction	CM5	5.H
Restoration activities resulting in seasonal flooding	CM5	5.E
Riparian restoration	CM5, CM7	5.E
Nontidal Marsh Restoration		
Marsh restoration	CM10	5.H
Conservation Hatcheries Facilities		
Facilities Operation and Maintenance	CM19	5.G

5.2.6.2 Use of Models in the Effects Analysis

Assessment of the effects of stressors resulting from the BDCP involves a combination of quantitative and qualitative models. A model is a logical organization of data and observations

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leading to a conclusion about how a system functions or performs. For purposes of the BDCP effects analysis, *models* include formal quantitative and qualitative models as well as analytical methods such as regression analysis. Quantitative models predict a numeric outcome of an action based on the manipulation of data by mathematical algorithms. The algorithms in a quantitative model reflect a conceptual model of the relationship between attributes, processes, and outcomes. Development of useful quantitative models requires that sufficient theory and data are available to construct algorithms that explicitly describe the relationship between system attributes. Qualitative models, including conceptual models, likewise describe a logical relationship between variables and summarize the results of scientific investigations, although the result is not a quantification of biological change. Conceptual models are the first step in constructing quantitative models but they can also stand alone as working hypotheses of the phenomenon.

Models used in the BDCP are listed and described in Table 5.2-4 along with a reference to the technical appendix where the models are applied. The models are categorized in Table 5.2-4 based on their general scope and intent. In addition, benefits and limitations of each model are listed in Table 5.2-4.

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Table 5.2-4. Models Used in the BDCP Effects Analysis for Covered Fish

					Appendix							
Model	**Description**	**Benefits**	**Limitations**	**Model Type**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
Conceptual models	Conceptual models organize factors and relationships to explain phenomena. They are a starting point for development of quantitative models and stand on their own as a way to structure discussion and analyses.	Organize information obtained from literature into comprehensive hypotheses.	Outputs are limited to qualitative assessments based on best professional judgment.	Conceptual	X	X	X	X	X	X		
DRERIP	The Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) conceptual models and scientific evaluation process were developed to aid in planning and decision making for potential ecosystem restoration actions in the Delta. The 2009 DRERIP assessment of the BDCP provided qualitative rankings for the effects on covered fish species from the conservation measures proposed at that time.	Conceptual models have been peer-reviewed and include individual fish species and habitat functions. Provides information on potential stressors and mechanisms for effects analysis.	Outputs are limited to qualitative assessments based on best professional judgment of topical experts.	Conceptual	X	X	X	X	X			
CALSIM II	The CALSIM II planning model simulates the operation of the CVP and SWP over a range of hydrologic conditions. CALSIM II produces key outputs that include river flows and diversions, reservoir storage, Delta flows and exports, Delta inflow and outflow, deliveries to project and non-project users, and controls on project operations.	Based on historical record and system-wide. Allows comparisons of changes in flows under a range of alternative operations. Used extensively to determine change in water operations and flows.	Monthly time step limits use for daily or instantaneous effects analysis; does not accurately simulate real-time operational strategies to meet temperature objectives	Environmental	X	X	X	X	X	X		X
DSM 2	DSM2 is a one-dimensional hydrodynamic and water quality simulation model used to simulate hydrodynamics, water quality, and particle tracking in the Sacramento-San Joaquin Delta. The DSM2 model has three separate components or modules: HYDRO, QUAL, and PTM.	See below for HYDRO, QUAL, and PMT.	See below for HYDRO, QUAL, and PMT.	Environmental	X	X	X		X			X
DSM 2 Hydro	DSM2-HYDRO predicts changes in flow rates and depths as a result of the BDCP and climate change. Outputs are used to determine the effects of these hydrodynamic parameters on covered terrestrial and fish species and as inputs to other biological models.	Numerous output nodes throughout the Plan Area. Provides information in short time steps that can be used to assess tidal hydrodynamics. Used extensively to determine change in water operations and flows.	One-dimensional model; very data intensive; runs for limited period (only 16 years).	Environmental		X	X					X
DSM 2 Qual	The DSM-QUAL module simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Outputs are used to estimate changes in salinity and their effects on covered species as a result of the BDCP and climate change.	Numerous output nodes throughout the Plan Area. Used extensively in Central Valley fishery assessments.	One-dimensional model; very data-intensive; runs for limited period (only 16 years).	Environmental		X			X			
DSM 2 Particle Tracking Model (PTM)	The DSM-PTM module simulates fate and transport of neutrally buoyant particles through space and time. Outputs are used to estimate the effect of hydrodynamic changes on the fate and transport of larval fish and toxics through the Delta, as well as entrainment of larval fish at various locations.	Allows assessment of particle fate, transport, and movement rate from numerous starting points to numerous end points. Provides information on movement of planktonic larval fish such as delta and longfin smelt in a tidal environment. Used extensively in Central Valley fishery assessments.	One-dimensional model; no “behavior” can be given to particles; very data-intensive and generally allows tracking for only up to 180 days.	Biological	X	X	X		X			X
DSM2-Fingerprinting	Calculates the proportion of water from different sources at specific locations in the Delta.	Allows assessment of water composition at numerous locations throughout the Plan Area. Useful for assessing changes in potential olfactory cues and attraction flows as well as water movement through the Delta.	One-dimensional model; very data-intensive; runs for limited period (only 16 years).	Environmental		X						
RMA	The RMA model output is used to evaluate the effects of tidal habitat restoration on flows throughout the Delta and the subsequent effects on covered species, aquatic and terrestrial. It is also used to calibrate CALSIM II and DSM 2.	The RMA model includes accurate channel geometry (two dimensional) and this may allow more accurate simulation of tidal flows and velocities.	It is intensive and runs shorter periods at a time (1 or 2 years).	Environmental					X			

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					Appendix							
Model	**Description**	**Benefits**	**Limitations**	**Model Type**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
SRWQM	Output from the Sacramento River Water Quality Model (SRWQM) is used as an input to a number of biological models for upstream life stages of salmonids and sturgeon.	Daily time step allows more accurate simulation of real-time operation strategies and can be used to assess temperature effects at a more biologically meaningful time step. Provides input to the Reclamation egg mortality and SALMOD models. Used extensively in Central Valley fishery assessments.	Temporal downscaling routines have limited precision and are not always accurate. Cannot reflect real-time management decisions for coldwater pool and temperature management.	Environmental		X	X					
USBR Temp Model	The USBR Temp Model is used to predict the effects of operations on water temperatures in the Feather, Stanislaus, Trinity, and American river basins, which are then used as inputs to the Reclamation Salmon Mortality Model and species-specific habitat evaluations.	Large geographic extent makes model widely applicable to the preliminary proposal effects analysis. Used extensively in Central Valley fishery assessments.	Monthly time step limits use for daily or instantaneous effects analysis; does not accurately simulate real-time reservoir operational strategies to meet temperature objectives.	Environmental		X	X		X			X
MIKE-21	Outputs of MIKE-21 are used to predict the area of inundated habitat in the Yolo Bypass for species such as splittail and Chinook salmon	Two-dimensional model provides improved definition over one-dimensional models. Can be used to assess changes in physical habitat conditions for fish within the inundated floodplain as a function of specific flows.	The model is static such that changes in flows are not modeled dynamically.	Environmental		X						
Striped Bass Bioenergetics Model	The bioenergetics model is used to estimate predation rates of striped bass on covered fish species at the proposed North Delta diversion intakes. Results of the model are also used as inputs to the Delta Passage Model and Interactive Object-Oriented Salmon Simulation (IOS) Model.	The growth or consumption estimates of an individual species are expanded to the stock or population level. Can estimate the dynamics of predator-prey interactions.	Predation of juvenile salmon is proportional to their relative abundance, regardless of size; this results in an overestimation of predation loss. Incorporates only the large prey equation, although smaller salmon fry would fall under the small prey category. The large prey predation regression was based on data for small striped bass (69–478 mm); thus they mainly reflect responses of juvenile striped bass.	Biological		X			X			
DPM	The Delta Passage Model (DPM) is used to predict relative reach-specific survival estimates for winter, spring, and fall-run juvenile Chinook salmon passing through the Delta, as well as estimates of salvage in the south Delta export facilities. Uses CWT salvage data to estimate the proportion of Chinook runs that would be entrained.	Provides estimates of overall proportions of migrating juvenile Chinook salmon runs that are lost to entrainment, while accounting for movement down different Delta channels ; allows differentiation of fall-run populations by Sacramento or San Joaquin river basin	Many of the model assumptions are based on results from large, hatchery-reared fall-run Chinook salmon that may not be representative of smaller, wild-origin fish. Model is applicable only to migrating fish and not to those rearing in the Delta.	Biological	X	X						
IOS	The Interactive Object-Oriented Salmon Simulation (IOS) model is used to evaluate the effects of multiple aspects of the BDCP on survival of winter-run Chinook salmon and population viability.	Life cycle model that includes many of the BDCP conservation measures.	It is primarily operations focused and includes ocean conditions, which are not affected by BDCP.	Population and Life History						X		
OBAN	Complementary to IOS, the Oncorhynchus Bayesian Analysis (OBAN) model is used to predict the effects of multiple BDCP actions on winter-run and spring-run Chinook salmon survival and population dynamics and population viability.	Life cycle model that reflects historical relationships between Chinook salmon abundance and environmental conditions.	Does not include Conservation Measure 1.	Population and Life History		X				X		
Sacramento Ecological Flows Tool	The Sacramento River Ecological Flows Tool (SacEFT) is used to predict the effects of flow changes in the Sacramento River on a set of physical (spawning area, juvenile rearing area, redd scour, and redd dewatering) and biological (egg survival, juvenile stranding, and juvenile growth) parameters for all races of Chinook salmon and steelhead. The model also predicts flow-based effects on green sturgeon egg survival.	Incorporates flow and water temperature inputs with multiple model concepts and field and laboratory studies to predict effects on multiple performance measures for fish species; peer-reviewed model.	Limited to upper Sacramento River; limited set of focal species (steelhead, Chinook salmon, and green sturgeon); third in a sequence of models (CALSIM and SRWQM), so limitations of previous models are compounded.	Population and Life History		X	X					X
SALMOD	SALMOD is used to predict the effects of flows in the Sacramento River on habitat quality and quantity and ultimately on juvenile production of all races of Chinook salmon.	Measures effects of flows on spawning, egg incubation, and juvenile growth in terms of smolt production. Used extensively in Central Valley fishery assessments.	Only assesses effects of flow and water temperature; not reasonably accurate for small spawner numbers (<500 fish).	Population and Life History		X						

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					B	**C**	**D**	**E**	**F**	**G**	**H**	**J**
USBR Salmon Mortality Model	The USBR Salmon Mortality Model is used to predict temperature-related proportional losses of eggs and fry for each race of Chinook salmon in the Trinity, Sacramento, Feather, American, and Stanislaus Rivers.	Assesses effects at multiple locations within multiple rivers. Used extensively in Central Valley fishery assessments.	Limited to effects on eggs only; monthly time step limits use for daily or instantaneous effects analysis; third in a sequence of models (CALSIM and Reclamation Water Temperature Model), so limitations of previous models are compounded.	Population and Life History		X						X
Delta Smelt Abiotic Habitat Index	Used to calculate area of delta smelt abiotic habitat.	Method has been peer-reviewed and includes regressions based on observed data.	Was developed based on a portion of delta smelt fall habitat (Suisun Bay, Suisun Marsh, and West Delta subregions) that does not incorporate other areas where recent occurrence has been appreciable; based on two abiotic factors; based on linked statistical models without accounting for uncertainty in each model.	Biological		X						X
Salvage-Density Method	The Salvage-Density Method uses historical salvage and flow data to predict entrainment.	Numerous data exist for all species. Method has been used before to analyze effects of other projects.	Assumes a linear relationship between flow and entrainment, which may not be justified. Estimates of numbers of fish entrained should be viewed as highly uncertain, and focus should be on relative change between scenarios.	Biological	X							X
Old and Middle River Flow Proportional Entrainment Regressions (delta smelt)	The Old and Middle River Flow Proportional Entrainment Regressions use linear regression (based on estimates from Kimmerer [2008] and estimates adjusted based on the rationale provided by Miller [2011]) and CALSIM data to estimate the proportion of delta smelt population that would be entrained.	Provides estimates of the overall proportion of the delta smelt population that is lost to entrainment; Miller's method also introduces other important predictors of entrainment such as turbidity	Regressions are based on relatively few data points and on predictors averaged over several months, which may simplify underlying dynamics. The analysis based on Kimmerer's approach does not include turbidity and assumes that entrainment is solely related to OMR pumping rate.	Biological	X							X
Manly (2011) Salvage Estimation Equation	The salvage estimation equation for delta smelt (Manly 2011) Uses multiple regression to estimate salvage of adult delta smelt as a function of OMR flows, turbidity, and population size.	Incorporates terms to account for turbidity, delta smelt distribution in relation to flow, and overall population size (from fall midwater trawl index)	Equation is quite complex and may be challenging to interpret. Future estimates assume that current relationship between flow and turbidity will continue into the future. If the Delta becomes substantially clearer and less turbid in the future, this assumption would result in predictions that overestimate future entrainment.	Biological	X							
Effectiveness of Nonphysical Barriers	The effectiveness of nonphysical barriers assessment discusses results of recent studies at Georgiana Slough and Old River as well as literature studies to determine potential effectiveness of barriers at these and other Delta locations.	Represents the analysis of a panel of experts and based partly on Delta-specific studies.	Does not directly address solely agricultural diversions within the BDCP ROAs (but is probably sufficiently similar). Qualitative analysis only (however, estimates of number of diversions to be decommissioned as part of BDCP habitat restoration allow some context for the extent of entrainment reduction). Considerable uncertainty about velocities in barrier vicinity and potential predation.	Biological	X	X						
Screening Effectiveness Analysis (North Delta Intake)	The screening effectiveness analysis estimates the potential for screening based on different sizes of fish approaching the north Delta intakes,	Based on published literature for exclusion of fish at screened intakes.	Little is known of the occurrence of larval fish in the area and how screenable-sized fish may respond to such large intakes. Qualitative discussion based on likely sizes of fish that would be excluded.	Biological	X							
Maunder-Deriso Delta Smelt Lifecycle Model	The Maunder-Deriso Delta Smelt Lifecycle Model is a state-space multi-stage lifecycle model that evaluates population impacts on delta smelt by allowing density dependence and environmental factors to impact different life stages.	Life cycle model	Difficult to formulate hypotheses regarding changes in stressors resulting from Plan.	Population and Life History						X		

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					Appendix							
Model	**Description**	**Benefits**	**Limitations**	**Model Type**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
Kimmerer et al. X2-abundance Regression (longfin smelt)	The Kimmer regression relationships use X2 to estimate annual abundance indices of longfin smelt in fall midwater trawls, bay midwater trawls, and bay otter trawls.	Method has been peer-reviewed and includes regressions based on observed data.	Changes in the nature of the relationship in recent years appear to have occurred as a result of factors other than outflow	Biological		X						
Selenium Loading	Selenium loading uses DSM 2 and the calculated total load of the contaminant within each watershed to estimate the diluted concentration of contaminant in the Plan Area.	Largemouth bass (example fish used in modeling) is a high level consumer and shows effects of bioaccumulation.	Water and fish tissue modeling results do not account reasonable future decrease in selenium in the system and likely overestimates concentrations.	Environmental			X					
Mercury/ Methylmercury Loading	Mercury/methylmercury loading uses DSM 2 and the calculated total load of the contaminant within each watershed to estimate the diluted concentration of contaminant in the Plan Area.	Largemouth bass (example fish used in modeling) tissue concentrations have been described recently over a wide area of the Delta and are they are excellent indicators of long-term average mercury exposure, risk, and spatial pattern for both ecological and human health.	The DSM2-estimated water concentrations consistently over-predicted the fish concentrations as compared to the regression model	Environmental			X					
Noise Effects of Underwater Construction	Underwater sound generated by impact pile driving was determined by using The California Department of Transportation (Caltrans) (2009) information on pile driving and estimating the attenuation of sound using a spreadsheet model created by the National Marine Fisheries Service (NMFS) (2009).	Based on best available science and understanding associated with underwater sound impacts to fish species.	Assumptions regarding type of pile driving results in uncertainty regarding the effects associated with underwater sound.	Environmental							X	
	Total Models			**32**	**11**	**19**	**12**	**4**	**9**	**5**	**1**	**10**

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5.2.6.3 Conceptual Models

Conceptual models organize information within a logical structure that provides a plausible explanation for a phenomenon. A conceptual model describes key attributes, linkages, and structure associated with an issue. An important value of conceptual models is that they explicitly lay out assumptions and logic underlying arguments and assessments. Conceptual models have been developed through regional processes that summarize information by groups of regional scientists. DRERIP (California Department of Fish and Game undated) has developed conceptual models for key species and processes in the Delta. The IEP has constructed conceptual models associated with the pelagic organism decline (POD) (Baxter et al. 2010). Conceptual models also appear in the appendices to explain issues surrounding stressors.

5.2.6.4 Environmental Models

Environmental models set the stage for the analysis of biological effects by describing key physical and chemical conditions across the Study Area. These conditions include flow, temperature, salinity, and turbidity. In the delta, the analysis of physical conditions and biological effects is most often based on, CALSIM II and DSM2 (Figure 5.2-3). Because flow is a *master variable* (Poff et al. 1997) in the sense that it creates and maintains many other habitat characteristics, CALSIM II and DSM2 are the basis for many other analyses used in the BDCP effects analysis (Figure 5.2-4). For example, CALSIM II and DSM2 are used extensively in Appendix 5.B, *Entrainment*, and Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*.

Inflow to the Delta from the Sacramento and San Joaquin Rivers is highly variable, reflecting annual variation in precipitation, regional climate trends, and hydrologic operations. As discussed above, water management changes between years to accommodate a variety of water needs. To reflect the range of flows expected over the BDCP implementation period, the analysis uses flow conditions over the 82-year CALSIM II base period averaged to reflect 5 water year types throughout the Plan Area (on the Sacramento River, San Joaquin River, and their tributaries). These water year types have been established by DWR for hydrologic analysis (California Department of Water Resources 2009b). For those actions that are affected by flow, a range of water year conditions are used to capture the array of impacts across water conditions. The analysis evaluates the change in biological condition resulting from BDCP actions for each of the following water year types.

- Critical (occur in 12 years out of the 82-year base period, or 15% of the time)
- Dry (18 years of 82, or 22%)
- Below Normal (14 years of 82, or 17%)
- Above Normal (12 years of 82, or 15%)
- Wet (26 years of 82, or 32%)

5.2.6.5 Biological Models

Biological models link environmental change, often characterized by the environmental models, to the change in biological performance of life stages or species. Biological performance is typically measured as a change in abundance, survival, or physical impact such as the percentage of a life stage entrained in pumps. Many of the biological models used in the effects analysis are statistical in nature and consist of single or multinomial regressions between physical change, such as flow or

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exports, and life stage biological performance. Biological models are often linked to environmental models and characterize a biological change expected from the modeled change in physical conditions. Figure 5.2-4, for example, shows the biological models used to assess entrainment effects on delta smelt and the relationship to CALSIM II and DSM2. This figure also shows how biological models relate to specific life stages and reflect unique hypotheses about stressors and biological performance. Models used to evaluate entrainment (Appendix 5.B, *Entrainment*) and the effects of flow, temperature, salinity, and turbidity (Appendix 5.C, *Flow, Salinity, Passage, and Turbidity*) on biological performance fall into this category.

5.2.6.6 Habitat Suitability Models

Habitat suitability models (or habitat suitability index models) evaluate multiple attributes of the environment as habitat for life stages and species. The result is an index of habitat suitability where 0 indicates entirely unsuitable habitat and 1 represents ideal habitat for the life stage and species. Habitat suitability brings together knowledge of life history, key habitats, and environmental requirements to create an index of habitat quality and quantity where a quantitative life cycle-habitat model is not available. Habitat suitability models collect a variety of types of information relating to habitat requirements to create hypotheses of species-habitat relationships rather than statements of proven cause and effect relationships (Schamberger et al. 1982).

Habitat suitability models are commonly used in fisheries assessments. Habitat suitability models are used to evaluate the value of restored wetland and intertidal environments (CM4, CM5, CM6, CM7) for covered fish species in Appendix 5.E, *Habitat Restoration*.

5.2.6.7 Population and Life History Models

Life history models integrate the effects of multiple stressors across multiple life stages to evaluate impacts of actions at population scales. Life history models are conceptually attractive because they offer the prospect of evaluating the effect of multiple stressors on the ultimate survival or abundance of the species (National Research Council 2011). However, life history models are not available for many species. Several life history models for salmonids are listed in Table 5.2-4, reflecting the rich quantitative literature associated with population dynamics of salmonids (Hilborn and Walters 1992). For other covered fish species such as longfin smelt, delta smelt, splittail, and sturgeon, life history models do not exist or are still relatively new. Maunder and Deriso (2011) have developed a life history model for delta smelt that is under review (Appendix 5.G, *Fish Life Cycle Models*).

5.2.6.8 Conceptual Model of the Effects Analysis

The conceptual model for the BDCP effects analysis is shown in Figure 5.2-5. The premise of the model is that the BDCP will alter the physical and biological environment of the Delta, which in turn will affect biological performance (abundance, persistence, and fitness) of covered fish species. The performance of a species in an environment is the result of characteristics of the habitat shaped by natural and anthropogenic factors (Southwood 1977; Peterson 2003). Alteration of these conditions through BDCP actions will produce a corresponding, though not typically proportional, change in species performance (Hall et al. 1997).

The quality and quantity of habitat available for a species is controlled at multiple scales by ecological drivers. Geology, biogeography, marine conditions and climate are large-scale drivers of

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conditions in the Study Area that set the intrinsic potential of the system. These interact with human-controlled land use to shape the environment that controls biological performance under present conditions. Flow is a secondary driver that is controlled in the Study Area by the primary drivers of climate (precipitation) and land use (flow regulation). It is included as a driver because of its importance in shaping freshwater and estuarine environments. The BDCP is a modifier of human land use that changes the underlying environmental template resulting in positive and negative changes in species performance.

5.2.6.9 Measures of Species Performance

5.2.6.9.1 Habitat

As stated above, a premise of the BDCP effects analysis is the relationship between qualities of the environment and species performance. Fundamental to this is the notion of *species perception* (Figure 5.2-5). This is the view of the environment from the perspective of the species and reflects the species' unique physiological and life history requirements (Mobrand et al. 1997). From the perspective of the species, the environment is viewed as *habitat,* which is the suite of physical, chemical, and biological factors determining species abundance and persistence over time (Hayes et al. 1996). As noted in Ecological Principle 7 from the BDCP Science Advisors, "habitat should be defined from the perspective of a given species and is not synonymous with vegetation type, land (water) cover type, or land (water) use type."

Habitat can be described in two general categories that relate to species performance (Figure 5.2-5). The *quantity* of habitat is a measure of area of suitable habitat. The *quality* of the habitat is characteristics of the habitat that relate to species performance such as temperature, water quality or turbidity. Habitat quantity and quality are not independent. Habitat quantity is not just the area (square meters) of particular habitats but is also a function of the quality of that habitat. Both habitat quantity and quality are defined with respect to life stages, which can often provide dramatically different habitat perceptions within the same species. For example, fish often seek particular types of habitat for spawning that are quite different than those used by adults for feeding.

5.2.6.9.2 Species Performance

Habitat quantity and quality can be related to measures of species performance. Quantity of suitable habitat is a key determinant of capacity of the environment for a species. Quality of habitat is a control on survival. In terms of fish population dynamics, quantity of habitat determines carrying capacity and quality of habitat controls density independent survival or productivity. Together, capacity and productivity control the abundance of fish that can be supported within an environment (Hilborn and Walters 1992). The quantity and quality of habitat can be quite variable over time and space due to variation in larger and smaller scale factors. Biological diversity within a species is a reflection of that habitat variation. Over larger scales spatial distribution of habitat patches across the landscape results in biological diversity and "spreads the risk" of failure or loss of habitat patches (Lindley et al. 2007).

Habitat characteristics can be measured in metrics of species performance such as growth, survival, abundance, and population recovery. The concept of viable salmonid population (VSP) (McElhany et al. 2000) provides a useful framework for defining fish population performance. Because VSP is based on general fisheries population biology, including stock-recruitment (Hilborn and Walters

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1992), the general outline of VSP has application for non-salmonid fish species, including delta fish species. Note that there are issues discussed in McElhany et al. (2000) that are specific to recovery of salmon populations that may not be applicable to all species.

VSP defines fish performance along four axes:

- Abundance or population size
- Population growth or productivity
- Diversity
- Spatial distribution of the population

Abundance is simply the number of fish making up a fish population defined by the carrying capacity of the habitat. Populations must be sufficiently abundant to counter the effect of stochastic events (e.g., catastrophes) and genetic effects of small population size.

Population growth or productivity is the rate of change in population size over time constrained by overall carrying capacity and density dependence. Density dependence means that survival and population growth are expected to be highest at low population abundance when competition for resources is least and declines as abundance increases and approaches capacity.

Diversity refers to the variety of morphological, behavioral, and life history traits that can occur within a fish population. Life history diversity represents the range of solutions that allow a population to cope with environmental variation and heterogeneity. Diversity is generally assumed to have a genetic component, although phenotypic plasticity also contributes to diversity within salmonid populations (Hutchings 2011).

Spatial distribution of the population refers to its structure across the landscape. To be viable over long time periods, populations need to have multiple centers of productivity to cope with catastrophic events, such as volcanic eruption or earthquakes, which could wipe out the population if it was confined to a single restricted location. Strictly speaking with respect to VSP, this measure refers to the structure of the population across the landscape within an evolutionarily significant unit (ESU) for salmon or distinct population segment (DPS) for steelhead. Although these types of population definitions have not been developed for nonsalmonids, the need for multiple centers of population production holds for others species as well.

Other measures of biological performance are encompassed by these four overall measures. Growth of individuals within a population, for example, reflects productivity and the availability of resources relative to abundance.

The VSP measures can be related to characteristics of habitat (McElhany et al. 2000) and hence to actions, including those in the BDCP. The following relationships are assumed to occur in Delta fish species.

- Abundance, as affected by carrying capacity, is a function of habitat quantity. Species have unique requirements that define key habitats for each life stage. Hence, habitat quantity refers the amount (e.g., square meters) of specific key habitats for the species and not simply the size of the environment.

- Productivity is affected by habitat quality that is set by values of environmental attributes filtered through the species perception. This includes species requirements for temperature, water quality, nutrients, and so on.

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- Diversity is a function of heterogeneity of habitat across the landscape. Habitat heterogeneity reflects the natural dynamics of flow and other habitat forming processes that create a mosaic of habitat of varying quantity and quality spatially and temporally. Within the genetic capabilities of the species, phenotypic, behavioral, and life history diversity develops in response to habitat heterogeneity.
- Spatial structure reflects the distribution of suitable habitat patches across the landscape that can support productive centers for population abundance and productivity (McElhany et al. 2000).

Biological performance and habitat conditions can be measured and monitored using a variety of indicators to chart progress over time. These indicators can be related to the biological goals and objectives developed for the BDCP. This provides a completed structure to relate BDCP actions to the biological goals and objectives.

5.2.6.10 Determining Net Effects on Fish Species

Typically, an effects analysis for an HCP or NCCP evaluates the adverse effects of development projects or other ground-disturbing activities that seek take coverage. These adverse effects are then combined with the beneficial effects of the conservation measures to determine the net effect of all covered activities (conservation measures are also covered activities). The BDCP is unusual in that the conservation measures themselves account for the majority of the covered activities and have both beneficial and adverse effects, depending on the covered species. To account for this structure, the effects analysis evaluates the combined effects of all covered activities, including the conservation measures, to determine the net effect of implementing the Plan.

To do this it is necessary to determine three outcomes for each covered species: the effects of incidental take on organisms and populations, the beneficial effects expected to result from the conservation strategy, and how these outcomes yield a net effect on the species during the BDCP term. HCPs are required to describe the impact of the take on each covered species. The impact of the take is defined as the effect of all take on species and their populations. Take is not necessarily equivalent to adverse effects; some adverse effects may not rise to the level of take. Beneficial effects are those effects that have a demonstrable benefit for the species, such as by supporting population recovery, establishing new or enhanced habitat, or reducing habitat fragmentation. Net effects are derived by integrating adverse and beneficial effects.

The biological effects of individual conservation measures were integrated to arrive at overall conclusions regarding the effects of the BDCP on covered fish species. Appendices 5.A through 5.J detail the results of quantitative and qualitative analysis and review of scientific literature associated with the covered activities and conservation measures. Table 5.2-3 identifies the different covered activities and conservation measures and where the analysis and results for each fish species related to these measures can be found.

The material and conclusions from each technical appendix are integrated in this chapter to form a set of overall conclusions on adverse, beneficial, and net effects. The integration procedure described below provides a transparent, systematic and comprehensive process for combining results from quantitative and qualitative analyses. A scoring system was devised that provides a clear basis for conclusions and illustrates direction of change in stressors due to the BDCP. The conclusions discussed in this chapter represent qualitative judgments of the effects of the BDCP that are grounded in the detailed quantitative and qualitative analyses in the appendices.

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The determination of net effects of the BDCP involved consideration of BDCP effects on covered species with respect to a set of stressors. Stressors are environmental attributes that can have a positive or negative effect on biological performance of the species. The integration process involved three steps (Figure 5.2-6). First, the stressors were ranked as limiting factors on the biological performance for each species life stage under current conditions. Stressors were ranked as integer values from 0 (no importance) to 4 (high importance). Stressors were ranked using professional judgment with reference to available literature and similar exercises such as DRERIP (e.g., Nobriga and Herbold 2009). Second, the effects of the BDCP on stressors were assigned integer scores ranging from -4 (strongly negative impact) to 0 (no impact) to +4 (strongly positive impact). The effect scores were assigned for each life stage to reflect the change in the stressor as a result of the BDCP during the period when the life stage would be present. BDCP effect scores were based on the quantitative and qualitative analyses in Appendices 5.A through 5.H. Third, the effect scores were multiplied by the stressor rankings to create an overall index of the biological effects of the BDCP on species and life stages due to the stressor. In other words, the indices of BDCP effects on the species were the effects scores for each stressor weighted by the biological ranking of the stressors for the species and life stage.

The result is a total score for the effect of the BDCP on the life stage by stressor. Those stressors that result in positive scores represent the beneficial effects of the BDCP while the negative scores describe the adverse effects. A score of zero indicates that the BDCP had no effect on the stressor.

As the stressor and impact evaluations were made, the certainty of the conclusion was evaluated on a 1 (speculative) to 4 (high degree of scientific support) rating. The certainty rankings were averaged across life stages to give an indication of the certainty of a stressor conclusion and were multiplied and standardized such that each overall conclusion had a certainty rating from 1 to 4 (Figure 5.2-6).

5.2.6.11 Biological Goals and Objectives for Covered Fish

As described in Chapter 3, *Conservation Strategy*, Sections 3.1.1 and 3.3, the BDCP biological goals and objectives reflect the expected ecological outcomes of the Plan and set out the broad principles that were used to help guide the development of the conservation strategy. Biological goals and objectives also serve as benchmarks for evaluating BDCP performance relative to ecological health. Goals and objectives are intended to be attainable by BDCP conservation measures. The specific biological goals and objectives of the Plan are described in Section 3.3, *Biological Goals and Objectives*. They are described at the landscape scale, for natural communities, and for some covered species (species-specific goals and objectives are not necessary for some covered species because the goals and objectives at the higher levels address their needs). In all cases, progress toward achieving these objectives can be measured as described in Section 3.6, *Adaptive Management and Monitoring Program*.

As described in Section 3.3, *Biological Goals and Objectives*, many of the biological objectives for covered fish are expressed as a population metric such as species growth or survival. Biological objectives with such specific metrics may be challenging to meet because of the natural variation in fish population dynamics, stressors that influence these populations beyond the influence of the BDCP, and other factors such as a change that has effects small populations. This chapter includes analyses that can be used to directly test the feasibility of many of the quantitative biological objectives for covered fish. However, not all of the biological objectives for covered fish can be evaluated at this time because of a lack of field data, lack of tools suitable for a robust assessment, or

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a combination of these factors. Table 5.2-5 lists each of the biological objectives for covered fish and describes whether and how the objectives are assessed in the effects analysis and where this assessment can be found.

The BDCP effects analysis links conservation measures and expected species response based on best available science applied through conceptual and quantitative models. Because of the complexities of biological responses, environmental variability, and limitations in scientific understanding, it can be difficult to directly link conservation measures to a species response and then to achievement of a biological objective. Hence, the conceptual and quantitative analyses in the effects analysis create an expectation of biological response based on the information available. These expectations represent a working hypothesis of the relationship between actions, stressors, and biological performance. The working hypotheses will be tested and refined through experimentation and adaptive management over the term of the BDCP. The effects analysis captures current scientific understandings of how environmental conditions relate to the biological response of covered fish species. However, analytical methods are expected to improve in the future, new information will be collected, and environmental conditions will change. These changes in conditions and current knowledge would be incorporated through the scientific synthesis step in adaptive management.

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Table 5.2-5. Biological Objectives for Covered Fish and their Assessment in the Effects Analysis

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Delta smelt	**DTSM1.1 (Growth and Health):** Achieve a fall mean body length increase of at least 2 mm longer than existing conditions in December as collected in Fall Midwater Trawl (62 mm vs. 60 mm fork length) within 15 years of BDCP implementation.	No	Analyzing this objective would require development of a bioenergetics model to determine whether an increase in growth would be achievable through the expected increase in primary and secondary productivity associated with habitat restoration implemented as part of BDCP. The increase in secondary productivity and the fraction of that that is available to delta smelt would need to be estimated as well.
	DTSM1.2 (Survival): Limit entrainment mortality associated with project operations to ≤10% of the delta smelt population on average over a 10-year period (across all life stages, not to exceed 20% in any given year) within 15 years of BDCP implementation.	Yes	Entrainment has been addressed with the Effects Analysis (Appendix 5.B, *Entrainment*), though losses of larvae/juveniles and adults are not yet combined to give total population losses. The effects analysis presented within Appendix 5.B may be most appropriate to use as a comparative tool between scenarios that gives indications of relative trends, because existing entrainment levels under the Biological Opinion (BiOp) Reasonable and Prudent Alternative (RPA) are less than those indicated in the EA and thus the lower entrainment estimated in the EA as a result of the project indicates that the project is likely to achieve the metrics presented in the objective.
	DTSM2.1 (Spatial Distribution): Increase the extent of suitable habitat in the Plan Area by 15,000 acres during the near-term (NT), 22,000 acres during early long-term (ELT), and 49,000 acres during late long-term (LLT), and expand the distribution of juvenile and pre-spawn adult Delta smelt into that habitat.	Yes	Evaluated in Appendix 5.E, *Habitat Restoration*, using the Habitat Suitability Index (HSI). The habitat suitability analysis focuses on the direct benefits to fish in terms of increased availability of suitable habitat. The habitat suitability analysis does not provide information regarding the extent to which covered fish species may or may not use the habitat.

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Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Longfin smelt	**LFSM1.1 (Abundance):** Achieve an annual average of the abundance indices from 1987–2000 per year, within 15 years of BDCP implementation.	Yes	Evaluated qualitatively in Appendix 5.E and quantitatively in Appendix 5.C. Natural communities restored as part of BDCP are anticipated to contribute to an increase in primary and secondary productivity, thereby potentially contributing to an increase in species abundance. However, currently no data are available to support a solid hypothesis for the magnitude of BDCP's contribute to an increase in food for longfin smelt, thus no way to quantify the benefit of an increase. The Kimmerer et al. 2009 methods predicts decreased abundance due to decreased outflow. The extent to which increased outflow can improve abundances is also uncertain. Using the 1987–2000 period captures the post-*Corbula* (introduction of invasive nonnative clam) and pre-Pelagic Organism Decline (POD) (significant decline in many covered fish species in the Bay-Delta) period.
	LFSM1.2 (Resilience): During we years, achieve a FMWT abundance index ≥ the abundance index predicted based on regression of prior (1987–2000) longfin abundance and outflow.	Yes	Evaluated qualitatively in Appendix 5.E. Habitats restored as part of BDCP are anticipated to contribute to an increase in primary and secondary productivity, potentially contributing to an increase in species abundance. However, the effects analysis currently uses the regression from the pre-*Corbula* period and indicates a negative effect due to reduced outflow under BDCP. Using the 1987–2000 period captures the post-*Corbula* (introduction of invasive nonnative clam) and pre-POD period.
	LFSM1.3 (Survival): Increase survival of longfin smelt larvae immediately following yolk-sac absorption within 15 years of implementation.	Yes	Evaluated qualitatively in Appendix 5.E. Habitats restored as part of BDCP are anticipated to contribute to an increase in primary and secondary productivity, contributing to an increase in species survival. Also evaluated quantitatively in Appendix 5.C, *Flow, Salinity, Temperature, and Passage*. The application of the Kimmerer et al. 2009 regression relationship between outflow and abundance predicts a decline in abundance (and reduced survival) related to reduced winter/spring outflow. However, it is unclear whether food or outflow is presently the key limiting factor; it could take a combination of both to achieve this objective.

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Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Winter-run Chinook salmon	**WRCS1.1 (Juvenile Survival):** Achieve a through-delta survival rate of juveniles of at least 30% measured as a 4-year running average within 15 years of plan implementation.	Yes	Evaluated qualitatively. Through Delta survival is evaluated using the Delta Passage Model (DPM) (Appendix 5.C). The DPM however, is best suited for smolts, which move through the Delta rather quickly. The DPM is not well suited for fry or those fish that may rear and grow within the Plan Area before they migrate out of the Delta.
	WRCS1.2 (Adult Passage): Limit adult passage delays at anthropogenic barriers and impediments to no more than >36 hours, within 15 years of implementation.	Yes	Qualitative analysis provided in Appendix 5.C for Fremont Weir, relying on DRERIP, although without regard for timing. Qualitative discussion for Suisun Marsh Salinity Control Gates is also provided, although there is uncertainty regarding effect of BDCP on their operation. No data available regarding the duration of passage delays so this cannot be evaluated quantitatively.
Spring-run Chinook salmon	**SRCS1.1 (Juvenile Survival):** Achieve a 4-year running average through-delta juvenile survival rate which will result in stable or expanding population within 15 years of implementation.	No	Not addressed. Would require modeling exercise to inform the necessary improvement in survival required to result in a stable or expanding population. No life-cycle models available that integrate the factors that BDCP will influence.
	SRCS2.1 (Migration): Reduce adult passage delays at anthropogenic barriers and impediments that cause median passage times of >36 hours, within 15 years of implementation.	Yes	See comments above for Winter-run WRCS1.2.
	SRCS3.1 (Habitat): Increase availability of floodplain habitat by 1,000 acres within 15 years of plan implementation, and channel margin habitat by 5 miles within 10 years of implementation, for spring-run migration and rearing compared to baseline conditions.	Yes	The benefits of floodplain and channel margin habitat are evaluated qualitatively in Appendix 5.E.
Fall-run Chinook salmon	**FRCS1.1 (Juvenile Survival):** Achieve a 4-year running average through-delta juvenile survival rate which will result in stable or expanding population within 15 years of plan implementation.	No	Not addressed. See above comments for Spring-run SRCS1.1.
	FRCS2.1 (Migration): Reduce passage delays at anthropogenic barriers and impediments that cause median passage times of >36 hours, within 3 years of implementation.	Yes	See comment above for Winter-run WRCS1.2.

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Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	FRCS3.1 (Life History Diversity and Spatial Distribution): Increase availability of floodplain habitat by 1,000 acres within 15 years of plan implementation, and channel margin habitat by 5 miles within 10 years of implementation, for fall-run migration and rearing compared to baseline conditions.	Yes	The benefits of floodplain and channel margin habitat are evaluated qualitatively in Appendix 5.E.
	FRCS4.1 (Life History Diversity and Spatial Distribution): Increase enforcement efforts to reduce illegal take in the Plan Area within 5 years of plan implementation.	Yes	Qualitatively evaluated in Appendix 5.F, *Biological Stressors on Covered Fish*. Current level of illegal harvest is unknown and potential reduction in illegal harvest from implementation of CM17 cannot be quantified.
Steelhead	**STHD1.1 (Juvenile Survival):** Achieve a 4-year running average through-delta juvenile survival rate which will result in stable or expanding population within 15 years of plan implementation.	No	Not addressed. See above comments for Spring-run SRCS1.1.
	STHD2.1 (Habitat): Increase availability of floodplain habitat by 1,000 acres within 15 years of plan implementation, and channel margin habitat by 5 miles within 10 years of implementation, for steelhead migration and rearing compared to baseline conditions.	Yes	See comment above for Spring-run SRCS3.1.
Green sturgeon	**GRST1.1 (Abundance):** Increased spawner adult abundance-to-juvenile abundance ratio compared to existing condition.	No	Current spawning-to-adult abundance is unknown, so evaluating an increase as a result of BDCP is not currently feasible.
	GRST2.1 (Stranding): Eliminate stranding of adult green sturgeon at the Fremont Weir within 15 years of implementation, minimize stranding until weir modifications can be made, and limit passage delays in the Yolo Bypass and other anthropogenic barriers to no more than 36 hours.	Yes	Qualitatively evaluated in Appendix 5.C. Fremont Weir improvements are discussed in general terms, without regard for timing. Stockton Deep Water Ship Channel dissolved oxygen is discussed. Qualitative discussion for Suisun Marsh Salinity Control Gates is also provided, although there is uncertainty regarding effect of BDCP on operations.

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Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	GRST3.1 **(Distribution):** Improve water quality parameters and physical habitat characteristics in the Bay-Delta.	Yes	Qualitative discussed in Appendix 5.D, *Contaminants*. Some uncertainty regarding white sturgeon sensitivity to water quality and whether current water quality conditions negatively affect white sturgeon. Thus, evaluating the response of white sturgeon to improved water quality conditions is difficult, and may be somewhat negative (low potential for effect). However, certain CMs to be implemented as part of BDCP will contribute to improved water quality, including *CM19 Urban Stormwater Treatment*, *CM12 Methylmercury Management*, and *CM14 Stockton DWSC DO Levels*. So while BDCP has a low potential for negative effects, certain CMs will be implemented to provide a benefit to covered fish species.
White sturgeon	**WTST1.1:** Increased spawner adult abundance-to-juvenile abundance ratio compared to existing condition within 15 years of BDCP implementation.	No	See comment above for green sturgeon GRST1.1.
	WTST2.1 (Passage and Stranding): Reduce stranding of adult white sturgeon at Fremont Weir by 75% over baseline conditions within 15 years of BDCP implementation.	Yes	Discussed qualitatively in Appendix 5.C with Fremont Weir improvements. No data available on current stranding rates at Fremont Weir but this will be measured during early implementation to create a baseline with which to compare after improvements are made to the weir.
	WTST3.1 (Distribution): Improve water quality parameters and physical habitat characteristics in the Bay-Delta to increase the spatial distribution of white sturgeon in the Plan Area within 15 years of BDCP implementation.	Yes	See comment above for green sturgeon GRST3.1.
Sacramento splittail	**SAST1.1 (Spawning and Rearing Habitat):** Maintain 5-year running average of splittail index of abundance in the Plan Area of 150% of baseline conditions by providing access to suitable spawning and rearing habitat in the Plan Area within 15 years of BDCP implementation.	Yes	Considered qualitatively in Appendix 5.C and 5.H.
Pacific and river lamprey	**PRL1.1:** Protect and enhance habitat suitable for larval settlement and development within the Plan Area within 15 years of BDCP implementation.	Yes	Considered qualitatively in Appendix 5.H. Cannot be considered quantitatively due to a lack of data on soil types and depths in larval lamprey habitat in the Plan Area.

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5.2.7 Effects Analysis for Wildlife and Plants

5.2.7.1 Take Assessment

Implementation of covered activities will result in incidental take of covered wildlife and plants. To meet regulatory requirements and to ensure adequate mitigation of effects, the amount of take must be discussed and, if possible, quantified. The allowable amount of take is quantified by estimating the loss of habitat for each covered species (methods for impact estimation are described below). Effects on plant populations will also be tracked to ensure permit compliance, as described in Section 5.2.7.1.1, *Use of Plant Occurrence Data*.

The following types of effects would result from covered activities and conservation measures.

- Permanent habitat loss or conversion
- Periodic inundation
- Temporary loss
- Long term loss
- Injury or mortality
- Permanent indirect and other indirect losses

A list of covered activities, these effects, and corresponding conservation measures are summarized in Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*, in Table 5.K-2. The detailed methods used to estimate effects and key assumptions related to these methods are also listed in Appendix 5.K in Table 5.K-1 and Figure 5.2-7.

The effects of construction of the water conveyance facility (CM1) can be assessed precisely based on a known maximum disturbance footprint. Similarly, the locations of construction for some other conservation measures are relatively well defined (e.g., CM2, CM18). However, the locations for other covered activities are to be determined during BDCP implementation through project planning (see *CM3 Natural Communities Protection and Restoration* and Chapter 6, *Implementation*) and therefore have been assessed at a programmatic level.

The habitat loss estimates for covered activities addressed at the programmatic level are intended to reflect approximate maximum losses rather than a precise quantification of effects on land cover types. Actual losses are expected to be lower through careful restoration design and avoidance and minimization measures. However, the estimates represent the limit, or cap, on total loss allowable under the Plan. The Implementation Office will track actual effects during Plan implementation to ensure that effects do not exceed the allowable levels. Once these habitat loss levels are reached, no further take is permitted pursuant to the Plan without a plan amendment (see Chapter 6, *Implementation*, for a description of the amendment process).

Hypothetical disturbance footprints were developed to estimate maximum loss of species habitat resulting from tidal natural community restoration (CM4) and seasonally inundated floodplain restoration. The hypothetical footprints for tidal restoration were developed using outputs of the tidal restoration model (RMA model output) described in Section 5.2.5.1, *Use of Models in the Effects Analysis.* The hypothetical footprint for floodplain restoration was developed by evaluating restoration opportunities and applying assumptions about the most likely locations for floodplain

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restoration as described in Chapter 3, *Conservation Strategy* (CM5) and Appendix 5.E. Both tidal and floodplain restoration hypothetical footprints are located in the conservation zones in which they are most likely to be implemented, based on existing conditions and restoration opportunities.

Assumptions were developed for each covered species that would potentially be affected by tidal inundation or desiccation (resulting from changes in the tidal prism as a result of tidal restoration), based on expected effects of inundation and desiccation on the species' habitat; these assumptions are provided in Appendix 5.K.

Other covered activities that potentially affect covered wildlife and plants and were analyzed at the programmatic level include nontidal marsh restoration, riparian restoration, and conservation fisheries enhancement. Effects resulting from these activities were assessed using the methods and key assumptions summarized in Appendix 5.K, Table 5.K-1.

5.2.7.1.1 Use of Plant Occurrence Data

Effects on plant species were assessed by using habitat models as well as plant occurrence information. Occurrence data include a general location of a current or historic plant population[2]. Occurrence data often also has additional information such as the total number of plants, the general condition of the occurrence, the status of the occurrence (e.g., extant, presumably extirpated) as well as any identifiable threats. Occurrence data are from the California Natural Diversity Database (CNDDB), the Consortium of California Herbaria, and the Delta Habitat Conservation and Conveyance Program.

All occurrence data were represented spatially in GIS. To assess the potential for take and inform the decision of maximum allowable loss of occurrences, occurrence data were intersected with those covered activities that had known or hypothetical footprints. If a footprint intersected with an occurrence, the potential for take was assessed and described. Considerations regarding the potential for take included the nature of the footprint, (known or hypothetical), the likelihood that the occurrence could be completely avoided, the abundance and distribution of the occurrence, the impact mechanism (habitat removal versus inundation or desiccation), and the species' life form (annual versus perennial).

During implementation, there is potential for temporary or partial loss of plant occurrences. Partial occurrence effects are defined as the loss of some individuals but not enough to compromise the long-term survivability of the occurrence. Temporary effects on plant occurrences are those that may affect most or all of an occurrence but the effect is such that the occurrence can naturally recolonize to an abundance and distribution similar to the preproject condition.

Discussing effects and benefits in terms of occurrences has limitations. Occurrence data often have numbers of individuals and these can fluctuate widely from year to year due to environmental variation (e.g., rainfall). Some occurrences in the CNDDB include estimates of numbers of individuals; however, many occurrences do not or the estimates are from only one year. Additionally, in the rare cases where there are multiple years' data, these numbers often vary widely (e.g., from hundreds in one year to thousands in another for just one occurrence). This especially

[2] Occurrence points may or may not correspond to a plant population. Widely separate occurrences likely represent distinct populations, while closely spaced occurrences may be part of the same population. Occurrence points were used as the unit of analysis because of their consistency across plant species. Most occurrence data does not allow translation into population units.

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makes tracking partial and temporary effects and recolonization success difficult given that factors outside the control of the Implementation Office can control the size of the affected occurrence as well as that of the recolonized occurrence.

Take limitations based on occurrences are proposed for a select number of plant species (Table 5.6-4, *Covered Plant Species Occurrences, Effects, and Conservation Requirements*). The protection of existing, extant occurrences is first conservation method. When the protection of unprotected or undiscovered occurrences is feasible, protection is required. However, when extant occurrences are unlikely to be found, the BDCP Implementation Office may create occurrences. For applicable species, rationale is provided to justify occurrence creation (e.g., known creation or restoration success, ability of plant to be grown in a nursery setting and outplanted, etc.).

In addition to the quantitative effects assessment, occurrence data were used to inform the qualitative effects discussion. Primarily, state-wide occurrence data were used to provide context for the Plan Area occurrences (i.e., what percent of the state's total occurrences are within the Plan Area).

5.2.7.1.2 Habitat Suitability Models

Habitat suitability models (or habitat suitability index models) evaluate multiple attributes of the environment as habitat for life stages and species. The result is an index of habitat suitability where 0 indicates entirely unsuitable habitat and 1 represents ideal habitat for the life stage and species. Habitat suitability brings together knowledge of life history, key habitats, and environmental requirements to create an index of habitat quality and quantity where a quantitative life cycle-habitat model is not available. Habitat suitability models collect a variety of types of information relating to habitat requirements to create hypotheses of species-habitat relationships rather than statements of proven cause and effect relationships (Schamberger et al. 1982).

Habitat suitability models are commonly used in wildlife and fisheries assessments and are used to evaluate the effects of the BDCP on terrestrial species that rely on cultivated lands (Swainson's hawk, sandhill crane, tricolored blackbird) as described for these species in Section 5.2.5, *Effects Analysis for Natural Communities*.

5.2.7.2 Analysis of Adverse Effects

Adverse effects on each species were assessed in each of five categories: permanent habitat loss, conversion, and fragmentation; periodic inundation; construction-related effects; effects of ongoing activities; and other indirect effects. Adverse effects from each of these categories were then assessed collectively in the context of species survival and recovery to determine the impact of take on the species. For each effect category, effects were assessed collectively for all covered activities, and for conveyance facility construction. For covered activities addressed at the programmatic level, only those activities with the greatest level of effects in each effect category were assessed in detail. Each of the effects categories applied in the adverse effects analysis is described below.

5.2.7.2.1 Permanent Habitat Loss, Conversion, and Fragmentation

This effect category includes permanent habitat loss as a result of development-related covered activities (e.g., water conveyance facility) and conversion to a different natural community type as a result of restoration (e.g., from grasslands to tidal brackish emergent wetland). It also includes habitat fragmentation effects. For example, tidal marsh restoration may result in habitat

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fragmentation for grassland-dependent species. Adverse effects were assessed for each of the covered activities listed in Appendix 5.K, Table 5.K-2.

Tidal restoration will result in a conversion of existing natural community types to tidal perennial aquatic and tidal marsh natural communities. In some areas, the tidal restoration footprint overlaps with existing tidal brackish emergent wetland and tidal freshwater emergent wetland natural communities. Therefore, for some of the natural community and species habitat types, it was assumed that tidal inundation would not result in a loss or conversion of the natural community or habitat. These assumptions are provided Appendix 5.K.

For most covered activities, habitat loss and conversion was assessed quantitatively by overlaying GIS data layers that represent the actual or hypothetical geographic footprints for BDCP covered activities with GIS data layers for species habitat models (Figure 5.2-7). As described above in Section 5.2.7.1, *Take Assessment*, the conveyance facility footprint represents the known location for this covered activity, while footprints for most other covered activities are hypothetical. For transmission line construction and riparian restoration, modeled species habitat loss was not quantified. Loss of natural community types was quantified and species effects were assessed based on their associations with affected natural communities. For many covered activities, assumptions were applied to the GIS output in order to adjust acreage numbers to further refine the effects analyses. Table 5.K-3 summarizes the methods applied to assess habitat loss and conversion for each type of activity, and describes the key assumptions related to each method.

Habitat fragmentation was assessed qualitatively based on an evaluation of covered activities in relation to modeled species habitat, and evaluation of the quality of habitat affected. The effects analysis recognizes that the quality of modeled species habitat, in terms of long-term conservation value and ability to sustain covered species populations, varies throughout the Plan Area. The quality of species habitat lost or converted as a result of covered activities was assessed to the extent possible with existing information. Information used to assess the quality of affected habitat include patch size and fragmentation of modeled habitat, adjacent land uses such as roads and other development based on aerial imagery, information from literature and species experts related to species distribution in the Plan Area, species occurrence data, and proximity to Category 1 or 2 open space. The open space categories are defined as follows.

- **Category 1 open space:** Lands that are subject to irrevocable protection against a change in primary land use through local, state, or federal authority and with a primary management goal related to ecological protection.
- **Category 2 open space:** Lands that are subject to irrevocable protection against a change in primary land use through local, state, or federal authority with a primary land management goal assessed to be that of open space for mixed use in a manner that maintains ecological value.
- **Category 3 open space:** Lands that are subject to irrevocable protection against a change in primary land use through local, state, or federal authority. However, these lands are not managed primarily for ecological protection nor are they managed as open space for mixed use in a way that maintains ecological value.

For species with habitat loss distributed in many locations throughout the Plan Area, habitat quality was only evaluated for areas with the greatest effects. More detailed habitat quality analysis was conducted for the conveyance facility effects, for which location of effects is known, than for other covered activities for which hypothetical footprints were used. The habitat quality factors

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considered differ by species, and are described in the methods sections for each species (Section 5.7, *Effects on Wildlife and Plants*.)

Species occurrence data were evaluated as a component of the quality assessment for habitat permanently lost or converted. For most of the covered species, occurrence data is incomplete and therefore has limited utility for assessing the extent to which modeled habitat is occupied or determining where the greatest population effects will occur. However, DWR has conducted extensive field surveys recently in and around the conveyance facility footprint and alternative alignments for this facility. Therefore, occurrence data are used to assess effects of the conveyance facility construction to a greater extent than they are used to assess effects of other covered activities. In general, the effects analysis relies on occurrence data for plants more than for wildlife, as described in Section 5.2.6.1.1, *Use of Plant Occurrence Data*.

5.2.7.2.2 Periodic Inundation

This effect category includes periodic inundation from flooding in the Yolo Bypass (CM2) and seasonal flooding in restored floodplains (CM5). Periodic flooding in the Yolo Bypass will increase as a result of *CM2 Yolo Bypass Fisheries Enhancement*, and the effects analysis addresses the difference between existing conditions and projected conditions after project implementation. The quantitative analysis of Yolo Bypass inundation is based on the change in aerial extent in the average annual maximum inundation footprint between existing and projected future conditions. The quantitative analysis of seasonally inundated floodplain inundation is based on the area between the setback levees in the hypothetical floodplain restoration footprint. These quantitative assessment methods are outlined, and key assumptions and limitations described, in Appendix 5.K, Table 5.K-1. Floodplain restoration will involve removal of sections of existing levee, allowing flood flows to periodically inundate portions of the historical floodplain.

5.2.7.2.3 Construction-Related Effects

This effect category includes nonpermanent, construction-related habitat loss and indirect effects of construction-related factors such as dust, noise, vehicle traffic, human disturbance, and night lighting. Habitat loss addressed in this category includes effects categorized as *short-term temporary* (restored to predisturbance conditions within 1 year after construction is complete) and *long-term temporary* (restored to preproject conditions, and timeframe undetermined but within permit term). Short-term temporary and long-term temporary habitat loss was assessed quantitatively and qualitatively using the same methods described above in Section 5.2.7.2.1, *Permanent Habitat Loss, Conversion, and Fragmentation* and as described in Appendix 5.K, Table 5.K-1.

Indirect effects on covered species habitat adjacent to development and restoration-related construction activities were quantitatively assessed based on covered activity footprints and species habitat models. The types of indirect effects assessed using this method included noise, lighting, line-of-sight disturbance, dust, and construction-related run-off. These effects would be temporary, as they would only occur during construction. The effect on each species was calculated by intersecting the assumed area of indirect effect extending from the construction area for each species with each species modeled habitat; the intersection represents the extent of effect expressed as acres of disturbed habitat. For noise and visual disturbances on covered wildlife species, existing areas of disturbance (e.g., road traffic, urban developments, farm buildings) that intersect disturbance areas associated with BDCP actions were also calculated and were subtracted from the

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area of effect calculated for BDCP actions. The indirect effect distances used for covered activities are summarized in Appendix 5.K, Tables 5.K-4 and 5.K-5.

5.2.7.2.4 Effects of Ongoing Activities

This effect category includes indirect effects on species habitat in the vicinity of facilities, related to ongoing maintenance and operation, and effects of reserve system management and enhancement. Ongoing indirect effects in the vicinity of facilities were assessed quantitatively based on designated disturbance distances as described above in Section 5.2.7.2.3, *Construction-Related Effects*, except that these indirect effects of ongoing activities were treated as permanent rather than temporary. Effects of reserve land enhancement and management activities such as native species plantings and nonnative species control were assessed qualitatively.

5.2.7.2.5 Other Indirect Effects

This effect category includes effects that, while not caused solely by BDCP covered activities, are influenced by covered activities and could result in effects that are not limited to the immediate vicinity of the covered activities. Two examples are the methylation of mercury and the increase or decrease in salinity related to tidal restoration. These potential effects were assessed qualitatively. For methyl mercury effects, only those species with potential effects from methyl mercury are discussed. These include wildlife species that feed on fish or invertebrates from the Bay and Delta with potential exposure to methyl mercury.

5.2.7.3 Summarizing Effects on Wildlife and Plants

Typically, an effects analysis for an HCP or NCCP evaluates the adverse effects of development projects or other ground-disturbing activities that seek take coverage. These adverse effects are then combined with the beneficial effects of the conservation measures to determine the net effect of all covered activities (conservation measures are also covered activities). The BDCP is unusual in that the conservation measures themselves account for the majority of the covered activities and have both beneficial and adverse effects, depending on the covered species. To account for this structure, the effects analysis evaluates the combined effects of all covered activities, including the conservation measures, to determine the net effect of implementing the Plan.

To do this it is necessary to determine three outcomes for each covered species: the effects of incidental take on organisms and populations, the beneficial effects expected to result from the conservation strategy, and how these outcomes yield a net effect on the species during the BDCP term.

HCPs are required (Section 10(a)(2)(A)(i) of the ESA) to describe the impact of the take on each covered species. The impact of the take is defined as the effect of all take on species and their populations. In the effects analysis, it considers the species' overall range, the importance of the Plan Area to the species as a whole, and the extent to which BDCP-related take will affect the species' long-term survival and recovery.

The beneficial effects analysis addresses effects to each species expected to result from implementation of the conservation strategy described in Chapter 3, *Conservation Strategy*. It includes a quantitative analysis of habitat restoration and projection acreages and, where applicable, protection or establishment of species occurrences. It also includes a qualitative assessment of anticipated benefits to the species based on quality of habitat to be protected and

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restored (habitat quality factors differ by species), and expected benefits of habitat management and enhancement actions.

The net effects analysis addresses the net effects on the species resulting from the adverse effects of covered activities and the beneficial effects of implementing conservation measures. This includes a quantitative analysis of net change in available habitat and, where applicable, species occurrences. In addition, the net effects analysis evaluates temporal loss related to any delays between habitat loss and habitat restoration. To the extent that information is available, the analysis also describes the quality difference between habitat lost and habitat restored and protected.

For each species, a determination was made as to whether the net effects on the species will result in a contribution to the species' recovery. The Plan's contribution to recovery was guided by the proportion of a species' range and life cycle within the Plan Area and the level of effect on that species. For example, all else being equal, the Plan's obligation to contribute to recovery for a species with a small portion of its range in the Plan Area is less than the Plan's obligation to contribute to recovery for a species with a large portion of its range in the Plan Area. For listed species, contribution to recovery means to contribute to factors that result in the species' no longer needing to be state or federally listed. For nonlisted species, contribution to recovery as defined in the BDCP refers to the BDCP's contribution to factors that prevent the species' need to become state- or federally listed in the future.

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5.2.8.1 Personal Communication

J. Burau pers. comm.

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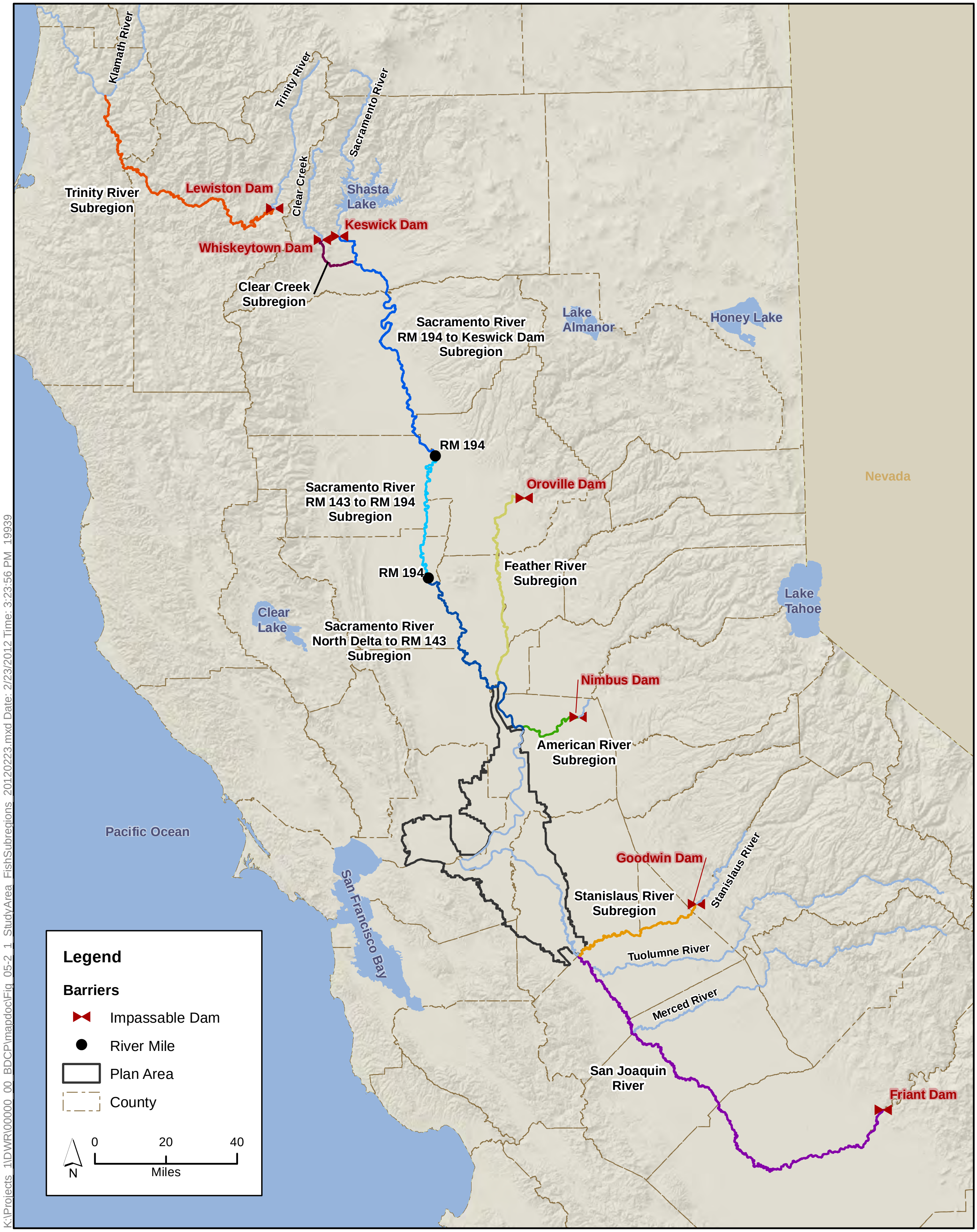

Source: Fish Barriers, DWR 2012; Subregion Flowlines, DWR 2012; Subregion Waterways, DWR 2012; Plan Area, DWR 2010; Counties, CDF 2009; Aerial Photograph, NAIP 2010.

Figure 5.2-1
BDCP Study Area

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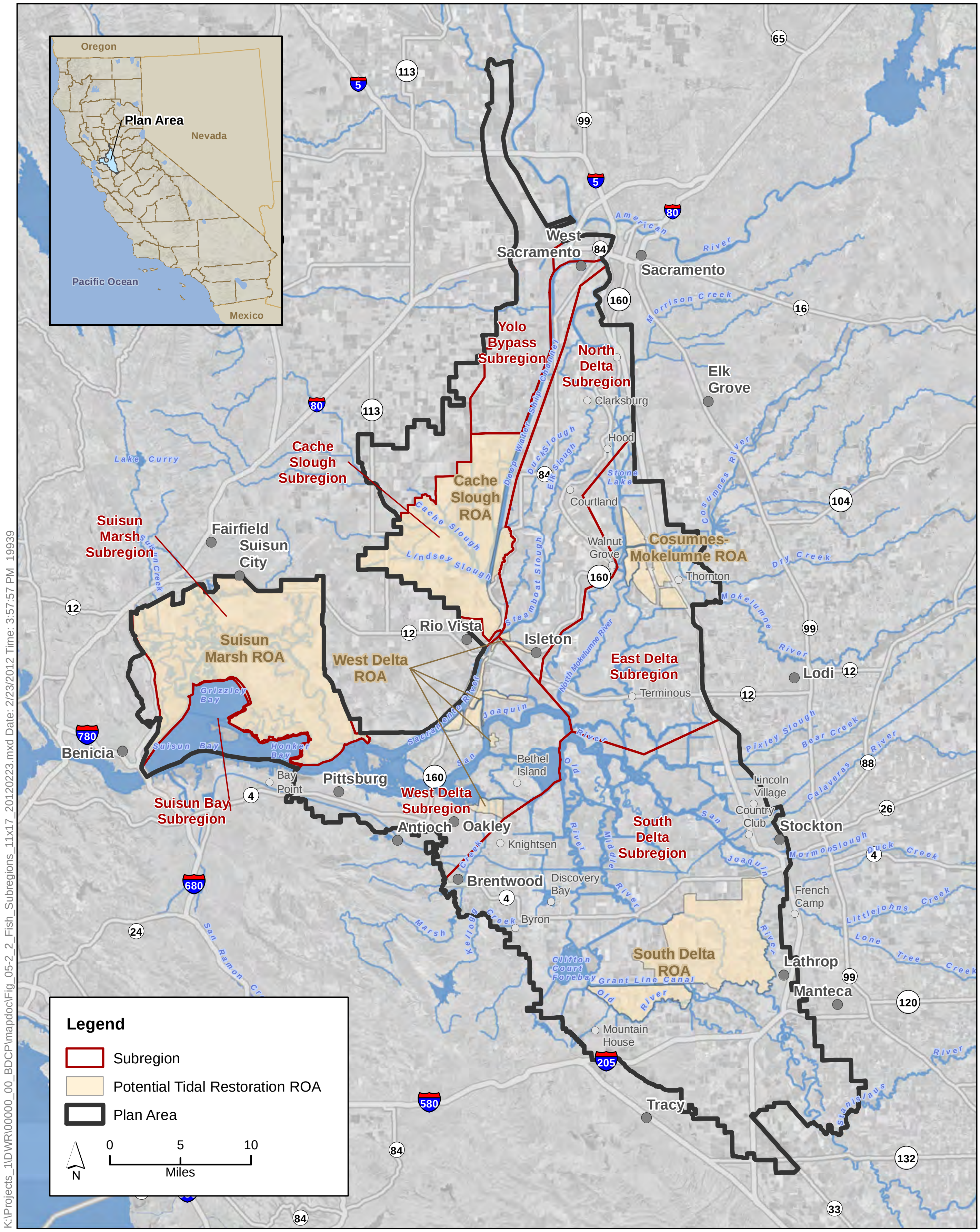

Sources: Plan Area, DWR 2010; Subregion, ICF 2011; ROAs, SAIC 2011; Hydrology, HDR 2011; Cities, U.S. Census Bureau 2010; Aerial Photograph, NAIP 2010.

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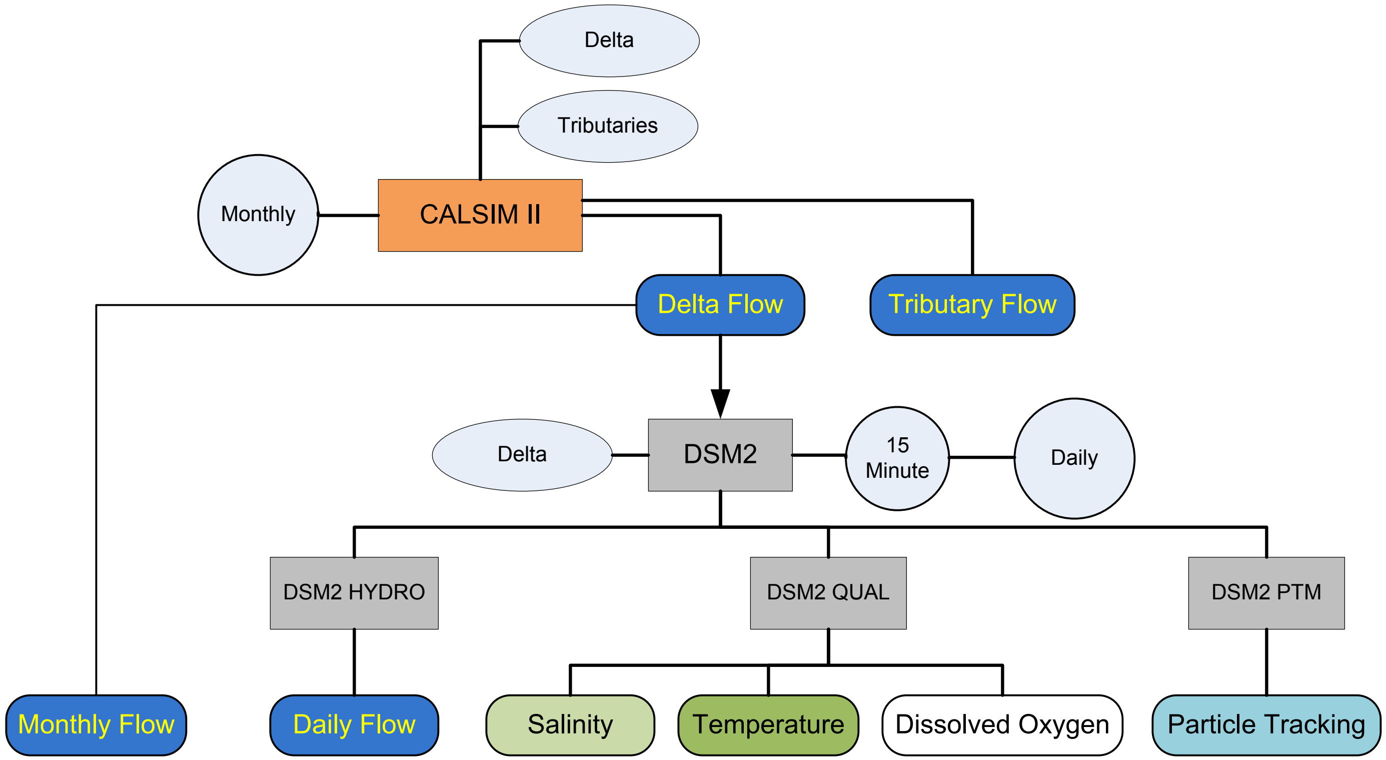
Figure 5.2-2
BDCP Plan Area, Geographic Subregions, and Restoration Opportunity Areas (ROAs)



BDCP Effects Analysis (2-22-2012) TG

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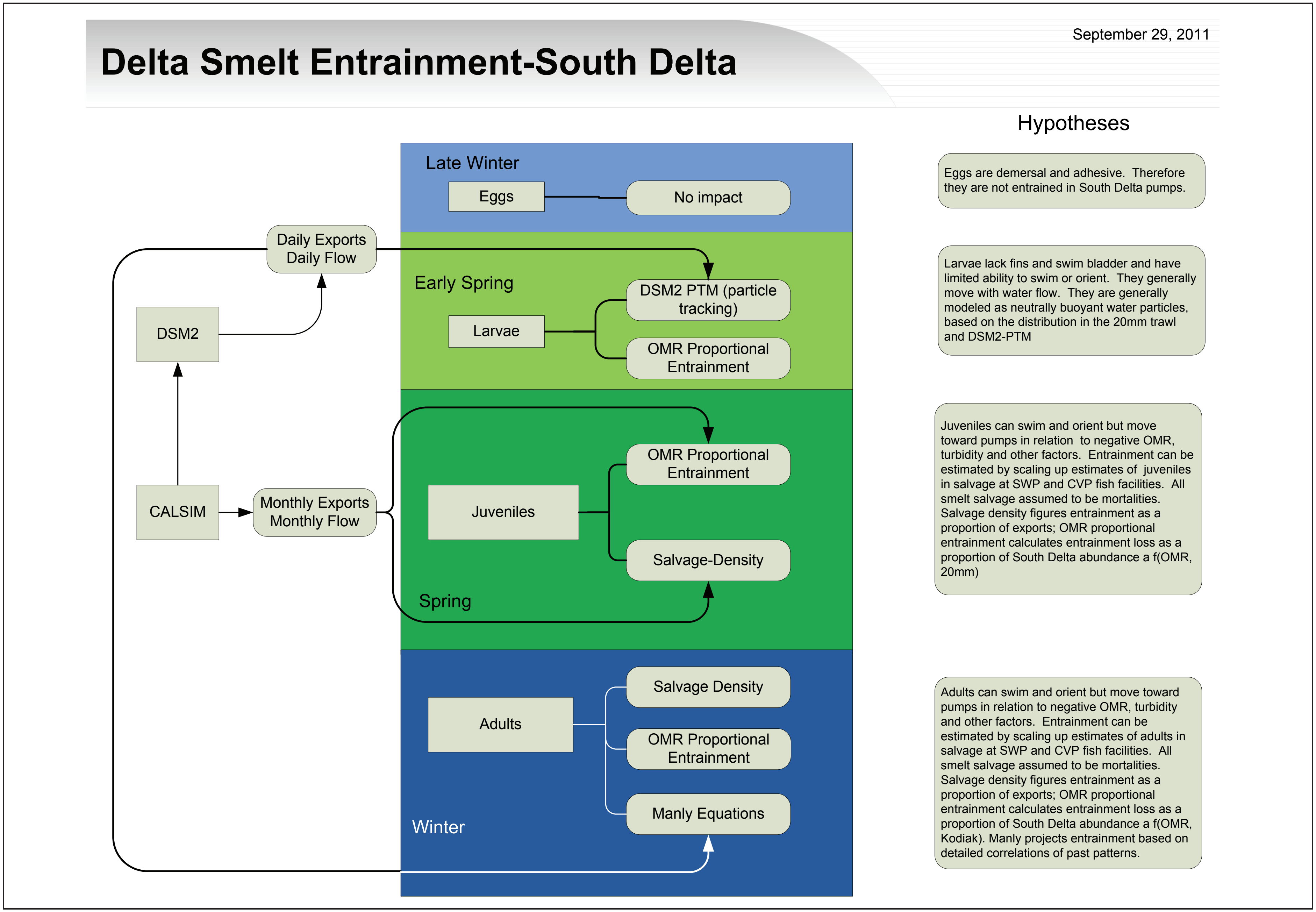
Figure 5.2-3
Relationship between Environmental Models and Their Major Outputs



BDCP Effects Analysis (2-22-2012) TG

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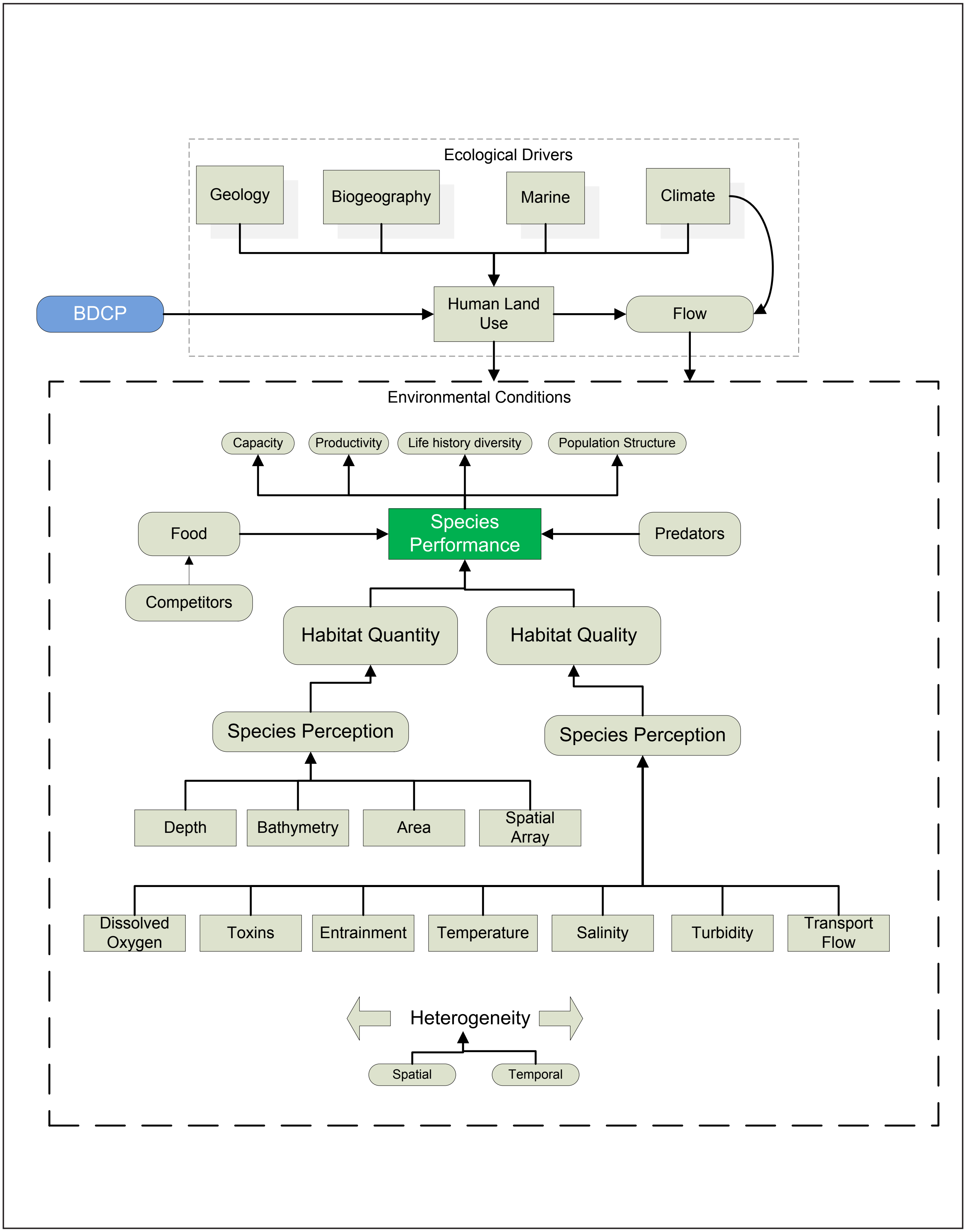
Figure 5.2-4
Relationship between Biological Models Used to Evaluate Entrainment and Environmental Models



BDCP Effects Analysis (2-22-2012) TG

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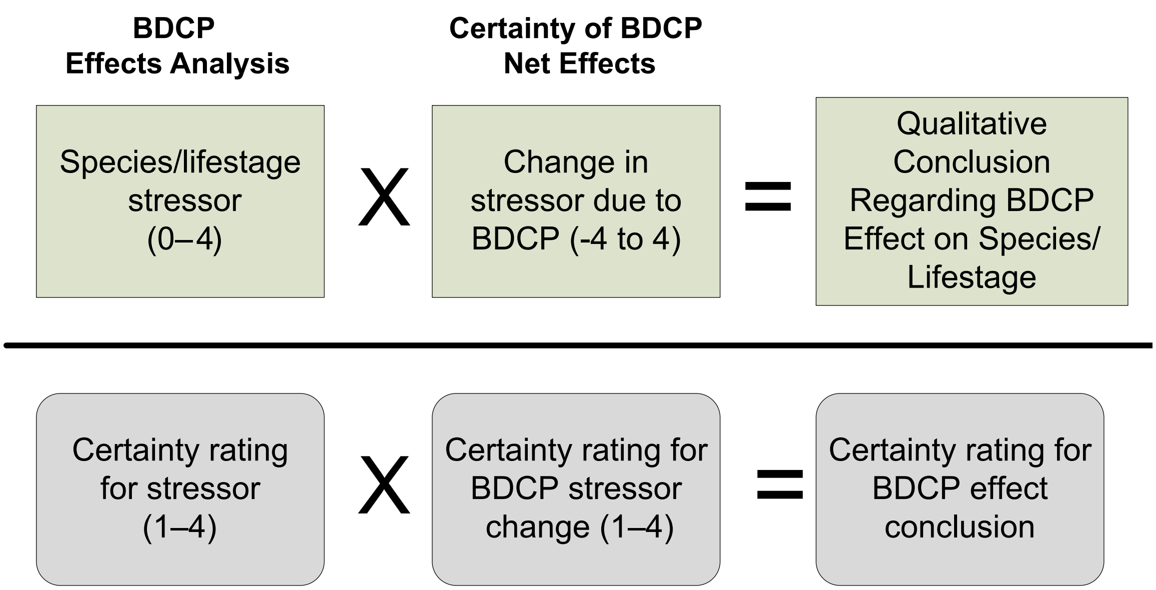
Figure 5.2-5
Conceptual Model of the BDCP Effects Analysis



Note: A description of the methods used for the covered fish net effects assessment is in Section 5.2.6.10.

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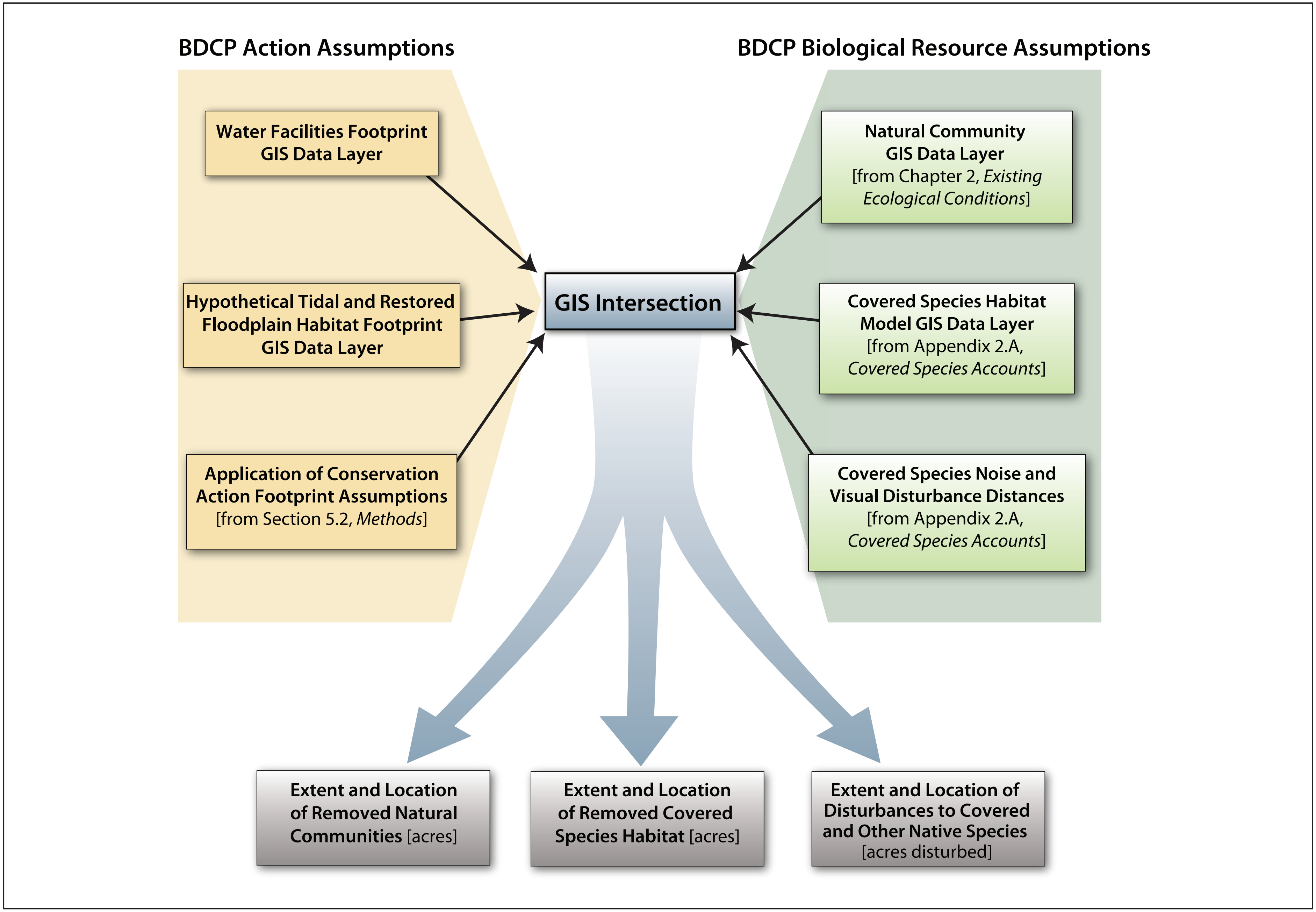
Figure 5.2-6
General Procedure for Integration of BDCP Effects on Covered Fish Species



G:Graphics/... BDCP EA/SAIC (created: 01/20/11) (Rev. 20120222 SS)

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Figure 5.2-7
Process for Calculating Extent of BDCP Covered Activity and Conservation Action Footprint Effects on Natural Communities and Covered Species Habitats

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Chapter 5
Effects Analysis

5.3 Ecosystem and Landscape Effects

Ecosystem and landscape effects are those that affect general ecological processes and phenomena. Such effects can be, but not necessarily are, expressed at large spatial scales. For example, turbidity generated during dredging is a highly localized effect that alters an ecosystem process (turbidity in the water column). This section describes the indirect and ecosystem-level effects on covered species during operation and construction of the BDCP. It describes the results of physical modeling of hydrology and hydrodynamics, modeling and evaluation of various water quality parameters, modeling and evaluation of toxic contaminants, and an assessment of the effects of in-water construction activities at the ecosystem and landscape levels. This section summarizes the detailed results of the analyses of these parameters and along with the appendices listed below, supports the more specific analyses and evaluation of results for each covered species provided in Section 5.4, *Effects on Natural Communities*, Section 5.5, *Effects on Covered Fish,* and Section 5.6, *Effects on Covered Wildlife and Plant Species.*

- Appendix 2.C, *Climate Change Implications and Assumptions*
- Appendix 5.B, *Entrainment*
- Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*
- Appendix 5.D, *Contaminants*
- Appendix 5.E, *Habitat Restoration*
- Appendix 5.F, *Biological Stressors on Covered Fish*
- Appendix 5.G, *Fish Life Cycle Models*
- Appendix 5.H, *Aquatic Construction Effects*
- Appendix 5.J, *Scenario 6 Comparison*

Aquatic ecosystem effects of the preliminary proposal (PP) are addressed relative to existing biological conditions. As with the specific species analyses, the ecosystem effects are evaluated for the near-term (NT), early long-term (ELT), and late long-term (LLT) time steps.

5.3.1 Flow

5.3.1.1 Overview of BDCP Effects on Flow

As discussed in Chapter 2, the hydrology of the Plan Area is influenced primarily by freshwater inflows from the Sacramento River from the north and the San Joaquin River from the south, and tidal action from the Pacific Ocean. Eastside streams, particularly the Mokelumne River, also contribute inflows to the Plan Area. Numerous upstream dams and diversions greatly influence the timing and volume of water flowing into the Delta. Multiple upstream tributaries to the Sacramento and San Joaquin Rivers influence flow into the Plan Area. The Feather and American Rivers and

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many large creeks drain directly into the Sacramento River, and Cache and Putah Creeks drain into the Yolo Bypass, which joins the Sacramento River in the Cache Slough area. The Yuba and Bear Rivers drain into the Feather River before its confluence with the Sacramento River. The Calaveras, Stanislaus, Tuolumne, Merced, and Kings Rivers drain into the San Joaquin River upstream (but south) of the Delta. The Cosumnes River drains directly into the Mokelumne River, and both drain into the San Joaquin River after entering the Delta.

When the effects of climate change are factored out, the BDCP would result in very minimal changes in upstream flows or reservoir operations compared to existing biological conditions (EBC). As such, there are only a few instances in which changes to the environment and related effects on fish may occur as described in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section C.6.2. In the Delta, flows in and around the San Joaquin River and south Delta, including Old and Middle River (OMR) flows, would increase, reflecting the reduced use of the south Delta export facilities in most water-year types. However, the flow patterns in the north Delta would be altered by operations of the new north Delta export facilities (CM1) and the increased inundation of the Yolo Bypass (CM2). These operational changes will reduce some Sacramento River flows, resulting in reduced flows in Sutter, Steamboat, and Georgiana Sloughs and the Delta Cross Channel (DCC). Similarly, the reduced flows in the Sacramento River would slightly reduce flows at Rio Vista and in Threemile Slough. These changes in flow patterns in the north Delta can affect the migration and passage of fish through and within the Delta, as described in Appendix 5.C, Section C.6.2. The changes in Delta flows are not expected to result in any substantial changes in turbidity or dissolved oxygen (DO), as described below. However, the changes in Delta operations under the preliminary proposal related primarily to the new north Delta intake could have effects on salinity in some locations as described below. In most instances, these changes in salinity are compounded by the effects of restoration activities that would occur as part of the preliminary proposal and sea level rise caused by climate change. The following sections discuss the general trends of changes in flows throughout the Plan Area.

The CALSIM results indicate that there would be some change in how reservoirs are operated. The largest changes to reservoir operations result from changes in runoff and inflow caused by climate change unrelated to the preliminary proposal. Carryover storage in all the upstream reservoirs is predicted to be generally higher under the PP compared to EBC2 at the same climate and sea level–rise conditions. Generally, this increased carryover storage is a result of:

- No Fall X2 standard under the PP.
- The ability to pump in the spring months when natural runoff is higher because of the added flexibility of north Delta intakes.
- Reduced pumping in the summer and fall months, when generally more water needs to be released from the reservoirs to maintain the water quality conditions in the Delta.

The increased Oroville storage is expected to allow more flexibility to operate for temperature needs under the PP. Coldwater pool management is predicted to be challenging for the CVP facilities in the LLT both with and without the PP because of the changes in inflows and sea level rise associated with climate change assumed in the LLT.

In general, the PP would increase carryover storage (end-of-September storage, often the lowest each year) compared to the EBC2[1] scenarios. However, SWP/CVP operations are expected to change

[1] EBC1 CALSIM scenarios in the LLT have not yet been evaluated or included in this analysis. However, because EBC1_LLT does not include Fall X2 actions, it is expected that carryover storage would be more similar to PP_LLT.

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to address the increased outflow needs caused by sea level rise and climate change. These results suggest that the management of storage for the coldwater pool (May storage is an indicator) would be increasingly difficult in the future, despite the fact that the PP would have increased carryover. The frequency of the end-of-September storage falling below 2,000 thousand acre-feet (TAF) would increase by about 10% under both the PP and EBC2 in the LLT. Considerable adaptation measures would need to be implemented on the upstream operation of the CVP to manage the coldwater pool under the extreme sea level rise and climate change by 2060. Operation of the PP would lessen these challenges, but the effect of climate change and sea level rise would overwhelm these improvements.

Foreseeable climate change effects on flow strongly influence the expected future condition of covered species and natural communities. These effects are detailed in Appendix 2.C, *Climate Change Implications and Assumptions* and are summarized where relevant below.

5.3.1.2 Delta

The primary changes in Delta flows result from the new north Delta intakes, the increased flows into the Yolo Bypass at the Fremont Weir, and reduced use of the south Delta export facilities. The north Delta intakes and Yolo Bypass divert water from the Sacramento River, reducing flows in Sutter, Steamboat, Threemile, and Georgiana Sloughs; in the DCC; and at Rio Vista. Reductions in south Delta pumping that are possible with the north Delta intakes increase OMR flows and San Joaquin River flows at Antioch by the amount of the reduced pumping. While climate change may affect flows in the San Joaquin, Mokelumne, and Cosumnes Rivers, the preliminary proposal would not. A summary of changes at each Delta location is provided below. However, these changes reflect the general trends and not necessarily the outer bounds of changes that could occur across water-year types and months within those water years. The effects analysis used detailed modeling results to determine the biological responses to specific daily, monthly, and water year–type changes.

5.3.1.2.1 Sacramento River Flows at Freeport

Other than flows exiting the Yolo Bypass, the Sacramento River flow at Freeport provides the largest Delta inflow and represents the water available for diversion at the proposed north Delta intakes. The average modeled annual inflow at Freeport was reduced by about 650 TAF (up to 4%), primarily as a result of the increased Fremont Weir spills into the Yolo Bypass that would occur under the preliminary proposal. Similarly, PP_ELT and PP_LLT monthly median flows at Freeport were similar to EBC1 but were shifted in some months as a result of the increased spills at the Fremont Weir and other changes in upstream reservoir releases, as discussed above.

The modeled Freeport median flows were similar in October, November, and December for the EBC1 and PP_ELT and PP_LLT cases. The Freeport median flows in January, February, and March for the PP cases were about 3,000 cubic feet per second (cfs) less than EBC1 flows, reflecting the increased spills at the Fremont Weir into the Yolo Bypass. The April and May median flows at Freeport were similar for the PP cases and EBC1 conditions. The June median flows were increased for the PP cases. The Freeport median flows for the PP cases in July, August, and September were reduced by about 3,000 cfs compared to EBC1 flows because of changes in upstream reservoir releases. The preliminary proposal north Delta intakes allowed higher exports in April, May, and June and subsequently allowed reduced reservoir releases and reduced exports.

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Intake Operation Effects

The proposed north Delta intakes would be located along the Sacramento River between Freeport and Courtland (opposite Sutter Slough). Tidal flows and water surface variations in this upstream portion of the Delta are moderate; the greatest tidal flows and largest range of tidal elevations are observed at relatively low Sacramento River flows. The tidal variations are reduced at higher river flows because the river surface gradient is greater, dampening the tidal flows. The general effect of each diversion is the reduction of the upstream flow by about 3,000 cfs (when operated at capacity). Because there is always a downstream flow requirement (5,000 cfs in July–September, 7,000 cfs in October and November, and at least 10,000 cfs from December to June), there almost always will be a net downstream flow below the operating north Delta intakes. However, there can be upstream flows and velocities during flood tide periods when the net river flow is reduced to less than half of the tidal flow magnitude. The upstream movement distance will depend on how long the tidal velocities are negative (upstream).

Tidal modeling results indicate that the greatest movement during the summer months with a bypass flow requirement of 5,000 cfs would be about 0.5 mile (with a reverse velocity for 3 hours). The downstream movement during the 12.5-hour tidal cycle would be about 6 miles. All water that enters the intake screens will come from upstream; the diverted water during the 3-hour tidal flow reversal will have just passed the intake from upstream about 3–6 hours previously. Intake structures could provide current breaks that disorient fish and allow increased predation of juvenile fishes. Additionally, the ratchet effect of moving downstream past the intake structure but then being brought back adjacent to it with incoming tides is of some concern, as it exposes juvenile fish to the intake structures twice instead of just once passing with river outflow and increased swimming performance is needed to avoid impingement on the screens.

5.3.1.2.2 Yolo Bypass Flows to the Delta

The Yolo Bypass flows are the sum of Fremont Weir spills and Cache Creek and Putah Creek flows. Although the PP_ELT and PP_LLT cases allow some additional flows into the Yolo Bypass at the Fremont Weir, the monthly sequences of Yolo Bypass flows were very similar. A few more months have flows of 2,000–6,000 cfs (notch capacity), and the high-flow months have slightly more flow (6,000 cfs) for the EBC1.

5.3.1.2.3 San Joaquin River Diversions to Old River

The preliminary proposal would not result in changes in the San Joaquin River flows at Old River, but some changes are expected as a result of climate change. The predicted median head of Old River flow for December through May was about half of the San Joaquin River flow at Vernalis. The median flows in June through September were about 40% of the San Joaquin River flow at Vernalis because of the effects of the south Delta rock barriers. The annual average head of Old River diversion flow was nearly the same for all six CALSIM cases modeled and was equal to about half of the San Joaquin River flow.

5.3.1.2.4 Old and Middle River Flows

The CALSIM modeling assumed that some OMR reverse flow restrictions would apply for each of the applicable months (December through June). The restrictions were assumed to vary somewhat with runoff conditions. The assumed restrictions were held constant for the EBC1 case, the three EBC2 cases, and the two PP cases. Because negative OMR flow is toward the south Delta pumps, the

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greatest negative values indicate higher pumping. The minimum values indicate the maximum pumping from the central Delta. For example, the October and November minimum flows for EBC1 were -10,000 cfs. The October and November median flows were -8,000 cfs. However, there are no OMR flow restrictions in October and November. The EBC1 December minimum flow was -9,600 cfs, but the median flow was -5,871 cfs (the assumed OMR limit in 30% of the years). This suggests that the OMR limits were reducing the December exports to this level in several of the years. The January through March and June minimum flows were -5,000 cfs because the assumed OMR limits were restricting pumping to this level in many of the years in these months. For April and May, the median pumping was increased slightly, so the OMR flows were reduced by about -1,500 cfs in April and about -1,000 cfs in May, from 675 cfs and 74 cfs in the EBC1 case to -1,263 cfs and -1,150 cfs for PP_ELT and -1,150 cfs and -1,081 cfs for PP_LLT. This was because the CALSIM modeling assumed the San Joaquin River/export ratio (NMFS BiOp), which is included in the EBC, would not apply with the PP. EBC1 flows in July through September were -11,000 to -10,000 cfs, and median flows were -10,000 to -9,000 cfs.

The preliminary proposal ELT and LLT cases shifted pumping from the south Delta to the north Delta intakes and thereby increased the OMR flows (reduced negative OMR flows) in most water years. The median predicted OMR flows for the preliminary proposal ELT and LLT cases were about 2,000 cfs higher in October and November; about the same in December; 2,000 cfs higher in January; 5,000 cfs higher in February; 3,500 cfs higher in March; 1,500 cfs higher in June; 6,000 cfs higher in July; 6,500 cfs in August; and 4,500 cfs higher in September.

5.3.1.2.5 Sutter Slough and Steamboat Slough Flows

Sutter and Steamboat Sloughs divert about 40% of the Sacramento River flow. The monthly median predicted diversion flows into Sutter and Steamboat Sloughs were similar for the EBC1 case and the three EBC2 cases because the Sacramento River flows were similar. The median diversions into Sutter and Steamboat Sloughs were lower for the PP_ELT and PP_LLT cases because the north Delta intakes reduce the Sacramento River flow at Sutter and Steamboat Sloughs. The median diversions in October, April, May, and June were about the same for the EBC and the preliminary proposal scenarios. The median diversions were reduced by 1,000 cfs in November, July, and September; 2,000 cfs in January and August; and 4,000 cfs in February and March. The reductions in the Sutter and Steamboat Slough diversions were about 40% of the simulated north Delta intake diversions. The annual average diversions into Sutter and Steamboat Sloughs were about 6,500 TAF (42% of the Sacramento River flow at Freeport) for the EBC1 case and three EBC2 cases, and were reduced to about 5,500 TAF (36% of the Sacramento River flow at Freeport) for the two preliminary proposal scenarios.

5.3.1.2.6 Delta Cross Channel and Georgiana Slough Flows

Similar to Steamboat and Sutter Sloughs, CALSIM predicted reduced monthly median diversion flows in the PP_ELT and PP_LLT cases for DCC and Georgiana Slough because the north Delta intakes reduced the Sacramento River flow. The annual average diversions into the DCC and Georgiana Slough were about 3,750 TAF (24% of the Sacramento River flow at Freeport) for the EBC1 case and three EBC2 cases and were reduced to about 3,150 TAF (21% of the Sacramento River flow at Freeport) for the two preliminary proposal cases.

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5.3.1.2.7 Sacramento River Flows at Rio Vista

The modeled minimum flows in September through December for Rio Vista (3,000–4,500 cfs, depending on water-year type) were generally satisfied. The EBC1 monthly median flows were about 5,500 cfs in October; 7,500 cfs in November; 12,500 cfs in December; 22,000 cfs in January; 29,000 cfs in February; 23,000 cfs in March; 13,000 cfs in April; 10,000 cfs in May; 6,500 cfs in June; 10,500 cfs in July; 8,500 cfs in August; and 6,500 cfs in September. The median flows at Rio Vista for the three EBC2 cases were similar because the Yolo Bypass and Sacramento River inflows were generally the same. The median monthly Rio Vista flows were reduced in the months when the north Delta intake diversions were simulated for the PP_ELT and PP_LLT cases. The reduced Rio Vista flows were generally about the same as the north Delta intake diversions. The annual average Sacramento River flows at Rio Vista were about 14,000 TAF for the EBC1 case and three EBC2 cases, and were reduced to about 12,000 TAF for the PP_ELT and PP_LLT cases.

5.3.1.2.8 Threemile Slough Flows

The Threemile Slough flows are about 3% of the Rio Vista flows and were reduced slightly for the preliminary proposal cases because the Rio Vista flows were reduced by the north Delta intake diversions as described above. The predicted annual average Threemile Slough flows were about 1,000 TAF for the EBC1 case and the three EBC2 cases and were reduced to about 750 TAF for the two preliminary proposal cases.

5.3.1.2.9 San Joaquin River Flows at Antioch

San Joaquin River flows at Antioch were increased in the PP_ELT and PP_LLT cases because the reduction in south Delta exports will increase OMR and San Joaquin River flows equal to the reduced exports. For the preliminary proposal cases, predicted monthly median flows at Antioch were about 0 cfs in October and November and were reversed to -2,000 cfs only in December. The San Joaquin River flows were about 1,500 cfs in January; 8,500 cfs in February; 6,500 cfs in March; 3,000 cfs in April; 2,500 cfs in May and June; 1,000 cfs in July; 500 cfs in August; and 150 cfs in September. The summer periods of reverse San Joaquin River flow were generally eliminated by the preliminary proposal north Delta intake diversions.

5.3.1.3 Delta Outflow

The CALSIM-simulated Delta outflow is the sum of all the upstream and Delta operations, and it is the major link with salinity in the Delta and with the X2 position. Delta outflow requirements often limit the Delta exports, so the simulated Delta outflow for many months is equal to the minimum Delta outflow requirement for each month. The EBC1 case did not include the Biological Opinion (BiOp) Fall X2 requirements, so the required Delta outflow was controlled by the State Water Resources Control Board (State Water Board) water right Decision 1641 (D-1641) objectives. The annual average outflow required for EBC1 (D-1641) was 4,250 TAF. The three EBC2 cases included the BiOp Fall X2 requirements, and the predicted average annual required outflow was about 5,000 TAF for EBC2, about 5,250 TAF for EBC2_ELT, and about 5,750 TAF for EBC2_LLT. The BiOp Fall X2 requirements (intended for wet and above normal years) raised the annual average required outflow by about 750 TAF. The EBC2_ELT and EBC2_LLT cases had even higher required outflows caused by changes in the outflow required to meet X2 because of sea level rise and habitat restoration effects on salinity intrusion. The three EBC2 cases, which included BiOp Fall X2 requirements in September through November of about half of the years (wet and above normal),

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had corresponding reduced X2 values in the 50–90% cumulative values. The changes in the monthly X2 ranges or in the monthly median values were relatively small because the monthly range in outflows remained similar for each of the EBC1 and EBC2 baseline cases. The preliminary proposal cases allowed some of the X2 positions to move upstream (lower outflow), with the higher exports that were allowed in some months with the north Delta intake. The required D-1641 X2 locations from February through June and the minimum Delta outflows were satisfied by the preliminary proposal cases, although CALSIM results reported above may be based on relaxations of the requirements in certain months.

5.3.1.3.1 Construction Effects

Temporary and localized hydrodynamic changes associated with the construction of different conservation measures could have an effect on fish in the Delta as described in Appendix 5.H, *Aquatic Construction Effects*. Such changes would stem from the construction of the new intakes and/or breaching or removing levees for habitat restoration areas. Changes in hydrodynamics during construction could result in the temporary creation of predator hot spots and in local increases in suspended particles and sediment plumes. Other in-water activities such as dredging the areas near intakes also will change hydrodynamics temporarily in the Plan Area. However, these changes in hydrodynamics are expected to be short in duration, lasting only during construction, and localized. Hydrodynamics will become relatively consistent once construction is completed and levee and bottom conditions are equilibrated.

5.3.1.4 Changes in Delta Flow Over Time

The BDCP helps to restore normative north-south flow regimes in the southern Delta that have been affected by the operation of the SWP/CVP south Delta exports. It also provides a new operational tool (north Delta intakes) to control flows. The following sections describe the changes in flows from pre-CVP/SWP, to D-1641 and the OCAP BiOps (EBC), and the expected changes resulting from BDCP.

5.3.1.4.1 Flows Prior to CVP and SWP Exports

The total volume and seasonal pattern of Delta inflow has shifted with the upstream development of reservoirs and irrigated lands. These changes have been most dramatic in the San Joaquin River watershed, but also are relatively large for the Sacramento River watershed. Although there is a wide range of annual runoff and the monthly pattern of flows between dry years and wet years, the monthly median unimpaired inflows (runoff) can be compared to the monthly mean inflows from the CALSIM modeling of EBC Delta inflows for 1922–2003. Figure 5.3-1 shows the monthly average unimpaired Delta inflows compared to the monthly average Delta inflow and monthly average Delta outflow under D-1641 operations for 1922–2003. The reservoir flood control requirements reduce storage in December-March. The seasonal reduction and shifting of the unimpaired Delta inflows caused by upstream reservoir storage and irrigation diversions are greatest in the months of March-June when the majority of the runoff is stored in the upstream reservoirs or diverted for irrigation in the spring and summer months. The median monthly Delta inflows are higher than the median monthly unimpaired runoff in the months of July to November because of releases for flood control and for Delta exports. The average annual unimpaired Delta inflow was about 29,500 taf, while the average annual CALSIM-simulated Delta inflow was about 22,000 taf. The monthly median Delta inflows were reduced from the median unimpaired flow in December through June. Delta exports and Delta diversions reduced the Delta inflow in every month, with an average outflow of about 15,000 taf under D-1641 operations (prior to the 2008/2009 BiOps).

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The general flow patterns in the Delta can be simplified for each inflow location. Prior to CVP and SWP exports, about half of the SJR inflow moved north past Stockton and about half was diverted into Old and Middle River channels and flowed north toward Franks Tract in the central Delta and back into the SJR. More than half of the Sacramento River inflow was diverted into Sutter and Steamboat Sloughs, and about 25% was diverted into Georgiana Slough toward the central Delta. The Sacramento River diversions into Sutter and Steamboat Sloughs rejoined the Sacramento River channel at Rio Vista and flowed west toward Chipps Island (Delta outflow). The Mokelumne and Cosumnes River inflow, joined by the Georgiana Slough diversions from the Sacramento River, flowed south into the SJR channel and west past Antioch toward Chipps Island (Delta outflow).

5.3.1.4.2 Existing Biological Conditions

As described above under Section 5.2, EBC modeling scenarios represent the baseline for comparison of effects of the BDCP. Under EBC, the majority of the San Joaquin River inflows are exported in the south Delta CVP and SWP pumping. About half of the San Joaquin River flow is diverted near Mossdale into Old River and Grant Line Canal toward the CVP and SWP pumps. The other half of the SJR inflow is diverted north of Stockton through Turner Cut or Columbia Cut to Middle River and back (south) toward the CVP and SWP pumps. Only when the San Joaquin River inflow is greater than the south Delta exports does any San Joaquin River inflow reach Chipps Island (Delta outflow). The majority of the Sacramento River inflow moves as it did prior to the CVP and SWP exports through the Sacramento River channel or through Sutter and Steamboat Sloughs past Rio Vista to Chipps Island. But the portion of the south Delta exports that is not supplied from the San Joaquin River inflow comes from the Sacramento River through the DCC, which was constructed as part of the CVP pumping facilities in 1952, or through Georgiana Slough to the central Delta and into Old and Middle River channels toward the CVP and SWP pumps. The combined flow in the OMR channels is therefore often reversed, flowing upstream (south) toward the CVP and SWP pumps.

When CVP and SWP pumping is high (more than 5,000 cfs) there may not be enough water from the San Joaquin River inflow or from the Sacramento River diversions to DCC and Georgiana Slough or from the Mokelumne River inflow. Under these high export conditions, more of the Sacramento River water is diverted through Threemile Slough or around Sherman Island and upstream in the San Joaquin River channel to Dutch Slough and False River connecting to Franks Tract and Old River. The net flow from the San Joaquin River (to Delta outflow) is called QWEST. When the exports are greater than the SJR inflow and the DCC and Georgiana diversions and Mokelumne River inflow, the QWEST is negative and net flow in the lower SJR reverses and moves east toward Old River. During periods of low Delta outflow, salinity intrusion from Suisun Bay moves into the central Delta past Jersey Point and into the south Delta exports.

The differences between the monthly average Delta inflow and the monthly average Delta outflow give a rough estimate of the monthly exports and diversion for Delta agriculture for existing conditions. The maximum monthly export capacity is 15,000 cfs, but only about 12,000 cfs is allowed with the existing SWP diversions limits. The minimum required monthly Delta outflow ranges from about 3,000 cfs in September to about 12,000 cfs in February–June (Chipps Island X2), so the allowable exports generally range from 5,000 cfs to 10,000 cfs. The maximum Delta diversions are about 15,000 cfs in the summer months. For example, the average monthly difference (reduction) between Delta inflow and Delta outflow was about 5,000 cfs for January-March, was about 4,000 cfs in April and May, was 9,000 cfs in June, was about 15,000 cfs in July and August, was 12,000 cfs in September and was about 10,000 cfs from October to December. The annual reduction

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for exports and Delta diversions was about 7,000 taf under D-1641, but exports were reduced by about 1,000 taf by the 2008/2009 OCAP BiOps (from 5,900 taf under D-1641 to 4,900 taf).

5.3.1.4.3 Delta Flows with BDCP

The two primary tools for managing Delta flows under EBC are inflow and SWP/CVP exports in the south Delta. The existing Delta operations rules (objectives) either require a minimum Delta outflow or limit the south Delta exports. Collectively, the D-1641 objectives and the USFWS/NMFS BiOp actions provide the required Delta outflow and limit the allowable exports. The D-1641 objectives introduced the Spring X2 (outflow) requirements and the E/I export limits and generally provide the fundamental guidelines for Delta operations. The BiOp actions introduced the Fall X2 (outflow) requirements and limited exports with the adaptive rules (decisions based on temperatures, turbidity, and fish monitoring) for reverse OMR flow restrictions from mid-December through June. Previous CALSIM modeling of D-1641 suggests that the USFWS/NMFS BiOp restrictions on reverse OMR flows have reduced the allowable south Delta exports by about 250–750 taf/yr. However, the export reductions each year will depend on the OMR adaptive management decisions (generally within the range of -1,250 cfs to -5,000 cfs).

The BDCP would introduce a new tool for managing Delta flows: relocating more than half of the south Delta exports to the new north Delta intakes. Figure 5.3-2 shows the CALSIM-simulated changes in the monthly average Old and Middle River (OMR) flows from D-1641 operations (no OMR limits) to the 2008/2009 BiOps (with OMR limits) to the BDCP operations (with north Delta intakes). The annual south Delta exports would be reduced from about 5,900 taf under D-1641 to about 4,900 taf for the CALSIM-simulated BiOps limits to about 3,000 taf for the BDCP (PP_ELT) in 2025. The reductions in the south Delta exports will increase the OMR flows. The BDCP operations will generally reduce the south Delta exports in all months, but especially in the months of January to June, when the monthly average OMR flows will be greater than -2,500 cfs. With the BDCP, the monthly average OMR flows will be slightly positive (flowing north) in February, March, April, and May.

5.3.2 Water Quality

Water quality affects both the physical properties of water and the chemical properties that elicit biological responses, ranging from higher primary productivity to mortality in covered fish species. An example of this is the lowering of water's capacity to carry oxygen at warmer temperatures. The metabolism of fish, for instance, is increased, requiring more food and more oxygen to survive. Salinity elicits direct responses from organisms depending on their ability to adapt to salinity gradients. For example, fish must swallow water when in fresh water to replace salt lost to their surrounding environment and excrete salt in their urine when in saltier environments. DO is required at different levels for different species and is acquired by moving water over body structures that have a gradient of oxygen into the body of the organism. Fish as an example must move water over their gills at a faster rate when in water that is lower in DO. Turbidity can have direct effects on organisms if levels are too high by causing irritation or in some instances suffocation. Turbidity also has indirect effects such as providing cover from predators or providing a background that make prey items easier to acquire. This section discusses the approach and results of the analysis for water temperature, salinity, DO, and turbidity as they relate to the BDCP.

Contaminants, such as methylmercury and selenium, within sediment and the water column also can elicit biological responses from covered fish species. Therefore, this section also discusses the

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approach for the analysis of toxic water and sediment quality constituents and the ecosystem-scale effects of methylmercury, selenium, copper, ammonia/um, pyrethroids, pesticides, endocrine disrupters, and other urban contaminants. Findings from Appendix 5.D, *Contaminants,* are summarized and include a discussion of loads from outside the Plan Area, loads from within the Plan Area, and summaries of the chemical and ecological effects of covered activities and conservation measures.

5.3.2.1 Water Temperature

Water temperature effects were broken into two categories: *upstream*, which characterizes conditions in the upstream Sacramento and San Joaquin Rivers and their tributaries; and *downstream*, which encompasses the BDCP Plan Area. The upstream analysis focuses on flow operations of the SWP and CVP, and the downstream analysis evaluates the effects of tidal marsh restoration on water temperature in the Delta.

5.3.2.1.1 Upstream

Water temperatures in rivers below the SWP and CVP reservoirs may be affected in the future by the combination of changes in reservoir operations caused by the BDCP Delta operations and by climate change effects on air temperatures and heat exchange between the atmosphere and the water surface of reservoirs and rivers. The physical factors that control the existing seasonal water temperature patterns in upstream tributary streams and the potential biological effects of increased temperature on various fish life stages are discussed below. Climate change also will affect precipitation and runoff; these expected changes in reservoir inflows will interact with reservoir operations (flood control releases and water supply storage) to also change the release temperatures from the major SWP and CVP reservoirs.

Water temperature in the Sacramento River immediately downstream of Shasta and Keswick Dams is determined by a number of factors that include the availability of cold water stored in the upstream reservoirs, seasonal atmospheric conditions, and the level of instream flow released to the river. Table 5.3-1 shows the monthly and annual mean temperature changes at four key locations in the upper Sacramento River. As described above, the BDCP would not result in changes in San Joaquin River flows and therefore would not contribute to any changes in temperature.

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Table 5.3-1. Summary of Upstream Temperature Results

Place	Mean Monthly Results	Mean Annual Results
Keswick	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 8.1% (PP_LLT in August).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 2.0 and 4.8% higher, respectively, than the EBC.
Balls Ferry	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 8.1% (PP_LLT in January).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 2.1 and 4.7% higher, respectively, than the EBC.
Red Bluff	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 7.3% (PP_LLT in January).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 2.1 and 4.7% higher, respectively, than the EBC.
American River	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 9.3% (PP_ELT in October).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 5.1 and 2.2% higher, respectively, than the EBC.

5.3.2.1.2 Tidal Marsh Restoration

Average Delta water temperatures are driven by atmospheric temperatures, and therefore they would not be affected by the BDCP. However, tidal marsh restoration may affect local water temperatures through establishment of broad, shallow-water areas that would be more influenced than adjacent channel environments by air temperatures and insolation. Based on the calculations using hypothetical restoration designs, the BDCP would restore approximately 1,000 acres of marsh between mean higher high water (MHHW) and extreme high water (EHW) in the near-term, 2,100 acres in the early long-term, and 3,900 acres in the late long-term. Much of this restored habitat (900 acres, or 86%, in the near-term; 2,000 acres, or 94%, in the early long-term; and 2,400 acres, or 61%, in the late long-term) would be in Cache Slough and Suisun Marsh (under the hypothetical designs) where fish species such as delta smelt often are found. Suisun Marsh water temperatures depend primarily on air temperature and the temperature of the tidal waters and river flows (particularly during high runoff conditions) (Kimmerer 2004). Other factors that can affect water temperatures include sunlight and wind-driven mixing.

The average water temperature in each ROA was calculated using the DSM2 model (North Delta, Cache Slough, West Delta, Suisun Marsh, East Delta, and South Delta ROAs). The DSM2 model computes outputs at 15-minute intervals. Because of limitations of accuracy in the model identified by model authors, 15-minute data were averaged into monthly values for each ROA. Table 5.3-2 summarizes temperature results by ROA.

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Table 5.3-2. Summary of Temperature Results Under Future Conditions with BDCP and Climate Change compared to Current Conditions

ROA	Mean Monthly Results	Mean Annual Results
North Delta	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 20.2% (PP_LLT in February)	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 2.1 and 10.0% higher, respectively, than the EBC
Cache Slough	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 13.5% (PP_LLT in January).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 2.6 and 8.2% higher, respectively, than the EBC.
West Delta	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 14.5% (PP_LLT in January).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 3.5 and 8.2% higher, respectively, than the EBC.
Suisun Marsh	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 13.8% (PP_LLT in January).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 3.5 and 7.3% higher, respectively, than the EBC.
East Delta	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 16.0% (PP_LLT in March).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 3.0 and 8.7% higher, respectively, than the EBC.
South Delta	Mean monthly water temperatures are predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 13.2% (PP_LLT in November).	Mean annual water temperature levels in the PP_ELT and PP_LLT are predicted to be 3.4 and 6.3% higher, respectively, than the EBC.
Note: These relatively large increases are due primarily to climate change, and not the BDCP.		

There is evidence in scientific literature for a warming effect of salt marshes on the overlying water column when high tide occurs during the day, and particularly during sunny days (Bohlen 2002; National Oceanic and Atmospheric Administration 2002; McKenna 2007; Trivino and Ortega undated). These diurnal variations in water temperature caused over marshes may influence the temperature of adjacent channels depending on the timing of high tide. There does not appear to be documentation of studies confirming a corollary cooling effect from high tides occurring at night, but this is hypothesized to occur in addition to daytime warming (C. Enright pers. comm.).

Restoration of intertidal habitat under the project may provide some localized water temperature reduction around the time of the full moon. The mechanism for this reduction involves the phenomenon through which the highest high tides during summer months, when water temperatures are generally highest, occur at night when air temperatures are lowest. The high surface area–to-volume ratio of water in tidal marshes at high tide maximizes the thermal exchange between the water surface and air, thus causing water temperatures to decline in the marsh. This occurrence is part of a 337-year cycle such that the pattern will be the opposite (the highest high tides, and therefore warming, will occur during the middle of the day in summer months) in approximately 170 years (Guerin pers. comm.). The conceptual basis for temperature reductions during summer months in tidal marsh is technically sound but is not supported by any formal analysis at this time (Enright pers. comm.). Modest system-wide temperature reductions have been

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observed for 1–2 days prior to the full moon when the highest high tides occur in the north Delta and Suisun Marsh (Enright pers. comm.).

It is reasonable to assume that establishment of broad, shallow areas subjected to inundation (through tidal habitat restoration and reintroduction of inundation to abandoned floodplains) will result in increased potential for water column temperatures to be affected by ambient air temperatures. This could cause an increase in water temperatures during high tides that occur during the day during warm seasons and on sunny days and a decrease in water temperatures during high tides that occur at night. Any incremental system-wide short-term decrease in water temperature that occurs as a result of increased tidal marsh habitat should provide refuge to species near their upper thermal tolerance. Because there is little evidence that this phenomenon occurs regularly, certainty of the effect is low.

5.3.2.2 Dissolved Oxygen

DO is a measure of how much oxygen is available in the water column for support of aquatic species that rely on oxygen for survival. Different species have varying tolerances of DO levels, but in general many of the fish species in the Delta require high DO levels (5–7 milligrams per liter [mg/L]). When DO levels fall, species become stressed and move toward areas of higher DO if pathways exist. Low DO levels can create passage barriers and increase species mortality.

The simulations of DO concentrations in the eight regions of the Delta for the six different scenarios using DSM-QUAL found only minor differences among the scenarios. The results of the simulations are presented in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section C.5.4. The greatest difference in the mean DO value for any day of the year was 0.95 mg/L in Suisun Marsh during March. For most of the regions, differences due to climate change were larger than those due to the effects of the preliminary proposal. Furthermore, except for the preliminary proposal in the San Joaquin River region, differences due to climate change were consistently negative while those due to the preliminary proposal were positive or close to zero.

The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the State Water Board because of low DO concentrations during late summer and early fall and often fails to meet water quality objectives established by the Central Valley Regional Water Quality Control Board (Central Valley Water Board) for DO (Central Valley Regional Water Quality Control Board 2005, 2007). Available data indicate that low DO that would affect salmonids is most likely to occur in September and October during the upstream migration period, and during June in the downstream migration period. This makes Chinook salmon more likely to be exposed to low DO levels than steelhead because peak migration for steelhead occurs outside of June, September, and October. Juvenile salmonids may be exposed to low DO periods during the end of their downstream migration period (primarily in June). In addition, juvenile white sturgeon, which rear in the San Joaquin River, exhibit reduced foraging and growth rates at DO levels below 58% saturation (5.8 mg/L at 15°C) (Cech and Crocker 2002).

Recent results for the DO aeration system in the Deep Water Ship Channel suggest that the aeration facility is effective at raising DO levels in much of the channel. Under CM14, shared funding of the long-term operation and maintenance costs associated with an aeration facility will occur. Studies conducted by DWR show that the aeration system can be effective at meeting the Basin Plan objectives for DO of 5 mg/L (or 6 mg/L from September through November) as long as the inflowing biochemical oxygen demand (BOD) does not exceed the capacity of the aeration facility to produce oxygen (California Department of Water Resources 2010). During periods when BOD is higher than

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the capacity of the aeration facility, the Basin Plan objectives may not be met, but the number of days that the objectives could be met is increased with the aeration facility. CM14 also includes adaptive management and monitoring to allow future adjustments to the aeration facility operations to improve its effectiveness at meeting the Basin Plan objectives for DO in the Deep Water Ship Channel.

5.3.2.3 Sediment and Turbidity

Water clarity in the Delta is determined primarily by the amount of suspended sediment transported in the water column (Kimmerer 2004). As rivers enter estuaries, sediment eroded from upstream areas is deposited in the estuary in varying degrees, depending on factors such as flow rate, tidal forcing, and local conditions. The patterns of geomorphic change occur on time scales varying from episodic, as storm flows can transport large volumes of sediment, to decadal, for example due to changes in climate patterns, the damming of rivers, and land usage.

The major source of sediment to the Delta is the Sacramento River plus the Yolo Bypass, which accounted for up to 85% of the sediment supply over the period 1999–2002 (Wright and Schoellhamer 2005). The San Joaquin River accounted for about 13%, with the eastside inflows (Cosumnes, Calaveras, and Mokelumne) accounting for the remaining 2% over the same period. The great majority of Sacramento River sediment (more than 80%) enters the Delta episodically during high-flow events in the wet periods, with sediment concentrations generally higher during “first flush” events (Schoellhamer et al. 2007). Although in recent history (since 1957) sediment supply to the Delta has been decreasing, the Delta remains depositional (Wright and Schoellhamer 2005; Schoellhamer et al. 2007). Water clarity has been increasing in the Delta, particularly in the central and south Delta (Data taken from B.J. Miller analysis pers. comm.)

The construction of reservoirs has resulted in an upstream accumulation of sediment within the reservoirs. In addition, previous stores of hydraulic mining–derived sediments have been depleted, and there have been various changes associated with channel adjustments downstream of dams and bank protection measures that decrease sediment supply. However, other factors such as land use changes (e.g., logging, grazing) and urbanization can increase sediment supply. The current balance between the factors regulating sediment supply to the Sacramento River is unknown (Wright and Schoellhamer 2004), so it is not possible to predict the evolution of sediment supply in the coming decades with any certainty. Thus, it is hard to predict whether sufficient sediment will enter the Delta to be available for all ROAs. In addition, sea level rise requires sediment deposition to maintain the elevation of current wetlands above tidal water levels.

Sediment is a critical resource in habitat creation. Tidal marsh and floodplain restoration efforts may require a sediment source as the substrate for the restoration effort, so knowledge of sediment transport patterns can enable the optimal siting of restoration areas for maximum sediment trapping from local waterborne sources (Ganju et al. 2004). Sediments are advected downstream into transitional areas where tidal forcing can mobilize the mass of fine sediments in an oscillation, the net direction of which (landward or seaward) is dictated by a variety factors such as net outflow, tidal strength (e.g., timing in the spring-neap cycle), and timing within the diurnal tidal cycle (Ganju et al. 2004). Deposition typically occurs at slack after ebb and flood tides. More generally, deposition occurs as flow velocity decreases, and coarser, heavier sediments fall out of the water column.

Table 5.3-3 summarizes the potential effects of two of the major contributors to water clarity in the Delta under the PP_LLT scenario due to the establishment of the ROAs—whether each subregion is likely to become a depositional or an erosional environment and the specific effect of seasonal

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summer winds on sediment resuspension within the ROAs. In areas of deposition, sediment that is suspended settles, creating clearer water conditions. A good example of this is the south Delta where submerged aquatic vegetation (SAV) collects sediment from the water column, making the water clearer. Areas of erosion are eroding sediment into the water column, making the water less clear.

Table 5.3-3. Potential Restoration Opportunity Area Effects in the Subregions in the PP_LLT Scenario in Comparison to the EBC2_LLT Scenario

Delta Subregions	Depositional or Erosional Change as a Result of Restoration	Effect of Deposition and Erosion on Water Clarity in Subregions
North Delta	U	U
Cache/Yolo	D	M
West Delta	M	I
Suisun Marsh	D	I
East Delta	M/U	I
South Delta	D	I
Note: Subregional water clarity is influenced by the “D”epositional or “E”rosional characteristics within the region. Some regions are “M”ixed (some deposition and some erosion), “U”ncertainty is too high to estimate the characteristics; “I”ncrease in water clarity. ROA = restoration opportunity area.		

The Delta will remain regionally depositional in the LLT timeframe, in both the EBC2 and the PP scenarios, although the location of the depositional regions will differ, and overall it will become clearer. The effects of sea level rise will depend on the balance between sediment supply from the watersheds and the rate of sea level rise, so it is unclear whether sediment supply will be sufficient to maintain the current extent of tidal marsh. The initial effect of restoration in the preliminary proposal is to decrease sediment supply downstream of the Plan Area, but the longer-term effects are uncertain as the areas of restoration reach a dynamic equilibrium.

5.3.2.4 Salinity

The concentration of the dissolved salt in a body of water is salinity. Usually measured in parts per thousand (ppt), the salinity gradient transitioning from the ocean to a freshwater stream can vary between 0.5 ppt (fresh water) to ~32–37 ppt (sea water). Historically in the Delta, the point in the salinity gradient that has been tracked and managed is 2 ppt bottom salinity and is referred to as X2. Salinity also can affect the allowable concentration of DO. In the Plan Area, fresh water can support DO concentrations as high as 9 mg/L, and saltwater can accommodate only up to 8 mg/L. Many fish species have a preferred range of salinity and a range of physiological tolerance to salinity, both of which can influence their distribution.

The salinity analysis assesses the potential for changes to habitat as a result of changes in flows as a result of the BDCP that may cause changes in salinity. The preliminary proposal allows more salt into the western Delta because of increased tidal mixing associated with the addition of tidal marsh areas and reduced Delta outflow. Salinity can be controlled somewhat by Delta outflow. Higher Delta outflow moves the salinity gradient west and lowers the X2 (decreases the distance from the Golden Gate Bridge). Under the PP scenarios, X2 moves upstream (lower outflow) in some months compared to EBC2 (baseline with Fall X2), with the reduced inflows or higher exports that are allowed with the north Delta intake. However, the PP scenarios will meet the required D-1641 X2

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locations from February through June and the minimum Delta outflows, as described above and shown in Table 5.3-4.

Table 5.3-4. Summary of the Location (Kilometers from the Golden Gate Bridge) of X2 under Each CALSIM Scenario

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
A. EBC1												
Min	67.1	51.7	47.3	47.2	47.2	47.2	47.3	48.5	49.1	56.2	66.0	63.5
Max	94.7	93.9	92.2	89.7	86.9	83.3	83.2	87.4	90.5	91.2	91.5	92.6
Avg	88.5	86.3	77.9	67.6	60.7	60.7	63.4	67.5	74.6	80.4	85.2	86.4
B. PP_ELT												
Min	72.8	52.2	47.7	47.6	47.6	47.7	47.7	49.3	51.0	62.3	74.7	71.4
Max	93.1	92.6	92.4	90.1	86.8	82.3	83.2	87.1	90.2	90.5	92.1	93.5
Avg	89.0	86.8	78.3	68.3	62.1	62.4	66.7	71.8	77.0	81.6	86.5	88.5
C. PP_LLT												
Min	73.8	54.6	48.8	48.7	48.7	48.7	49.0	51.6	54.8	69.9	83.4	79.3
Max	92.4	94.3	91.6	90.1	85.7	83.5	84.5	89.1	92.1	91.6	91.9	92.7
Avg	85.7	85.1	79.7	68.9	63.2	63.8	68.0	73.7	78.9	83.2	87.5	89.2
D. EBC2												
Min	67.3	51.7	47.3	47.2	47.2	47.2	47.3	48.5	49.3	57.1	67.3	65.8
Max	94.6	93.4	92.2	87.2	83.2	82.3	82.5	87.2	90.2	90.9	90.8	92.4
Avg	84.1	82.3	76.3	67.4	60.8	61.0	63.6	67.8	74.7	80.4	85.2	82.5
E. EBC2_ELT												
Min	69.5	52.4	47.8	47.6	47.6	47.7	47.9	49.8	51.5	62.1	73.6	70.9
Max	93.9	94.4	93.6	90.4	87.0	82.7	83.1	87.6	90.2	90.8	90.9	92.6
Avg	84.1	82.3	76.6	67.9	61.7	61.9	64.6	68.9	75.9	80.3	85.1	82.7
F. EBC2_LLT												
Min	72.2	55.4	50.0	49.6	49.6	49.5	50.0	53.1	55.7	71.4	81.2	73.9
Max	94.6	94.7	94.0	90.4	87.3	83.8	84.6	88.7	90.9	90.9	92.1	94.3
Avg	83.7	82.7	78.2	69.4	63.5	63.7	66.5	71.4	77.6	80.8	85.8	83.4

The three EBC2 cases, which included BiOp Fall X2 requirements in September through November of about half of the years (wet and above normal), had corresponding reduced X2 values in the 50–90% cumulative values. The changes in the monthly X2 ranges or in the monthly median values were relatively small because the monthly range in outflows remained similar for each of the EBC1 and EBC2 baseline cases. The preliminary proposal cases allowed some of the X2 positions to move upstream (lower outflow), with the higher exports that were allowed in some months with the north Delta intake. The required D-1641 X2 locations from February through June and the minimum Delta outflows were satisfied by the preliminary proposal cases, although CALSIM results reported above may be based on relaxations of the requirements in certain months.

Relatively small changes in salinity (electrical conductivity [EC]) resulted from the simulated BDCP tidal habitat restoration areas. EC from seawater intrusion was increased slightly at most Delta stations. The incremental changes in EC from historical conditions depend on the assumed locations of tidal habitat restoration area and their connections to the existing channels. Restoration in Suisun

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Marsh generally reduced the tidal flows at Chipps Island and upstream, thereby reducing the seawater intrusion effects at upstream locations. However, tidal trapping on Grizzly Island increased the salinity at Chipps Island and upstream. Reductions in the net diversions from the Sacramento River to the San Joaquin River (DCC, Georgiana Slough, and Threemile Slough) reduced the freshening effects from the Sacramento River (lowest EC) and increased the EC at the San Joaquin River stations. Finally, South Delta ROAs tended to increase the tidal mixing of seawater into the south Delta (OMR) and to the south Delta exports. Table 5.3-5 and Table 5.3-6 summarize the mean monthly and annual salinity changes in each ROA for comparison between EBC1 and PP_ELT and PP_LLT and comparison between EBC2 and PP_ELT and PPT_LLT.

Table 5.3-5. Summary of ROA Salinity Results (EBC1 to PP_ELT and PP_LLT)

ROA	Mean Monthly Results	Mean Annual Results
North Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC in all months by up to 0.2% (PP_LLT in November and August) and -0.04% (PP_LLT in April)	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 0.05 and 0.07% higher, respectively, than the EBC.
Cache Slough	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC in all months by up to 34.4% (PP_LLT in November) and -19.1% (PP_ELT in April)	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be -7.9 and 7.4% lower and higher, respectively, than the EBC.
West Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC in all months by up to 39.7% (PP_LLT in April) and -18.6% (PP_LLT in November)	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 6.1 and 4.7% higher, respectively, than the EBC.
Suisun Marsh	Mean monthly EC (specific conductance) is predicted to be higher in the PP_ELT and PP_LLT relative to the EBC in all months by up to 100.9% (PP_LLT in February).	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 48.5 and 42.0% higher, respectively, than the EBC.
East Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC in all months by up to 8.3% (PP_LLT in June) and -8.7% (PP_LLT in January)	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 2.2 and 1.5% higher, respectively, than the EBC.
South Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC in all months by up to 12.9% (PP_LLT in June) and -14.6% (PP_LLT in November)	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be -3.0 lower, than the EBC.
Note: The differences between these scenarios include BDCP and climate change effects.		

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Table 5.3-6. Summary of ROA Salinity Results (EBC2_ELT to PP_ELT and EBC2_LLT to PP_LLT)

ROA	Mean Monthly Results	Mean Annual Results
North Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC2_ELT and EBC2_LLT_ in all months by up to 0.16% (PP_LLT in August) and -0.04% (PP_LLT in April).	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 0.04% and 0.06% higher, respectively, than the EBC2_ELT and EBC2_LLT.
Cache Slough	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC2_ELT and EBC2_LLT by up to 34.74% (PP_LLT in November) and -18.96% (PP_ELT in April).	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be -7.59% and 8.80% higher, respectively, than the EBC2_ELT and EBC2_LLT.
West Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC2_ELT and EBC2_LLT by up to 25.82% (PP_ELT in September) and -9.51% (PP_ELT in February).	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 11.09% and 12.17% higher, respectively, than the EBC2_ELT and EBC2_LLT.
Suisun Marsh	Mean monthly EC (specific conductance) is predicted to be higher in the PP_ELT and PP_LLT relative to the EBC2_ELT and EBC2_LLT_ in all months by up to 107.28% (PP_ELT in December).	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 49.90% and 43.73% higher, respectively, than the EBC2_ELT and EBC2_LLT.
East Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC2_ELT and EBC2_LLT by up to 8.43% (PP_LLT in June) and -5.59% (PP_LLT in January).	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 2.70% and 2.32% higher, respectively, than the EBC2_ELT and EBC2_LLT.
South Delta	Mean monthly EC (specific conductance) is predicted to be higher or lower in the PP_ELT and PP_LLT relative to the EBC2_ELT and EBC2_LLT by up to 13.82% (PP_ELT in October) and -5.85% (PP_ELT in August).	Mean annual EC levels in the PP_ELT and PP_LLT are predicted to be 2.23% and 4.36% higher, respectively, than the EBC2_ELT and EBC2_LLT.

5.3.2.5 Contaminants

The BDCP will not introduce new contaminants or increase the concentrations of contaminants in the Plan Area directly, with the exception of herbicides, which would be applied in limited and safe concentrations to control invasive aquatic weeds. However, the BDCP conservation strategy includes restoration and changes in water operations that have the potential to change how contaminants already present in the Plan Area are mobilized and transported. Conceptual models were developed that included all factors that influence the environmental fate and transport, mobility in an aquatic system, and bioavailability to covered fish species for each toxin. Quantitative analyses are applied where they were useful in describing factors within the conceptual models, and if data inputs and available analytical and modeling tools were deemed sufficient to provide reliable results. In general, the following conclusions can be drawn from the analysis presented in Appendix 5.D, *Contaminants*:

- Preliminary proposal water operations will have few to no effects on toxins in the Delta.

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- Preliminary proposal restoration will increase bioavailability of certain toxins, especially methylmercury, but the overall effects on covered fish species are expected to be localized and of low magnitude.
- Available data suggest that species exposure to toxins would be below sublethal and lethal levels.
- The long-term benefits of restoration will reduce exposure to existing toxins in the environment and eliminate sources.

Table 5.3-7 summarizes the conclusions for each constituent. Details of these conclusions are provided in Appendix 5.D, *Contaminants*.

Table 5.3-7. Summary of Contaminant Conclusions

Contaminant	Conclusion
Methylmercury	• Modeling showed small, insignificant changes in total mercury and methylmercury levels in water and fish tissues due to the BDCP.
Selenium	• The BDCP would result in a less than 10% annual average selenium increase in San Joaquin River water in the south Delta relative to other source waters (including the Sacramento River). • In the long term, selenium inputs to the Delta should decrease as the proportion of agricultural lands decreases as a result of land use changes, including restoration to marsh habitat by the BDCP; selenium no longer would be concentrated by irrigation and leaching of these formerly farmed areas.
Copper	• The BDCP will result in decreased flow in the Sacramento River under certain conditions. • Copper concentrations are consistently low throughout the Sacramento River and copper concentrations in the Sacramento River watershed have been tied to flow rates, appreciable effect on copper concentrations is not expected.
Ammonia/um	• Changes in dilution capacity of the Sacramento River under the BDCP would result from changes in upstream reservoir operations and are not expected to be significant. • Diversion of water to the Yolo Bypass is not expected to affect dilution capacity, as this will occur only during high river flows. • The north Delta intake is downstream of Freeport and will not affect dilution of Sacramento WWTP discharges. • Few to no effects are expected from the BDCP on ammonia/um.
Pesticides—Pyrethroid	• The BDCP will result in reductions in Sacramento River flow at Freeport under certain conditions, mainly due to upstream reservoir operations. • Reduction in flow could limit the dilution of Sacramento wastewater treatment plant effluent and urban runoff, resulting in increased pyrethroid concentrations affecting covered fish species. • Based on the analysis presented CM1 of the BDCP will have no effects on pyrethroids. • Current information does not allow estimation of resultant pyrethroid mobilization due to preliminary proposal restoration.
Endocrine Disruptors	• Endocrine disruptors are a diverse group of chemicals. • It is not possible to evaluate fully the potential effects on the distribution and bioavailability of these chemicals from the BDCP.

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Contaminant	Conclusion
Pesticides—Organochlorine	• Flooding of formerly agricultural land is expected to result in an increase in accessibility to some organisms. • Concentrations in the water column should be relatively short-lived because these pesticides settle out of the water column in low-velocity flow. • Organochlorine pesticides are not expected to be mobilized.
Pesticides—Organophosphates	• BDCP CM1 operations are not expected to affect organophosphate concentrations in the Delta. • Organophosphate pesticides are likely present in ROA soils that would be inundated under the BDCP. • The solubility, tendency to adhere to soils and particulates, and degradation rates for these compounds vary; however, organophosphate pesticides are metabolized by fish and do not bioaccumulate.

5.3.2.6 Construction Effects

Appendix 5.H, *Aquatic Construction Effects*, analyzes the water quality effects on covered fish species during construction of different conservation measures. The potential effects of turbidity, suspension of potentially toxic sediments, and accidental spills associated with these activities are summarized in Table 5.3-8. In addition to the avoidance and minimization measures related to permit requirements, the BDCP includes implementation of CM22, which is a suite of avoidance and minimization measures that compliment those likely to be required by permits.

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Table 5.3-8. Potential for Construction Activities to Affect Water Quality

Activity	Conservation Measures	Location	Potential Water Quality Effects	Avoidance and Minimization Measures
Channel dredging/excavation	4, 5, 15	In-water	• Increased turbidity • Resuspension of toxins attached to sediments • Disturbance/removal of channel sediments • Injury or loss of benthic invertebrates	• Section 404 and Section 10 permits will require BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels • CM22
Installation of sheet pile for cofferdam	1, 21	In-water	• Increased suspension of bottom sediments and turbidity • Suspension of toxic-contaminated sediment	• Section 404 and Section 10 permits will require BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels • CM22
Pile driving	1, 16, 21	In-water	• Increased suspension of bottom sediments and turbidity • Suspension of toxic-contaminated sediment	• Section 404 and Section 10 permits will require BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels • CM22
Discharge of treated water from dewatering activities	1	In-water	• None	• Water will be treated prior to discharge and will meet NPDES permit requirements • CM22
Stormwater discharge (from upland construction areas)	1, 2, 4, 5, 6, 7, 14, 15, 16, 18, 19, 21	In-water	• Small discharges from upland construction areas	• Subject to NPDES Permit requirements • CM22
Accidental spills (from construction equipment)	1, 2, 4, 5, 6, 7, 14, 18, 19, 21	In-water	• Small discharges of petroleum products	• Pollution prevention programs • CM22
Excavation for restoration	2, 4, 5, 6, and 7	In-water	• Increased suspended sediment • Mobilization of toxic-contaminated sediment	• Section 404 and Section 10 permits will require BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels • CM22

Basin Plan = water quality control plan.
BMPs = best management practices.
NPDES = National Pollutant Discharge Elimination Service.

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5.3.2.6.1 Contaminants and Turbidity

In-water construction activities will disturb bottom sediments and could result in turbidity levels that could affect covered fish species. In-water construction activities will have minimal effects on covered fish species and will depend on the location and presence of the fish species. The in-water construction activities that could generate increased turbidity would be temporary and localized. As such, the expected increases in turbidity and suspended sediment will be of short duration, limited in extent, and monitored for compliance with regulatory standards. In addition, any localized increases in suspended sediment and turbidity likely will be diluted quickly as a result of the mixing potential associated with channel currents. Potential effects on covered fish species likely will be limited to indirect effects resulting from the behavioral response of fish to turbid water and suspended sediment in the affected portion of aquatic habitats. Such responses include avoidance of high turbidity, changes in foraging ability, increased predation risk, and reduced territoriality (Meehan and Bjornn 1991; Bash et al. 2001). However, most increases in turbidity and suspended sediment will occur in the summer period when fewer individuals of migratory species (e.g., Chinook salmon, steelhead, splittail, sturgeon) are likely to be present in the south Delta.

Sediment disturbance caused by in-water construction may cause localized and temporary suspension of potentially contaminated sediments. These effects would be minimized by implementation of CM 22, compliance with required local permits, clearances, and NPDES permits or other waste discharge requirements (WDRs) from the Central Valley Water Board and implementation of appropriate BMPs to protect water resources from contamination. In addition, turbidity, and in turn suspension of sediments, will be minimized by requirements of the U.S. Army Corps of Engineers (USACE) Section 404 permit and the Section 10 Water Quality Permit, along with water quality control plan (Basin Plan) requirements to maintain low turbidity during construction. Exposure of covered fish species to any disturbed contaminated sediments will be minimized by restrictions on in-water work to between June 1 and October 31, when the potential for many of the covered species to be present in the vicinity of construction will be at a minimum. Although sturgeon are assumed to be potentially present year-round and therefore could be affected by water quality, they are bottom feeders so disturbance of sediments will not change their potential exposure to them; therefore, effects are considered low.

5.3.2.6.2 Spills

Because the in-water construction periods for the construction measures will be short-term and the in-water construction equipment will be generally limited to barges, pile-driving equipment, and dredges, the potential for direct accidental spills to the aquatic environment is short-term, and any spills that may occur will be of very limited quantities. The most likely types of accidental spills will be fuel, oil, and hydraulic fluids. These types of spills are readily contained by booms, and all personnel will be trained to identify and rapidly respond to such accidents. There is also a potential for spills in upland areas to flow into the aquatic system, but the probability of these types of effects is also low, given the spill prevention and response programs required by permitting requirements.

5.3.3 Aquatic Habitat and Foodweb

This section provides a summary of the ecosystem-scale effects of BDCP, such as hydrology and hydrodynamics and habitat restoration, on aquatic foodwebs. BDCP conservation measures for restoring aquatic habitat are based, in large part, on objectives for geographic diversity of habitat, diversity of habitat types (seasonal floodplain, intertidal and shallow subtidal areas, and channel

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margin habitat), and heterogeneity and diversity of habitat characteristics within and among areas that are compatible with existing topography, hydrology, and water quality conditions. The aquatic restoration opportunity areas for tidal restoration are geographically distributed throughout the Delta (see Chapter 3, *Conservation Strategy* for a full description of locations, including a map).

The design of each restoration area would consider a number of factors such as (1) the area that meets the design water depth conditions, (2) location and size of levee breaches, (3) tidal hydrodynamics in the area, (4) proximity to migration corridors and spawning areas, (5) compatibility with existing land uses and infrastructure, (6) current patterns and circulation within the restored habitat, and (7) avoidance of areas that would increase the risk of stranding, exposure to increased predation, and adverse water quality conditions. The design also would consider the likelihood that the area would be colonized by tules and other emergent vegetation, SAV, and floating aquatic vegetation (FAV) such as *Egeria*; colonization by nonnative clams (e.g., *Corbula*, *Corbicula*); areas of high velocity and turbulence such as levee breaches where juvenile fish would have increased risk of predation; and diversity of spatial habitat features such as variable water depths and channels under existing and future conditions assuming sea level rise.

Although there is scientific information collected from the Delta, Yolo Bypass, and Suisun Marsh areas of the Delta that shows evidence of benefits of aquatic habitat restoration (Sommer et al. 2001a; Simenstad et al. 2000), as well as results from a number of restoration projects conducted in the Pacific Northwest that focused on juvenile salmon rearing (Miller and Simenstad 1997; Gray et al. 2002; Bottom et al. 2005a, 2005b), a number of areas of uncertainty remain (Brown 2003; Clipperton and Kratville 2009). These areas of uncertainty include, but are not limited to:

- The restored habitat may not meet the objectives and expected outcomes, or it takes substantially longer than expected to meet the biological objectives.
- The risk that the restored habitat will be colonized extensively by nonnative submerged vegetation and nonnative predatory fish.
- The change in magnitude of predation mortality on covered fish.
- Foodweb responses to habitat restoration actions on both a local and a regional scale.
- The risk of adverse effects resulting from unsuitable changes in water quality and exposure to toxic contaminants.
- The proportion of the covered species population that actively inhabit restored habitats and the change in growth rate, survival, abundance, life history strategies, and population dynamics.

Regardless of these uncertainties, large-scale restoration of the magnitude proposed under the Plan has never been attempted in the Delta and, based on the information collected from smaller restoration efforts in the Plan Area, there is potential for substantial benefits to covered fish species by providing additional habitat as well as restoring the foodweb. Habitat restoration projects would be designed with a phased approach to serve as a large-scale experimental program that documents changes in ecosystem function, both beneficial and adverse, in terms of each of the covered fish species. If results of monitoring identify adverse effects that would not support meeting the expected biological outcomes, the existing and future restoration actions would be modified and refined as part of adaptive management. In the event that a restored habitat is found to have substantial adverse effects on the reproductive success, growth, survival, or population dynamics of the covered fish, substantial modifications would be made to address and mitigate these adverse effects.

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The proposed tidal marsh, channel margin, floodplain, and riparian restoration measures will increase availability to suitable habitat for all covered fish species and restore important ecological functions of the Delta. Uses of this restored habitat include, depending on specific life histories, adult holding, foraging, and spawning; egg and larval development; and juvenile rearing. The restoration is expected to provide increased production of periphyton, phytoplankton, zooplankton, macroinvertebrates, insects, and small fish that contribute to the local and regional trophic foodweb associated with each restoration area. The extensive restoration proposed will promote linkages between various habitat types, mimicking historical conditions. Overall, the proposed restoration of aquatic habitats has the potential to provide a large net benefit to each covered fish species,although fully achieving this potential will require careful design, and when appropriate management, of restored areas.

The following sections provide general information about the Bay-Delta foodweb and trophic pathways, and the expected outcomes of habitat restoration actions under the BDCP with respect to hydrodynamics, residence time, and increased food productivity.

5.3.3.1 Bay-Delta Foodweb and Trophic Pathways

This section provides background on the Bay-Delta foodweb and trophic pathways, along with a summary of current information on the diets of covered fish species. There are two basic trophic pathways in estuarine foodwebs: the phytoplankton-based pathway and the detrital pathway. Organic carbon from the detrital pathway typically is much more abundant than photosynthetically derived carbon from the phytoplankton-based foodweb. However, the conversion of detritus to microbial biomass is a relatively slow and inefficient process compared to phytoplankton production. The Bay-Delta is unusual in that community metabolism is driven by microbial consumption of organic detritus (Sobczak et al. 2005), but phytoplankton is the main source of organic matter for zooplankton and the foodweb supporting fish (Jassby and Cloern 2000; Jassby et al. 2002, 2003; Muller-Solger et al. 2002, 2006; Sobczak et al. 2002, 2005; Kimmerer et al. 2005). The following sections summarize the main features of the phytoplankton-based foodweb and the detrital pathway based on current understanding.

5.3.3.1.1 Overview of Phytoplankton-Based Foodweb

Phytoplankton

Phytoplankton production in the Bay-Delta has undergone a number of major changes over the past 150 years. During the gold rush era, high turbidity resulting from upstream hydraulic mining kept phytoplankton at low levels (Alpine and Cloern 1992; Cloern 1996; Cole and Cloern 1984, 1987; Cloern and Dufford 2005; Cloern et al. 2007; Jassby et al. 2002; Kimmerer 2004). Between 1975 and 1995, phytoplankton production dropped dramatically, declining by more than 40% because of a combination of new stressors (Jassby et al. 2002), including excessive grazing by two introduced clams—the overbite clam (*Corbula*) in brackish waters and the Asian clam (*Corbicula)* in fresh water (Kimmerer et al. 1994; Kimmerer and Orsi 1996; Orsi and Mecum 1994, 1996). Recent research indicates that another major factor has been WWTP discharges of high levels of ammonium, which inhibits diatom production (Glibert 2010; Glibert et al. 2011; Kimmerer 2005; Wilkerson et al. 2006; Dugdale et al. 2007).

The decreased diatom production and invasive clams have altered the species composition of the phytoplankton, as well as overall phytoplankton abundance (Jassby 2008). Flagellates, green algae,

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and cyanobacteria have increased as diatom populations have declined. These species are poor food sources for the zooplankton that are the preferred prey of native fish species. For example, studies show that the survival of copepods, the main prey of delta smelt and other native fish species, is depressed with increasing abundance of the cyanobacterium *Microcystis aeruginosa* (microcystis) relative to more palatable phytoplankton (Ger 2008). Microcystis is now widespread in the Delta in late summer and fall (Lehman et al. 2005, 2008, 2010).

Since the mid-1990s, phytoplankton production has recovered to some extent in the Delta, although production remains low (Jassby 2008). At the same time, no trend has been apparent in phytoplankton in Suisun Bay, even though grazing by *Corbula* remains a factor. Scientists hypothesize that export of phytoplankton production from the upper estuary is helping to maintain the Bay's zooplankton (Baxter et al. 2010).

Zooplankton

With the decline in diatoms, there have been parallel declines in the Delta's zooplankton populations, many of which are known to be limited by phytoplankton production (Mueller-Solger et al. 2002; Sobczak et al. 2002). The decline in mesozooplankton, particularly calanoid copepods (*Eurytemora affinis, Pseudodiaptomus forbes*) and cladocerans (*Daphnia* spp.), is a major factor contributing to recent declines of native fishes (Cloern 2007; Sommer et al. 2007; Glibert 2010; Glibert et al. 2011; Maunder and Deriso 2011; Miller et al. 2011; Winder and Jassby 2010).

Historically, calanoid copepods and cladocerans formed the zooplankton prey base for most fish species in the Delta because of their large size and visibility. However, the introductions of *Corbula* and *Corbicula* led to major alterations in the zooplankton community by decimating phytoplankton populations (Jassby 2008). Predation by *Corbula* has been implicated in the decline of both *Eurytemora* and the native mysid shrimp *Neomysis mercedis* (Feyrer 1999; Winder and Jassby 2010). *Neomysis* is an important food for many native fish species, including delta smelt (Herbold et al. 1992; Kimmerer 1992). Since 1995, the introduced mysid, *Hyperacanthomysis longirostris* (formerly *Acanthomysis bowmani*) has been the most abundant mysid in the upper estuary (Kimmerer et al. 1994; Kimmerer and Orsi 1996; Orsi and Mecum 1994, 1996). This species has less nutritional value than *Neomysis* (Moyle 2002).

At present, the calanoid copepods *Eurytemora* and *Pseudodiaptomus* and the introduced cyclopoid copepod *Limnoithona tetraspina* are the primary zooplankton species in the brackish portions of the Bay-Delta. Introduced in 1993, *Limnoithona* rapidly became the most abundant copepod in these areas (Orsi and Mecum 1996). Because of its small size, sedentary behavior, and ability to avoid predators, it is thought that *Limnoithona* may be an inferior food for fish, and therefore may contribute to the decline in food quantity and quality for delta smelt and other pelagic fishes (Bouley and Kimmerer 2006; Gould and Kimmerer 2010).

In the freshwater portions of the Delta, cladocerans and the calanoid copepods *Diaptomus* and *Limnocalanus* are the dominant zooplankton (Kimmerer and Orsi 1996; Kimmerer 2004). Amphipod crustaceans, including the introduced *Hyperacanthomysis longirostris*, provide alternative prey for fish that formerly fed extensively on *Neomysis* (Feyrer et al. 2003), but they are not currently monitored sufficiently to understand their importance in the foodweb (Kimmerer et al. 2008).

Macroinvertebrates and Fish

The changes in the phytoplankton and zooplankton communities have greatly reduced the food resources for *Neomysis* and native fishes (Winder and Jassby 2010). *Neomysis* and other mysids feed primarily on copepods, providing an energetic link between plankton and planktivorous fishes such as delta smelt, longfin smelt, and Chinook salmon. The benthic-feeding sturgeon feed on epibenthic organisms such as amphipods, bay shrimp, and bivalves, including the introduced clams (Israel and Klimley 2008; Israel et al. 2009).

Corbula has eliminated much of the plankton available for native planktivores, and diverted much of the estuary's production to the benthos (Winder and Jassby 2010), resulting in an energetic "dead end." The decline in the phytoplankton-based pelagic foodweb is thought to be one of the major reasons for the POD that began in 2002 (Kimmerer et al. 2000; Bennett 2005; Rosenfield and Baxter 2007; Sommer et al. 2007; Thomson et al. 2010; Baxter et al. 2010). Delta smelt, longfin smelt, striped bass, and threadfin shad are pelagic fishes that have experienced sharp declines over the past decade.

5.3.3.1.2 Export of Food Resources from Restored Habitats

Export of Marsh-Derived Production

The findings of Howe and Simenstad (2011) suggest that a benefit of BDCP tidal habitat restoration is the export of marsh-derived production, including both detritus and phytoplankton. In the Bay-Delta, there is evidence that tidal marshes export food resources to adjacent channels and downstream systems (Cloern et al. 2007; Lehman et al. 2008). Studies in both southern California (Kwak and Zedler 1997) and the Bay-Delta (Benigno and Sommer 2008; Howe and Simenstad 2007, 2011) show that tidal wetlands export food resources both to adjacent channels and the wider estuary (Kneib et al. 2008 and Simenstad 2008 and references therein). Marsh export may include advection and tidal exchange, as well as export of productivity in the form of macroinvertebrates and small fishes (Kneib et al. 2008). The BDCP includes substantial restoration that has the potential to produce and export detritus and phytoplankton into the open estuary where fish can consume it. The magnitude of this benefit depends on site-specific conditions of the restored areas, hydrodynamics in and around the restored areas, and the distribution of fish. Careful design of restored areas, including application of adaptive management, can increase the likelihood that this benefit would be realized.

Export of Phytoplankton and Zooplankton from the Delta

Phytoplankton, zooplankton, and other food resources produced on inundated floodplains in the upper estuary provide subsidies to foodwebs downstream (Schemel et al. 1996; Jassby and Cloern 2000; Mitsch and Gosselink 2000; Moyle et al. 2007; Moss 2007; Lehman et al. 2008). The export of resources from the diversity of habitats in the Cache Slough ROA also has great potential to increase downstream productivity. According to Baxter et al. (2010), Durand of the University of California at Davis (UC Davis) found that transport from upstream areas was essential for maintaining the *P. forbesi* copepod population in Suisun Bay. Mueller-Solger et al. (2006) noted that areas rich in high-quality phytoplankton and other nutritious food sources, including the southern Delta and small tidal marsh sloughs, may be critical source areas for important fish prey organisms such as *P. forbesi* and *E. affinis*. Opperman (2008) has described the importance of export of food to downstream foodwebs, and Sobczak et al. (2005) discussed the links between carbon produced on floodplains and the downstream foodweb.

5.3.3.2 Physical Effects

The habitat restoration and enhancement conservation measures would result in changes to physical parameters such as hydrodynamics and residence time that would be expected to influence productivity and food export. The expected changes under the BDCP are described below.

5.3.3.2.1 Hydrodynamics

The proposed tidal restoration would add a substantial increment to the existing Delta surface area at high tide (+4 feet) and low tide (-2 feet). The existing MHHW surface area upstream of Martinez would increase from about 90,000 acres to 140,000 acres, an increase of more than 55%. The existing MLLW surface area would increase from about 83,000 acres to 115,000 acres, an increase of more than39%.

The simulated tidal flow changes from the BDCP restoration of tidal habitat areas were generally low in the Delta channels, except for some existing channels near the restoration areas. Restoration in the Suisun Marsh ROA resulted in significant simulated increases in tidal flow at the mouth of Montezuma Slough (+100%). Tidal flow at the head of Montezuma Slough was increased by about 60%. At Chipps Island (West Delta ROA), the tidal flows were reduced by about 5%. These reductions in Chipps Island tidal flows were the result of Suisun Marsh restoration. More of the tidal prism (tidal flows) went into the expanded Suisun Marsh tidal habitat, and less went upstream into the Delta channels and expanded tidal habitat. The BDCP tidal restoration also caused tidal muting (reduced tidal amplitude and reduced tidal flows) throughout the Delta. Tidal flows in the lower Sacramento River (West Delta ROA) were reduced by the downstream restoration in Suisun Marsh and were increased by the upstream restoration in Cache Slough ROA. The net effect on tidal flows was an increase of about 3% in the lower Sacramento River (West Delta ROA) flows. Tidal flows in the lower San Joaquin River (West Delta ROA) were reduced by about 10%. Simulated tidal elevations would be muted and tidal flows would be reduced in the Sacramento River. The tidal range (high tide to low tide elevation) was reduced from about 2 feet to about 1.5 feet. The flows were always positive, but the tidal variation was reduced from 6,000 cfs to about 5,000 cfs.

5.3.3.2.2 Residence Time

Increased residence time can lead to both positive and negative effects on the Delta ecosystem depending on its location and length. It is generally believed that an increase in residence time would cause an increase in primary production because the phytoplankton population would spend more time integrating light and nutrients within Delta channels and growing. However, an increase in residence time potentially could increase exposure of aquatic organisms to pesticides and heavy metals. Residence time is calculated using a DSM2 particle-tracking model. Residence time is calculated up to the time at which 50% of the particles leave the Delta (by exiting the west end at Martinez, SWP/CVP exports, or agricultural diversions).

These results indicate that residence time will increase by 3–4 days (9%–19%) as a result of the preliminary proposal on average for the hydrologic modeling scenarios used in the DSM2 analyses. There is large variation among hydrologic scenarios in these results, which reduces the certainty of the conclusions (compounding the existing uncertainty of DSM2 outputs). The small average increases of 3 to 4 days predicted by this analysis are unlikely to cause major changes in primary production, particularly with respect to the large level of uncertainty and large variation in results. It

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is not known what the effect of 3–4 days more of exposure to pesticides or metals will have on different aquatic organisms.

5.3.3.3 Habitat Productivity

The Habitat Productivity Analysis was used to assess potential foodweb enhancements that may result from proposed tidal habitat restoration activities. Increased food productivity is expected in all ROAs as a result of the BDCP, but the Suisun Marsh, Cache Slough, and South Delta ROAs are expected to see the greatest increases in productivity. While Suisun Marsh and Cache Slough ROAs will immediately provide increased productivity because restoration is planned first on those ROAs, the South Delta ROA will provide benefits in the late long-term. Food produced in the ROAs is expected to directly benefit covered fish in the ROAs as well as in areas to which food is exported from ROAs. Accordingly, the restoration of these areas and the associated food production are expected to create better linkages between upstream spawning areas and downstream rearing areas for juvenile Chinook salmon, splittail, sturgeon, delta smelt, and longfin smelt. The analysis examined two main sources of foodweb support: phytoplankton production and marsh-derived production.

5.3.3.3.1 Phytoplankton Production

The relationship between phytoplankton growth rate and depth developed by Lopez and coauthors (2006) was used to characterize how habitat restoration could contribute to the phytoplankton-based foodweb (Figure 5.3-3).

This relationship was applied to the estimated depths for each tidal-area stratum. In addition, a consideration of the area of habitat of an average depth was added to the estimates of phytoplankton growth rate. It was assumed that a larger area of a given phytoplankton growth rate has a greater value than a smaller area with the same rate. To capture this notion, the phytoplankton growth rate was calculated from the estimated average water depth of each tidal-area stratum, and then multiplied by the area of the stratum, resulting in a metric termed “prod-acres” (phytoplankton growth rate X area). The analysis provided estimates of phytoplankton growth rate and calculated prod-acres by ROA for existing conditions and conditions under the BDCP as shown in Table 5.3-9.

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Table 5.3-9. Depth-Averaged Phytoplankton Growth Rate and Prod-Acres for Existing Conditions and the Plan in the Late Long-term, Assuming No Sea Level Rise

ROA	Scenario	Phytoplankton Growth Rate	Prod-Acres
Cache Slough	Existing	0.60	4,526
	Plan	0.85	13,858
Suisun Marsh	Existing	0.69	4,018
	Plan	0.92	13,089
West Delta	Existing	0.76	293
	Plan	0.74	2,907
Cosumnes-Mokelumne	Existing	0.00	0
	Plan	1.06	3,116
South Delta	Existing	1.14	98
	Plan	1.12	15,892
All	Existing		8,935
	Plan		48,862

Note: *Existing conditions* is EBC2 (OCAP BiOps with Fall X2 included). Prod-acres are the product of phytoplankton growth rate and acreage.

5.3.3.3.2 Marsh-Derived Production

The contribution of the detrital pathway to marsh production was examined on the basis of an analysis by Kneib (2003), which included estimates of the amount of production flowing to resident nekton (actively swimming aquatic species) as well as the export of production to the estuary by means of a “trophic relay” by migrant nekton. Most Bay-Delta foodweb studies have focused on the phytoplankton-based foodweb, considering the detrital pathway to be relatively unimportant (Jassby et al. 1993; Jassby and Cloern 2000; Szobeck 2002, 2005). However, recently Grimaldo et al. (2009) showed that many marsh organisms are supported by a number of additional sources of primary production. Howe (2006) and Howe and Simenstad (2007, 2011) found that marsh-derived organic matter contributed significantly greater amounts of organic matter to the foodweb supporting the marsh ecosystem than bay-produced phytoplankton. Other studies have shown that tidal wetlands export production to both adjacent channels and the wider estuary (Kneib et al. 2008). Therefore, it is expected that the tidal marsh restoration would contribute to the overall marsh production of the Plan Area.

5.3.3.3.3 Restoration Opportunity Areas and Conservation Measures

The BDCP habitat restoration and habitat enhancement conservation measures are expected to produce and export food for covered fish species. Different types of habitat restoration would occur under the conservation measures in the different ROAs. The contribution of the conservation measures and each ROA and for each habitat restoration and enhancement is discussed below.

Tidal Habitat Restoration (CM4)

Studies in locations throughout the United States indicate substantial ecological benefits from restoring tidal wetlands, including foodweb support for fish species (Boesch and Turner 1984; Baltz et al. 1993) and the export of nutrients and prey organisms to adjacent channels (Shreffler et al.

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1992; Lucas et al. 2002; Schemel et al. 2004; Sommer et al. 2004a, 2004b; Lopez et al. 2006). Studies conducted in the lower Bay-Delta estuary and elsewhere along the Pacific coast also provide evidence of tidal marsh benefits for fish, especially salmonids (Simenstad 1982; West and Zedler 2000; Bottom et al. 2005; Maier and Simenstad 2009; Simenstad et al. 2000; Howe and Simenstad 2011).

Of the Delta habitats, the tidal marsh sloughs have the highest particulate organic matter (POM) and phytoplankton concentrations and support the greatest zooplankton growth rates (Müller-Solger et al. 2002; Sobczak et al. 2002). The shallow littoral edges of marsh systems often are associated with high standing stocks of fishes in California (e.g., Allen 1982; Moyle et al. 1986; Nobriga et al. 2005) and elsewhere (e.g., Kneib 1997, 2003). When tidal mudflat is inundated, it serves as shallow open-water habitat for pelagic fish species, including splittail, salmonids, and sturgeon, and provides forage on benthic invertebrates.

Tidal wetlands also have the capacity to export food resources to adjacent channels and to downstream systems (Cloern et al. 2007; Lehman et al. 2008). The export of food may include movement of phytoplankton and zooplankton by advection and tidal exchanges as well as the export of productivity in the form of macroinvertebrates, small fishes, and other larger organisms (Kneib 1997, 2003).

Cache Slough Restoration Opportunity Area

The phytoplankton growth model estimates that the measure of production, production-acres (prod-acres), in the Cache Slough ROA are currently high and will increase by more than threefold by the end of the permit term. This increase in phytoplankton growth and assumed increases in zooplankton will provide benefits to delta smelt in two major ways: the resident population of delta smelt in Cache Slough will benefit directly from increases in copepod abundance in the Cache Slough ROA, and larvae and juveniles will derive an indirect benefit to the extent that food resources are exported downstream to rearing areas in the low salinity zone (LSZ). Likewise, Sacramento splittail will benefit directly from increased production in restored Cache Slough wetlands, as well as from production that is exported downstream to areas such as Suisun Bay and Suisun Marsh, where it will support splittail rearing. Young Chinook salmon and steelhead forage in tidal habitat and will benefit from the increase in phytoplankton at the base of the foodweb, and sturgeon, which feed on benthic invertebrates, including those found on marsh mudflats, will benefit from the transfer of increased production to mudflat fauna in restored marshes. Cache Slough restoration may contribute to food production that supports longfin smelt locally in Cache Slough but also in other downstream areas.

Suisun Marsh Restoration Opportunity Area

The phytoplankton growth model indicates that the Suisun Marsh ROA, like Cache Slough, has significantly more prod-acres under the baseline scenario than the other ROAs and will increase by more than threefold by the end of the permit term. An increase in phytoplankton at the base of the pelagic foodweb will enhance food production for delta smelt. Juvenile fish will benefit directly from increased production in marsh channels and indirectly from production exported to deeper, open-water areas. Larval longfin smelt frequently are found in marsh environments, but soon after they reach free-swimming post-larval stages, they concentrate in deepwater environments. Therefore, the primary benefit to longfin smelt of restoration in the Suisun Marsh ROA will be the export of food resources to deeper waters. Increased production of phytoplankton will support production of benthos, on which splittail juveniles and adults, who spend most their lives in Suisun Marsh, Suisun Bay, and the Delta, can feed. Likewise, Chinook salmon and steelhead fry and juveniles forage in tidal

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marshes, channels, and sloughs, and emergent vegetation communities support invertebrate prey populations. Juvenile salmonids also benefit indirectly from exported food resources. The export of food may include movement of phytoplankton and zooplankton by means of advection and tidal exchanges, as well as the export of productivity in the form of macroinvertebrates and small fishes.

West Delta Restoration Opportunity Area

The phytoplankton model estimates that primary production in the West Delta ROA is currently very low. The BDCP is expected to increase production in this ROA tenfold but production will remain relatively low compared to that in other ROAs. Delta smelt and longfin smelt will benefit from new production exported from these restored tidal habitats, but the minor increase in production estimated by the phytoplankton growth model in the West Delta ROA will not have a significant effect on the overall pelagic foodweb. However, the restored habitats will provide a potentially important linkage between upstream spawning and rearing habitat for splittail and the major splittail habitat downstream in Suisun Marsh and Bay. The increase in food production indicated by the phytoplankton model would have a minor benefit for these individuals. Similarly, rearing salmonids in the west Delta migrate to and from the Cosumnes and Mokelumne Rivers, and these individuals will benefit from food production in the West Delta ROA.

Cosumnes-Mokelumne Restoration Opportunity Area

The phytoplankton model indicates that there are no prod-acres in the Cosumnes/Mokelumne ROA under the baseline scenario, reflecting the current lack of aquatic habitat in the area as the restoration areas are leveed islands. With tidal wetland restoration, production will increase but will remain modest. Limited numbers of delta smelt feeding in this area will benefit from increased production in tidal habitats, but feeding success will be highly dependent on prey densities. Longfin smelt occur infrequently in this area and therefore will derive the greatest benefit from production that is exported downstream. Increased phytoplankton growth will provide foodweb support for rearing juvenile Chinook salmon and splittail migrating from the Cosumnes and Mokelumne Rivers.

South Delta Restoration Opportunity Area

The phytoplankton model estimates that there are no prod-acres in the South Delta ROA under baseline conditions. With restoration, prod-acres will increase dramatically, with the highest total increase estimated for this ROA. Most (75%) of the increase occurs in the deep zone. Although delta smelt and longfin smelt are not generally found in the south Delta, and they would not benefit directly from increased phytoplankton and zooplankton production resulting from tidal habitat restoration, they would benefit indirectly to the extent that food resources are exported to deeper habitats used by delta smelt. The increase in phytoplankton will enhance the foodweb supporting splittail, helping to promote growth and survival of both juveniles and adults, particularly those migrating to and from the San Joaquin River. Permanent tidal marshes in the South Delta ROA will contribute new holding and rearing areas for juvenile fish and improved survival in the San Joaquin River system for salmonids

Channel Margin Habitat (CM6)

The physical elements (e.g., woody debris, rocks) and vegetation (emergent plants, woody riparian, SAV) associated with channel margin habitat, shallow water, and banks can serve as substrates for invertebrate communities that would support foraging fish. The use of channel margin habitat by fish depends on species- and age-specific dietary preferences and foraging behavior. Isotope studies

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indicate that the majority of fishes in littoral habitats have diets dominated by nearshore invertebrates such as amphipod grazers from SAV and epiphytic macroalgae. In the Delta, juvenile Chinook salmon (both hatchery and untagged fish) rely predominantly on zooplankton and chironomids, with some amphipods derived from channel margin habitat and other littoral sources (Grimaldo et al. 2009). Studies of littoral habitats in the Pacific Northwest have found that sub-yearling juvenile Chinook salmon feed primarily on amphipods (*Corophium* spp.), dipteran insects, and some zooplankton (*Daphnia* spp.), with a shift in diet from insects to amphipods and larval fish as juveniles increase in length and move toward the estuary mouth (McCabe et al. 1986 and Bottom and Jones 1990 as cited in Lott 2004). Delta smelt and other pelagic species are not expected to benefit from food resources in channel margin habitats because they typically are associated with open-water habitat.

Channel margin habitat would be located along the major migration routes and linked to other important habitats through the Delta. Evidence from the northwest United States suggests that connectivity of foraging habitat (e.g., the length, condition, and complexity of pathways) affects the importance of habitats to juvenile Chinook salmon. For instance, juvenile Chinook salmon were less abundant in dendritic tidal channel systems as distance from the main distributary channels increased (Beamer et al. 2005 cited in Fresh 2006). However, recent work in the San Francisco estuary, including the Plan Area, has shown occupation by fish of very small intertidal dendritic channels (Gewant and Bollens 2011).

There is some indication that channel margin habitat could be extremely important rearing habitat in years with low precipitation when floodplains are not functioning. A study by McLain and Castillo (2009) found that densities of Chinook salmon fry in the Sacramento River and Steamboat Slough were higher compared to Miner Slough and Liberty Island Marsh during a low outflow year. Marshy habitats at the downstream end of the Yolo Bypass apparently were bypassed by fry because outflow during the winter was relatively low, and flows into the Yolo Bypass were negligible.

Floodplain Restoration (CM5)

Floodplain restoration is anticipated to increase in the productivity of foodwebs that support Delta fish species. For example, Delta smelt and longfin smelt are two species dependent on zooplankton. Floodplains should export food resources, especially algae, to support foodwebs in downstream communities. Periodically, pulsing small "floodplain activation floods" may pump high concentrations of algae to downstream waters. The restoration aims to export of floodplain-produced algae to downstream aquatic ecosystems during flood events).

Restoration potentially could increase the quantity and quality of riverine phytoplankton biomass available to the aquatic foodweb by passing river water through a floodplain such as the Yolo Bypass during the flood season. Central Valley floodplains should produce increased levels of phytoplankton and other algae, particularly during long-duration flooding that occurs in the spring. The shallow water depth and long residence time in floodplains will facilitate settling of suspended solids, resulting in reduced turbidity and increased total irradiance available for phytoplankton growth in the water column. At the Cosumnes River Preserve, the inundated floodplain should progress from a physically driven system when connected to the river floods, to a biologically driven, pond-like system with increasing temperature and productivity. Periodic small floods should boost aquatic productivity of phytoplankton by delivering new pulses of nutrients, mixing waters, and exchanging organic materials with the river. Aquatic productivity is expected to be greater in

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floodplain ponds than in river sites. Zooplankton biomass should increase rapidly following each flood event.

Providing river–floodplain connectivity should enhance production of lower trophic levels at relatively rapid time scales. In the Yolo Bypass, some foodweb organisms should respond within days and attain high densities soon after inundation, including smaller fast-growing algae, vagile organisms such as drift insects, and organisms associated with wetted substrate such as chironomids. These organisms, particularly chironomids, will provide a food source to fish that is available prior to the development of foodweb productivity.

Yolo Bypass Fisheries Enhancement (CM2)

The Yolo Bypass is expected to provide spawning, substrate, rearing habitat, and food production benefits to covered fish species. Specifically, the most important spawning habitat for splittail occurs in the seasonally inundated floodplains of the Sutter and Yolo Bypasses of the Sacramento River. The analysis of floodplain habitat availability for splittail is directed primarily at the egg/embryo, larval, and juvenile stages because production of these life stages is especially important in determining year class abundance. Results of the analyses show that the frequency and duration of inundation events are greater under the PP than under either of the existing biological conditions (EBC1 and EBC2), especially for dry and critical year types. For wet year types in particular, the preliminary proposal results in a reduced frequency of shorter-duration events and an increased frequency of longer-duration events. This change is attributable to the influence of the Fremont Weir notch at lower flows. In addition to the numerous splittail benefits expected, benefits to juvenile salmon also are expected. Benefits to juvenile salmon associated with floodplain habitats are well-documented and result in increased growth and survival (Sommer 2001; Jeffres 2008).

Riparian Restoration (CM7)

Modern ecological theory suggests that natural disturbances (e.g., flooding) contribute physical and biological energy that links the terrestrial and aquatic environments in the riparian zone, similar to that outlined by the River Continuum theory (Vannote et al. 1980). These hydrologic pulses (Junk 1999; Tockner et al. 2000) support recruitment of diverse tree and shrub species, and together these species create a heterogeneous landscape. This riparian vegetation in turn promotes a diversity of associated terrestrial and aquatic species. In the Cosumnes River Preserve, researchers found that flood-induced disturbance is an important factor in promoting heterogeneous riparian habitats, including woody and herbaceous species diversity (Viers et al. 2006). Biodiversity is a key parameter for all BDCP habitat restoration actions because the number of species in a habitat directly relates to the complexity and connectivity of the foodweb (Martinez 1993, 1994; Martinez and Lawton 1995).

Although the covered fish species do not rely primarily on riparian habitat, they are directly and indirectly supported by the habitat services and food sources provided by the highly productive riparian ecosystem, particularly during floodflows when riparian habitats are inundated. Riparian vegetation is a source of organic material (e.g., falling leaves), insect food, and woody debris in waterways and can influence the course of water flows and structure of instream habitat. This debris is an important habitat and food source for fish, amphibians, and aquatic insects (Opperman 2005).

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5.3.3.4 Construction Effects

As discussed in Appendix 5.H, *Aquatic Construction Effects*, construction activities in the BDCP ROAs would include in-water work such as pile driving and dredging, which will temporarily disturb or modify habitat, including benthic habitat and on-bank and channel habitat. Benthic organism removal from dredging, and burying deposit feeders, suspension/deposit feeders, and suspension feeders, will occur in portions of the dredged area. Removing these organisms through dredging or disposal may cause short-term effects on fish species residing in the dredge area by limiting food resources. Benthic substrate that is excavated contains macroinvertebrates that provide prey for covered fish species. Covered fish species that consume benthic macroinvertebrates include white and green sturgeon and Sacramento splittail. While it is speculative to assign numbers or values to how much construction activities will affect food production, over the scale of the BDCP ROAs it would have a minimal effect and most likely is not measurable.

Construction activities could affect channel habitat that provides detritus to the foodweb and rearing habitat. The affected habitat associated with the intake facilities for CM1 is currently armored levee bank with limited riparian vegetation and of low value for species rearing. Cofferdams will be used to isolate the entire work area from the wetted channel of the Sacramento River during construction of each of the five intake facilities. At each intake, between 2.9 and 5.1 acres of river area will be temporarily isolated by the cofferdams during the entire construction period, for a total area of about 22.6 acres. Additionally, approximately 4 miles of channel habitat will be permanently converted as a result of the construction of the intakes. Some riparian trees and shrubs that grow on the levee banks will be lost, slightly reducing instream cover and shade and the contribution of leaves, small debris, and insects falling into the river from overhanging vegetation. However, bank armoring and lack of physical structure currently limit the quality of this kind of habitat. Other conservation measures would include modifications of habitat such as the realignment of Putah Creek (CM2). It will permanently remove existing grassland, managed wetlands, and cultivated lands. Although this habitat modification will be permanent, it is designed to provide better habitat for covered fish species, including herbaceous riparian vegetation in the upstream half of the realignment and freshwater tidal marsh in the downstream half of the realignment. Therefore, the effects on covered fish species of construction activities related to the realignment and construction of other conservation measures are expected to be minor and temporary.

5.3.4 Climate Change Adaptation

The BDCP will have numerous benefits for adapting to ongoing climate change and its effects on the Bay-Delta region (see recent review of projected climate changes by Cloern et al. 2011). Studies suggest that northern California will experience a continuing change from snow to rain in winter, leading to reduced snowpack, earlier snowmelt, and reduced river flows and reservoir storage in summer (Knowles and Cayan 2002; Miller et al. 2003; Mote et al. 2005). Air temperatures will continue to rise, increasing water temperatures and the movements of aquatic species in search of cool water refuges. Accelerated rates of relative sea level rise will increase the intrusion of seawater into the upper estuary (Cayan et al. 2009). Sea level rise combined with an increase in coastal storms, storm surge, and river runoff will increase shoreline flooding and erosion.

These physical changes are expected to be widespread and long-lasting, even if meaningful reductions in greenhouse gas emissions (i.e., climate change mitigation) are made now. The BDCP will not counter or reverse these physical trends. However, BDCP conservation measures will

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provide numerous benefits to the Bay-Delta ecosystem, natural communities, and covered species that is expected to reduce their vulnerability to the adverse physical and biological effects of climate change. Table 5.3-10 below identifies the expected benefits of BDCP for climate change adaptation.

Table 5.3-10. Summary of Expected Climate Change Adaptation Benefits of BDCP

Benefit	Description
Enhanced ecosystem services	Restoration of wetlands, floodplains, and riparian habitats will restore ecosystem services that benefit humans as well as ecosystems, including flood control, water purification, sediment retention, carbon sequestration, and the provision of habitats and biota (Mitsch and Gosselink 2000).
Protection from sea level rise	Increased wetland plant biomass, including belowground production, helps to promote accretion and the ability of the marsh to keep pace with sea level rise (Callaway et al. 2011; Parker et al. 2011). A wider and more extensive marsh plain in tidal wetlands and a wider floodplain in river systems increases protection of upland habitat and human structures from flooding and storm surges, which are predicted to get worse with climate change (Cayan et al. 2008).
Carbon sequestration and climate change mitigation	Marsh grasses, microalgae, and phytoplankton and woody biomass included in riparian restoration remove CO_2 from the atmosphere and marsh soils store carbon from marsh organisms, helping to control CO_2 emissions that contribute to climate change (Marsh et al. 2005; Trulio et al. 2007).
Protection of migrating birds	The brackish marshes in the North Bay and Suisun Marsh provide an important resting place for birds along the Pacific Flyway. These birds will experience increasing loss of mudflats used for forage and resting during long-distance migration (PRBO Conservation Science 2011).
Increased upland transition zones	The tidal wetland restoration will have a wide upland transition area, providing refuge for wetland animals during extreme high tides (predicted to increase with climate change) and opportunities for wetland migration upslope in response to sea level rise (Callaway et al. 2011; Parker et al. 2011).
Reduction in risks of levee failure	When wetlands behind levees dry out, the organic matter in the soil oxidizes, which can increase subsidence. This can reduce the stability of levees and increase the risk of levee failure during flooding, resulting in saltwater intrusion into aquifers and farmlands (Mount and Twiss 2005).Restoration would increase inundation and reduce subsidence.
Natural water management	Improved floodplain connections to rivers will restore the ability of floodplains to absorb flood flows and provide a reservoir of water to help aquatic species withstand droughts.
Increased resilience to invasive species	Seasonally inundated floodplains provide more resilience to invasive species by increasing numbers and health of native species and excluding invasive species (Moyle et al. 2007).
Increased habitat variability	Supports species diversity by providing a mosaic of habitats that can be used by different species that have evolved to use specific habitats.
Increased habitat complexity	Wetland restoration will include networks of channels within marshes that are used by fish for foraging, refuge, and movement in and out of the marsh. Currently, such channels are rare (Parker et al. 2011).
Increased habitat patch size and connectivity	Protection and restoration of a variety of natural communities will increase the patch size and connectivity of these habitats. Increasing patch size will tend to increase population sizes of native species, which provides more resiliency against a changing climate. Increasing connectivity allows more genetic exchange among populations and movement to more suitable habitats as environmental conditions change.

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In addition to the benefits described above, reductions in ecosystem stressors to covered species are expected to occur as a result of implementing the BDCP. It is expected that covered species would be better able to adapt to climate change by a reduction in these stressors. Stressors include predation, entrainment, food, and IAV. The BDCP conservation strategy is expected to lessen predation associated with the different habitat restoration and enhancement efforts. For example, Moyle et al. (2007) showed that floodplains can be managed to favor native fishes and exclude invasives. The BDCP conservation strategy is expected to keep entrainment at current low levels and is expected to result in additional food production. Restoration of tidal marsh will help increase phytoplankton and marsh-derived production to enhance primary and secondary food production, which will benefit covered fish species. Chinook salmon fry feed primarily on chironomids, which are associated with emergent marsh vegetation in wetlands in the Plan Area (Simenstad et al. 2000). Tidal marsh sloughs have the highest levels of dissolved organic carbon, particulate organic carbon, and phytoplankton-derived carbon among various Bay-Delta habitats (Jassby and Cloern 2000; Muller-Solger et al. 2002; Sobczak et al. 2002; Sobczak et al. 2005). Finally, the BDCP conservation strategy is expected to reduce IAV. Specifically, Egeria and associated nonnative fish (primarily centrarchid species) will be excluded from the habitat restoration and enhancement sites (Nobriga and Feyer 2007). For terrestrial covered species, the adverse effects of fragmentation will be reduced through improved habitat connectivity.

Operational and adaptive management considerations of the BDCP conservation strategy also will support climate change adaptation. These considerations include increased flexibility in water operations to address higher variation in hydrology expected by climate change; monitoring to address data gaps that would address changing conditions and uncertainties associated with climate change; and physical and biological models developed for the BDCP conservation strategy to support adaptive management and shoreline planning.

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M. Guerin pers. comm.

B.J. Miller pers. comm.

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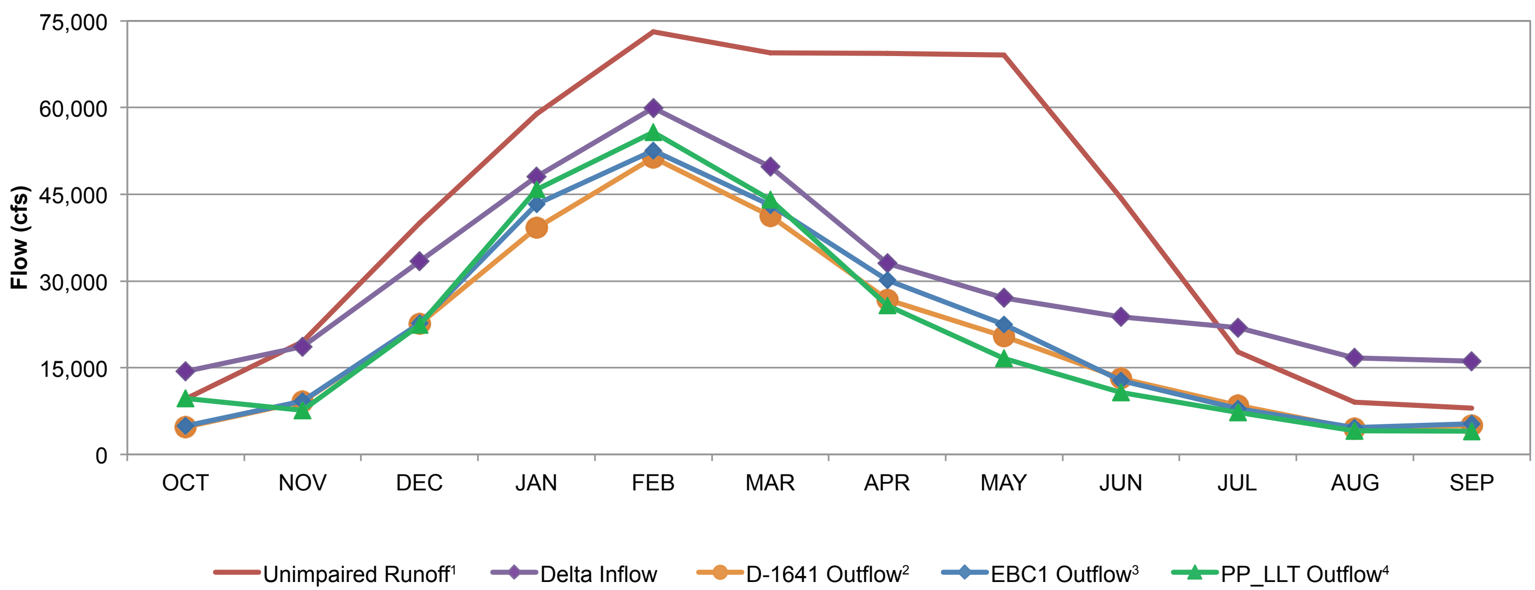
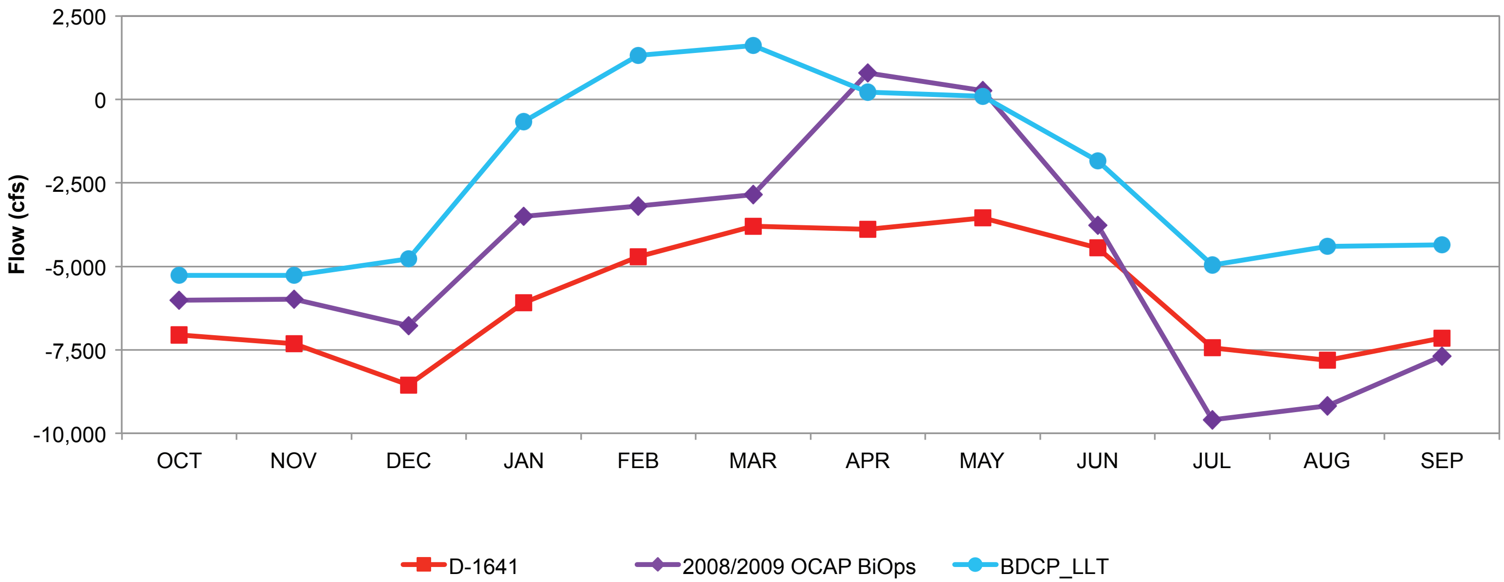


1. DWR-estimated natural runoff from Sacramento and San Joaquin watersheds
2. D-1641 represents the baseline prior to USFWS/NMFS BiOps for OCAP
3. EBC1 does not include Fall X2 requirements of the 2008 USFWS BiOp
4. BDCP Operations in late long-term (2060)

Graphics/... BDCP EA/ (Rev. 20120227 AB)

DRAFT

Figure 5.3-1
Comparison of Monthly Average Unimpaired Runoff and Delta Inflow and Delta Regulated Outflows for 1922–2003 (from CALSIM results)



Note: Positive flow in Old and Middle River channels is north; negative flow (reversed) is south toward CVP and SWP pumps.

Graphics/... BDCP EA/ (Rev. 20120227 AB)

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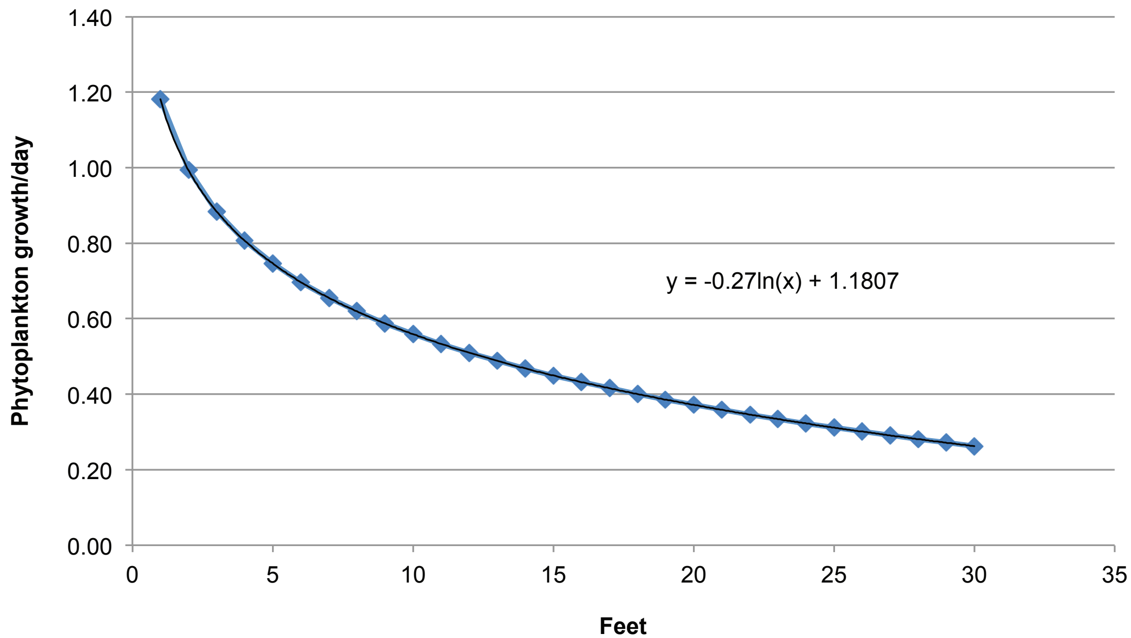
Figure 5.3-2
Comparison of Monthly Average Flows in Old and Middle River (OMR) under D-1641, with the 2008/2009 OCAP BiOps and with the BDCP for 1922–2003 (from CALSIM results)



Note: Equation has been modified to measure depth in feet, not meters.

Graphics/... BDCP EA/ (Rev. 20120222 SS)

Source.Lopez et al. 2006.

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Figure 5.3-3
Relationship between Phytoplankton Growth Rate and Depth

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Chapter 5
Effects Analysis

5.4 Effects on Natural Communities

This section provides the results of the effects analysis for natural communities. Section 5.2.5, *Effects Analysis for Natural Communities*, described the methods used to conduct this analysis. Table 5.4-1, *Natural Community Loss by Covered Activity*, quantifies the acreage of habitat that would be removed through each covered activity and Table 5.4-2, *Net Effects, Natural Communities*, summarizes the net effects to each natural community.

5.4.1 Tidal Perennial Aquatic

The tidal perennial aquatic community occurs throughout the Plan Area in all conservation zones and consists of open water habitat associated with tidal brackish emergent wetland, tidal freshwater emergent wetland, valley/foothill riparian, and grassland communities. It can occur as large open water bodies such as Suisun Bay, inundated Delta Islands such as Franks Tract and Liberty Island, reservoirs such as Clifton Court Forebay, perennial water courses such as the Sacramento, San Joaquin, and Mokelumne Rivers, and also as smaller open water areas in the many distributaries, sloughs, and channels of the Plan Area.

5.4.1.1 Adverse Effects

5.4.1.1.1 Permanent Loss and Fragmentation

In general, covered activities are not expected to adversely affect tidal perennial aquatic habitat because the ecological functions and biological resource values of tidal perennial aquatic habitat in the Plan Area are expected to benefit from the restoration of large areas of tidal aquatic habitat and the protection, restoration, and management of associated wetland and upland communities.

As part of BDCP a total of 65,000 acres of tidal habitat will be restored, of which 10,000 acres will consist of tidal perennial aquatic habitat will be restored by the LLT evaluation period. While the overall restoration of 65,000 acres will result in a net increase in tidal perennial aquatic habitat, negative effects on existing tidal perennial aquatic natural communities will also occur as a result of this restoration and as a result of other BDCP covered actions and conservation measures.

Currently, in the Plan Area, a total of approximately 86,236 acres of tidal perennial aquatic habitat exists. Restoration of an additional 65,000 acres by the LLT is anticipated to result in the desiccation of approximately 27 acres of existing tidal perennial aquatic habitat, as additional areas is exposed to tidal influence. Construction of the northern bypass is anticipated to result in the permanent removal of approximately 28 acres of existing tidal perennial aquatic habitat and temporarily affect approximately 120 acres. Improvements associated with the Fremont Weir and Yolo Bypass are anticipated to result in the permanent loss of approximately 7 acres of existing tidal perennial aquatic habitat. Floodplain restoration will require the removal of existing and construction of new levees. These construction activities are anticipated to result in the permanent loss of 2 acres of existing tidal perennial aquatic habitat and temporarily affect 5 acres. Thus, BDCP will result in the

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permanent loss of 65 acres of tidal perennial aquatic habitat and temporarily affect approximately 125 acres (Table 5.4-1).

5.4.1.1.2 Effects of Ongoing Activities

Operation, Maintenance, Enhancement and Management

Restoration, management, and operation actions associated with the BDCP and tidal perennial aquatic habitat that could affect salinity gradients will result in complex and inseparable interactions between the effects of water operations (e.g., Sacramento River outflow and changes in the operation of the Suisun Marsh Salinity Control Gates in the fall) and the effects of tidal habitat restoration (reduced tidal prism and compression of tidal range) that make it impossible to completely separate/isolate their independent effects on the tidal perennial aquatic community.

Tidal habitat restoration actions will restore 65,000 acres of tidal habitat at the LLT evaluation point. The restoration actions will increase the extent of the area inundated and influenced by tidal waters through the breaching of levees and dikes. Such actions will result in the dampening of the tidal prism as the extent of area exposed to tidal flow increases and thus fluctuations in tidal elevation may not be as significant as current fluctuations, thus the desiccation of some existing tidally influenced habitats, as mentioned previously.

Changes in flow, salinity, water temperature, DO and turbidity are expected to occur in the Plan Area as a result of the BDCP. Additionally, changes in how toxins that are already present in the Plan Area are mobilized and transported may influence the exposure to and effects of toxins on covered fish species. As mentioned above, it is difficult to isolate the effects of tidal aquatic habitat restoration and changes in outflow associated with water facilities and operations. Appendix 5.C, *Flow, Passage, Salinity and Turbidity*, provides further discussion and an overview of the effects of BDCP associated with flow and habitat restoration actions. Appendix 5.D, *Contaminants,* provides further discussion and an overview of the effects of habitat restoration and changes in flow conditions resulting from implementation of the BDCP.

In summary:

- **Salinity:** Under the preliminary proposal scenarios, X2 moves upstream (lower outflow) in some months, with the reduced inflows or higher exports that were allowed with the north Delta intake. However, the PP scenarios will meet the required D-1641 X2 locations from February through June.
- **Water Temperature and DO:** Water temperatures and DO in the Delta are primarily affected by atmospheric conditions (air temperature, winds, solar radiation, and climate change). Water temperatures are typically in thermal equilibrium with the atmospheric conditions and therefore are not influenced strongly by changes in river flows affected by proposed project operations. Similarly, DO concentrations in the river channels and bays are typically in equilibrium with atmospheric conditions, and proposed project operations are not anticipated to result in biologically significant changes in the Delta. As a result of these factors, it was concluded that proposed project operations will not result in adverse changes in either water temperatures or DO concentrations in the Delta that will affect the target species.
- **Turbidity:** The analysis focused on whether the different subregions will become erosional, which will increase turbidity, or depositional, which will decrease turbidity. The analysis also evaluated whether seasonal wind resuspension in ROAs is likely to be greater with BDCP,

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thereby increasing turbidity. Factors such as SAV, benthic filter feeders, organic materials, and the potential substantial effects on the critical shear stress of erosion from changes in benthic algae and macrofauna have not been considered in the present analysis of turbidity because of a lack of data, a lack of modeling tools, or both. These factors likely have relatively significant influence on turbidity levels, thus the analysis does not quantify effects but provides a relative expectation of whether turbidity will increase or decrease under BDCP. The Delta will remain regionally depositional in the LLT time frame, in both EBC and preliminary proposal scenarios, although the location of the depositional regions will differ. The effects of sea level rise will depend on the balance between sediment supply from the watersheds and the rate of sea level rise, so it is unclear whether sediment supply will be sufficient to maintain the current extent of tidal marsh. The initial effect of the ROAs in the preliminary proposal is to decrease sediment supply downstream, but the longer-term effects are uncertain as the ROAs reach a dynamic equilibrium.

- **Toxins:** Two pathways of effects on toxins are examined in Appendix 5.D, *Contaminants*, in connection with water operations; an increase in the proportional amount of flow from the San Joaquin River and a reduction in flow in the Sacramento River. The first pathway is the potential for increased loading of selenium from increased contributions of water from the San Joaquin watershed as Sacramento River inputs were diverted by north Delta intakes. Based on the evaluation of current and expected future reductions in selenium from the San Joaquin watershed, and source-water fingerprinting that indicates no increase of San Joaquin water contribution at Suisun Marsh and a only a slight increase in the south Delta, minimal effects on selenium or associated effects on covered fish species are expected.

- **Dilution Capacity:** The second issue connected to preliminary proposal water operations is the potential for decreased dilution capacity of the Sacramento River, especially for Sacramento Regional Wastewater Treatment Plant (WWTP) effluent, and more specifically for ammonia and pyrethroids. Modeling results presented in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity* indicate that reduced dilution capacity in the Sacramento River at the Sacramento WWTP will result from changes in upstream reservoir operations associated with the PP, not from diversion of water to the Yolo Bypass or from north Delta intakes located downstream of the WWTP. Quantitative analysis presented in this appendix indicates that the Sacramento River will have sufficient dilution capacity under the preliminary proposal for both ammonia and pyrethroids to avoid adverse effects from these toxins on the covered fish.

- Restoration actions will result in some level of mobilization and increased bioavailability of methylmercury, copper, and pesticides (including organophosphate, organochlorine and pyrethroid pesticides). Given current information, it is not possible to estimate the concentrations of these constituents that will become available to covered fish species, but review of the conceptual models for each of these toxins indicates that the effects should be limited both temporally and spatially. The most problematic of these potential effects is methylmercury. To address this issue, the Plan includes *CM12 Methylmercury Management,* which provides for site-specific assessment of restoration areas, integration of design measures to minimize methylmercury production, and site monitoring and reporting. The areas with the highest potential for methylmercury generation are the Yolo Bypass, and to a lesser extent, the Mokelumne-Cosumnes River. With the implementation of CM12, effects of methylmercury mobilization on covered fish at the tidal wetland restoration sites are expected to be minimized.

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In general, the following conclusions can be drawn regarding toxins.

- Preliminary proposal water operations will have few to no effects on toxins in the Delta.
- Preliminary proposal restoration will increase bioavailability of certain toxins, especially methylmercury, but the overall effects on covered fish species are expected to be localized and of low magnitude
- Available data suggest that species exposure to toxins will be below sublethal and lethal levels.
- The long-term benefits of restoration will reduce exposure to existing toxins in the environment and eliminate sources

5.4.1.2 Beneficial Effects

Restoring tidal perennial aquatic natural communities will benefit covered fish species by contributing to: an increase in primary productivity, which is essential to maintain a robust food base for covered fish species; increasing the extent of suitable rearing habitat for juvenile covered fish species, and; increasing the extent of potentially suitable spawning habitat for some covered fish species.

The habitat restoration actions have two principal objectives:

- To increase the amount of available habitat for covered fish species. This objective relates to the direct habitat needs unique to each species and life history stage, and
- To enhance the ecological function of the Delta.

For the expected benefits of restoring tidal perennial aquatic habitat, refer to Section 3.3.5, *Species Biological Goals and Objectives*, for discussion of the benefits of the restoration of tidal perennial aquatic habitat for each of the covered species (i.e. discussions of the benefits of the Natural Community Objectives TPANC1.1 and TPANC2.1). Further discussion of the effects of restoring tidal perennial aquatic natural community habitats is presented in Appendix 5.E, *Habitat Restoration*.

5.4.1.3 Net Effects

While construction activities associated with the north Delta diversion and the enhancement and restoration of natural community habitats will result in the permanent loss of an estimated 65 acres, the temporary loss of an estimated 125 acres and further periodic effects on an estimated 644 acres of tidal perennial aquatic natural community habitat, the overall restoration of 65,000 acres of tidal habitats, including 10,000 acres of tidal perennial aquatic habitat in Conservation Zones 1, 2, 4, 5, 7, and 11 will be a substantial increase in the amount of habitat contributing to primary productivity and food resources important to covered fish species. Specific restoration projects have not been designated. However, restoration sites will be designed to support habitat mosaics and an ecological gradient of shallow subtidal aquatic, tidal mudflat, tidal marsh, transitional uplands, and riparian habitats, as well as uplands (e.g., grasslands, agricultural lands) to accommodate anticipated future sea level rise, as appropriate to specific restoration sites.

Although specific locations for restoration actions have not been identified, general areas for expected restoration have been delineated as ROAs. ROAs are areas in BDCP subregions (Appendix 5.A, *Conceptual Foundation and Analytical Framework for Effects Analysis*) that have been identified as having particularly high potential for restoration. ROAs form the geographic scale of the evaluation of restoration potential that appears in Appendix 5.E, *Habitat Restoration.* Appendix 5.E

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also provides a brief description of the different ROAs, including location, connectivity to adjacent water bodies, predominant land use and existing vegetation, topographic and bathymetric data, and salinity ranges.

Also summarized in Appendix 5.E are the desired post restoration conditions for each ROA. These post restoration conditions are expected to produce physical and ecological functions in each ROA.

This substantial increase in tidal perennial aquatic habitat will help to offset the permanent and temporary effects and periodic effects mentioned above, as well as offset the historical loss of such habitat in the Plan Area.

5.4.2 Tidal Mudflat

The tidal mudflat natural community occurs in all conservation zones at the interface of tidal brackish and freshwater emergent wetlands and tidal perennial aquatic communities, and along river channels and slough margins. Tidal mudflat is not mapped in the Plan Area; it occurs in areas of disturbance or sediment deposition associated with various intertidal elevations of tidal brackish and tidal freshwater emergent wetlands, and with the upper elevations of the tidal perennial aquatic natural community. To a lesser degree, it also occupies microhabitats in areas of sediment deposition along natural and artificial levees in the valley/foothill riparian natural community, and seasonal floodplain and channel margin natural communities. Tidal mudflat often shifts in distribution over time and is sustained through disturbances to other nearby communities or through the deposition of mineral soil in the intertidal zone.

5.4.2.1 Adverse Effects

5.4.2.1.1 Permanent Loss and Fragmentation

Covered activities potentially resulting in permanent loss of the tidal mudflat natural community include tidal natural communities restoration, and seasonally inundated floodplain restoration. Because the tidal mudflat natural community is not mapped in the Plan Area, the acreage and distribution of loss cannot be determined. Furthermore, tidal mudflat is dynamic in its extent and distribution, shifting over time in response to multiple factors including fluvial, tidal, and erosional disturbances. Therefore, it is difficult to predict or quantify effects on this natural community potentially resulting from covered activities.

Tidal natural communities restoration will result in changes in the tidal range, which may increase the height of MLLW and reduce the height of the MHHW, narrowing the protective band of tules, bulrushes, and cattails and leading to higher rates of erosion and consequent increases in tidal mudflat natural community. The local persistence of tidal mudflat habitat will then depend on the persistence of the dominant species and the rates of sediment supply, making even qualitative predictions of potential effects on the natural community uncertain.

The removal of levees to restore seasonally inundated floodplains is expected to result in an indeterminate loss of narrow bands of tidal mudflat community that are often present at the interface of the water surface and the levee banks. Construction of low benches and other enhancement features along channel margins is also expected to result in the loss of narrow bands of tidal mudflat habitat that are often present at the interface of the water surface and levee banks.

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5.4.2.1.2 Periodic Inundation

The tidal mudflat natural community is not expected to be adversely affected by periodic inundation.

5.4.2.1.3 Construction-Related Effects

The construction of intake facilities will result in the temporary removal of an indeterminate extent of the tidal mudflat community that occurs as narrow bands along river channel margins. These removed areas of tidal mudflat community are expected to be reestablished through natural processes along the altered channel margins following the completion of intake facility construction. Noise and visual disturbances during the construction and subsequent maintenance of the intake facilities (including human activities at work sites, staging areas, spoils sites, and other work areas along the construction corridor) could temporarily disturb covered and other native wildlife that use the surrounding tidal mudflat community. These effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.2.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

No adverse effects on the tidal mudflat natural community are expected to result from facilities operation and maintenance.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected areas supporting tidal mudflat natural community, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. These effects are expected to be minimal, and will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

Other Indirect Effects

No data exist that enable quantifiable predictions of BDCP operations-driven changes of water salinity effects on the tidal mudflat community. Increases or decreases in channel water salinity could temporarily increase or reduce local dominance of some species until a new dynamic equilibrium is established, but the potential changes are indeterminate.

5.4.2.2 Beneficial Effects

The restoration of 65,000 acres of tidal natural communities (CM4) is expected to benefit tidal mudflat. Tidal restoration along an elevation gradient will result in a range of intertidal zones, within which tidal mudflat is expected to develop between shallow subtidal aquatic (tidal perennial aquatic) areas and emergent marsh plains (tidal and freshwater emergent wetland). At least 20 linear miles of transitional intertidal areas, including tidal mudflat natural community and patches of subtidal and lower marsh, will be restored in the restored tidal natural communities.

Seasonally inundated floodplain restoration (CM5) and channel enhancement (CM6) are expected to promote development of the types of mudflats that occur adjacent to riparian natural communities

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along channel margins. These mudflats develop as a result of fluvial processes and sediment deposition, and provide substrate that supports covered plant species including delta mudwort, Delta tule pea, Mason's lilaeopsis and Suisun Marsh aster. Furthermore, fluvial processes are instrumental in the production of tidal mudflat through sediment transport to intertidal areas. Nonnative invasive plants can encroach into tidal mudflats and thereby diminish the extent of this natural community. Invasive plants will be managed as needed to protect tidal mudflats (CM11).

5.4.2.3 Net Effects

The extent and distribution of tidal mudflat natural community that will be adversely affected by BDCP covered activities cannot be determined with existing information, because this natural community was not mapped and it is a dynamic component of tidal and fluvial systems in the Plan Area as microhabitats that shift over time in tidal and riparian natural communities in response to a complexity of environmental variables. The BDCP will benefit this natural community through tidal restoration (CM4), which will result in at least 20 miles of tidal edge, a portion of which is expected to support tidal mudflats, and through floodplain restoration (CM5) and channel enhancement (CM6) to provide tidal mudflat for rare plant species along rivers and channels.

5.4.3 Tidal Brackish Emergent Wetland

The extent of this natural community in the Plan Area is entirely in Conservation Zone 11 (Suisun Marsh).

5.4.3.1 Adverse Effects

5.4.3.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in permanent loss of up to 515 of tidal brackish emergent wetland natural community, all from tidal habitat restoration activities (site preparation and inundation) to occur in Suisun Marsh (Conservation Zone 11) (Table 5.4-1). Because the loss estimates from tidal restoration are based on hypothetical footprints and the tidal restoration model rather than detailed project-level design, actual permanent loss of tidal brackish emergent wetland natural community will likely differ from this estimate. However, loss of this community type will be tracked through compliance monitoring to ensure that the total permanent loss of tidal brackish emergent wetland resulting from covered activities does not exceed 515 acres.

5.4.3.1.2 Periodic Inundation

Periodic inundation related to Yolo Bypass operations and floodplain restoration will not affect this natural community.

5.4.3.1.3 Construction-Related Effects

Construction equipment for tidal habitat restoration could disturb, injure, or kill native wetland wildlife. Noise and visual disturbances during these construction activities could result in temporary disturbances that will affect native wildlife use of tidal brackish marsh habitat. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. These effects will

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be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.3.1.4 Effects of Ongoing Activities

Operation and Management

Ongoing operation and maintenance activities are not expected to result in adverse effects on tidal brackish emergent wetlands.

Habitat Enhancement and Management

Habitat enhancement and management activities in tidal brackish marsh could result in temporary vegetation changes, but effects on desirable native plants will be minimal as enhancement and management actions will be targeted to control undesirable or non-native plant species that are limiting the tidal marsh restoration goals.

5.4.3.1.5 Other Indirect Effects

Invasive Plants

Ground disturbance associated with tidal restoration will increase opportunities for colonization for invasive species such as nonnative cordgrass (*Spartina alterniflora*), which could exclude establishment of native tidal brackish emergent wetland species.

Methylmercury

Tidal natural communities restoration is expected to result in the methylation of mercury contained in the sediment of restored areas that could adversely affect long-lived fish such as sturgeon and increase the risk of mercury bioaccumulation in wildlife that feed in aquatic and marsh habitats. Increases in methylmercury production are attributable to tidal restoration are estimated for the Bay-Delta. In contrast, the Suisun Management Plan (Bureau of Reclamation et al. 2010) anticipates that tidal restoration under the Plan will generate less methylmercury than existing managed wetlands, because daily tidal flushes prevent low dissolved oxygen conditions needed to methylate mercury. Additionally, it is not feasible with available information to predict how much of the methylmercury produced in restoration area substrates would be transported to the water column where it would be available to the predominantly pelagic foodweb for listed species. However, *in situ* methylmercury production would have the potential for direct effects on the benthic community and animals that feed on small fish near the bottom. Currently, it is unknown if or how much of the sediment-derived methylmercury in the Bay-Delta system enters the food chain or what tissue concentrations are harmful to covered species or other wildlife.

Temperature

Tidal natural communities restoration will potentially affect water temperatures, although this effect has not been quantified. Restoring tidal exchange to broad, shallow areas will subject the water column to temperature influences from the atmosphere that will be based on the timing and duration of the inundation and ambient weather conditions (e.g., air temperature, insolation, and wind mixing effects). It is hypothesized that occurrence of extreme high tides at night may contribute to a cooling effect from restored tidal habitats. Effects of tidal habitat restoration on water temperature have not been modeled or predicted in detail but are expected to result in

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localized changes that could include increased or decreased temperature of water exported to adjacent channels. These changes will affect aquatic life if they occurred at/near critical temperature thresholds for various life stages and/or functions. Temperature effects are expected to be more dramatic for tidal emergent habitats than for subtidal habitats, based on water depths.

5.4.3.2 Beneficial Effects

At least 4,800 acres of tidal brackish emergent wetland community will be restored in Conservation Zone 11 (CM4). Tidal natural communities restoration will decrease habitat fragmentation by providing additional connectivity between isolated patches of tidal brackish emergent wetland. Changes in water operations will restore parts of Suisun Marsh to more natural salinity levels and tidal regimes, resulting in changes in plant composition in the natural community, at some locations (e.g., increased saltgrass and pickleweed where less inundation results in increased salinity). Restored tidal marshes are expected to provide increased phytoplankton production which will benefit zooplankton such as copepods that are an important prey item for listed fish (e.g., delta smelt, longfin smelt, and splittail), other estuarine fish, and other aquatic organisms. Substrates in restoration areas will provide habitat for macroinvertebrates which will also result in beneficial food web effects. Vegetation in these areas is expected to provide diverse functions including food web/detritus production, refuge and nursery areas for aquatic species, and water quality renovation and nutrient cycling functions.

Tidal brackish emergent wetland will benefit from the BDCP climate change adaptation strategy. Currently unprotected upland areas around the fringe of existing tidal brackish emergent wetland will be protected, to provide opportunities for this community to migrate upslope in response to sea level rise.

Much of the fringe TBEW in Suisun is susceptible to wave erosion in storms because wave energy hits levees. Restoring a complete marsh plain will help TBEW be more resilient to storm events, which are expected to increase in frequency and severity with climate change. BDCP will provide a large, unfragmented expanse of tidal brackish emergent wetland natural community that will have a diversity of plant species and vegetation structure, as well as topographic heterogeneity, providing habitat value for covered species and a diversity of native wildlife.

Habitat quality is expected to increase as a result of tidal marsh restoration and changes in salinity levels and tidal regimes from water operations. The potential for any adverse effects of mercury methylation will be minimized with the implementation of methylmercury management avoidance and minimization measures. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under that plan will generate less methylmercury than the existing managed wetlands. For BDCP, it has been conservatively assumed that management measures will result in a 10 percent reduction in methylmercury production in restoration areas. This value could be substantially higher depending on final determinations of need for fill and/or regrading to achieve targeted elevations in restoration areas. Additionally, it is anticipated that long-term monitoring for methylmercury effects will lead to increased understanding of the propensity for methylation to occur in various habitats/substrate types, and the factors affecting transport and bioaccumulation.

The general overall effect of water operations will be a return to more-natural salinity and tidal range conditions. However, both the rate of change from current conditions to future conditions and

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changes in the extent and location of the tidal emergent wetland community are highly uncertain, especially with sea level rise due to climate change.

Future conditions in restored tidal marsh emergent wetland are projected to include:

- Growth of tules (*Schoenoplectus californicus* and *S. acutus*) and cattails (*Typha*) lining the larger channels with *S. californicus* growing outward into the channels to elevations of 35 cm below MLLW.
- Growth of bulrushes (*S. americanus* and *Bolboschoenus maritimus*) from the upper margin of the channel to the marsh plain, as soil conditions become increasingly saline.
- Conversion of tall emergent vegetation to low vegetation consisting initially of saltgrass (*Distichlis spicata*) and then to pickleweed (*Sarcocornia pacifica*) with increases in soil salinity and decreases in inundation duration.

5.4.3.3 Net Effects

Implementation of the BDCP will result in overall benefits for the tidal brackish emergent wetland natural community through restoration of 4,800 acres of this community. BDCP actions are expected to permanently remove 515 acres of tidal brackish marsh habitats, respectively (Table 5.4-2). The projected 515 acres of habitat loss will be phased with about half (245 acres) the habitat loss occurring by the near-term evaluation point of the project, and two-thirds (351 acres) by the near long-term evaluation point. This will allow some affected areas to recover before new effects are initiated.

Following implementation of tidal marsh restoration actions, there will be a 51% increase in the total extent of tidal brackish marsh habitats in the Plan Area (Table 5.4-2). Restored tidal brackish marsh natural community is expected to support higher habitat functions for associated covered and other native wildlife species because most is protecting habitat, and future restoration will connect isolated patches of existing tidal brackish marsh habitat in the Plan Area. Restored and existing sites will also function more naturally relative to salinity levels and tidal regimes with proposed changes in water operations. Restored habitat is also expected to reduce contaminants by producing less methylmercury than managed wetlands. Restoration and subsequent management of this community to maintain its ecological functions is expected to benefit aquatic food web processes in support of the covered and other native fish species and covered and other native wildlife and plant species dependent on Suisun Marsh tidal habitats.

5.4.4 Tidal Freshwater Emergent Wetland Natural Community

Tidal freshwater emergent natural community is present in all conservation zones in the Plan Area, but is most prominent in the central Delta.

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5.4.4.1 Adverse Effects

5.4.4.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in the permanent loss of up to 93 acres[1] of the tidal freshwater emergent wetland natural community (1% of this natural community in the Plan Area) (Table 5.4-1). Most (91%) of this loss will result from tidal natural communities restoration, which will result in desiccation due to the reduced high tide range predicted to result from tidal habitat restoration. Most of this loss will occur in small patches in the highest reaches of tidal influence such as in the Cosumnes and Mokelumne river confluences (Conservation Zone 4) where over 61 percent of the loss will occur.

5.4.4.1.2 Periodic Inundation

The only BDCP covered activity that will result in periodic inundation of tidal freshwater emergent wetland is inundation of Yolo Bypass.

Yolo Bypass Operations

This activity will periodically inundate 111 acres of the tidal freshwater emergent wetland natural community (Table 5.4-1). Tidal freshwater emergent community, mostly at the south end of the Yolo Bypass and in narrow bands along drainages, is tolerant of, and will not be adversely affected by, the increase in frequency and duration of flood flows.

5.4.4.1.3 Construction-Related Effects

BDCP construction activities will result in the temporary loss of up to 11 acres of the tidal freshwater emergent wetland natural community. All areas of vegetation removal associated with construction activities, such as staging areas, temporary roads, and pipeline corridors, will be revegetated to promote restoration of the area with the expectation of recovery to pre-project conditions in a few years. These minimization measures are described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.4.1.4 Effects of Ongoing Activities

The only ongoing covered activities that will affect this natural community are natural communities enhancement and management.

Natural Communities Enhancement and Management

Habitat enhancement and management may at times result in the removal of vegetation in this community. However, because the removal will target plant species considered detrimental to the natural communities health or recovery, the overall effects are not considered adverse.

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[1] Because affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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5.4.4.1.5 Other Indirect Effects

Water operations are generally not expected to affect the dominant plant species of this community, with the possible exception of the western Delta where there is a transition from fresh to brackish water. The changed salinity conditions in the western Delta are expected to be small, subtle, and complex, which leads to uncertainty in determining their effects on the tidal freshwater emergent wetland community (see Appendix 5.E, *Habitat Restoration*, for details). A shift of higher salinity water from Suisun Bay up the Sacramento and San Joaquin rivers from changes in water operations or climate change may reduce the composition of woody species, such as willow, that co-dominate this community with bulrushes and tules. These changes may affect covered species that use woody riparian (e.g., riparian passerine birds), but not those that are typically found in emergent wetlands (e.g., California black rail). The overall magnitude of the effect on native species is expected to be very low.

5.4.4.2 Beneficial Effects

The implementation of CM4, *Tidal Natural Communities Restoration*, will restore 65,000 acres of tidal habitats, including at least 13,900 acres of tidal freshwater emergent wetland community in Cache Slough (Conservation Zone 1, 2, and 3), the Cosumnes-Mokelumne area (Conservation Zone 4), West Delta (Conservation Zone 5 and 6), and South Delta (Conservation Zone 7) ROAs. Achieving this objective will promote vegetation diversity and structural complexity (as incorporated into the restoration design) in restored tidal freshwater marsh. High plant diversity and vegetation structure creates a variety of ecological niches to support high wildlife diversity. The diversity of plant types in freshwater tidal marshes provides complex structure that supports a greater diversity of animals, especially birds and insects, than in saline marshes (Nobriga 2008).

Additionally, reducing the introduction and proliferation of nonnative plant species will benefit native plants and wildlife using the tidal freshwater emergent wetland natural community. The tidal marsh will be monitored and nonnative invasive species will be controlled if they pose a threat to covered species populations or native plant diversity, as described in *CM11 Natural Communities Enhancement and Management*.

5.4.4.3 Net Effects

Full implementation of the BDCP will result in a 13,807-acre (154%) increase (13,900-acre gain vs. 93-acre loss) of the tidal freshwater marsh natural community in the Plan Area (Table 5.4-2). The restored tidal freshwater emergent wetland community is expected to provide higher habitat quality for associated-covered and other native plants and wildlife species because it is expected to be much larger in size and provide greater habitat diversity and structural complexity than the existing tidal freshwater emergent wetlands that primarily occur in small and isolated patches of tules. Follow-up enhancement and management measures will help to ensure restoration success over the long term. Tidal restoration will be timed to ensure that it stays ahead of the loss of tidal natural communities (Figure 5.4-1).

5.4.5 Valley/Foothill Riparian

There are 17,930 acres of valley/foothill riparian natural community distributed widely across the Plan Area, in all conservation zones.

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5.4.5.1 Adverse Effects

5.4.5.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in the permanent loss of up to 1,070 acres[2] of the valley/foothill riparian natural community (6% of this natural community in the Plan Area), including 24 acres from conveyance facility construction, 225 acres from Fremont Weir/Yolo Bypass improvements, 778 acres from tidal natural communities restoration, and 43 acres from levee construction for floodplain restoration (Table 5.4-1). Although the greatest loss (73%) is from tidal natural communities restoration, the estimate of loss resulting from tidal restoration is based on projections of where restoration may occur, and actual loss is expected to be lower because of the ability to select sites that minimize effects on valley/foothill riparian natural community. Actual loss will be tracked through compliance monitoring to ensure that it does not exceed this estimate.

The valley/foothill riparian natural community that will be removed consists mostly of small, fragmented patches and narrow strips of trees along waterways. These areas are not likely to provide significant, intact wildlife movement corridors and are vulnerable to edge effects such as run-off from adjacent development and agriculture, human disturbance, and encroachment of invasive plants and nonnative predators.

The quality of the natural community to be removed was evaluated by categorizing each mapped polygon of riparian vegetation that will be removed, based on the hypothetical footprints, as supporting low, moderate, or high habitat functions for riparian-associated and other native wildlife based on the following criteria:

- Polygon size (size of the patch of riparian vegetation within which loss will occur).
- Type of vegetation (woodland, scrub, or herbaceous).
- Extent and structural qualities of riparian vegetation (dense multistoried vegetation versus a few trees with no understory) within the polygon.
- Hydrology and connectivity (on the banks of an active, unarmored stream or in a floodplain, or an isolated patch with no connection to a channel.
- The ability of the vegetation to rapidly restore (e.g., a site that consists of willow or blackberry scrub can recover quickly compared with a mature woodland, and so it was given a lower rating).

Based on this analysis, over two-thirds of all riparian polygons overlapping with the hypothetical covered activity footprints are smaller than 1 acre (Figure 5.4-2). Out of 361 habitat patches, only 12 (3%) were greater than 10 acres in size. One limitation of this analysis, however, is that patches that consisted of different vegetation alliances but that were connected to each other were counted separately instead of lumped together. Based on the quality analysis and as shown in Figure 5.4-3, most of the habitat lost is low and moderate quality valley/foothill riparian natural community.

[2] Because affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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5.4.5.1.2 Periodic Inundation

Yolo Bypass Operations

This activity will periodically inundate 265 acres of the valley/foothill riparian natural community. The inundated area will include the highest quality riparian patches consisting of woodland at the northern end of the Plan Area just below Fremont Weir and along Putah Creek, with recorded occurrences for Swainson's hawk and nearby rare sighting for least Bell's vireo; although these areas are already affected by periodic inundation of the bypass under existing conditions. No adverse effects of increased inundation frequency will result because these valley/foothill riparian stands have persisted under the existing Yolo Bypass inundation regime and changes to frequency and inundation are within the tolerance of the riparian species. Inundation of the valley/foothill riparian community will promote the germination and establishment of native riparian plants.

Floodplain Restoration

This activity will result in seasonal inundation of approximately 43 acres of valley/foothill riparian natural community. Because inundation will occur infrequently (e.g., every 5 years), the potential effects on composition, distribution, and density of riparian vegetation are minimal. Furthermore, as described below under *Beneficial Effects*, floodplain restoration and periodic inundation are expected to .be a net benefit to this natural community

5.4.5.1.3 Construction-Related Effects

Approximately 170 acres of valley/foothill riparian natural community will be temporarily removed as a result of development of water conveyance facilities (22 acres), Yolo Bypass fisheries enhancement construction (112 acres), and construction of setback levees (35 acres). Temporarily affected areas will be restored as riparian habitat within 1 year following the completion of construction activities, but are not expected to mature to pre-project conditions for several years or more, depending on the successional stage of the affected area. The time it will take for the restored riparian habitat to develop such that the habitat functions of the affected habitat are replaced may range from 5 years to several decades, depending on the type of affected riparian habitat. However, most of the affected habitat consists of riparian scrub, and habitat functions for this type of vegetation can typically be replaced in 5 years. Habitat for species that require early- to mid-successional riparian, such as yellow-breasted chat and least Bell's vireo, can be restored within 5 years (Kus 2002). To offset the effects of temporal loss, at least 100 acres of high quality valley/foothill riparian community, in patches of at least 25 acres in size in Conservation Zone 7 along the San Joaquin River, will be protected within the first 5 years of Plan implementation.

5.4.5.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Operation or construction equipment for water conveyance construction, Yolo Bypass fisheries enhancement, and tidal habitat restoration may injure or kill native riparian wildlife. Noise and visual disturbances during these construction activities could result in temporary disturbances that will affect native wildlife use of the valley/foothill riparian community. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. These effects will be

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minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Habitat Enhancement and Management

Activities associated with implementation of natural communities enhancement and management in the protected valley/foothill riparian natural community, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. These effects are expected to be minimal, and will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

5.4.5.1.5 Other Indirect Effects

Water operations will result in salinity changes that could affect the valley/foothill riparian natural community. However, data is lacking on the salinity tolerances of riparian plants. Changes in channel water salinity may cause plant species shifts in the lower Delta, but the effect cannot be predicted even qualitatively due to the inherent variability of the system. Changes in tidal stages that increase MLLW and reduce MHHW may cause a corresponding shift in riparian vegetation, but this potential effect is also difficult to predict. Muted tidal ranges will complicate this scenario by narrowing the protective band of tules, bulrushes, and cattails independent of channel water salinity, leading to higher rates of erosion. Riparian restoration projects will be focused in areas least likely to be adversely affected by salinity changes (e.g., north of the intakes, and in Conservation Zones 7 which has freshwater influence from San Joaquin River). Salinity effects on restored valley/foothill riparian natural community will be monitored and riparian restoration efforts will be adaptively managed to ensure that restoration targets are met in areas that do not experience stress due to high salinity that might reduce the diversity and habitat functions of the community.

5.4.5.2 Beneficial Effects

The Implementation Office will restore 5,000 acres of riparian forest and scrub in Conservation Zones 1, 2, 4, 5, 6, and 7 (CM7), and protect 750 acres of existing valley/foothill riparian natural community (CM3). Approximately 2,000 acres of riparian restoration will be distributed in tidal and channel margin restoration areas and will occur generally as long narrow strips. The majority of restoration, approximately 3,000 acres, will occur in the south Delta seasonal floodplain restoration site in Conservation Zone 7, where the lack of existing constraints allows restoration of larger tracts of riparian natural community. Large tracts of this vegetation are an important component of habitat for covered species such as the yellow-billed cuckoo, which only breed in large patches (minimum 100 acres) of habitat. The establishment of large tracts of riparian community will also establish large core areas that are better buffered from encroachment of humans, invasive plants, and nonnative animals as well as from noise and other disturbances associated with surrounding agricultural and urban land uses. Restoration of riparian community in Conservation Zone 7 will also provide habitat for riparian brush rabbit and riparian woodrat which have a very limited distributions, restricted only to areas within and adjacent to Conservation Zone 7.

Riparian restoration in the Plan area will create the potential for many species to recolonize some of their historical range. Several BDCP covered species, such as yellow-billed cuckoo, least Bell's vireo, riparian brush rabbit, side-flowering skullcap, and valley elderberry longhorn beetle are riparian obligates and are found almost exclusively in this natural community. Other species, such as Swainson's hawk and white-tailed kite, forage in open country, but nest in tall trees, often in patches

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of riparian forest. For many of the BDCP covered species, as well as numerous other native riparian species, population declines and/or range contractions have been linked to loss of riparian habitat. The restoration or creation of 5,000 acres and protection of 750 existing acres in the Plan Area will be an important step toward the conservation and recovery of those species.

The structural heterogeneity of riparian vegetation, including understory (low shrubs), midstory (large shrubs and small trees) and overstory (upper canopy formed from large trees), will be enhanced and maintained. Both early to mid-successional and late successional riparian vegetation will be maintained (CM7, CM11). This will provide habitat requirements for a diversity of wildlife species. Different bird species nest and forage at different vegetation heights, necessitating the presence of multiple vegetation layers. Low shrubs provide cover for many wildlife species, tall trees provide perching opportunities, and canopy cover provides shading. Horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands increases opportunities for insects produced in riparian vegetation to be distributed into channels and other communities to provide food supply for wildlife.

5.4.5.3 Net Effects

Full implementation of the BDCP will result in an approximately 4,680-acre (26%) increase of the valley/foothill riparian natural community in the Plan Area (Table 5.4-2) and a 5,720-acre (105%) increase of this natural community in protected lands.

The valley/foothill riparian natural community that will be removed consists mostly of small, fragmented patches and narrow strips of trees along waterways. These areas are not likely to provide significant, intact wildlife movement corridors and are vulnerable to edge effects such as run-off from adjacent development and agriculture, human disturbance, and encroachment of invasive plants and non-native predators. The valley/foothill natural community that will be restored will consist of some narrow strips and small patches along channel margins and adjacent to tidally restored areas, but most of the restored natural community and all of the 750 acres of protected natural community will consist of large, interconnected riparian areas that will exhibit structural heterogeneity and will be managed and enhanced to provide high habitat value for covered species and other native riparian species in the Plan Area. As shown on Figure 5.4-3, riparian restoration will stay ahead of riparian loss throughout the permit term.

5.4.6 Nontidal Perennial Aquatic and Nontidal Freshwater Perennial Emergent Wetland Natural Community

5.4.6.1 Adverse Effects

There are 1,135 acres of nontidal perennial aquatic natural community and 5,421 acres of nontidal perennial emergent wetland natural community distributed throughout the Plan Area in all conservation zones. These natural communities occur in the Plan Area mostly as small isolated patches and along drainage and irrigation ditches in a cultivated landscape.

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5.4.6.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in the permanent loss of up to 92 acres[3] of the nontidal perennial freshwater emergent wetland (8% of total in Plan Area) and 245 acres of nontidal perennial aquatic natural community (4% of total in Plan Area) (Table 5.4-1). Covered activities resulting in permanent loss of nontidal perennial freshwater emergent wetland include conveyance facilities construction and tidal natural communities restoration: most (91 of 92 acres) results from tidal natural communities restoration. Covered activities resulting in permanent loss of nontidal perennial aquatic natural community include conveyance facility construction, tidal natural communities restoration, Fremont Weir/Yolo Bypass improvements, and floodplain restoration: most (71%) of this loss results from tidal natural communities restoration. The natural communities that will be lost are low quality in that they consist of small patches and narrow, linear ditches and canals in a cultivated landscape.

5.4.6.1.2 Periodic Inundation

Periodic inundation is not expected to result in adverse effect on nontidal perennial freshwater emergent wetland or tidal perennial aquatic natural communities, because inundation is a necessary component sustaining these natural communities.

5.4.6.1.3 Construction-Related Effects

Construction of conveyance facilities, Fremont Weir/Yolo Bypass Improvements, and levees for floodplain restoration will result in temporary loss of approximately 36 acres of nontidal perennial aquatic (0.6% of total in Plan Area) natural communities. Temporarily disturbed areas will be restored to preproject conditions within 1 year after construction is completed.

Vernal pool complex could be affected in the vicinity of tidal restoration construction activities. These effects could include hydrologic alteration, run-off and sedimentation from construction sites, or petroleum and contamination spills. These effects, however, will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.6.1.4 Effects of Ongoing Activities

Operations and Maintenance

Future operations and maintenance activities could result in ongoing temporary periodic noise and visual disturbances that could affect native wildlife use of the surrounding nontidal marsh natural community. In addition, while maintenance activities are not expected to remove grassland communities, operation of equipment could temporarily disturb small areas of vegetation around maintained structures. These effects will be minimized with the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

[3] Because affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Management and Enhancement

Activities associated with implementation of natural communities enhancement and management within the protected and enhanced nontidal perennial aquatic and nontidal freshwater emergent natural communities, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. These effects are expected to be minimal, and will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

5.4.6.2 Beneficial Effects

Full BDCP implementation will result in restoration of 400 acres of nontidal marsh, consisting of at least 250 acres of nontidal perennial aquatic and at least 100 acres of nontidal perennial freshwater emergent wetland (the remainder of which will consist of either or both of these two communities). The restoration will occur in blocks that will be contiguous with the larger reserve system. The nontidal marsh will be restored in the vicinity of giant garter snake subpopulations identified in the recovery plan for this species (U.S. Fish and Wildlife Service 1998): one in Conservation Zone 2 in the vicinity of the Yolo Bypass/Willow Slough population and one in Conservation Zone 4 in the vicinity of the Coldani Marsh/White Slough population. The restoration natural communities will be managed to maintain native biodiversity and to sustain giant garter snake and western pond turtle populations.

5.4.6.3 Net Effects

Full implementation of the BDCP will result in an approximately 5-acre (0.1%) increase in nontidal perennial aquatic and an approximately 58-acre (5%) increase in nontidal perennial freshwater emergent wetland in the Plan Area (Table 5.4-2). The natural communities to be lost consist of small, fragmented patches and linear canals and ditches in a cultivated landscape. The restored natural communities will consist of relatively large, unfragmented patches that will be located in areas most beneficial to giant garter snake and will be managed to support western pond turtle and to sustain native biodiversity. The BDCP will result in a net benefit to this natural community. Nontidal marsh restoration will be timed to ensure that it stays ahead of the loss of nontidal aquatic and wetland natural communities (Figure 5.4-4).

5.4.7 Alkali Seasonal Wetland

There are 3,722 acres of alkali seasonal complex wetland natural community scattered throughout the Plan Area in all conservation zones except Conservation Zone 3. Most (74%) of the alkali seasonal wetland complex consists of relatively large patches in Conservation Zone 2, on Category 1 open space[4] on and near Tule Ranch. The remainder consists of small patches in a matrix of grassland and vernal pool complex natural communities. Factors considered in assessing the quality of alkali seasonal wetland natural community, to the extent that information is available, include patch size, connectivity with other natural communities, proximity to protection lands (Categories 1 and 2 open space), and presence of covered species occurrences in the vicinity.

[4] See Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories.

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5.4.7.1 Adverse Effects

5.4.7.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in the permanent loss of up to 136 acres[5] of the alkali seasonal wetlands natural community (4% of this community in the Plan Area), including 91 acres from tidal natural communities restoration and 45 acres from Fremont Weir/Yolo Bypass improvements (Table 5.4-1).

Tidal restoration will convert approximately 91 acres of this community to tidal natural communities in Conservation Zone 1, in the Cache Slough ROA, where this natural community occurs in a transitional area between tidal freshwater emergent wetlands in Lindsey Slough and adjacent grasslands and vernal pool complex. The alkali seasonal wetland complex that will be removed is considered moderate to high quality: although it is present in small patches and consists of the more common, saltgrass dominated alkali seasonal wetland rather than the less common woody iodine bush scrub type, it occurs in a matrix of other natural community types, is in and near category 1 open space, and is contiguous with high quality grasslands and vernal pool complex with many covered species occurrences in the Jepson Prairie area. Tidal restoration will not result in fragmentation of this natural community because the affected areas are on the edges of alkali seasonal wetland complex in Conservation Zone 1.

Fremont Weir/Yolo Bypass improvements will remove 45 acres of alkali seasonal wetland natural community in Conservation Zone 2, as a result of Putah Creek realignment. The alkali seasonal wetland complex that will be removed is considered moderate to high quality: although it consists of the more common, saltgrass dominated alkali seasonal wetland rather than the less common woody iodine bush scrub type and there are few covered species occurrences in the vicinity, it is part of a relatively large, contiguous patch of alkali seasonal wetland and is in category 1 open space. Putah Creek realignment will not result in fragmentation of this natural community because the affected areas are on the edges of alkali seasonal wetland complex in this area.

5.4.7.1.2 Periodic Inundation

The only covered activity that will result in periodic inundation of alkali seasonal wetlands is Yolo Bypass operation.

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Appendix 5.K, Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 145 acres of alkali seasonal wetland complex. The alkali seasonal wetland complex that will be inundated is considered moderate to high quality: although it consists of the more common, saltgrass dominated alkali seasonal wetland rather than the less common woody iodine bush scrub type and there are few covered species occurrences in the vicinity, it is part of a relatively large, contiguous patch of alkali seasonal wetland and is in category 1 open space. This natural community is adapted to seasonal inundation and adverse effects from inundation are expected to be minimal, if any: plant composition may shift if the

[5] Because affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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duration of inundation is increased, but not to the extent that it is expected to convert to a different natural community type.

5.4.7.1.3 Construction-Related Effects

Construction-related activity will not result in temporary loss of alkali seasonal wetland complex natural community. Alkali seasonal wetland complex could be affected in the vicinity of Putah Creek realignment. These effects could include hydrologic alteration, run-off and sedimentation from construction sites, or petroleum and contamination spills. These effects, however, will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.7.1.4 Effects of Ongoing Activities

Activities associated with implementation of natural communities enhancement and management in the protected and enhanced alkali seasonal wetland natural community, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. These effects are expected to be minimal, and will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

5.4.7.2 Beneficial Effects

At least 150 acres of protected alkali seasonal wetland will be protected in Conservation Zones 1, 8, or 11, in a mosaic of protected grasslands and vernal pool complex (CM3). This will result in protection of the highest quality currently unprotected alkali seasonal wetland complex in the Plan Area. Alkali seasonal wetlands in Conservation Zones 1, 8, and 11 occur in a matrix of grasslands and vernal pool complex in a large, unfragmented natural landscape supporting a diversity of native plant and wildlife species. Protection of alkali seasonal wetland complex in Conservation Zone 8 provides the only opportunity in the Plan Area to protect the rarer woody iodine bush scrub type alkali seasonal wetland natural community. Protected alkali seasonal wetland complex will be managed and enhanced to maintain appropriate seasonal inundation with overland flow and some ephemeral ponding: conditions necessary to sustain native species adapted to seasonally wet conditions in alkaline soils (CM11). The protected alkali seasonal wetlands will also be managed and enhanced to increase the cover of native alkali seasonal wetland plants relative to invasive nonnative species, to minimize competition posed by invasive plants to native plant species, and improve overall habitat suitability for native wildlife, through activities such as control of invasive plants and fencing alkali seasonal wetland areas to protect them from adverse effects of grazing livestock (CM11).

5.4.7.3 Net Effects

Full implementation of the BDCP will result in an approximately 132-acre (0.4%) decrease of the alkali seasonal wetland natural community in the Plan Area (Table 5.4-2) and a 150-acre (3%) increase of this natural community in protected lands.

The quality of alkali seasonal wetland that will be adverse affected is low to moderate quality, in that it is consists of portions of relatively large patches of alkali seasonal wetland, or occurs in a matrix of grasslands and vernal pool complex, in an intact natural landscape in or near existing protected lands, and has covered species occurrences in the vicinity. The rarer iodine scrub type of alkali seasonal wetland complex will be adversely affected by BDCP activities. The alkali seasonal wetland

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that will be protected will be high quality, occurring in a matrix of grasslands and vernal pool complex that forms an unfragmented landscape with many covered species occurrences and near existing protected lands (CM3). The rarer iodine bush scrub type of alkali seasonal wetland will be protected in Conservation Zone 8. The protected alkali seasonal wetlands will be managed and enhanced to sustain or increase native biodiversity (CM11). Full implementation of the BDCP will result in a net benefit to the alkali seasonal wetland complex natural community. Alkali seasonal wetland protection will be timed to ensure that it stays ahead of the loss of the alkali seasonal wetland natural community (Figure 5.4-5).

5.4.8 Vernal Pool Complex

There are 7,098 acres of vernal pool complex natural community in the Plan Area, in Conservation Zones 1, 2, 4, 5, 8, 9, and 11. Core recovery areas identified in the vernal pool recovery plan (U.S. Fish and Wildlife Service 2005) overlap with portions of Conservation Zone 1 (Jepson Prairie core recovery area), Zone 11 (Jepson Prairie and Suisun core recovery area), and Zone 8 (Altamont Hills core recovery area). Most of the community present in Conservation Zones 2 and 4 are in protected lands (Category 1 or 2 open space[6]), and vernal pool complex in Conservation Zone 9 consists of small patches that are isolated among developed areas and cultivated land.

5.4.8.1 Adverse Effects

5.4.8.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in the permanent loss of up to 88 acres[7] of the vernal pool complex natural community (1% of this natural community in the Plan Area), all of which will result from tidal natural communities restoration in the Cache Slough ROA (Conservation Zone 1) and Suisun ROA (Conservation Zone 11) (Table 5.4-1).

Loss of the highest quality vernal pool complex will take place in the Cache Slough ROA in Conservation Zone 1, along the upper edges of Lindsey Slough and Hass Slough. The vernal pool complex that will be lost in this area occurs along the edge of Lindsey Slough and is part of a large, unfragmented expanse of vernal pool complex in the Jepson Prairie Core Recovery Area; however, the tidal restoration at Lindsey Slough will occur along the northeastern edge of this large block of vernal pool complex and will not contribute to fragmentation. The vernal pool complex that will be lost to tidal restoration in the Suisun ROA, along the eastern boundary of Conservation Zone 1, is dotted along the northern and eastern boundaries of Suisun Marsh. Along the northern boundary of Suisun Marsh, the vernal pool complex that will be lost is north of the Portrero Hills Landfill entrance, directly adjacent to existing category 1 open space and part of the Jepson Prairie Core Recovery Area identified in the vernal pool recovery plan (U.S. Fish and Wildlife Service 1998).

Because the estimates of natural community loss resulting from tidal inundation are based on projections of where restoration may occur, actual loss is expected to be lower because of the ability to select sites that minimize effects on rare natural communities such as vernal pool complex.

[6] See Section 5.3.5.2 *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories.

[7] Because affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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5.4.8.1.2 Periodic Inundation

The only activity potentially adversely affecting vernal pool complex through periodic inundation is Yolo Bypass operations.

Yolo Bypass Operations

This activity may result in increased periodic inundation of up to 243 acres of vernal pool complex in the Yolo Bypass. This natural community is adapted to seasonal inundation and adverse effects from inundation are expected to be minimal, if any: plant composition may shift if the duration of inundation is increased, but not to the extent that it is expected to convert to a different natural community type.

5.4.8.1.3 Construction-Related Effects

Construction-related activities are not expected to result in any temporary loss of vernal pool natural community. Vernal pool complex could be affected in the vicinity of tidal restoration construction activities. These effects could include hydrologic alteration, run-off and sedimentation from construction sites, or petroleum and contamination spills. These effects, however, will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.8.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing facilities operation and maintenance activities could result in ongoing temporary periodic noise and visual disturbances that could affect native wildlife use of the surrounding vernal pool complex natural community. In addition, while maintenance activities are not expected to remove vernal pool complex communities, operation of equipment could temporarily disturb small areas of vegetation around maintained structures. These effects will be minimized with the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Natural Communities Enhancement and Management

A variety of management actions (CM11) that are designed to enhance wildlife values on BDCP protected lands may result in localized ground disturbances that could temporarily remove small amounts of vernal pool complex vegetation supporting habitat for associated covered and other native species. Ground-disturbing activities such as removal of nonnative vegetation and road and other infrastructure maintenance activities are expected to have minor effects on the availability of these species' habitats and will result in overall improvements and maintenance of vernal pool complex values over the term of the BDCP.

5.4.8.2 Beneficial Effects

With full implementation of the BDCP, 600 acres of vernal pool complex will be protected in Conservation Zones 1, 8, and 11 (CM3) and additional vernal pool complex will be restored to achieve no net loss (CM9). The protected vernal pool complex natural community will be managed and enhanced to increase native biodiversity, maintain native pollinators, and maintain appropriate seasonal ponding characteristics (CM11).

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The 600 acres of protected vernal pool complex and additional restored vernal pool complex will be components of a large, interconnected reserve system incorporating a mosaic of grasslands, vernal pool complex, and alkali seasonal wetlands to optimize protection of plant pollinators, provide for the dispersal of plants and animals, sustain important predators of herbivores such as rodents and rabbits (U. S. Fish and Wildlife Service 2005), and minimize effects of adjacent urbanization. Protection will be concentrated in core recovery areas identified in the vernal pool recovery plan (U.S. Fish and Wildlife Service 2005). These targeted conservation areas are situated at elevations that are suitable as wildlife upland habitats adjacent to restored tidal habitats, and can be protected to build on existing and planned preserves in Solano County between Conservation Zones 1 and 11. Protection of vernal pool complex natural community in Conservation Zones 1 and 11 will protect an important connection between Suisun Marsh and the Cache Slough area.

The strategic distribution of vernal pool protection in Conservation Zones 1, 8, and 11 will ensure that the reserve system in the Plan Area (including currently protected areas and areas to be protected and restored under the BDCP) conserves a range of landforms, hydrogeomorphic conditions, and vegetation alliances, as described further in Chapter 3 *Conservation Strategy.* The full range of vernal pool types in the Plan Area and a range of vernal pool inundation characteristics will be protected, including larger, deeper pools with long inundation periods and smaller, shallower pools with short inundation periods, to increase the probability of sustaining species during both long-term high and low rainfall periods, and to contribute to biodiversity, since many vernal pool species depend on a narrow range of inundation periods.

5.4.8.3 Net Effects

Full implementation of the BDCP will result in no net loss of the vernal pool natural community in the Plan Area, and an approximately 689-acre (15%) increase of this natural community in protected lands (Table 5.4-2). Vernal pool complex to be removed is moderate quality: although the areas that will be affected are part of large, contiguous vernal pool complexes with many covered species occurrences and protected lands, they are at the edges of these complexes and have a low density of pools. The vernal pools to be protected and restored will be high quality: they will be located in core recovery areas, in locations that support the highest concentrations of covered and other native vernal pool species and adjacent to existing protected lands. The protected and restored vernal pool complexes will be managed and enhanced to increase native biodiversity and sustain populations of covered and other native species. The BDCP will result in a net benefit to this natural community. Vernal pool complex restoration and protection will be timed to ensure that it stays ahead of the loss of vernal pool complex natural community. (Figure 5.4-6).

5.4.9 Managed Wetland

There are 64,861 acres of managed wetlands in the Plan Area, 76% (49,614 acres) of which are in Suisun Marsh (Conservation Zone 11), and the remainder of which are distributed throughout the Plan Area in all conservation zones.

5.4.9.1 Adverse Effects

5.4.9.1.1 Permanent Loss and Fragmentation

Tidal natural communities restoration will remove approximately 12,170 acres of managed wetland (19% of total managed wetland natural community in the Plan Area), 11,616 acres of which will be

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removed from Suisun Marsh in Conservation Zone 11 (Table 5.4-1). These areas will be tidally inundated, resulting in a permanent conversion from managed wetland to tidal habitats. In addition, construction of the water conveyance facilities will result in the permanent removal of approximately 3 acres, and construction of conveyance channels as part of improvements to Fremont Weir/Yolo Bypass improvements will permanently remove up to 24 acres.

Tidal restoration that will result in the loss of managed wetlands will occur at primarily six locations in Suisun Marsh. Some of the areas to be affected (Simmons Island, Montezuma Slough, and the east side of Suisun Slough) are currently managed as seasonal wetlands that are inundated during the winter months). Other areas to be affected (Nurse Slough, Hill Slough, West Suisun, and the west side of Suisun Slough) are managed primarily as semi-permanent wetlands, providing inundated wildlife habitat for longer periods of the year. All these affected areas are currently connected by managed wetlands that will not be affected by tidal restoration, and the managed wetlands that will be lost to tidal restoration will continue to provide connectivity to other managed wetlands for most of the covered species that use managed wetlands. Tidal restoration will not contribute significantly to fragmentation of managed wetland which is ubiquitous in Suisun Marsh.

5.4.9.1.2 Periodic Inundation

Yolo Bypass Operations

Yolo Bypass operations will increase the frequency and duration of flood water inundation in the Yolo Bypass on approximately 331 acres of managed wetland. In years that proposed Fremont Weir operations are solely responsible for inundation of managed wetlands, this inundation may temporarily remove habitat for wildlife that do not use or make lesser use of inundated floodplain habitat. During these years, there may also be a reduction in some invertebrate and plant foods important to wintering waterfowl and shorebirds.

Floodplain Restoration

Up to 6 acres of managed wetland will be periodically inundated (about every 5 to 7 years) in newly restored floodplains. Affected managed wetland will convert to shallow open water habitat during this short time period. Following drawdown, the managed wetland habitat functions are expected to return. While inundation will provide benefits to fish, waterfowl, and other aquatic organisms, inundation will temporarily remove habitat for managed wetlands species that make less use of aquatic habitats.

5.4.9.1.3 Construction-Related Effects

Proposed construction activities will result in the temporary loss of managed wetlands. Construction of the water conveyance facilities will result in the temporary removal of approximately 9 acres of managed wetland, construction of fisheries enhancements at Yolo Bypass is expected to temporarily remove 41 acres, and development of the transmission line alternative with the greatest effect will result in the temporary removal of approximately 4 acres. Temporarily disturbed areas will be restored within 1 year following completion of construction.

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5.4.9.1.4 Effects of Ongoing Activities

Operation and Maintenance

Managed wetlands may be temporarily disturbed through maintenance of infrastructure such as ditches or berms. Operation and maintenance activities associated with the water conveyance facilities and transmission lines could temporarily disturb native wildlife. However, any temporarily disturbed areas will be restored to pre-maintenance conditions, and adverse effects on this natural community are expected to be minimal.

Management and Enhancement

Activities associated with implementation of natural communities enhancement and management within the protected and enhanced nontidal perennial aquatic and nontidal freshwater emergent natural communities, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. These effects are expected to be minimal, and will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

5.4.9.2 Beneficial Effects

At least 1,500 acres of managed wetlands will be managed and enhanced in the Grizzly Island marsh complex, consistent with the salt marsh harvest mouse recovery plan (CM3): although the primary purpose of this is to protect and enhance habitat for the salt marsh harvest mouse, it is also expected to benefit the managed wetland natural community and the diversity of species that use it, including migratory waterfowl and the western pond turtle. By acquiring 1,500 acres of managed wetland for protection, the Implementation Office will be able to manage and enhance these lands as needed to achieve BDCP biological goals and objectives, such as the control of invasive species measures to increase the diversity of native species. Additionally, at least 320 acres of managed wetlands will be restored in greater sandhill crane Winter Use Areas in Conservation Zones 3, 4, 5, or 6: although the purpose of this managed wetland restoration is to provide roosting habitat for greater sandhill crane, it will also increase the extent of managed wetlands available for migratory waterfowl, western pond turtle, giant garter snake, and other native wildlife.

5.4.9.3 Net Effects

Full implementation of the BDCP will result in a 10,374 (16%) decrease in managed and an 8,829-acre (17%) decrease in protected managed wetlands in the Plan Area (Table 5.4-2). Most (95%) of the managed wetland loss will result from tidal restoration, in which the managed wetlands will be converted to tidal marsh that is expected to provide habitat values for covered species and other native wildlife that use managed wetlands, including but not limited to salt marsh harvest mouse, California clapper rail, California black rail, and white-tailed kite. The 1,500 acres of managed wetlands to be protected and enhanced will provide higher habitat values for covered species than the managed wetlands that will be removed (greater structural diversity of vegetation and refugia for Suisun wildlife species during high tide events). The 320 acres of managed wetlands to be restored will have high habitat value for sandhill crane, western pond turtle, giant garter snake, and other native wildlife. Although BDCP will result in a net loss of managed wetlands, it will result in net benefits to covered species that use managed wetlands.

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The restored tidal brackish emergent wetland and tidal freshwater emergent will provide habitat values similar to those of the managed wetlands they will replace. Managed wetlands currently support pickleweed and other marsh vegetation that provides suitable habitat for saltmarsh harvest mouse, clapper rail, California black rail, and a diversity of other native wetland species: these habitat functions will be maintained or improved with conversion to tidal brackish emergent wetlands. Similarly, tidal freshwater emergent wetlands are expected to provide habitat values for many native wildlife species that use the managed wetlands to be replaced.

[***Note to Reader:*** *Additional analysis is forthcoming that will quantify the functions of managed wetlands for waterfowl and shorebirds and assess the functions restored by the tidal and other restoration, based on a model developed by Ducks Unlimited*.]

5.4.10 Grassland

There are 77,490 acres of grassland natural community distributed throughout the Plan Area in all conservation zones. The largest, contiguous grassland areas are in Conservation Zones 1, 8, and 11. Grasslands in the remainder of the conservation zones consists primarily of isolated patches surrounded by cultivated lands.

5.4.10.1 Adverse Effects

5.4.10.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in the permanent loss of up to 2,810 acres[8] of the grassland natural community (Table 5.4-1). Approximately 199 acres will be removed through construction of above ground water conveyance facilities in Conservation Zones 4, 5, 6, and 8: these grasslands consist of relatively small patches interspersed among agricultural lands in the Delta. Construction of conveyance channels and levee improvements in the Yolo Bypass will remove approximately 262 acres of grassland: this grassland loss will take place along linear footprints in relatively large but scattered, disjunctive patches of grasslands in Conservation Zone 2. Tidal natural communities restoration will permanently remove up to 1,854 acres of grassland community from multiple locations throughout Conservation Zones 1, 2, 4, 5, 6, 7, 8, and 11: the grasslands to be removed mostly consist of scattered, isolated patches. Construction of setback levees for floodplain restoration will remove up to 50 acres of grassland community in Conservation Zone 7, and riparian restoration in the new floodplains and will displace an additional 399 acres of grasslands: these grasslands consist of small patches and narrow strips on the edges of cultivated lands and irrigation ditches and canals.

The highest quality grasslands in the Plan Area, consisting of large, unfragmented areas that support many covered species occurrences and are in or near protected lands (category 1 and 2 open space[9]), are located in the southwestern portion of Conservation Zone 1 (Jepson Prairie and surrounding area) along the western edge Conservation Zones 8 (west of Clifton Court Forebay) and around the perimeter of Suisun Marsh in Conservation Zone 11. Tidal restoration will remove some (less than 420 acres) of this high quality grassland near Jepson Prairie in Conservation Zone 1.

[8] Because affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

[9] See Section 5.2, *Methods*, for definitions of open space categories

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Grassland loss in Conservation Zone 8 will consist of fragmented patches surrounded by cultivated lands, located east of the higher quality grasslands, and none of the high quality grasslands in Conservation Zone 8 will be permanently removed through BDCP covered activities. Up to 72 acres of grasslands will be removed from the perimeter on Suisun Marsh in Conservation Zone 11: this represents less than 1% of the grasslands surrounding Suisun Marsh. Therefore, most of the 2,814 acres of grassland loss will take place outside these high quality grassland areas in Conservation Zones 1, 8, and 11.

Construction of conveyance channels associated with Yolo Bypass improvements may create a localized barrier that impedes the movement of native grassland-associated amphibians, reptiles, and small mammals to and from habitat areas on each side of the channels. This effect could result in local changes in the abundance and distribution of affected native species.

5.4.10.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Appendix 5.K, Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate approximately 334 acres of grasslands. During periods when grasslands are inundated, the affected grassland will convert to shallow open water habitat. Following drawdown, the grassland habitat functions are expected to return as they do under the existing Yolo Bypass inundation regime, although longer and more frequent inundation could change the grassland plant species composition and render the grasslands unsuitable for some grassland wildlife species. While more-frequent and longer-duration inundation will provide benefits to fish, waterfowl and other water birds, and other aquatic organisms, increased inundation frequency and duration make the grasslands periodically unavailable to some terrestrial species. For example, longer springtime inundation could preclude use by foraging Swainson's hawks, white-tailed kites, tricolored blackbirds, and other native species that forage in grassland habitats.

Floodplain Restoration

Up to 334 acres of grassland community will be periodically inundated in newly restored floodplains. During seasonal inundation, affected grassland habitat will convert to shallow open water habitat. Following drawdown, the grassland habitat functions are expected to return. While inundation will provide benefits to fish, waterfowl and other waterbirds, and other aquatic organisms increased inundation frequency and duration make the grasslands periodically unavailable to some terrestrial species. For example, spring inundation could preclude use by foraging Swainson's hawks, white-tailed kites, tricolored blackbirds, and other native species that forage in grassland habitats. However, most of the inundation is expected to take place during the winter, when breeding birds will not be affected. Under current hydrologic conditions, floodplains will be inundated about every 5 to7 years and adjacent uplands will be protected for any wildlife that may be affected by seasonal inundation: consequently, wildlife that may be displaced by seasonal inundation, including prey species for Swainson's hawk and other raptors, is expected to repopulate affected habitats between inundation events.

5.4.10.1.3 Construction-Related Effects

Construction-related activity will temporarily disturb 253 acres of the grassland natural community. Temporarily disturbed areas will be restored within 1 year following construction. Construction of

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the water conveyance facilities may temporarily fragment grassland habitat, primarily in the northern portion of Conservation Zone 4. This temporary fragmentation could impede the ability of native amphibians, reptiles, and small mammals to move among habitat areas. Because the majority of the conveyance facility will be underground, this is a temporary effect and will be localized as construction activities move along the project corridor.

5.4.10.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Future maintenance of Yolo Bypass fisheries enhancement structures could result in ongoing temporary periodic noise and visual disturbances that could affect native wildlife use of the surrounding grassland habitat. In addition, while maintenance activities are not expected to remove grassland communities, operation of equipment could temporarily disturb small areas of vegetation around maintained structures. These effects will be minimized with the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Natural Communities Enhancement and Management

A variety of management actions (CM11) that are designed to enhance wildlife values on BDCP preserve lands may result in localized ground disturbances that could temporarily remove small amounts of grassland vegetation supporting habitat for associated covered and other native species. Ground-disturbing activities such as removal of nonnative vegetation and road and other infrastructure maintenance activities are expected to have minor effects on the availability of these species' habitats and will result in overall improvements and maintenance of grassland habitat values over the term of the BDCP.

5.4.10.2 Beneficial Effects

At least 8,000 acres of grasslands will be protected and 2,000 acres restored in Conservation Zones 1, 8, and 11. Grassland protection and restoration will improve connectivity among habitat areas in and adjacent to the Plan Area, improve genetic interchange among native species' populations, and contribute to the long-term conservation of grassland-associated covered species.

Grasslands and associated vernal pool and alkali seasonal wetland complex will be protected in large contiguous landscapes encompassing the range of vegetation, hydrologic, and soil conditions that characterize these communities. Restored grassland will be sited and designed to increased grassland connectivity. Grasslands and associated vernal pool complex and alkali seasonal wetland complex in Conservation Zones 1 and 11 will be protected to increase habitat linkages between Suisun Marsh, Jepson Prairie, and the Cache Slough Complex for California tiger salamander, western spadefoot toad, and other grassland and vernal pool dependent wildlife. Thus, lands will be protected along the upland fringe of Suisun Marsh to maintain connectivity with much larger protected (e.g., Jepson Prairie Preserve) and unprotected grassland landscapes that are immediately adjacent to the Plan Area. The protected grasslands in Conservation Zones 1 and 11 will form a component of a continuous gradient of protected natural communities that will range from grassland upland communities down slope to existing and restored tidal wetland communities in Suisun Marsh. Additionally, grasslands and associated vernal pool and alkali seasonal wetland complex in Conservation Zone 8 will be protected to maintain habitat connectivity with protected grassland and vernal pool landscapes at the southwest end of the Plan Area where it overlaps with

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the East Contra Costa County HCP/NCCP, providing habitat contiguity for San Joaquin kit fox and other grassland and vernal pool associated wildlife.

In addition to the large, continuous expanses of grassland and associated vernal pool and alkali seasonal wetland complexes that will be protected and enhanced in Conservation Zones 1, 8, and 11, the 8,000 acres of protected grasslands will include some smaller patches of grassland associated with maintained agricultural habitats (e.g., vegetated levee slopes) throughout the Plan Area. These grassland patches are expected to serve as upland habitat for giant garter snake and western pond turtle, and foraging habitat for Swainson's hawk and white-tailed kite.

Grasslands in the reserve system will be managed to sustain or increase native biodiversity and wildlife habitat values. They will be managed to sustain a mosaic of grassland vegetation alliances and increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs. They will also be managed to increase opportunities for movement by broad-ranging animals through grasslands, increase burrow availability for burrow-dependent species, and increase prey, especially small mammals and insects, for grassland-foraging species.

5.4.10.3 Net Effects

Full implementation of the BDCP will result in an approximately 7,189-acre (9%) increase of the grassland natural community in the Plan Area (Table 5.4-2) and an approximately 49% increase of this natural community in protected lands. The grasslands that will be adversely affected are widely scattered throughout the Plan Area and range from low to high quality. The protected and restored grasslands will be high quality, consisting primarily of large, contiguous expanses that will be located in areas with high concentrations of covered grassland and vernal pool complex associated species in Conservation Zones 1, 8, and 11 and will provide essential habitat connectivity for California tiger salamander, San Joaquin kit fox, and other covered species (See *Beneficial Effects*, above). The BDCP will therefore result in a net benefit to the grassland natural community. Grassland restoration and protection will be timed to ensure that it stays ahead of the loss of the grassland natural community (Figure 5.4-7).

5.4.11 Inland Dune Scrub

[***Note to reader:*** *USFWS and DFG are currently in discussions to determine whether or not this natural community should be included. Until a decision is made, this section remains as a placeholder.*]

5.4.12 Cultivated Lands

There are 503,779 acres of cultivated lands distributed throughout the Plan Area, in all conservation zones. Cultivated lands make up 64% of all natural community acreage in the Plan Area.

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5.4.12.1 Adverse Effects

5.4.12.1.1 Permanent Loss and Fragmentation

BDCP covered activities will result in the permanent loss of up to 41,084 acres[10] (8%) of the cultivated lands (Table 5.4-1). Of this, 2,253 acres (5%) will result from conveyance facility construction, 29,484 acres (71%) will result from tidal natural communities restoration, 649 acres (2%) will result from Fremont Weir/Yolo Bypass inundation, 5,737 acres (14%) will result from floodplain restoration (levee construction and riparian restoration), and 400 acres (1%) will result from nontidal marsh restoration. Approximately 37% of the loss consists of alfalfa and irrigated pasture, which has high habitat value for some wildlife and covered species, while approximately 4% consists of orchards and vineyards, which have little to no value to native wildlife or covered species. Approximately 60% of the cultivated lands that will be removed consist of other cultivated crops and agricultural lands with varying levels of wildlife value. Rice, which has high habitat value for many wildlife species, will not be permanently removed as a result of BDCP activities.

5.4.12.1.2 Periodic Inundation

Yolo Bypass Operations

An estimated 1,681 acres of cultivated lands will be affected by increased inundation in the Yolo Bypass. During periods when cultivated land is inundated, the affected cropland area will convert to shallow open water wildlife habitat. Following drawdown, the affected wildlife habitat functions are expected to return to those of cultivated lands as they do under the existing Yolo Bypass inundation regime. In years when the Fremont Weir is operated later in spring, the ability to plant crop types that otherwise will be planted may be precluded because of the inability to prepare fields for planting. These lands are expected to be either planted with alternate crop types that can be grown later in the season or left fallow until the following year. While more-frequent and longer duration inundation will provide benefits to fish, waterfowl and other waterbirds, and other aquatic organisms, increased inundation frequency and duration will increase the frequency and duration that habitat for cropland-associated native species is temporarily removed. For example, longer springtime inundation could preclude use by foraging Swainson's hawks, white-tailed kites, tricolored blackbirds, and other native species, such as giant garter snake, that use agricultural habitats. The analysis assumes that effects of Fremont Weir operations will not result in year-over-year cropping patterns and thus will not affect habitat functions of cultivated land as habitat for covered wildlife species except the few years over the term of the BDCP that the Fremont Weir may be operated in late-spring such that planting of some current crop types may be precluded.

Floodplain Restoration

This activity will periodically inundate an estimated 9,104 acres of the cultivated lands. While these lands are inundated, affected cultivated land will convert to shallow open water wildlife habitat. Following drawdown, previous cultivated land uses are expected to be reestablished. While inundation will provide benefits to fish, waterfowl and other waterbirds, and other aquatic organisms, inundation will temporarily remove habitat for cultivated land-associated native species.

[10] Because affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Inundation of restored floodplains is expected to drown and temporarily reduce the abundance of small mammals and other native species on cultivated lands. Under current hydrological conditions, floodplains will be inundated about every 5 to 7 years. Consequently, affected species are expected to repopulate affected habitats between inundation events if upland refugia are available during inundation events.

5.4.12.1.3 Construction-Related Effects

Up to 2,492 acres of cultivated lands will be temporarily removed during construction activities, and restored to preproject conditions within 1 year after completion of construction. Additionally, as estimated 1,449 acres of cultivated lands will be removed for spoils and borrow sites during construction: these areas will be restored within the permit term but in an undetermined timeframe.

5.4.12.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Cultivated lands are not expected to be adversely affected by ongoing operation and maintenance activities.

Habitat Enhancement and Management

Activities associated with implementation of natural communities enhancement and management in the protected cultivated lands could result in local, temporary adverse natural community effects. However, cultivated lands are frequently disturbed and species that use this natural community are accustomed or habituated to such disturbances. Any adverse are expected to be minimal, and will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.12.2 Beneficial Effects

At least 20,000 acres of cultivated non-rice lands that provide suitable habitat for covered and other native wildlife species will be protected and managed to sustain covered species populations. Cultivated lands will be protected in areas where they provide connectivity between other protected lands. Protection of cultivated lands will ensure maintenance of the highest habitat values for covered species and other native wildlife that use cultivated lands. Irrigated pastures, alfalfa, and annually cultivated irrigated cropland provide foraging habitat for BDCP covered species including Swainson’s hawk, white-tailed kite, western burrowing owl, greater sandhill crane, and tricolored blackbird. Grain, corn, and rice fields provide foraging habitats for sandhill cranes, waterfowl, wading birds, and shorebirds. Additionally, least 4,600 acres of rice lands or similarly functioning habitat for giant garter snake will be maintained in Conservation Zone 2. Rice fields provide foraging habitat for many bird species as well as important aquatic habitat for giant garter snakes and western pond turtle.

Small patches of important wildlife habitats associated with cultivated lands, such as isolated oaks, trees and shrubs along field border and roadside, remnant groves, riparian corridors, water conveyance channels, grasslands, pons, and wetlands will also be protected. Maintenance of these small but important wildlife habitats, consistent will benefit BDCP covered wildlife species as well as a diversity of noncovered native wildlife. Cultivated lands are used primarily for foraging by several

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species that nest in riparian areas, roadside trees, or isolated trees and groves. Wetlands, streams, ponds, hedgerows, groves, and other remnant natural or created habitats will be maintained to provide the full range of habitat elements necessary to support BDCP covered species in cultivated lands.

5.4.12.3 Net Effects

Full implementation of the BDCP will result in an approximately 41,089-acre (8%) decrease of cultivated lands in the Plan Area (Table 5.4-2) and an approximately 20,000-acre (4%) increase of cultivated lands in protected status. Cultivated lands will be protected in crop types and areas that are most beneficial to covered and other wildlife species, based on connectivity and proximity to associated natural community types such as riparian areas that provide suitable nesting habitat for Swainson's hawks and other raptors that forage in cultivated lands. Protected cultivated lands will also include wetlands that provide nesting habitat for tricolored blackbirds or roosting habitat for sandhill cranes. Protected cultivated lands will be managed and enhanced to optimize habitat value for covered and other wildlife species within the constraints of the farming operation. As described in Section 5.6, cultivated lands will be protected, managed, and enhanced to replace lost foraging habitat values for Swainson's hawk, sandhill crane, and tricolored blackbird. Additionally, rice lands will be maintained for giant garter snake. The BDCP will offset adverse effects on the wildlife habitat values of cultivated lands and contribute to the recovery of covered species that rely on cultivated lands in the Plan Area.

5.4.13 References

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Essex Partnership. 2009. DRERIP Evaluations of BDCP Draft Conservation Measures. Summary Report. Available: <http://science.calwater.ca.gov/pdf/workshops/workshop_eco_052209_BDCP-DRERIP_Summary_with_Appendices1.pdf>. Accessed: December 9, 2011.

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Table 5.4-1. Natural Community Loss by Covered Activity

		Tidal Restoration (CM4)			Conveyance Option (CM1)			Fremont Weir/Yolo Bypass Improvements (CM2)			Floodplain Restoration (CM5)					
		Tidal Natural Communities[1] Restoration Effects (Inundation)	Tidal Natural Communities[2] Restoration Effects (Desiccation)	Tidal Natural Communities Restoration Effects (Riparian)	Tunnel/Pipeline Effects [8]			Yolo Bypass Fisheries Enhancement [7, 14]	Yolo Bypass Fisheries Enhancement [14]	Yolo Bypass Operations	Floodplain Restoration Effects (Riparian) [14]	Floodplain Restoration Effects (Inundation) [15]	Floodplain Restoration Levee Construction Effects[15]	Floodplain Restoration Levee Construction Effects[15]	Nontidal Marsh Restoration [14]	Conservation Hatcheries Facilities [14]
Natural Community	Total Existing Natural Community in Plan Area	Acres Removed/ Converted[3] (Permanent)[6]	Acres Removed/ Converted[3] (Permanent)[6]	Acres Removed (Permanent)	Acres Removed (Permanent)[8]	Acres Removed (Temporary)[9]	Acres Removed [4] (Long-Term Temporary)[16]	Acres Removed (Permanent)	Acres Removed (Temporary)	Acres Affected (Periodic)	Acres Removed (Permanent)	Acres Affected (Periodic)	Acres Removed (Permanent)	Acres Removed (Temporary)	Acres Removed (Permanent)	Acres Removed (Permanent)
Tidal perennial aquatic [13]	86,236	0	27	0	28	120	0	7	0	290	0	39	2	5	0	0
Tidal mudflat[5]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tidal brackish emergent wetland [12]	8,351	0	515	0	0	0	0	0	0	0	0	0	0	0	0	0
Tidal freshwater emergent wetland [13]	8,947	0	85	0	2	10	0	6	0	74	0	3	1	1	0	0
Valley foothill riparian	17,930	778	0	0	24	47	0	225	112	105	0	265	43	35	0	0
Non-tidal perennial aquatic	5,421	174	0	0	9	3	0	35	17	31	0	25	28	16	0	0
Non-tidal permanent freshwater emergent wetland	1,135	91	0	0	1	0	0	0	0	2	0	8	0	0	0	0
Alkali seasonal wetland complex	3,722	91	0	0	0	0	0	45	0	120	0	0	0	0	0	0
Vernal pool complex	7,908	88	0	0	0	0	0	0	0	75	0	0	0	0	0	0
Managed wetlands	64,861	12,170	0	0	1	10	0	24	41	300	0	6	0	0	0	0
Other natural seasonal wetland	321	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Grassland	77,495	1,851	0	11	202	178	151	262	148	303	399	513	50	32	0	35
Inland dune scrub	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cultivated lands[10]					0		0									
Alfalfa	82,282	7,877	0	300	721	159	63	0	35	74	866	2,194	604	333	0	0
Irrigated Pasture	49,694	3,096	0	18	50	67	0	431	1	441	62	158	70	33	0	0
Vineyard	28,901	1,016	0	0	606	69	325	0	0	0	0	336	115	67	0	0
Orchard	18,019	167	0	0	139	139	68	0	82	3	0	85	15	10	0	0
Rice	12,637	0	0	0	0	0	0	0	0	424	0	0	0	0	0	0
Other Cultivated Crops	229,828	12,535	0	544	1,927	740	784	130	275	550	2,134	4,987	1,037	598	400	0
Subtotal: Cropland only	421,361	24,691	0	862	3,442	1,175	1,241	561	393	1,492	3,062	7,759	1,840	1,040	400	0
Other cultivated lands	82,418	4,793	0	98	412	139	208	88	2	189	531	1,345	304	193	0	0
Subtotal: All cultivated lands	503,779	29,484	0	960	3,859	1,731	1,449	649	394	1,681	3,593	9,104	2,144	1,234	400	0
Total	786,125	44,728	626	971	4,126	2,099	1,600	1,252	713	2,983	3,991	9,965	2,269	1,322	400	35

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Table 5.4-1. Natural Community Loss by Covered Activity (Continued)—Total Effects

Natural Community	Total Existing Habitat in Plan Area	Total Effects			
		Total Acres Removed (Permanent & Muck)	Total Acres Removed (Temporary)	Total Acres Removed (Borrow & Spoil)	Total Acres Affected (Periodically)
Tidal perennial aquatic [13]	86,236	65	125	0	330
Tidal mudflat[5]	N/A	N/A	N/A	N/A	N/A
Tidal brackish emergent wetland [12]	8,351	515	0	0	0
Tidal freshwater emergent wetland [13]	8,947	93	5	0	77
Valley foothill riparian	17,930	1,070	170	0	370
Non-tidal perennial aquatic	5,421	245	36	0	56
Non-tidal permanent freshwater emergent wetland	1,135	92	0	0	10
Alkali seasonal wetland complex	3,722	136	0	0	120
Vernal pool complex	7,908	88	0	0	75
Managed wetlands	64,861	12,194	47	0	306
Other natural seasonal wetland	321	1	0	0	2
Grassland	77,495	2,810	253	151	817
Inland dune scrub	19	0	0	0	0
Cultivated lands[10]					
Alfalfa	82,282	10,367	526	63	2,268
Irrigated Pasture	49,694	3,727	101	0	598
Vineyard	28,901	1,737	136	325	336
Orchard	18,019	321	231	68	88
Rice	12,637	0	0	0	424
Other Cultivated Crops	229,828	18,706	1,613	784	5,538
Subtotal: Cropland only	421,361	34,858	2,608	1,241	9,251
Other cultivated lands	82,418	6,226	334	208	1,534
Subtotal: All cultivated lands	503,779	41,084	2,942	1,449	10,786
Total	786,125	58,393	3,578	1,600	12,948

[1] Inundation: Tidal flooding of existing wetland habitat as a result of tidal restoration actions. See Table 5.K-3 for a description of relevant assumptions.

[2] Desiccation: The drying out of wetland habitat as a result of tidal dampening (the downward shift in tidal range), the result of which is a conversion from a tidal brackish or freshwater emergent wetland community to the grassland community. See Table 5.K-3 for a description of relevant assumptions.

[3] Removed/Converted: Removed: habitat is no longer usable for any life stage of the species. Converted: change from one habitat type (e.g. primary) to another habitat type (e.g. secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g.., primary or secondary) to another, lesser function. See Table 5.K-2 for a description of relevant assumptions.

[4] Borrow/Spoil Area: Borrow: a location from where construction material, such as sand or clay, will be taken. Spoil: area where construction by-prodcuts, such as removed earth, will be placed and stored. Borrow/spoil: an area that will originally be used for borrow and then later be used for spoil.

[5] Tidal mudflat features were not mapped within the BDCP vegetation layer, however will be evaluated in linear miles of tidal marsh/shallow subtidal aquatic interface.

[6] Calculation of impacts based on hypothetical restoration designs include only areas modeled by RMA that were classified as either 'Below MLLW' or 'MLLW to MHHW' except where noted

[7] Disturbance effect acreages reflect those associated with Fremont Weir improvements, Putal Creek realignment activities Lisbon weir and fish crossing improvements, and Sacramento Weir improvements.

[8] The impact numbers do not incorporate the impacts associated with temporary Transmission Line corridors used during construction as alignments were not available at the time of the analysis.

[9] Features in this category include the following conveyance-related facilities: Forebay, Intake Facilities, Permanent Access Roads, and Shaft Locations. Totals under

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		Total Effects			
Natural Community	**Total Existing Habitat in Plan Area**	**Total Acres Removed (Permanent & Muck)**	**Total Acres Removed (Temporary)**	**Total Acres Removed (Borrow & Spoil)**	**Total Acres Affected (Periodically)**
Conveyance Option (CM1) include Transmission Line impacts.					
[10] Features in this category include the following conveyance covered activities: Barge Unloading Facility, Control Structure Work Area, Intake Road Work Area, Intake Work Area, Pipeline, Pipeline Work Area, Road Work Area, Safe Haven Work Area, Temporary Access Road Work Area, Tunnel Work Area. Totals under Conveyance Option (CM1) include Transmission Line impacts.					
[11] Does not include removal of agricultural lands to restore 2,000 acres of grassland and 200 acres of vernal pools. These effects will be included in the next version of this table.					
[12] Impacts assessed for tidal marsh restoration reflect those incurred to tidal brackish emergent wetland habitat components inundated based on RMA modeling results.					
[13] Impacts assessed for tidal marsh restoration reflect those incurred to aquatic habitats expected to be inundated based on RMA modeling results.					
14 Based on restoration design assumptions described in Appendix 5.E, *Habitat Restoration*, and effects analysis assumptions detailed in Table 5.K-2.					
[15] Calculation of effects based on hypothetical floodplain restoration designs.					
[16] Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Table 5.K-6, *Natural Community Loss by Covered Activity*.					
Note: The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use - Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.					
N/A = no specific acreage associated with this category or subcategory at this time.					

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Table 5.4-2. Net Effects, Natural Communities

Natural Community	Acres of Natural Community in Plan Area	Acres of Natural Community Existing Protected [1]	Acres of Natural Community Removed (Permanent)[4]	Acres of Protected Modeled Natural Community Removed (Permanent)[4]	Acres of Natural Community Removed (Temporary)	Acres of Natural Community Removed (Long-Term Temporary)[6]	Acres of Natural Community Affected (Periodic)	Acres of Natural Community Protected under BDCP	Acres of Modeled Natural Community Restored	Net Change in Acres of Natural Community	Percent Change in Total Natural Community	Acres of Natural Community in Protected Status with Full BDCP Implementation	Percent Change in Protected Modeled Natural Community
Tidal perennial aquatic	86,236	18,085	65	25	125	0	645	0	10,000	9,935	12%	28,060	55%
Tidal mudflat[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tidal brackish emergent wetland	8,351	5,102	515	485	0	0	0	0	4,800	4,285	51%	9,417	85%
Tidal freshwater emergent wetland	8,947	4,991	93	11	5	0	114	0	13,900	13,807	154%	18,880	278%
Valley foothill riparian	17,930	5,424	1,070	30	170	0	498	750	5,000	3,930	22%	11,144	105%
Nontidal perennial aquatic	5,421	1,250	245	49	36	0	10	0	250	5	0%	1,451	16%
Nontidal permanent freshwater emergent wetland	1,135	407	92	48	0	0	15	0	150	58	5%	509	25%
Alkali seasonal wetland complex	3,722	2,769	136	57	0	0	120	150	0	-136	-4%	2,862	3%
Vernal pool complex	7,908	4,536	88	30	0	0	75	600	89	1	0%	5,195	15%
Managed wetlands[5]	64,861	52,689	12,194	10,649	47	0	306	1,500	320	-11,874	-18%	43,860	-17%
Other natural seasonal wetland	321	245	1	0	0	0	2	0	0	-1	0%	245	0%
Grassland	77,495	18,263	2,810	1,009	253	151	817	8,000	2,000	-810	-1%	27,254	49%
Inland dune scrub	19	17	0	0	0	0	0	0	0	0	0%	17	0%
Cultivated lands	503,779	57,168	41,084	6,553	2,942	1,449	12,948	20,000	0	-41,084	-8%	70,615	24%
Total	786,125	170,946	58,393	18,946	3,578	1,600	15,550	31,000	36,509	-21,884	-3%	219,509	28%

[1] Known, protected lands were categorized by three protection categories: Category 1 = Protected in perpetuity and managed for ecological protection; Category 2 = Protected in perpetuity and use that maintains ecological value; and Category 3 = Protected in perpetuity but not managed to maintain ecological value.

[2] The extent of existing tidal mudflat cannot be delineated based on available information.

[3] Removed/Converted: Removed = habitat is no longer usable for any life stage of the species. Converted=change from one habitat type (e.g. primary) to another habitat type (e.g. secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g. primary or secondary) to another, lesser function. See Table 5.K-2 for relevant assumptions

[4] Calculation of impacts based on hypothetical restoration designs include only areas modeled by RMA that were classified as either "Below MLLW" or "MLLW to MHHW"

[5] Grey-shaded cell: Suisun Marsh is considered Category 1 protected lands, however, most of the managed wetlands in Suisun are not being manage specifically for the benefit of covered species.

[6] Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Table 5.K-6, *Natural Community Loss by Covered Activity*.

N/A = no specific acreage associated with this category or subcategory at this time.

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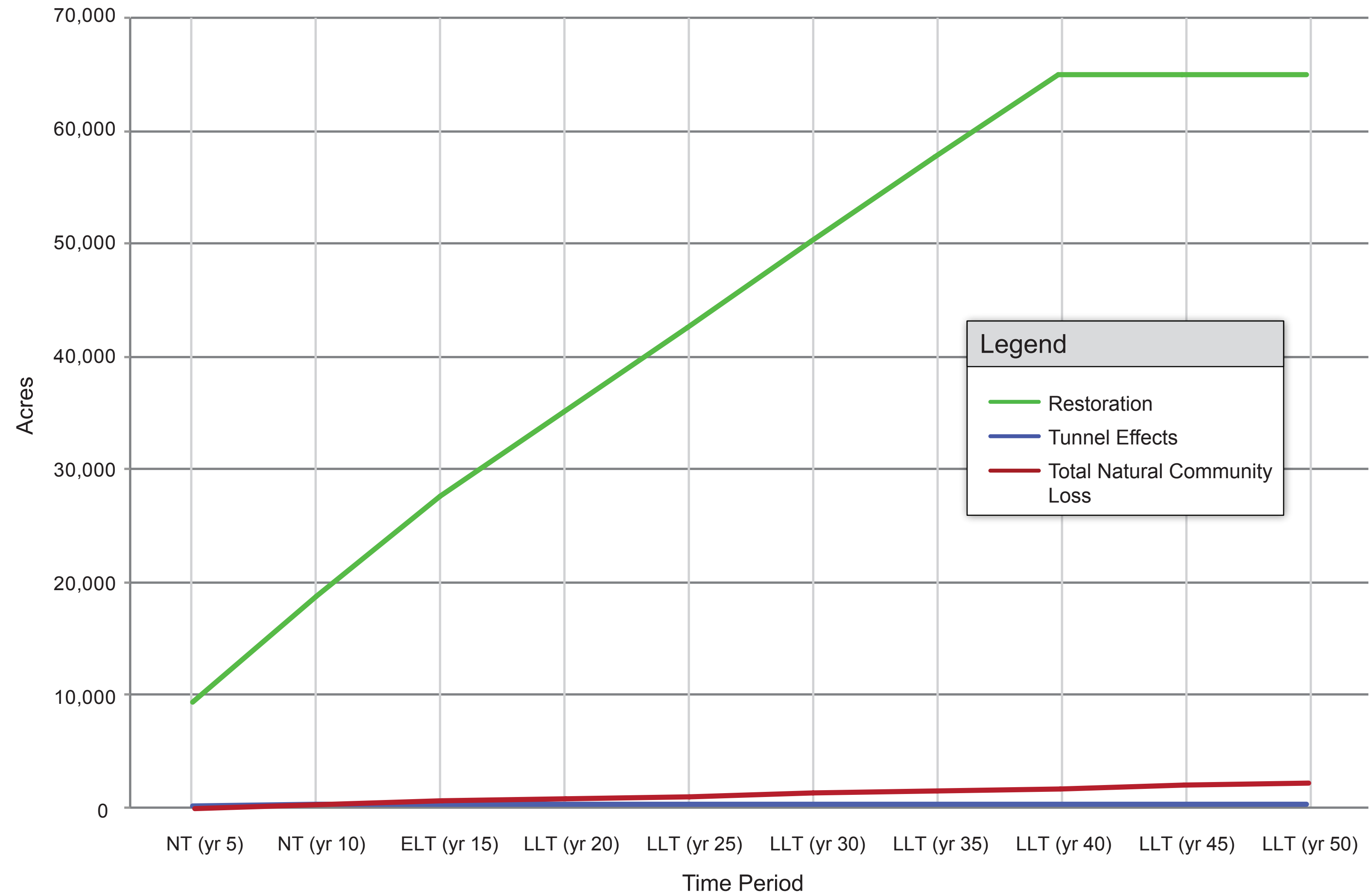

Note: Assume that natural community loss is evenly distributed within each time period. Natural community loss is permanent loss calculated for tidal perennial aquatic, tidal brackish emergent wetland, and tidal freshwater emergent wetland.

Graphics…/BDCP Other Chapters/SAIC Nov 2010 (created 11/3/10) (Rev. 2/22/12 TG)

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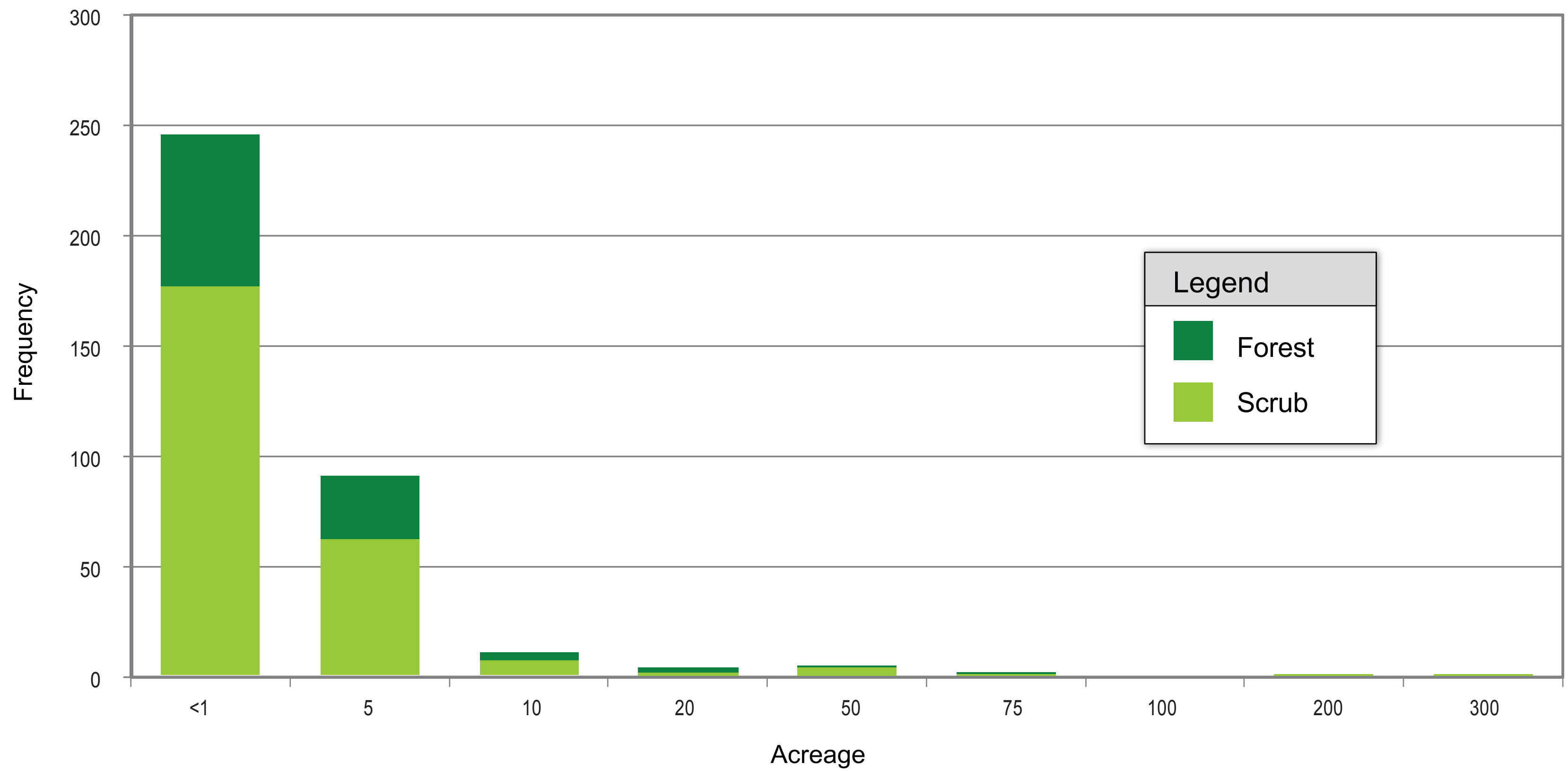
Figure 5.4-1
Tidal Natural Communities Restoration versus Permanent Loss



Graphics/... BDCP EA/SAIC Nov 2010 (created: 11/18/10) (Rev. 02/21/12 JD)

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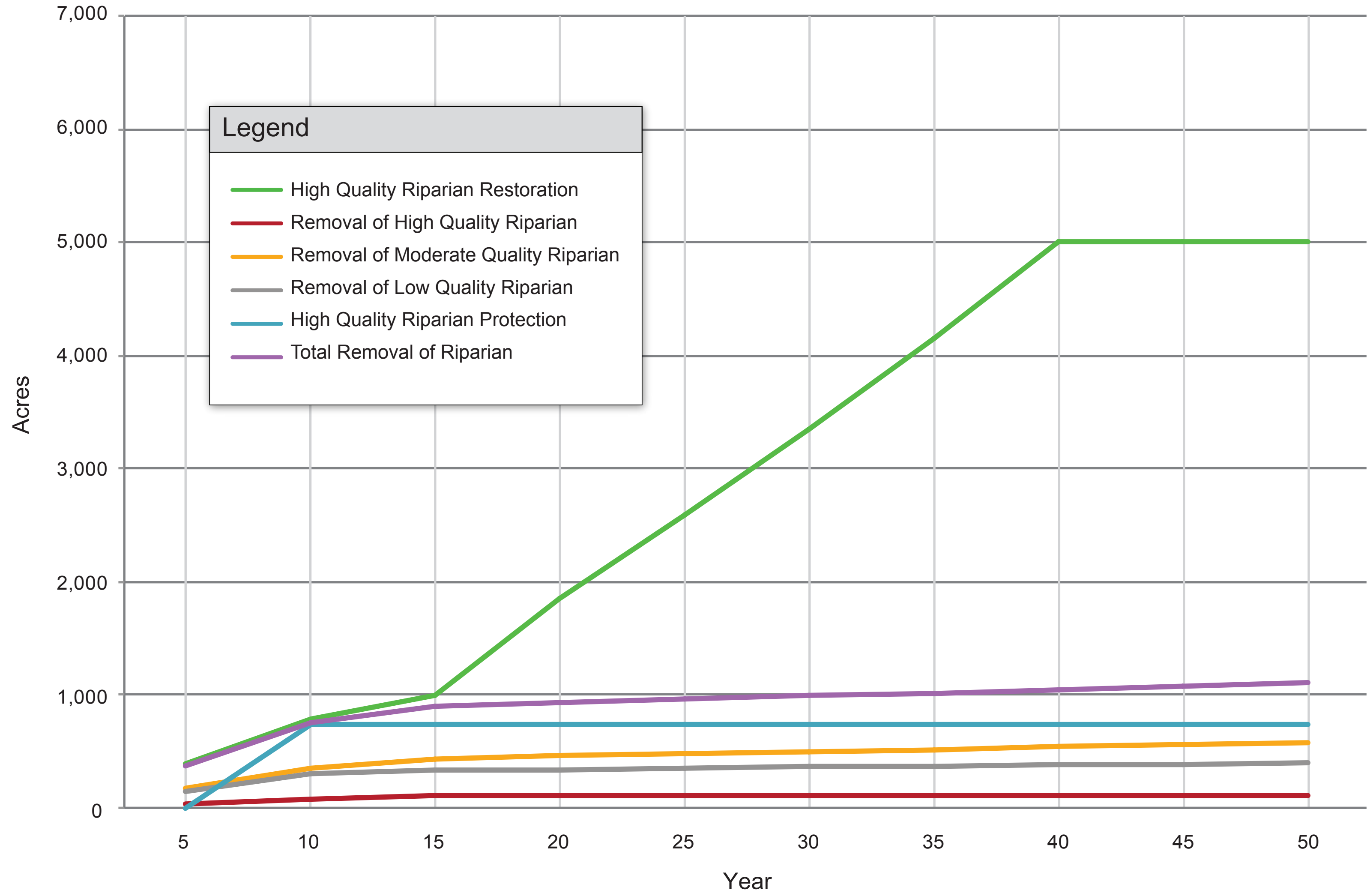
Figure 5.4-2
Size Distribution of Affected Riparian Forest and Scrub Polygons



Graphics.../BDCP Other Chapters/SAIC Nov 2010 (created 11/3/10) (Rev. 2/22/12 TG)

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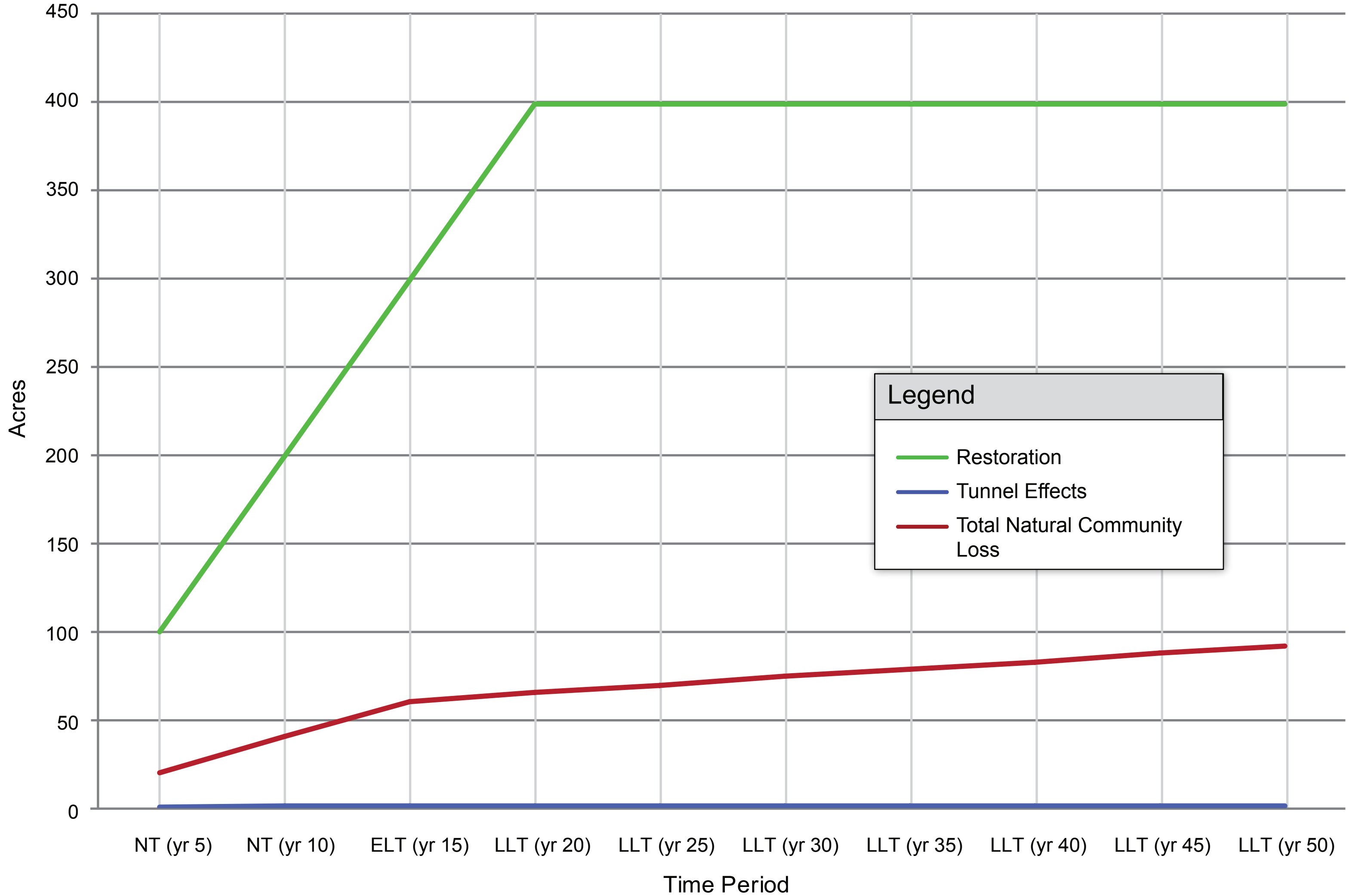
Figure 5.4-3
Cumulative Riparian Restoration and Protection versus Cumulative Permanent Removal



Note: Assume that natural community loss is evenly distributed within each time period. Natural community loss is permanent loss calculated for nontidal freshwater emergent wetland.

Graphics.../BDCP Other Chapters/SAIC Nov 2010 (created 11/3/10) (Rev. 2/22/12 TG)

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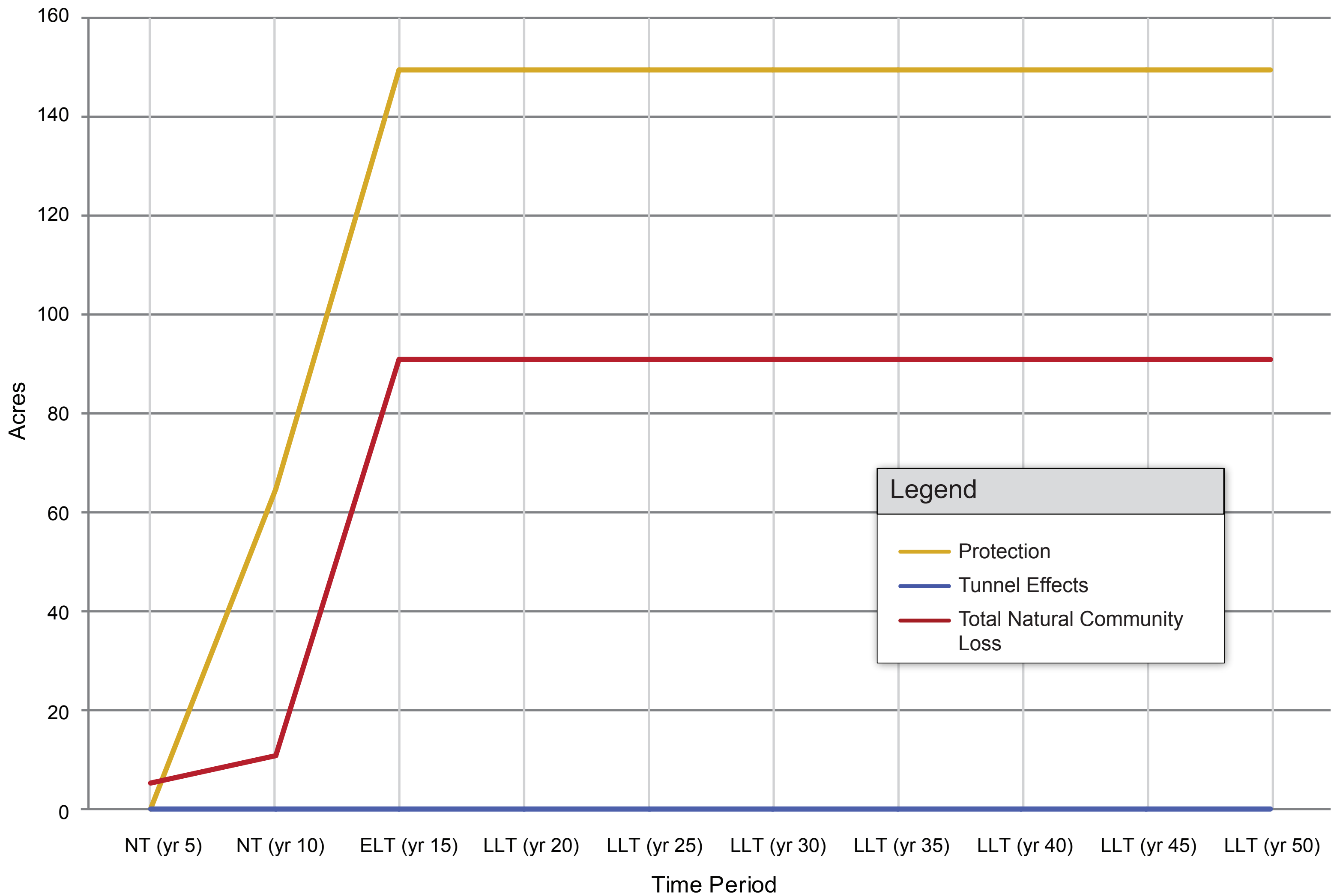
Figure 5.4-4
Nontidal Marsh Restoration versus Permanent Loss



Note: Assume that natural community loss is evenly distributed within each time period. Natural community loss is permanent loss calculated for alkali seasonal wetland complex.

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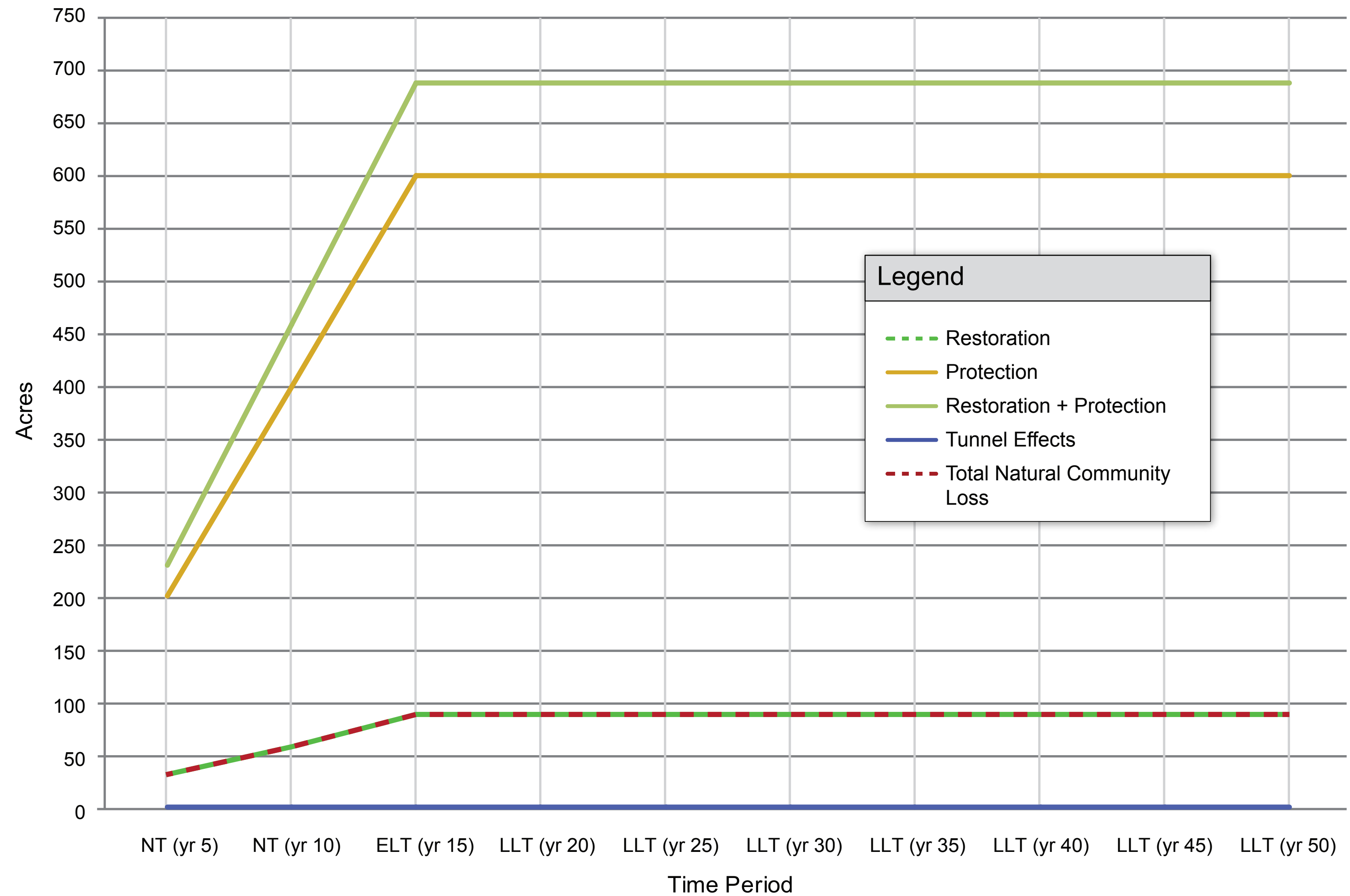
Figure 5.4-5
Alkali Seasonal Wetland Complex Natural Community Protection versus Permanent Loss



Note: Assume that natural community loss is evenly distributed within each time period. Natural community loss is permanent loss calculated for vernal pool complex.

Graphics.../BDCP Other Chapters/SAIC Nov 2010 (created 11/3/10) (Rev. 2/22/12 TG)

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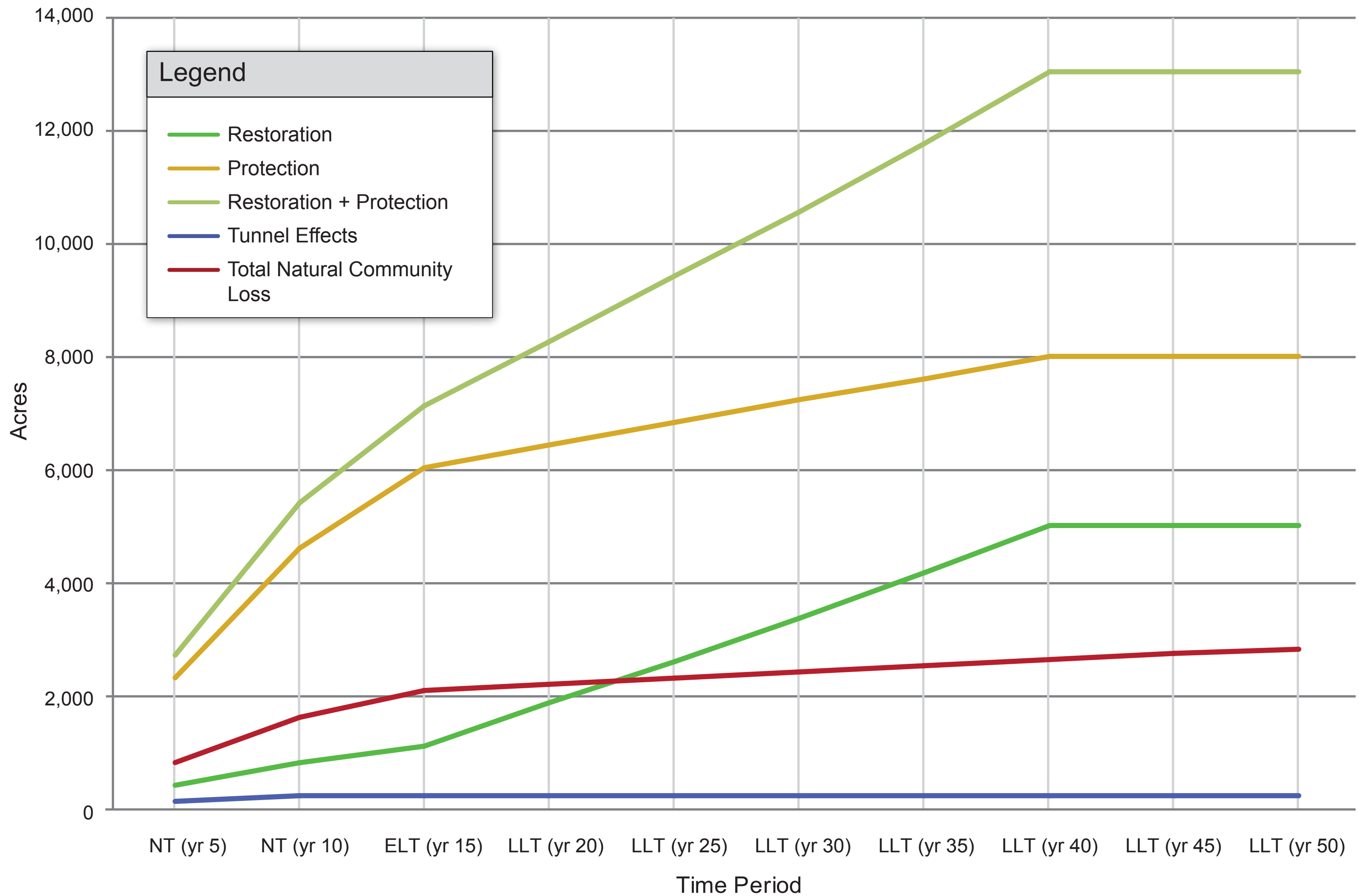
Figure 5.4-6
Vernal Pool Complex Natural Community Restoration and Protection versus Permanent Loss



Note: Assume that natural community loss is evenly distributed within each time period. Natural community loss is permanent loss calculated for grassland.

Graphics.../BDCP Other Chapters/SAIC Nov 2010 (created 11/3/10) (Rev. 2/21/12 JD)

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Figure 5.4-7
Grassland Natural Community Restoration and Protection versus Permanent Loss

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Chapter 5
Effects Analysis

5.5 Effects on Covered Fish

This section describes the net effects of the Plan on each covered fish species.

5.5.1 Delta Smelt

Delta smelt are a small (typically 60–70 mm standard length) (Moyle 2002), translucent fish endemic to the San Francisco estuary (Moyle 2002). The species is distributed throughout the Plan Area, although occurrence in the upper regions of the Yolo Bypass is limited. Delta smelt also occurs outside the Plan Area in the Napa and Petaluma Rivers and occasionally upstream in the Sacramento River. Delta smelt relative abundance declined in the early 1980s, increased somewhat in the 1990s, and then dropped to record lows in the 2000s (Thomson et al. 2010). The species is listed under the federal and state Endangered Species Acts (ESAs). The life cycle of delta smelt generally spans a single year that ends with spawning in the early spring, although a small proportion of the population survives to spawn a second time (Bennett 2005). The delta smelt life history is described as diadromous by Sommer and coauthors (2011), reflecting the general pattern of spawning during spring in freshwater areas followed by juvenile migration to shallow, turbid, open-water, low-salinity areas of the Plan Area to feed and mature in the summer and fall. Evidence suggests that delta smelt are present in some subregions of the Plan Area year-round, e.g., Cache Slough (Sommer et al. 2011). It is unclear whether this represents the same individuals remaining in the same subregion throughout their lives. Genetic analyses suggest that the species is a single panmictic population without distinct subpopulations (Fisch et al. 2011).

A detailed species account of delta smelt is presented in Appendix 2.A, *Covered Species Accounts*. Stressors on the delta smelt population in the Plan Area are presented in Table 5.5-1, together with scores for the magnitude of importance, the certainty of the importance, and a brief description of the rationale for the scores. More detail is presented on the rationale for the importance of different stressors to delta smelt as necessary in the sections below. A qualitative assessment of changes to stressors as a result of the Plan is shown in Table 5.5-2 and is discussed below.

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Table 5.5-1. Population-Level Stressors—Delta Smelt

Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching Eggs	Hatch to Fully Developed Fins and Air Bladder Larvae	Actively Feeding and Growing Juveniles	Sexually Mature and Migrating Fish Adults	Rationale for Stressor Rankings
Food	Food resources	Quantity and quality of food resources available to life stages	0	4	4	0	Several studies show link between abundance of food (e.g., copepods) and delta smelt (Kimmerer 2008; Nac Nally et al. 2010; Glibert et al. 2011; Maunder and Deriso 2011; Miller et al. 2012). There is no evidence for food limitation in adult delta smelt (Baxter et al. 2010).
	Competition for food	Decrease in food resources due to competition with other consumers	0	3	3	0	Most delta pelagic fish species consume zooplanton. Invasive clams appear to have affected the abundance and species composition of plankton (Winder and Jassby 2011), thus affecting the delta smelt foodweb. Rankings follow Nobriga and herbold (2009).
	Nutrient balance	Impact of wastewater treatment plant effluent (for example) and other inputs on delta food resources	0	3	3	0	Several authors draw links between ammonium concentrations in delta and phytoplankton species composition and amount that may affect zooplankton community (Dugdale et al. 2007; Jassby 2008; Glibert et al. 2011).
Water Operations	Transport flows	Change in flow through the delta as a result of upstream regulation or diversion	0	0	0	0	Little evidence that transport flows currently are important for delta smelt life stage (Nobriga and Herbold 2009). Larval transport for delta smelt is relevant in the context of Old and Middle River flows, which is a compnent of South Delta entrainment.
	Alternative channels	Effect of fish movement into Interior Delta through Georgiana Slough and the Delta Cross Channel	0	0	0	0	Stressor is primarily related to migration of salmonids and therefore is not of relevance to delta smelt.
	Passage barriers	Structures that may impede or change migration patterns within the region such as the salinity control gates	0	0	1	1	The main passage barriers in the Plan Area where delta smelt are located are the Suisun Marsh Salinity Control Gates. Assumed low importance follows Nobriga and Herbold (2009).

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Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching Eggs	Hatch to Fully Developed Fins and Air Bladder Larvae	Actively Feeding and Growing Juveniles	Sexually Mature and Migrating Fish Adults	Rationale for Stressor Rankings
Water Operations—Entrainment	North Delta entrainment/ impingement	Entrainment and impingement of fish at proposed North Delta intake (assumed effect in the future)	0	1	1	1	Delta smelt rarely found in vicinity of proposed intakes. Expectation is the relatively few delta smelt would encounter the proposed intakes. Intakes screened and low approach velocity. Eggs adhere to substrates and would not be entrained. Considerable uncertainty.
	South Delta entrainment	Entrainment at existing South Delta export facilities	0	2	2	2	Ranking of 4 for DRERIP (Nobriga and Herbold) reflected pre-OCAP BiOp. Entrainment monitoring data indicate that impact of SD pumps greatly diminished by BiOp RPA, although entrainment still occurs. Eggs adhere to substrate and would not be entrained.
	North Bay Aqueduct entrainment	Entrainment at North Bay Aqueduct	0	1	0	0	Relatively small diversionl screened, therefore should exclude adults and juveniles; generally low entrainment numbers but without monitoring (U.S. Fish and Wildlife Service 2008). Eggs adhere to substrate and would not be entrained.
	Agricultural diversion entrainment	Entrainment in agricultural and smaller diversions throughout the delta	0	1	1	1	Generally small diversions that seem to entrain relatively few delta smelt relative to the density in the water column (Nobriga et al. 2004). Rating similar to DRERIP (Nobriga and Herbold 2009). Eggs adhere to substrate and would not be entrained.
Habitat	Tidal habitat	Impact of loss of tidal habitat in terms of direct habitat for the species	1	2	2	1	Abundant populations existed under similar extent of tidal habitat conditions to current (e.g., 1960s–1980s), but it is unclear to what extent delta smelt may have used other tidal habitats (e.g., wetlands) in the past; no evidence of limitation by spawning habitat (although not examined in detail). There is more recent evidence, however, showing that delta smelt are associated with restored tidal marsh in the Cache Slough subregion, i.e., Liberty Island (Sommer et al. 2011).
	Channel margin	Impact of loss or change in channel margin in terms of direct habitat for the species	1	0	0	0	Delta smelt assumed to spawn in shallow water (Benner 2005). Loss of channel margin habitat may have an effect through not studied. Lack of channel margin habitat not assumed ot be an issue because species generally occurs away from shore and is not associated with structure (Nobriga and Herbold 2009).

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Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching	Hatch to Fully Developed Fins and Air Bladder	Actively Feeding and Growing	Sexually Mature and Migrating Fish	
			Eggs	**Larvae**	**Juveniles**	**Adults**	**Rationale for Stressor Rankings**
	Floodplains	Impact of loss of area or connectivity to floodplains in terms of direct habitat for the species.	0	0	0	0	Delta smelt not found on floodplains (Nobriga and Herbold 2009).
	Low salinity zone	Habitat quantity and quality in the Low Salinity Zone	0	0	3	0	Low-salinity zone is occupied by juveniles for rearing (Baxter et al. 2010). Larvae rear upstream of LSZ, wheras adults migrate upstream of it for spawning. Habitat quality in the LSZ has decreased over time (Feyrer et al. 2011). Links to population-level response have not been found statistically (Mac Nally et al. 2010; Miller et al. 2011). Lowest population indices coincide with lowest values of habitat index in the fall (Feyrer et al. 2011).
	Invasive aquatic vegetation	Shallow water habitat occupied by aquatic vegetation	1	2	2	1	IAV has been shown to influence fish assemblage composition in the Plan Area (Nobriga et al. 2005; Brown and Michniuk 2007). Rankings reflect the potential use of nearshore habitat occupied by IAV (primarily *Egeria densa*). Other effects of IAV (e.g., changes in turbidity and predation) are captured under those stressors.
	Temperature	Water temperature	0	2	3	0	Based on tolerances (Swanson et al. 2000; Bennett 2005) and field distribution timing (Nobriga et al. 2008), impacts of temperature would be most pronounced for larvae and, in particular, juveniles. Prespawning adults move toward spawning areas in winter and would not be limited by temperature. Conclusion based on coincidence of life stage and temperature conditions.

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Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching Eggs	Hatch to Fully Developed Fins and Air Bladder Larvae	Actively Feeding and Growing Juveniles	Sexually Mature and Migrating Fish Adults	Rationale for Stressor Rankings
	Turbidity	Water clarity	0	4	4	4	Association between delta smelt distribution/feeding and turbidity clear in lab (UC Davis Fish Conservation and Culture Lab) and field (Bennett 2005; Nobriga et al. 2008; Baxter et al. 2010; Feyrer et al. 2011). Rationale is that turbidity enhances feeding success and provides protection from predators (Bennett 2005). In lab, turbidity initiates feeding by larvae (Baskerville-Bridges and Lindberg, Powerpoint) and presumed to provide cover from predation in field (Bennett 2005). Adult upstream migration coincides with turbidity increase (Grimaldo et al. 2009).
	Dissolved oxygen	Dissolved oxygen	0	0	0	0	Critical values only occur locally (e.g., managed wetlands in Suisun Marsh, Stockton Deep Water Ship Channel) and not assumed to be a major issue to delta smelt.
Water Quality	Contaminants	Non-biological substances with adverse effects to biota	1	1	1	1	No evidence of acute effects, chronic effects not clear. DRERIP conceptual model (Nobriga and Herbold 2009) uncertain as to effects.
	Microcystis toxicity	Naturally occurring toxins from algal populations	0	0	2	0	Even at low abundance, microcystis may impact estuarine fishery production through toxic and food web impacts at multiple trophic levels (Lehman et al. 2010). Timing and spatial distribution suggest that only juveniles would be affected.
Predation	Predation	Non-normative consumption of target species by piscivorous species	2	2	2	2	Effects uncertain based on DRERIP (Nobriga and Herbold 2009); recent studies show a potential statistical link between delta smelt decline and increase in predator abundance/predation though no direct evidence of predation (Mac Nally et al. 2010; Maunder and Deriso 2010).
	Harvest	Human predation on the species in the delta	0	0	0	0	Delta smelt are not harvested.

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Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching Eggs	Hatch to Fully Developed Fins and Air Bladder Larvae	Actively Feeding and Growing Juveniles	Sexually Mature and Migrating Fish Adults	Rationale for Stressor Rankings
Note: Stressors are ranked by relative importance on a scale from 0 (unimportant) to 4 (highly important). LSZ = low salinity zone. [1] Stressors are ranked by their impact on biological performance of the species under current habitat conditions. [2] Stressors are attributes of the environment affecting the biological performance of the species. [3] Presumed impact in the future.							

(white)	High degree of scientific certainty, supported by consistent quantitative analysis.
(light gray)	Appreciable qualitative information supported by general scientific literature.
(dark gray)	Uncertain, conflicting quantitative analysis, limited support in literature.
(black)	Speculative, no quantitative analysis and little applicable literature.

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Table 5.5-2. Change to Stressors because of the BDCP by Life Stage—Delta Smelt

Stressor Category	Stressors	Change to the Stressor for the Life Stage (-4 to 4) Because of BDCP			
		Eggs	Larvae	Juveniles	Adults
Food	Food resources	0	3	3	0
	Competition for food	0	-1	-1	0
	Nutrient balance	0	0	0	0
Water operations	Transport flows	0	0	0	0
	Alternative channels	0	0	0	0
	Passage barriers	0	0	0	0
Water operations—entrainment	North Delta entrainment/impingement	0	-1	-1	-1
	South Delta entrainment*	0	0	0	2
	North Bay Aqueduct entrainment	0	1	0	0
	Agricultural diversion entrainment	0	1	1	0
Habitat	Tidal habitat	4	4	4	4
	Channel margin	0	0	0	0
	Floodplains	0	0	0	0
	Low salinity zone	0	0	-2	0
	Invasive aquatic vegetation	0	0	0	0
	Temperature	0	0	0	0
	Turbidity***	–	–	–	–
	Dissolved oxygen	0	0	0	0
Water Quality	Contaminants	-1	-1	-1	-1
	Microcystis toxicity	0	0	-1	0
Predation	Predation	0	1	1	1
	Harvest	0	0	0	0

Note: Changes to stressors as a result of the Plan are expressed as integers from -4 (high negative change) to 4 (high positive change).
* The scores presented for this change from BDCP reflect a comparison of the PP to EBC2, which includes the current OMR flow requirements of the USFWS BiOp (2008) and results in low entrainment of delta smelt compared to pre-BiOp entrainment.
** This score is based on a comparison of the PP to EBC2. Comparison to EBC1 would result in a score of 0 for this stressor.
*** Changes to turbidity as a result of BDCP implementation are difficult to predict and are likely to vary by ROA and subregion, as discussed in Section 5.3.2.3. At this time no conclusion is made regarding the change to turbidity as a result of Plan implementation.
[1] Stressors are ranked by their impact on biological performance of the species under current habitat conditions.
[2] Stressors are attributes of the environment affecting the biological performance of the species.
[3] Presumed impact in the future.

	High degree of scientific certainty, supported by consistent quantitative analysis.
	Appreciable qualitative information supported by general scientific literature.
	Uncertain, conflicting quantitative analysis, limited support in literature.
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5.5.1.1 Beneficial Effects

Tidal habitat restoration would substantially increase the amount of tidal habitat in the Plan area, mostly in the Cache Slough and Suisun Marsh subregions, substantially increasing suitable habitat for delta smelt and potentially increasing food for local consumption and export to open-estuary areas.

Loss of tidal wetlands in the Delta is the most obvious and pervasive change that has occurred as a result of development (Kimmerer 2004; BDCP Science Advisors 2007). CM4 requires restoration of at least 65,000 acres of intertidal habitat resulting in a substantial increase in the total Delta tidal habitat. The extent to which the current lack of tidal habitat limits the delta smelt population is uncertain. Considerable loss of tidal habitat had occurred prior to the major population decline in delta smelt observed over the last several decades, which may be linked to a number of factors such as deterioration of remaining habitat and food availability (Baxter et al. 2010). However, it is uncertain what relationship exists between trends in abundance since routine surveys began in the 1950s/1960s and abundance of delta smelt before that time (Nobriga and Herbold 2009). Delta smelt have been found across a wide range of habitats, including open-water areas (e.g., Moyle 2002), as well as small intertidal marsh channels (Gewant and Bollens 2011). It is likely that habitat characteristics within tidal habitat (e.g., tidal excursion, velocity, temperature, turbidity) influence their use by delta smelt and that channel width itself is not a constraint (Sommer and Mejia 2011). The importance of loss of tidal habitat for occupation by larval and juvenile delta smelt is assumed for this effects analysis to have moderately low importance (score = 2), with moderately low certainty (score = 2). Adult delta smelt hold in spawning areas for probably at least a month after moving upstream before spawning (Sommer et al. 2011), but it is assumed that there is less importance of tidal habitat for this life stage (score =1; certainty = 2). Spawning habitat for delta smelt in the wild is unknown but, if similar to other smelts, may consist of sandy beaches (Bennett 2005:17). It is presently unknown the extent to which loss of spawning habitat may limit the species, although Miller and coauthors (2012:18) suggested that density-dependent effects observed as part of historical trends in delta smelt abundance deserve more study and that factors such as quantity of spawning habitat have not been examined. For this effects analysis it was assumed that the importance of tidal habitat and channel margin habitat for eggs is currently low (score of 1) but with low certainty (score = 1). Floodplains are assumed not be important for any life stage (score = 0; certainty = 4) because delta smelt do not occur on floodplains (Nobriga and Herbold 2009:28).

Analysis of larval and juvenile delta smelt habitat suitability in the ROAs demonstrated that the Plan would result in a considerably more habitat suitable for delta smelt than currently exists (Appendix 5.E, Section E.6.2) (Table 5.5-3 and Table 5.5-4). Habitat suitability would decrease slightly for larval delta smelt over time, and more so for juvenile delta smelt because of temperature effects associated with climate change during the summer and fall, but the overall effect of CM4 remains positive because increases in habitat quantity are greater than decreases in quality. It should be noted that there is uncertainty related to future trends in turbidity, as described above; the analysis assumed turbidity would be similar to existing conditions. As noted for the egg life stage above, the Cache Slough, Suisun Marsh, and West Delta subregions appear to offer the best geographic locations for delta smelt occupancy with respect to the current distribution of the species. With sea level rise and increasing salinity, there may be greater occupation of upstream areas by delta smelt, in which case habitat restoration in the Cache Slough and West Delta ROAs would gain importance. The current occupation of the Cache Slough subregion year-round by delta smelt (Sommer et al. 2011) also may add importance to the restoration in this area. Conservation of adjacent upland areas under the Plan

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would allow expansion of aquatic habitat as sea level rises. It is concluded that the overall change in the tidal habitat stressor related to BDCP tidal habitat restoration measures on delta smelt larvae and juveniles is high (score = 4), with moderately low certainty (score = 2) reflecting uncertainty regarding selection of habitat types by delta smelt. Use of restored areas by delta smelt may depend on the habitat characteristics within the habitats (e.g., the extent of tidal excursion and velocity, temperature, and turbidity) (Sommer and Mejia 2011). There is also uncertainty related to how much restored habitats may be reduced in value because of colonization by IAV and associated nonnative fish species that may prey on delta smelt or compete for food. CM13 aims to control invasive aquatic vegetation in the ROAs, but there is uncertainty related to the ability to do so effectively.

Table 5.5-3. Habitat Units and Habitat Suitability Indices for Delta Smelt Larvae for Existing Conditions and the Plan in the Late Long-Term, Assuming No Sea Level Rise

Restoration Opportunity Area	Scenario	Habitat Units	Habitat Suitability Index
Cache Slough	Existing	6,810	0.91
	Plan	21,227	0.89
Suisun Marsh	Existing	5,236	0.90
	Plan	17,131	0.85
West Delta	Existing	344	0.90
	Plan	3,877	0.89
Cosumnes-Mokelumne	Existing	0	-
	Plan	3,877	0.89
South Delta	Existing	37	0.43
	Plan	6,089	0.43
All	Existing	12,427	
	Plan	52,201	

Note: *Existing conditions* is EBC2 (U.S. Fish and Wildlife Service [2008] Operations Criteria and Plan [OCAP] BiOps with Fall X2 included, i.e., the 2-ppt near-bottom salinity isohaline [X2] located no farther upstream than 74 km and 81 km from the Golden Gate Bridge in falls of wet and above normal years, respectively).

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Table 5.5-4. Habitat Units and Habitat Suitability Indices for Delta Smelt Juveniles for Existing Conditions and the Plan in the Late Long-Term, Assuming No Sea Level Rise

Restoration Opportunity Area	Scenario	Habitat Units	Habitat Suitability Index
Cache Slough	Existing	5,935	0.80
	Plan	18,593	0.81
Suisun Marsh	Existing	4,270	0.70
	Plan	13,198	0.63
West Delta	Existing	290	0.75
	Plan	3,261	0.75
Cosumnes-Mokelumne	Existing	0	0.17
	Plan	3,261	0.75
South Delta	Existing	9	0.09
	Plan	1,384	0.08
All	Existing	10,504	
	Plan	39,697	

Note: *Existing conditions* is EBC2 (U.S. Fish and Wildlife Service [2008] OCAP BiOps with Fall X2 included, i.e., the 2-ppt near-bottom salinity isohaline [X2] located no farther upstream than 74 km and 81 km from the Golden Gate Bridge in falls of wet and above normal years, respectively).

Tidal habitat restoration under CM4 would increase considerably the amount of suitable spawning habitat available to delta smelt because of the extent of restoration in the current areas most frequently occupied by delta smelt, particularly in the Cache Slough ROA (doubling of habitat units for the egg stage) but also in the West Delta and Suisun Marsh ROAs (orders of magnitude more spawning habitat; Appendix 5.E, Section E.6.2.3; Table 5.5-5). Based on the current delta smelt distribution and environmental changes modeled for the future, it is unlikely that tidal habitat restoration in the South Delta or Cosumnes-Mokelumne ROAs would provide significant habitat benefits to the delta smelt egg stage, or indeed any other life stage because of high water temperature and water clarity (see below for a discussion of food production in these ROAs and export to other areas). Channel margin enhancement (CM6) (Appendix 5.E, Section E.6.4) is aimed primarily at restoring habitat in important migration channels for juvenile salmonids that are mostly upstream of the main distribution of delta smelt, but may offer some minor benefit to delta smelt if habitat of the type hypothesized to be important for the species is restored. As noted above, it is unknown whether the availability of suitable spawning habitat is limiting egg production for delta smelt, but it seems unlikely at their current low population levels. More benefit would be obtained from channel margin enhancement if delta smelt population abundance increases in the future and spawning habitat becomes limited. Although habitat suitability generally decreases in each ROA because of climate change, the extent of habitat across the delta suitable for delta smelt eggs increases and is made more geographically diverse as a result of the restoration. It is uncertain the degree to which encroachment of IAV may occur in the low-salinity or freshwater ROAs (Cache Slough and West Delta), but careful design of ROAs could limit the suitability of habitat for IAV. In addition, implementation of CM13 (Invasive Aquatic Vegetation Control) has the potential to limit IAV in the ROAs (Appendix 5.F, Section F.2). Expansion of tidal habitat is assessed to give a high positive change for delta smelt eggs (score = 4) with moderately low certainty (score = 2).

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[***Note to reader:*** *ICF recognizes the need to augment the habitat suitability index analyses to incorporate data from existing habitat areas outside the ROAs. Data will be obtained in order to address this for the public draft BDCP.*]

Table 5.5-5. Habitat Units and Habitat Suitability Indices for Delta Smelt Eggs for Existing Conditions and the Plan in the Late Long-Term, Assuming No Sea Level Rise

Restoration Opportunity Area	Scenario	Habitat Units	Habitat Suitability Index
Cache Slough	Existing	4,836	0.85
	Plan	10,469	0.75
Suisun Marsh	Existing	724	0.83
	Plan	10,469	0.69
West Delta	Existing	20	0.85
	Plan	2,368	0.79
Cosumnes-Mokelumne	Existing	0	0.82
	Plan	2,368	0.79
South Delta	Existing	4	0.83
	Plan	2,215	0.76
All	Existing	5,584	
	Plan	27,889	

Note: *Existing conditions* is EBC2 (U.S. Fish and Wildlife Service [2008] OCAP BiOps with Fall X2 included, i.e., the 2-ppt near-bottom salinity isohaline [X2] located no farther upstream than 74 km and 81 km from the Golden Gate Bridge in falls of wet and above normal years, respectively).

A decrease in food resources (principally calanoid copepods) has been linked to declines in delta smelt abundance in several studies. Kimmerer (2008) demonstrated a strong positive correlation between survival of juvenile delta smelt from summer to fall and density of calanoid copepods during that period. Miller and coauthors (2012) found that minimum density of the calanoid copepods *Eurytemora affinis* and *Pseudodiaptomus forbesi* during the spring delta smelt larval period (April–June) and average density of *E. affinis* and *P. forbesi* during the fall (September–December) was significantly related to interannual trends in fall delta smelt relative abundance. Maunder and Deriso (2010) found that April–June minimum density of *E. affinis* and *P. forbesi* before the larval life stage and July–August average density of *E. affinis* and *P. forbesi* after the juvenile life stage (July–August) were important factors associated to changes in delta smelt abundance in their life cycle model (see also Appendix 5.G, *Fish Life Cycle Models*). Mac Nally and coauthors (2010) found some statistical evidence that summer calanoid copepod density was associated with annual trends in abundance of delta smelt in the fall. The decrease in food resources may have been because of a factor such as a change in phytoplankton and zooplankton assemblages related to biological invasions (e.g., the invasive clam *Corbula amurensis*) (Winder and Jassby 2011) and anthropogenic factors such as nutrient balance (Dugdale et al. 2007; Glibert et al. 2011). For this effects analysis it is assumed that the quantity of food resources for larval and juvenile delta smelt as a stressor has high importance for delta smelt (scores = 4) with moderately high certainty (score = 3). Baxter and coauthors (2010) noted that there was no evidence that food is limiting for adult delta smelt, so it was scored accordingly low (score = 0, certainty = 4).

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A major reason for restoration of tidal habitat (CM4) is to contribute to food production in the Delta in addition to the direct habitat benefits discussed above. The hypothesis is that restoration of shallow tidal areas will increase the growth of phytoplankton and thereby increase the amount of zooplankton that are the food base for delta smelt and other species (Baxter et al. 2010). Restoration of tidal habitat was evaluated using the relationship between phytoplankton growth rate and average habitat depth developed by Lopez and coauthors (Lopez et al. 2006). That relationship was used as an indicator of potential food productivity increases in the ROAs as a result of restoration of shallow tidal areas (Appendix 5.E, Section E.5.1.3.1). The analysis suggested the potential for a considerable increase in primary productivity (Table 5.5-6) (Appendix 5.E, Sections E.6.2.3.1, E.6.24.1, E.6.2.5.1, E.6.2.6.1, and E.6.2.7.1), which may translate into increased food resources for larval and juvenile delta smelt in the ROAs, as well as export beyond the ROAs. However, the direct relationship between primary productivity and food for higher trophic levels is unclear because of the influence of invasive clams, transfer rates, and other factors (Lopez et al. 2006). Therefore, while the production of increased zooplankton (i.e., food) is expected from the increased phytoplankton production, the magnitude of this change is unknown. Increased food production under the Plan would be of considerable importance in and adjacent to areas currently occupied by delta smelt—the Cache Slough, West Delta, and Suisun Marsh ROAs; there was estimated to be more than a threefold increase in phytoplankton productivity in these ROAs (Table 5.5-6).

The value of potentially high production in the South Delta ROA would depend on export to areas where delta smelt larvae and juveniles are more likely to occur. A large body of literature supports the hypothesis that restoration of tidal marsh and floodplain habitat will increase local food production and export of additional food resources to downstream areas (Jassby and Cloern 2000; Kneib et al. 2008; Opperman 2008). Food production in the West Delta and Suisun Marsh ROAs also may be enhanced by increases in residence time caused by changes in hydrodynamics. The degree to which additional food resources produced in restoration areas will become available to delta smelt outside the ROAs is uncertain. Lehman and coauthors (2010) demonstrated that export of material from Liberty Island in the Cache Slough subregion varied considerably because of tidal action; the area was both a source and a sink of materials during their study. Careful design of the restored aquatic habitats and monitoring would aim to reduce or avoid the adverse effects of colonization by benthic organisms such as invasive clams *Corbula* and *Corbicula*, but the ability to limit colonization is uncertain. Restoration designs could be refined through adaptive management as new restoration areas are developed. After consideration of the various factors described above, it is concluded that there would be a moderately high positive benefit of the Plan on food resources for larval and juvenile delta smelt (score = 3), with moderately low certainty (score = 2).

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Table 5.5-6. Depth-Averaged Phytoplankton Growth Rate and Prod-Acres for Existing Conditions and the Plan in the Late Long-Term, Assuming No Sea Level Rise

Restoration Opportunity Area	Scenario	Phytoplankton Growth Rate (per day)	Prod-Acres
Cache Slough	Existing	0.60	4,526
	Plan	0.85	13,858
Suisun Marsh	Existing	0.69	4,018
	Plan	0.92	13,089
West Delta	Existing	0.76	293
	Plan	0.74	2,907
Cosumnes-Mokelumne	Existing	0.00	0
	Plan	1.06	3,116
South Delta	Existing	1.14	98
	Plan	1.12	15,892
All	Existing		8,935
	Plan		48,862

Notes: Existing conditions is EBC2 (OCAP BiOps with Fall X2 included). Prod-acres are the product of phytoplankton growth rate and acreage.

Overall entrainment of delta smelt under the Plan would remain at or be less than low levels experienced in the recent past. This is because the north Delta diversion operations would reduce reliance on south Delta export facilities, with additional minor benefits from decommissioning of agricultural diversions in restoration areas and implementation of an alternative intake for the North Bay Aqueduct (NBA). Some losses of delta smelt may occur because of entrainment and impingement at the north Delta diversions, but these would be relatively low because much of the population occurs downstream of the diversions.

The BDCP would ensure that current low entrainment required by the BiOps would be maintained in the future. Losses of delta smelt larvae and juveniles to entrainment at the south Delta export facilities in spring (March–June) were estimated to range from 0% to 26% of the population during 1995–2006 (Kimmerer 2008, as reported by Miller 2011:5). Implementation of south Delta export restrictions under the USFWS (2008) OCAP BiOp appears to have limited entrainment loss of larval and juvenile delta smelt (e.g., Smelt Working Group 2010). Analyses of factors that could have influenced changes in abundance of delta smelt over time have included larval/juvenile entrainment and spring water exports. Several of these analyses did not find evidence linking spring entrainment loss or exports to population trends of delta smelt (Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012) whereas Mac Nally and coauthors (2010) found that there was some weak evidence to suggest an inverse relationship between delta smelt fall abundance and spring exports. Correlative analyses may not detect effects of spring entrainment because of subsequent factors influencing survival (e.g., food abundance) (Kimmerer 2008), but at the existing low abundance of delta smelt it is possible that the population productivity is density-independent, which means that mortality in one life stage due to entrainment might not be compensated for by greater survival in later stages and so affect population performance (Kimmerer 2011). As noted by Baxter and coauthors (2010:61), combined substantial losses of adult and larval/juvenile delta smelt in the same generation may cumulatively affect the delta smelt population.

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Similar to larval-juvenile delta smelt, considerable proportional entrainment loss of adult delta smelt at the south Delta export facilities has been estimated historically: Kimmerer (2008) found that up to 50% of the adult population had been lost in December–March 2003 and that appreciable losses occurred in other years. A reexamination of Kimmerer's (2008) estimates by Miller (2011) prompted Kimmerer (2011) to suggest a downward revision of his original estimates by around one quarter, but nevertheless the estimates were high in some years. Implementation of south Delta export pumping restrictions under the USFWS (2008) OCAP BiOp has considerably limited entrainment loss of adult delta smelt (Smelt Working Group 2010; U.S. Fish and Wildlife Service 2011). The restrictions aim to keep proportional adult entrainment loss below around 5% of the population (U.S. Fish and Wildlife Service 2008:387). Some links between proportional entrainment loss of adult delta smelt or winter exports and trends in the delta smelt population have been found in several studies. Mac Nally and coauthors (2010) found some weak evidence of an inverse relationship between winter exports and delta smelt fall abundance, whereas Thomson and coauthors (2010) found that winter exports had a high probability of inclusion in models explaining variation in delta smelt abundance but could not explain the step change in abundance during the POD. Entrainment loss of adult delta smelt was included in some of the better-fitting iterations of the state-space life cycle model of Maunder and Deriso (2011) although did not appear in the best model (see Appendix 5.G, *Fish Life Cycle Models*). Finally, Miller and coauthors (2011) found that survival of delta smelt from fall to summer was statistically negatively associated with total proportional entrainment of delta smelt (i.e., adults and larvae/juveniles from the next generation), although survival from fall to fall (i.e., the full life cycle) was not related to total entrainment.

In light of the reduction in entrainment in recent years because of the OCAP BiOp, for this effects analysis it is considered that entrainment of delta smelt larvae, juveniles, and adults at the south Delta export facilities under existing conditions is a stressor with moderately low population effect (score = 2), with moderately low certainty (score = 2). This score is due, in part, to the recent substantial reductions in entrainment due to the requirements of the OCAP BiOp, which are part of the existing baseline conditions.

Analyses showed that there was little difference in proportional entrainment loss of delta smelt larvae/juveniles between the Plan and existing conditions scenarios averaged over all years in the late long-term. However, results varied by water-year type, with greater use of the north Delta intakes in wetter years leading to appreciably less overall entrainment under the Plan, whereas an increased reliance on the south Delta export facilities in drier years meant that overall entrainment was slightly greater under the Plan. Given that the daily management of water exports to limit entrainment existing conditions also would occur under the Plan, it is concluded that there is no effect of the Plan in changing this stressor for larval and juvenile delta smelt (score = 0, certainty = 3).

Analyses suggested that, averaged over all years in the late long-term, proportional entrainment loss of adult delta smelt under the Plan was lower than under existing conditions. Greater use of the north Delta intakes in wet, above normal, and below normal water-year types led to considerably less overall entrainment under the Plan, whereas an increased reliance on the south Delta export facilities in dry and critical years meant that overall entrainment was similar between the Plan and existing conditions. Of probable importance to the delta smelt population is the avoidance of appreciable losses in both the adult and subsequent larval/juvenile population (Baxter et al. 2010). It is concluded that there is a moderately low positive change from the Plan on this stressor for adult delta smelt (score = 2) with moderately high certainty (score = 3).

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The centerpiece of the Plan's CM1 is implementation of dual conveyance by construction of five intakes with 15,000 cfs total water diversion capacity along the Sacramento River in the North Delta subregion. Delta smelt mostly occur well downstream of this area but also they have been found in the vicinity of the screens as adults and larvae in USFWS seine surveys and DFG striped bass egg and larval surveys. Delta smelt greater than about 15–16-mm standard length would be expected to be excluded from entrainment by the proposed screen mesh of 1.75 mm (Turnpenny 1981; Margraf et al. 1985; Young et al. 1997). For individuals contacting the screens, the potential for impingement-related injury and mortality exists (Swanson et al. 2005). Approach and sweeping velocity criteria for the north Delta intake screens have not been finalized, but approach velocity would be less than 0.33 feet per second (fps) (the criterion for salmonid fry) and may be limited to 0.2 fps (the existing criterion for juvenile delta smelt). As noted by Nobriga and coauthors (2004), delta smelt tend to be less abundant near the shore, so it may be that a relatively low proportion of individuals occurring near the intakes would be affected, but this is uncertain. Given the relatively low proportion of the delta smelt population that is likely to occur near the north Delta diversions and the use of state-of-the-art screening technology, it is concluded that this will be a low adverse effect on larval, juvenile, and adult delta smelt (score = -1), with moderately high certainty (score = 3). Monitoring of entrainment and impingement would further inform the effect of this stressor following implementation.

[***Note to reader:*** *ICF intends to incorporate detailed methods and results for the north Delta intake entrainment and impingement analysis in the Appendix 5.B,* Entrainment*, for the public draft. Additional modeling of potential hydraulic characteristics by DWR is being undertaken and may further inform this analysis*.]

There are more than 2,500 water diversions, including agricultural diversions, in the Plan Area (Herren and Kawasaki 2001; Appendix 5.B, Section B.2.6). Losses of delta smelt occur at agricultural water diversions in the Plan Area (Cook and Buffaloe 1998; Nobriga et al. 2004). The extent of the entrainment is not known, but Nobriga and Herbold (2009) considered it unlikely to be affecting delta smelt because (1) the zone of hydrodynamic influence is very small and close to the shore, whereas delta smelt tend to be away from the shore, (2) many irrigations do not divert water every day, (3) many diversions are found in the south Delta, where risk for entrainment at the SWP/CVP export facilities is relatively high and habitat conditions are poor, (4) agricultural water use patterns have not changed since the 1930s, and (5) other, littoral species that would be more prone to entrainment at agricultural diversions do not appear to be affected and have healthy populations. For the purposes of this effects analysis, it was assumed that entrainment at agricultural diversions is a stressor of low importance (score = 1) with moderately high certainty (score = 3) for larval, juvenile, and adult delta smelt. Particle-tracking modeling suggested that entrainment of delta smelt larvae at the agricultural diversions would be lower under the Plan than existing conditions as a result of altered hydrodynamics from CM1 (Appendix 5.B, Section B.4.4.1.1). Further, tidal habitat restoration under CM4 was estimated potentially to result in the decommissioning of more than 12% of Plan Area agricultural diversions in the late long-term, and the DRERIP (2009) evaluation of the previously proposed conservation measure to decommission agricultural diversion suggested a low magnitude effect with low certainty (Appendix 5.B, Section B.4.4.3.1). Given that agricultural diversions typically are greatest during the larval or juvenile phases of the delta smelt life cycle (Appendix 5.B, Section B.3), it is concluded that there would be a low beneficial change to this stressor from the Plan (score = 1) for larval and juvenile delta smelt, with low certainty (score = 1).

Entrainment loss at the SWP NBA Barker Slough pumping plant (described in Appendix 5.B, Section B.2.5) in the Cache Slough subregion was estimated to range from less than 400 to more

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than 32,000 delta smelt larvae between 1995 and 2004 (U.S. Fish and Wildlife Service 2008:170). The estimates were based on multiplying density of fish in the water column by pumping rate; USFWS (2008:171) noted that entrainment may have been lower because of the fish screen at the facility, but direct entrainment estimates were not made. For this effects analysis, it is considered that entrainment of delta smelt larvae at NBA under existing conditions is a stressor with low population effect (score = 1; certainty = 1). Implementation of a dual conveyance, with a new Sacramento River alternative intake under the Plan that could be used instead of the Barker Slough intake, should lower entrainment of delta smelt larvae at NBA compared to existing conditions. Particle-tracking modeling results that do not account for the change in alternative intake location but focus solely on pumping differences and changes in hydrodynamics because of habitat restoration in the Cache Slough subregion suggested that entrainment of particles at the NBA would be relatively lower under the Plan than under existing conditions (average reduction of around 1% fewer particles being entrained, depending on starting distribution) (Appendix 5.B, Section B.4.3.1.1). It is concluded that there would be a low beneficial change (score = 1, certainty = 2) of the Plan on this stressor for delta smelt larvae.

Plan conservation measures may lower predation of larval, juvenile, and adult delta smelt to a small extent; there is low certainty in this conclusion.

The importance of predation to delta smelt is unclear because little is known of predation rates (Nobriga and Herbold 2009). Estimates of predation of delta smelt by species such as striped bass are very uncertain (e.g., California Department of Fish and Game 1999) (Appendix 5.F, Section F.3.5.2.4). Recent modeling efforts indicated some support for a potential negative effect of largemouth bass and other inshore predators on trends in delta smelt abundance (Mac Nally et al. 2010; Maunder and Deriso 2011) although other studies did not show such a link (Thomson et al. 2010; Miller et al. 2012). There was no evidence for links between striped bass predation and trends in delta smelt abundance from the studies by Maunder and Deriso (2011) and Miller and coauthors (2012). For this effects analysis it is assumed that predation is of moderately low importance (score = 2) to all delta smelt life stages but with low certainty (score = 1).

As indicated in Appendix 5.F, Section F.3.5.2, the Plan may have several effects on predation related to delta smelt. Changes in water operations under CM1 may result in lower proportions of delta smelt larvae/juveniles and adults being entrained at the south Delta export facilities, which in turn would reduce exposure to predation (such losses are essentially captured in the calculations of changes in entrainment loss discussed above). CM1 may result in added predation pressure at the proposed north Delta diversions, although this is upstream of much of the range of delta smelt. *CM15 Predator Control* may reduce predation pressure at key locations such as during the south Delta salvage process (e.g., by predator capture and by increasing numbers of release sites), although many of the sites initially considered under this measure are of greater relevance to migration pathways of juvenile salmonids and have less overlap of the current geographic distribution of delta smelt (Appendix 5.F, Section F.3.4.5). It is concluded that the Plan may lead to a small reduction in predation of delta smelt larvae, juveniles, and adults (scores = 1), with low certainty (scores = 1).

5.5.1.2 Adverse Effects

Fall abiotic habitat for juvenile delta smelt in the open-water areas of the Suisun Bay, Suisun Marsh, and West Delta subregions would be lower under the Plan than under existing conditions that include the Fall X2 Reasonable and Prudent Alternative (RPA) because of lower outflow, but would increase relative to existing conditions without the Fall X2 RPA. The decline in fall abiotic habitat conditions in the open estuary is largely offset by tidal marsh habitat restoration when considered across all water year types relative to both EBC1 and EBC2 baselines.

The low salinity zone (LSZ) is an important ecological feature of the Delta that has been associated with the distribution of abiotic habitat conditions such as turbidity and salinity as well as the distribution of fish and zooplankton (Jassby et al. 1995; Kimmerer 2004; Baxter et al. 2010). The location of the LSZ has been associated with abundance of some fish species, but the relationship with delta smelt abundance has not been shown (Jassby et al. 1995). The general location of the LSZ is identified using X2, which is directly related to outflow (Jassby et al. 1995). Fall outflow under the Plan would reduce abiotic habitat in the LSZ compared to EBC2 but would maintain habitat conditions in the fall under EBC1 as a result of habitat restoration.

Fall abiotic habitat conditions in the LSZ in the Suisun Bay and West Delta subregions are hypothesized to affect the Delta fish community by bottom-up and top-down mechanisms (Baxter et al. 2010:58), but there is uncertainty related to its importance to juvenile delta smelt.. The only published method for evaluating the relationship between X2 and delta smelt, Feyrer et al. 2011, evaluated fall abiotic habitat condition using an index combining habitat quantity weighted by quality in terms of salinity (conductivity) and water clarity (Secchi depth). It should be noted that DWR and potential BDCP applicants have concerns related to this method, including (1) that it is limited to only two abiotic factors (conductivity and Secchi depth), (2) it does not include biotic factors such as food density, (3) there is much data variability that is not explained by the underlying relationship between delta smelt presence and the two abiotic factors, (4) statistical uncertainty in the underlying relationship is not accounted for when linking the derived abiotic habitat index with X2, which is a surrogate for outflow, and (5) it does not include areas of habitat for which there is increasing evidence of importance for delta smelt (e.g., the Cache Slough subregion) (Sommer et al. 2011). Nonetheless, this method is used to provide a conservative analysis of the potential change in abiotic habitat that may occur under the Plan using the most recently applied method for evaluating the effects of outflow on delta smelt habitat.

The actual mechanisms underlying the hypothesized relationship between X2 location in the fall and the health and condition of pre-spawning adult delta smelt are unknown. Several potential mechanisms have been identified and tested using data primarily from the DFG Fall Midwater Trawl surveys extending back to 1967. Data from the Fall Midwater Trawl surveys were used to examine the potential relationship between Fall X2 location and the geographic distribution of delta smelt. Results of these analyses showed that the centroid of the delta smelt geographic distribution moves upstream and downstream in relationship to Fall X2 location; however, this does not mean that all smelt are confined to a narrow geographical distribution at that specific salinity gradient (Sommer et al. 2011).

Additional analyses examined the relationship between X2 location and survival of pre-spawning delta smelt in the fall using both the DFG monthly indices of delta smelt abundance each year and refined estimates of delta smelt abundance derived from Fall Midwater Trawl surveys by Newman (2008). As a result of high variability in the estimated fall survival rates derived from these analyses,

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no conclusions were drawn regarding the potential relationship between Fall X2 location and delta smelt survival in the fall.

For this effects analysis it is assumed that the LSZ stressor has moderately high importance (score = 3) for juvenile delta smelt, with moderately low certainty (score = 2). The moderately high importance score is given because of agency concerns regarding the potential relationship between X2 and delta smelt, while the moderately low certainty reflects the uncertainty between abiotic habitat and abundance, as described below.

This effects analysis showed that under the Plan, which does not include any Fall X2 actions, the fall abiotic habitat index in the late long-term on average would be more than 1,000 hectares less (22 % less) relative to EBC2. This difference was driven by substantially lower abiotic habitat in falls following wet and above normal water years. However, when compared to the current condition without the Fall X2 action (EBC1), the Plan results in little change in the fall abiotic habitat index, and in fact the index increases substantially in dry years, reflecting the substantial habitat restoration proposed under the Plan.

The effects analysis also considered the change in abiotic habitat from restoration in Suisun Marsh and West Delta ROAs under CM4 (Appendix 5.E). This analysis showed that if restored habitat had quality similar to adjacent existing areas, this may offset the lower habitat index under the Plan relative to EBC2. With full (100%) use of the restored habitat in these ROAs, the abiotic habitat indices under existing conditions and the Plan would be essentially the same averaged across all water years, although there would be less fall abiotic habitat in wet and above normal water years and a greater fall abiotic habitat index in other water-year types. Compared to the current condition without the Fall X2 provision (EBC1), the Plan resulted in a substantial increase in abiotic habitat. These results are highly dependent on the assumption of occupancy of the restored habitat and would decrease at lower occupancy rates.

Even with the compensation for abiotic habitat loss in the LSZ by habitat restoration, the decrease in the fall abiotic habitat index is a potential adverse effect of the Plan on the portion of the delta smelt population that rears near the confluence of the Sacramento and San Joaquin Rivers in the West Delta and Suisun Bay subregions, depending on which baseline is used for comparison. It is concluded that, relative to EBC2, this is a moderately low negative change to this stressor (score = -2) because of the potential for juvenile delta smelt to use restored habitat in the Suisun Marsh and West Delta ROAs, with low certainty (score = 1).

As noted above, there is uncertainty related to the importance of abiotic habitat, particularly in the fall (i.e., Fall X2), to juvenile delta smelt. Targeted research could address the importance of Fall X2 for juvenile delta smelt. USFWS and Reclamation have designed and plan to continue adaptive experiments to test the benefit of increased abiotic habitat. This research should help reduce the uncertainty of the effects of reduced fall outflow associated with the Plan. This potential adverse effect could be eliminated or reduced if it is determined, based on this research and other information that would be developed over the implementation period of the BDCP, that reduced outflow is less important than assumed for this analysis, or if it determined that this stressor is as important as it is assumed for this analysis, the BDCP operations could be modified within the bounds of the adaptive limits to increase outflow during the fall.

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The combination of the movement of X2 and tidal habitat restoration may increase delta smelt exposure to the toxic blue-green alga microcystis and provide additional opportunities for invasive mollusks, including *Corbicula* and *Corbula*, to colonize in delta smelt habitat, affecting delta smelt food availability.

The toxic blue-green alga microcystis has been shown to have potentially negative effects on the aquatic food web of the Delta, principally in the South Delta subregion and the upstream-most portions of the West Delta subregion such as Franks Tract (Lehman et al. 2010). The distribution of microcystis has been negatively correlated with chloride, total suspended solids, and total organic carbon and positively correlated with nitrate-N, soluble phosphorus, and total nitrogen (nitrate-N plus ammonium-N) (Lehman et al. 2010). There was no correlation with total nitrogen to soluble phosphorus ratio or with ammonium-N (Lehman et al. 2010). The blooms of microcystis occur in late summer and fall, coinciding with the delta smelt juvenile life stage. Although direct effects on delta smelt have not been examined, Baxter and coauthors (2010) considered that, based on the work of Lehman and coauthors (2010), there was some likelihood of potential negative effects on juvenile delta smelt. It is considered that microcystis is a low stressor to delta smelt juveniles (score = 1), with moderately low certainty (score = 2). Under the Plan, the LSZ generally would be located farther upstream than under EBC2 (although in the late long-term there also would be an upstream movement because of sea level rise) and a portion of the juvenile delta smelt population residing in the LSZ also may be found farther upstream. This could increase the potential for delta smelt to be exposed to microcystis toxicity (Appendix 5.F, Section F.4). It is concluded that there would be a small negative change (score = -1) to this stressor for delta smelt juveniles, with low certainty (score = 1).

As described above in relation to food production in restored habitat area, the invasive mollusk *Corbula amurensis* may have negatively affected the delta smelt foodweb through consumption of plankton. The extent of *Corbula* in the Plan Area is related to salinity, with increased upstream penetration during lower outflow years. Recruitment of *Corbula* larvae at the upstream extent of the range in the west Delta subregion occurs in summer/fall (July–December) at salinities at or above 2 ppt, and adults may persist at salinities as low as 0.1 ppt (Nicolini and Penry 2000). The influence of *Corbula* as a competitive stressor on delta smelt because of food limitation is assumed to be moderately high on larval and juvenile delta smelt occupying the LSZ (scores = 3) with moderately high certainty (scores = 3). Lower outflow during the *Corbula* summer/fall recruitment period may increase the upstream extent of the species in the Plan Area and therefore increase the potential to reduce food availability for delta smelt juveniles in the LSZ (Appendix 5.F, Section F.5). It is concluded that this is a small negative change to this stressor for larval and juvenile delta smelt (score = -1) with low certainty (score = 1).

Exposure of delta smelt life stages to contaminants may occur following restoration under the Plan; exposure to agriculture-related contaminants later in the Plan term may decrease because of restoration of agricultural areas.

It is uncertain to what extent contaminants may have contributed to the current status of pelagic fish species (Brooks et al. 2011). Spawning and early life stages could be affected by elevated concentrations of contaminants during typical winter runoff, but this has not been demonstrated for delta smelt. The effects of contaminant exposure on delta smelt eggs have not been evaluated, and lethal and sublethal effect levels are unknown. There is some evidence that fish embryos are less sensitive to pyrethroids than larvae are (Oros and Werner 2005); however, they may be exposed to higher concentrations because they are in direct contact with the substrate where pyrethroids are more concentrated. The population-level effect of exposure of delta smelt eggs to contaminants is

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expected to be low but may be larger if sublethal effects have substantial population-level implications. For the purposes of this effects analysis it is assumed that contaminants have low effects on delta smelt life stages (score = 1), recognizing that there is low certainty in this designation (score = 1).

The Plan could adversely affect delta smelt eggs and other life stages through changes in contaminants as a result of changes in water operations (CM1, CM2) and habitat restoration (principally, CM4). Analyses presented in Appendix 5.D, *Contaminants,* suggested that there was low potential for increased contaminant exposure from the Plan and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded that overall this represents a low adverse change to this stressor for all delta smelt life stages (score = -1), with low certainty (score = 1).

In-water construction and maintenance effects of the Plan could affect delta smelt but would be minimized with careful management.

In-water construction activities at the proposed north Delta intakes (CM1) would be limited to one construction season during the months of June–October (Appendix 5.H). Delta smelt generally occur well downstream of the construction area, although as noted above for impingement/entrainment, some individuals do occur in the vicinity of the proposed intakes. The seasonality of construction suggests that most delta smelt would have left the area, as spawning would have been largely completed and larvae would have moved downstream. Any delta smelt present may experience adverse effects from underwater sound (pile driving), entrapment in enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment and suspension of toxic materials), and accidental spills. Habitat would be temporarily and permanently affected by intake construction, although existing habitat at the intake sites is generally of low quality (steep sloping, revetted banks). Maintenance dredging also may decrease water quality temporarily. Habitat restoration activities associated with CM4–CM7 may reduce water quality and would be more likely to affect delta smelt because the activities are closer to the species' main distribution. Breaching of levees to create tidal habitat may reduce areas of channel margin, but there would be considerable gains of habitat caused by the breaching. In-water activities associated with *CM14 Stockton Deepwater Ship Channel Dissolved Oxygen Levels, CM15 Predator Control, CM16 Nonphysical Fish Barriers*, and *CM21 Nonproject Diversions* would have little to no effect on delta smelt because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* would reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on delta smelt. It is concluded that construction and maintenance associated with the Plan represent a minor adverse effect on delta smelt life stages with high certainty.

5.5.1.3 Impact of Take on Species

The Plan may result in incidental take of delta smelt from several mechanisms. Construction and maintenance at the proposed north Delta intakes, restoration sites, conservation hatcheries, and nonphysical barriers may result in a number of adverse effects on delta smelt, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (see Appendix 5.H, *Aquatic Construction Effects*). These effects, however, would be temporary and are unlikely to have a considerable effect on delta smelt because the species is mostly well downstream of the area where the main in-water activities (construction of north Delta diversion facilities) would be located, and a

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number of measures would be taken to minimize effects, including timing of in-water work to minimize potential adverse effects on delta smelt. As a result, there would be minimal impact of take from these activities.

At the south Delta diversion facilities, cumulative annual salvage of delta smelt at the SWP and CVP between water years 1996 and 2009 ranged from approximately 336 to 154,650 individuals per year, with the highest salvage recorded in 1999 and 2000. Salvage decreased fairly dramatically in 2005 and has remained relatively low since (336 to 3,752 fish salvaged annually in 2005 to 2009), potentially due to the low abundance of delta smelt during this period and changes in operations to conserve the species (U.S. Fish and Wildlife Service 2008). Based on the reductions in entrainment estimated for the delta smelt population under the Plan as described above, there may be a reduction in take of delta smelt at the south Delta facilities that has the potential to provide a minor benefit at the population level for delta smelt (see *Beneficial Effects* above). Take of delta smelt at the south Delta facilities could increase in the future if the population size increases as a result of the Plan or other actions; however, this would not represent an increase in loss as a proportion of the population. There also may be take of larval delta smelt at diversions to the NBA, but this take would be reduced by implementation of the alternative intake on the Sacramento River. It is anticipated that decreases in entrainment at the south Delta export facilities, NBA Barker Slough pumping plant, and at numerous agricultural diversions that would be decommissioned in tidal habitat restoration areas would more than offset any entrainment and impingement at the proposed north Delta diversion facilities.

Lower outflow in the fall would decrease the fall abiotic habitat index for delta smelt by an average of 1,000 hectares compared to EBC2, with greatest decreases in wet and above normal years. Restoration of tidal habitat may offset these losses to some extent, although the magnitude of benefit the restoration will provide is uncertain. In comparison to a baseline without the Fall X2 (EBC1), there is little difference between existing conditions (baseline) and the Plan.

5.5.1.4 Abundance

Habitat restoration under the Plan considerably increases the extent of suitable habitat for delta smelt. Abundance of delta smelt has the potential to be beneficially affected by the substantial increase in tidal habitat under the Plan. Habitat suitability analysis indicated that the quantity of suitable habitat (expressed as habitat units) in the ROAs would greatly increase and that decreases in habitat quality in the ROAs because of climate change may be offset by increased area. Lower outflow in late summer/fall may decrease the area of the LSZ and therefore has the potential to adversely affect the area of suitable habitat, although as noted above, a portion of the population rears in other areas such as Cache Slough (Sommer et al. 2011). Also as noted above, the relative adverse effect would depend on the baseline condition (i.e., if the USFWS [2008] OCAP BiOp standard for Fall X2 is implemented).

5.5.1.5 Productivity

The Plan offers the potential to increase productivity of the delta smelt population principally by increasing food supply within and outside restored areas and reducing entrainment by implementation of dual conveyance. However, reduced outflow during late summer/fall of wet and above normal years may adversely affect the portion of the population occurring in the LSZ through increased potential exposure to stressors such as microcystis. Lower outflow may also facilitate

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increases in *Corbula* clam recruitment in the LSZ, which could cause reductions in planktonic organisms that form the basis of the food that delta smelt eat.

5.5.1.6 Life History Diversity

Restoration of tidal habitat under the Plan has the potential to contribute to an increase in life history diversity for delta smelt. There is increasing evidence of life history contingents in the delta smelt population, particularly in the Cache Slough subregion. As described by Sommer and coauthors (2011:12), “The 'contingent hypothesis' proposed that these fishes have divergent migration pathways that could help the species survive in variable and heterogenous environments, a particularly important benefit given the challenges presented by climate change effects.”

Restoration in the Cache Slough subregion would facilitate the expression of these contingent life history strategies by increasing the amount and spatial diversity of suitable habitat. Habitat restoration in other ROAs adds to the spatial extent and diversity of habitats and also may contribute to life history diversity. Lower outflow during late summer/fall may adversely affect life history diversity by affecting the portion of the population residing in the existing areas of the Suisun Bay and West Delta subregions.

5.5.1.7 Spatial Diversity

As indicated by the habitat suitability analysis summarized above, tidal restoration in the Plan ROAs has the potential to increase greatly the areas of suitable habitat across the Plan Area. Spatial diversity potentially would increase because of the restoration of significant areas of suitable habitat in the Suisun Marsh and Cache Slough ROAs, where habitat would increase by a factor of three or four. There would be a lesser benefit from the West Delta ROA because of the relatively small size of the ROA, although its position coincides with an important location within the range of the species, along the migration route from rearing areas in the Suisun Bay/Suisun Marsh subregions to upstream spawning areas. Habitat with relatively low suitability would be restored in the South Delta and Cosumnes-Mokelumne ROAs, which would be less likely to benefit delta smelt. Lower outflow in late summer/fall of wet and above normal water years under the Plan potentially would decrease the extent of suitable habitat in the existing Suisun Bay and West Delta subregions, and there is uncertainty about the extent to which restored habitat may compensate for these losses.

5.5.1.8 Net Effects

Figure 5.5-1 provides a graphical depiction of the relative population-level outcomes, by stressor, for delta smelt resulting from implementation of the Plan.

Delta smelt are currently at very low levels of abundance. The Plan has the potential to provide substantial benefits to each life stage of delta smelt. The Plan provides very low levels of entrainment relative to conditions prior to the USFWS (2008) OCAP BiOp, and maintains entrainment loss at the south Delta export facilities at levels at or below those achieved under the BiOp. The Plan provides the additional benefit of habitat restoration, which will increase considerably the extent of tidal habitat in the Plan Area. Proposed habitat restoration areas are spatially diverse, are adjacent to very important existing areas occupied by delta smelt (e.g., the Cache Slough subregion), and would provide a range of habitat conditions that would be suitable for delta smelt spawning and rearing. Expansion of habitat in the Cache Slough subregion in particular may be of particular importance in the late long-term as the species faces increasingly challenging

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environmental conditions caused by a warming climate and rising sea level. Delta smelt residing in the restoration areas would receive direct habitat benefits from the restoration as well as increased primary and secondary production from the tidal marshes and newly available open waters. The potential export of food resources from the restoration areas into other areas inhabited by delta smelt may be the most important function of habitat restoration.

The magnitude of this benefit is uncertain and depends on a number of factors, including whether the phytoplankton produced in the restoration areas will convert to zooplankton, whether the food will be exported to or created in areas where delta smelt can consume it, and whether adverse conditions such as invasive vegetation and clams colonize in the ROAs. The potential for large or small benefits from restoration is likely to be region-specific, e.g., there may be appreciable benefits resulting from export of food from the Suisun Marsh, West Delta, and Cache Slough ROAs, and less benefit from the South Delta and Cosumnes-Mokelumne ROAs because they are farther from the species' main range. The Cache Slough subregion also may receive increased food production from the Yolo Bypass.

Although there is uncertainty related to the magnitude of beneficial effects of tidal habitat restoration in relation to increased food production for delta smelt, there is potential for considerable beneficial effects. The USFWS (2008) OCAP BiOp RPA action 6 required a program to create or restore 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. As noted by USFWS (2008: 381): "New evidence indicates how tidal marsh may benefit delta smelt even if they do not occur extensively within the marsh itself." The evidence was from Liberty Island, where spawning and rearing of delta smelt occurs. USFWS (2008: 381) concluded: "…these data suggest that freshwater tidal wetlands can be an important habitat type to delta smelt with proper design and location." Implementation of the Plan includes more than eight times the amount of tidal wetlands called for in the USFWS BiOp, and will include deliberate restoration design and management to promote food production and export to areas where delta smelt occur. While the magnitude of this benefit cannot be quantified because of uncertainties related to the specifics of the restoration site, adaptive management over the period of implementation will aim to yield large food benefits to delta smelt. The anticipated benefits of restoration for delta smelt will be tested and verified by the BDCP Implementation Office with an initial series of tidal wetland restoration projects in the first 5–10 years of implementation through the adaptive management and monitoring program. Because of the uncertainties in scaling differing Plan effects, it was not possible to conclude with certainty at this time that BDCP restoration would provide the food benefits needed to increase delta smelt populations. However, the BDCP has the potential to provide a substantial net benefit to delta smelt as a result of the large amount of tidal wetland restoration and the expected food production to support the species. If these substantial benefits are realized, the BDCP would have the potential to contribute greatly to the recovery of delta smelt. Predation reduction measures generally are focused on areas important to juvenile salmonid migration, with some benefit to delta smelt possibly occurring at the south Delta export facilities release sites.

The principal potential negative effect of the Plan on delta smelt relative to existing conditions with the USFWS (2008) OCAP BiOp Fall X2 standard included is appreciably lower outflow in the late summer and fall of wet and above normal water-year types. For delta smelt occupying the Suisun Bay and West Delta subregions, low outflow may decrease abiotic habitat potentially resulting in increased exposure to less desirable environmental conditions such as toxicity from microcystis blooms. It is also possible that lower outflow may result in increased abundance of the invasive clam *Corbula* as a result of greater areas of suitable salinity (>2 ppt) in the West Delta subregion; this may increase consumption of primary and secondary productivity that otherwise would form part of the

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delta smelt foodweb. As described above, there is little evidence linking delta smelt abundance to X2, and the method used to determine this adverse effect of the Plan is limited to the portion of the population that rears in Suisun Bay and West Delta.

The Plan will not result in changes in several stressors for delta smelt. As described in Appendix 5.D, *Contaminants*, ammonium levels , an important stressor influencing plankton communities in the Plan Area, will not change as a result of the Plan. *Alternative channels* relates to different migration routes through the Plan Area (e.g., entry to the East Delta subregion through the Delta Cross Channel and Georgiana Slough) and is more of a concern for juvenile salmonids migrating through the Plan Area that could be affected by *CM16 Nonphysical Fish Barriers*. Delta smelt occur mostly downstream of proposed nonphysical barrier locations and have relatively poor swimming ability in relation to juvenile salmonids; therefore, it was concluded that there would be no effect. The principal passage barriers that delta smelt may encounter in the Plan Area are the Suisun Marsh salinity control gates, for which changes in operations under the Plan are uncertain and probably of short duration, so they were assumed to have no effect on delta smelt. Neither channel margin habitat enhancement nor floodplain restoration/increased flooding of Yolo Bypass under CM2 has appreciable effects on delta smelt in terms of habitat for occupancy by different life stages (although, as described above, there may be some minor addition of spawning habitat from channel margin enhancement depending on the location of the enhancement). *CM13 Invasive Aquatic Vegetation Control* is focused on IAV treatment in the ROAs and as such does not address existing IAV outside the ROAs.

Temperature effects of the Plan in relation to existing conditions were not evident in the analyses of median spawning day of the year, number of stressful days, and number of lethal days (Appendix 5.C, Section C.6.4.3.16). This suggested that climate rather than water operations governed temperature changes in the Plan Area. It is evident that climate change could have appreciable effects on delta smelt by making the spawning season earlier in the year and possibly disrupting its coincidence with other important variables (e.g., day length, flows) (Wagner et al. 2011). The number of stressful and lethal days would increase into the future. As temperature increases, bioenergetic demands will greatly increase, particularly in the warmer months of the year.

Turbidity is a very important habitat characteristic for delta smelt and is a significant predictor of occurrence (Nobriga et al. 2008; Feyrer et al. 2011). Cloern and coauthors (2011) noted the uncertainty in future turbidity trends in the Plan Area: it is unclear whether a 40-year average decline in turbidity of 1.6% per year will continue. Should such a trend continue, it presumably would further decrease delta smelt habitat quality in the Plan Area. How the Plan may affect turbidity in the late long-term is uncertain. As described in Appendix 5.C, Section C.6.4.6, a number of factors are important such as whether the ROAs capture sediment that otherwise would have moved to downstream areas, and whether the ROAs have characteristics that are conducive to sediment resuspension (e.g., wind fetch). Thus the ROAs may increase water clarity in the subregions in which they are located because of sediment capture, but themselves may have relatively turbid water because of factors such as wind resuspension that could be enhanced by careful design of the ROAs. Given the interplay of these effects, at this time no conclusion is made regarding the effects of the Plan on turbidity within the range of delta smelt.

In conclusion, in relation to existing conditions, the Plan's main beneficial effect for delta smelt is potentially greater food production from habitat restoration, and the main adverse effect, relative to existing conditions with the USFWS (2008) OCAP BiOp Fall X2 included, is lower outflow in the fall of wet and above normal water years, which would reduce abiotic habitat in the LSZ. However,

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compared to EBC1 without Fall X2, there is no change in abiotic habitat. The effect on delta smelt abundance related to these changes is uncertain and the degree to which these and other effects of the Plan offset each other is not known. However, both outcomes can be adaptively managed to maximize the benefit of the Plan. Habitat restoration design and management would be implemented to continuously increase the magnitude of benefits received from restored areas. This could be achieved through careful siting and sizing of restoration areas and breaches, and control of invasive species. Likewise, as new information is developed about the importance of X2 in the fall to delta smelt abundance, and if that information demonstrates increased certainty regarding the importance of X2, the Plan water operations could be adapted within the adaptive limits to increase outflows. If new information reduces the importance of X2 for delta smelt abundance, the adverse effect would be less than it is assumed in this analysis. As such, the primary driver of the Plan effects is the magnitude of the benefit tidal wetland restoration may provide. While there is great potential for large benefits for delta smelt, there is currently no way to validate this with a high level of certainty in this effects analysis. As such, it is concluded with some uncertainty that the Plan has at least a minor beneficial effect on the species, but that the Plan has great potential for larger benefits depending on actual food production and location of delta smelt population in relation to those areas. The adaptive management and monitoring program would provide the opportunity to address existing uncertainties and alter the Plan to maximize its long-term benefits. The Real-Time Response Team would provide the ability to respond immediately to potential threats to the species that might occur as a result of project operations, unforeseen changes in species distributions, or other factors.

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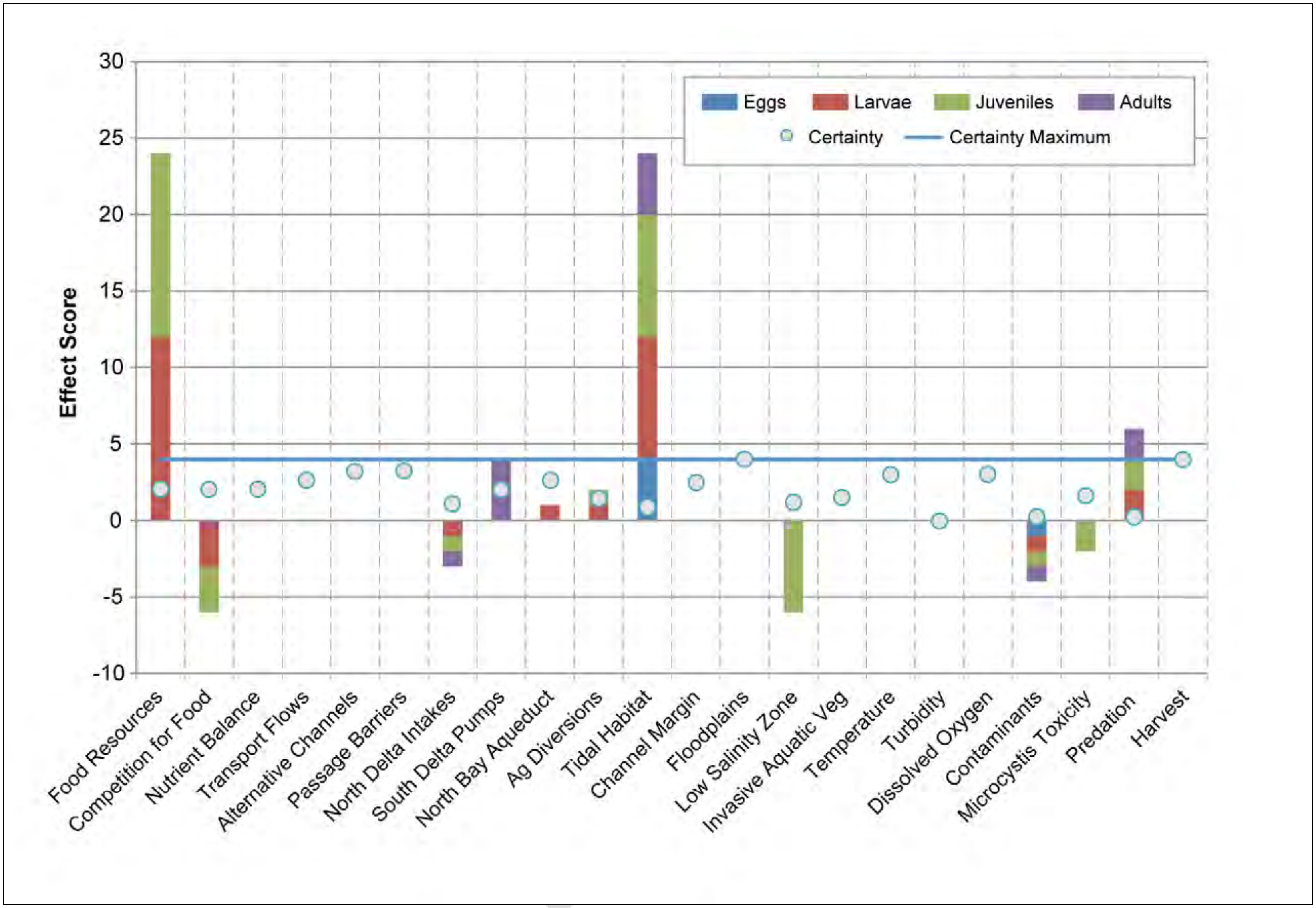

Figure 5.5-1. Effect of the BDCP Conservation Strategy on Delta Smelt

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5.5.2 Longfin Smelt

Longfin smelt is a pelagic species that inhabit the Delta for a relatively short period of their life cycle. Longfin smelt use the Delta during the upstream migration of pre-spawning adults for staging and holding, spawning in the lower reaches of tributary rivers, downstream larval transport after hatching, and for rearing of the early juvenile life stage in the low-salinity areas of the Delta and Suisun Bay. Juvenile and adult longfin smelt migrate westward into San Francisco Bay. Longfin smelt spawn adhesive eggs that are thought to be deposited on sand and gravel and possibly other hard substrates. Spawning occurs primarily in the lower reaches of the Sacramento River in the vicinity of Cache Slough and Rio Vista, although some spawning occurs in the lower San Joaquin River based on presence of early larval longfin smelt in DFG larval trawl samples. Longfin smelt spawn in the late winter and early spring months when water temperatures in the lower rivers and Delta are seasonally cool.

After hatching from the incubating eggs, longfin smelt larvae are planktonic and drift passively with water flows. Larvae are typically present in the Delta during the late winter and early spring months. Juvenile longfin smelt rear for a relatively short period of time in the spring (approximately March to June) in the Suisun Bay and the West Delta subregions before migrating downstream of the Plan Area into San Pablo and San Francisco Bays and nearshore coastal marine waters where they continue to rear for a year or more.

Adult longfin smelt inhabit primarily brackish water and marine areas in San Pablo and San Francisco Bays and nearshore coastal marine waters. Adult longfin smelt are present in the Delta typically from approximately November through March. Based on historical patterns, a substantial proportion of the adult longfin smelt population is expected to be in the Delta during these months in drier years. In wetter years, adult longfin smelt are expected to be distributed near the confluence of the Sacramento–San Joaquin Rivers or in Suisun Bay or areas to the west (e.g., the Napa River). During the fall, pre-spawning adult longfin smelt migrate upstream into Suisun Bay, the lower Sacramento River, and the Delta prior to spawning. During the fall and winter months when adult longfin smelt are present in the Plan Area, they potentially would be affected by the BDCP conservation strategy.

Historically during the late 1960s through mid-1990s, indices of longfin smelt abundance based on results of the DFG Fall Midwater Trawl surveys were variable among years but showed that the longfin smelt population abundance was relatively high compared to other fish species (California Department of Fish and Game unpublished data). Longfin smelt abundance declined substantially in the mid-1990s and has remained at relatively low levels to date. The abundance index based on the DFG Fall Midwater Trawl survey conducted in 2007 was the lowest on record over the 1967 to 2011 survey period (California Department of Fish and Game unpublished data). Fall Midwater Trawl abundance indices suggest that abundance of longfin smelt in the Bay-Delta estuary has declined by more than 95% since the survey began (California Department of Fish and Game unpublished data; Interagency Ecological Program unpublished data). The major stressors thought to have contributed to the decline in longfin smelt abundance (not in order of importance) are believed to be reduced Delta outflows during the winter and spring, reduced spawning habitat, reduced access to rearing habitat, reduced food availability, prey consumption and predation by nonnative species, entrainment, exposure to toxins, exposure to seasonally elevated water temperatures, reduced turbidity, and low DO levels (Rosenfield 2010).

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As a result of their life history, longfin smelt are expected to be affected by conditions in the Plan Area, both positively and negatively, for only a portion of their life cycle. The analysis of potential effects of the BDCP conservation strategy was developed based on the potential changes to conditions under Plan operations, such as changes in the risk of entrainment at the south Delta SWP and CVP export facilities or changes in habitat as a result of enhanced tidal marsh, considered individually for each action and life stage of the species.

5.5.2.1 Summary of Effects on Longfin Smelt Stressors

A detailed species account of longfin smelt is presented in Appendix 2.A. Stressors on the longfin smelt population in the Plan Area are presented in Table 5.5-7, together with scores for the magnitude of importance, the certainty of the importance, and a brief description of the rationale for the scores. More detail is presented on the rationale for the importance of different stressors to longfin smelt as necessary in the sections below. A qualitative assessment of changes to stressors as a result of the Plan is shown in Table 5.5-8 and is discussed below.

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Table 5.5-7. Population-Level Stressors—Longfin Smelt

Stressor Category	**Stressor**	**Eggs**	**Early Life Stages Actively Feeding and Growing in the Delta** **Larvae**	**Juveniles Migrating toward San Francisco Bay** **Juvenile**	**Adults Moving Upstream through Delta and River** **Adults**	**Rationale for Stressors**
Food	Food Resources	0	4	3	3	Importance of food resources as part of decline in longfin smelt is suggested by changes in productivity of population pre-/post-*Corbula* and in the POD (Baxter et al. 2010); some evidence that trends in longfin smelt abundance area related to changes in prey such as calanoid copepods and mysids (Mac Nally et al. 2010). Importance for larvae (early juvenile life stages) inferred from DRERIP conceptual model ranking for juveniles (Rosenfield 2010).
	Competition for food	0	3	3	0	Longfin smelt in the larval and early juvenile life stages consume zooplankton. *Corbula* and *Corbicula* consume phyto and zooplankton and appear to have affected the abundance and species composition of zooplankton. Step changes in longfin smelt abundance-outflow relationship occurred concurrent with invasion by *Corbula*.
	Nutrient balance	0	3	3	0	Several authors draw links between ammonium concentrations in the Delta and phytoplankton species composition and amount that may affect zooplankton community (Glibert et al. 2011; Dugdale et al. 2007; Jassby et al. 2008).
Water Operations	Transport flows	0	4	4	0	Eggs are demersal and attached. Transport flows key for moving juveniles into San Francisco Bay (Rosenfield 2010). Strong correlation of juvenile production with outflow through the Delta, well documented, high magnitude, and statistically significant (Stevens and Miller 1983; Jassby et al. 1995, Meng and Matern 2001; Kimmerer 2002; Kimmerer et al. 2009).
	Alternative channels	0	0	0	0	Longfin smelt generally occur downstream of such channels (i.e., Georgiana Slough and Delta Cross Channel) as per USFWS beach seine data.
	Passage barriers	0	0	1	0	Applies only to Suisun Marsh Salinity Control Gates for which there is no evidence of negative effects.
Entrainment	North Delta intakes[3]	0	1	1	1	Longfin smelt extremely rare in vicinity of proposed intakes (USFWS beach seine data).
	South Delta pumps	0	2	2	1	Highest entrainment of larvae and subjuveniles during low Delta outflow periods (Rosenfield 2010: Figure 9). It is assumed that pumping regulations recommended by Smelt Working Group for OCAP delta smelt BO and DFG ITP have reduced losses.

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Stressor Category	Stressor	Eggs	Early Life Stages Actively Feeding and Growing in the Delta Larvae	Juveniles Migrating toward San Francisco Bay Juvenile	Adults Moving Upstream through Delta and River Adults	Rationale for Stressors
	North Bay Aqueduct	0	1	0	0	Relatively small intake, screened but within longfin smelt distribution. Little evidence of entrainment of open-water species in small diversions (Nobriga et al. 2004).
	Agricultural diversions	0	1	0	0	More than 2,500 unscreened diversions; current thinking is that they are low impact, but few or no data to support hypothesis; no evidence of entrainment from studies in the Plan Area (Cook and Buffaloe 1998; Nobriga et al. 2004). Possibly a small risk to larvae.
Habitat	Tidal habitat	1	1	1	0	Abundant populations existed under similar habitat conditions to current (e.g., 1960s–1980s); no evidence of limitation by spawning habitat. Not identified as a stressor by DRERIP (Nobriga and Herbold 2009)
	Channel margin	1	0	0	0	Could be loss of some spawning habitat due to riprap armoring, but no data to support hypothesis.
	Floodplains	0	0	0	0	LFS not thought to use floodplain habitat, but are found in adjacent channels (Ted Sommer pers. comm. August 16, 2011).
	Low-salinity zone	0	3	2	1	Relationship of position of low salinity zone to larval success and distribution is well documented (Rosenfield 2010); adults are thought to use a wide range of salinities; aggregate in or near 2ppt bottom salinity especially in the fall as they move up and into the LSZ (Rosenfield 2007, 2010)
	Submerged aquatic vegetation	2	2	2	0	The proliferation of SAV has occurred since the 1980s and has changed the availability of shallow edge habitat and lowered turbidity. Longfin smelt generally downstream of most SAV.
	Temperature	0	3	2	0	Temperature affects incubation rate and success but relationships are unstudied (Rosenfield 2010).
	Turbidity	0	3	4	0	Effects of turbidity relatively unstudied but it is assumed that its function is the same as in other osmerid species such as delta smelt in presumably aiding prey capture and predator avoidance. There was some evidence of turbidity (water clarity) being related inversely to trends in abundance of longfin smelt (Thomson et al. 2010).
	Dissolved oxygen	0	0	0	0	Critical values occur only locally (e.g., duck ponds in Suisun, Stockton Deep Water Ship Channel

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Stressor Category	Stressor		Early Life Stages Actively Feeding and Growing in the Delta	Juveniles Migrating toward San Francisco Bay	Adults Moving Upstream through Delta and River	Rationale for Stressors
		Eggs	**Larvae**	**Juvenile**	**Adults**	
Water Quality	Contaminants	0	2	2	0	No evidence of acute effects; chronic effects not clear. Moderately low score is consistent with DRERIP conceptual model (Rosenfield 2010).
	Mycrocystis toxicity	0	0	0	1	Even at low abundance, *Mycrocystis* may affect estuarine fishery production through toxin and foodweb effects at multiple trophic levels (Lehman et al. 2010). Timing and spatial distribution of microcystis suggests that adult longfin smelt migrating upstream in the early fall could be affected. However, most longfin smelt are not in the upper Plan Area by the time *Mycrocystis* is prevalent.
Predation	Predation	2	2	2	1	Medium/moderate importance follows general pattern from DRERIP conceptual model (Rosenfield 2010).
	Harvest	0	0	0	1	Bycatch of longfin smelt occurs in commercial shrimp fisheries downstream of the Plan Area, with some capture also in the downstream part of Suisun Bay (DFG 2009).
	Life stage score	6	35	32	9	
	Life stage rank	4	1	2	3	

Note: Stressors are ranked by relative importance on a scale from 0 (unimportant) to 4 (highly important).

[1] Stressors are ranked by their effect on biological performance of the species under current habitat conditions.

[2] Stressors are attributes of the environment affecting the biological performance of the species.

[3] Presumed effect in the future.

(white)	High degree of scientific certainty, supported by consistent quantitative analysis.
(light gray)	Appreciable qualitative information supported by general scientific literature.
(dark gray)	Uncertain, conflicting quantitative analysis, limited support in literature.
(black)	Speculative, no quantitative analysis and little applicable literature.

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Table 5.5-8. Change to Stressors because of BDCP by Life Stage—Longfin Smelt

Stressor Category	Stressors	Change to the Stressor for the Life Stage (-4 to 4) Because of BDCP			
		Eggs	Larvae	Juveniles	Adults
Food	Food resources	0	3	3	2
	Competition for food	0	-1	-1	-1
	Nutrient balance	0	0	0	0
Water operations	Transport flows	0	-2	-2	0
	Alternative channels	0	0	0	0
	Passage barriers	0	0	0	0
Entrainment	North Delta intakes[3]	0	-1	-1	-1
	South Delta pumps	0	1	0	2
	North Bay Aqueduct	0	0	0	0
	Ag diversions	0	1	0	0
Habitat	Tidal wetlands	3	3	3	0
	Channel margin	0	0	0	0
	Floodplains	0	0	0	0
	LSZ	0	0	0	0
	SAV	0	0	0	0
	Temperature	0	0	0	0
	Turbidity*	–	–	–	–
	Dissolved oxygen	0	0	0	0
Water Quality	Contaminants	0	1	1	0
	Microcystis toxicity	0	0	0	0
Predation	Predation	0	0	0	0
	Harvest	0	0	0	0

Note: Changes to stressors as a result of the Plan are expressed as integers from -4 (high negative change) to 4 (high positive change).

* Changes to turbidity as a result of BDCP implementation are difficult to predict and are likely to vary by ROA and subregion, as discussed in Section 5.3.2.3. At this time no conclusion is made regarding the change to turbidity as a result of Plan implementation.

[1] Stressors are ranked by their effect on biological performance of the species under current habitat conditions.

[2] Stressors are attributes of the environment affecting the biological performance of the species.

[3] Presumed effect in the future.

(white)	High degree of scientific certainty, supported by consistent quantitative analysis.
(light gray)	Appreciable qualitative information supported by general scientific literature.
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5.5.2.2 Beneficial Effects

Tidal habitat restoration would substantially increase the amount of tidal habitat in the Plan area, mostly in the Cache Slough and Suisun Marsh subregions, substantially increasing suitable habitat for longfin smelt and potentially increasing food for local consumption and export to open-estuary areas.

The extent to which a lack of tidal habitat limits the longfin smelt population is uncertain. Considerable loss of tidal habitat had occurred prior to the major population decline in longfin smelt observed over the last decade. Changes in habitat quality and availability for pelagic fish in the estuary may be linked to a number of factors such as deterioration of remaining habitat and reduced food availability (Baxter et al. 2010). Although longfin smelt are commonly characterized as an open-water species, adult longfin smelt are thought to spawn in relatively shallow-water channel margin habitat, and production of organic carbon, phytoplankton, and zooplankton in tidal marsh habitats is thought to be an important factor influencing the pelagic foodweb for longfin smelt.

The importance of tidal habitat for occupation by larval and juvenile longfin smelt is assumed for this effects analysis to have low importance (score = 1), with moderately low certainty (score = 2). Adult longfin smelt may hold for a period of time after moving upstream before spawning, but it is assumed that tidal habitat is less important for this life stage (score =0; certainty = 2). Spawning habitat for longfin smelt in the wild is unknown but, if similar to other smelts, may consist of sandy beaches and gravel/sand substrate. The extent to which availability of spawning habitat may limit the species is unknown. For this effects analysis it was assumed that the importance of tidal habitat and channel margin habitat for eggs is currently low (score = 1), but with low certainty (score = 1). Floodplains are assumed not to be important for any life stage to occupy (score = 0, certainty = 4) because longfin smelt do not occur extensively on seasonally inundated floodplains.

[***Note to Reader:*** *ICF intends to incorporate an HSI analysis for the public draft BDCP document. This was not completed for the admin draft.*]

There would be considerably more suitable habitat under the BDCP conservation strategy than under existing conditions because of *CM4 Tidal Natural Communities Restoration* (Appendix 5.E, Section E.6.2; Table E.2-1). Habitat suitability is likely to decrease for larval longfin smelt over time, as it was assessed to do for delta smelt, and in particular would also decrease for juvenile longfin smelt because of temperature effects associated with climate change during the late spring. It is anticipated that the overall effect of CM4 would be similar to that for delta smelt and therefore remain positive because increases in habitat quantity are greater than decreases in quality, providing a mechanism to at least partially offset the future effects of climate change. It should be noted that there is uncertainty related to future trends in turbidity, as described above for delta smelt; the analysis assumed turbidity would be similar to existing conditions. The Cache Slough, Suisun Marsh, and West Delta subregions appear to offer the best geographic locations for longfin smelt with respect to the current distribution of the species. With sea level rise and increasing salinity, there may be greater distribution of longfin smelt into upstream areas, in which case habitat restoration in the Cache Slough and West Delta ROAs would gain added importance. Conservation of adjacent upland areas under the Plan would allow expansion of aquatic habitat as sea level rises.

Based on results of the effects analysis, it was concluded that the effect of tidal habitat restoration for longfin smelt larvae and juveniles occupation is moderately high (score = 3), with moderately low certainty (score = 2) because the extent to which longfin smelt would use the restored habitat as opposed to the adjacent deeper pelagic habitats is uncertain. There is also uncertainty related to

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how much restored habitats may be reduced in value because of colonization by IAV and associated nonnative fish species such as largemouth bass, striped bass, threadfin shad, and other species that may prey on longfin smelt or compete for food. CM13 aims to control IAV in the ROAs, but there is uncertainty related to the ability to do so effectively.

Although the exact locations and conditions where longfin smelt spawn are unknown in the Delta and tributaries, it is thought that longfin smelt spawning takes place in relatively shallow intertidal or subtidal habitats where sand and gravel substrate is available. Tidal habitat restoration under CM4 would increase the amount of suitable spawning habitat available to longfin smelt because of the extent of restoration in the current areas most frequently occupied by pre-spawning adult longfin smelt, in particular the Cache Slough ROA (doubling of habitat units for the egg stage) but also in the West Delta and Suisun Marsh ROAs (orders of magnitude more spawning habitat) (Appendix 5.E, Section E.6.2; Table E.2-1). Based on the current longfin smelt distribution and environmental changes modeled for the future, it is unlikely that tidal habitat restoration in the South Delta or Cosumnes-Mokelumne ROAs would provide significant contributions to the habitat for longfin smelt. Channel margin enhancement (CM6) (Appendix 5.E, Section E.6.4) is aimed primarily at restoring habitat in important migration channels for juvenile salmonids but may offer some minor benefit to longfin smelt if habitat of the type hypothesized to be important for the species is restored. As noted above, it is unknown whether the availability of suitable spawning habitat is limiting egg production for longfin smelt, but it seems unlikely at their current low population levels. More benefit would be obtained if longfin smelt population abundance increases in the future and spawning habitat becomes limited. Although habitat suitability may generally decrease in each ROA because of climate change, the extent of habitat suitable for longfin smelt eggs would increase and is made more geographically diverse because of the restoration. The quality of habitat available to longfin smelt in restored tidal and channel margin habitat areas is expected to vary based on factors such as water depths, tidal action, substrate, and the potential for deposition of fine sediment that could adversely affect the health and hatching success of incubating eggs. Habitat areas that have shallow intertidal and subtidal zones with sand and gravel substrate and low fine sediment deposition are expected to provide the best conditions for spawning and egg incubation success. The addition of small gravel, currently scarce in the Delta, to localized areas in a restoration area where fine sediment deposition is low potentially would improve habitat for longfin smelt spawning. It is uncertain the degree to which IAV may occur in the low-salinity or freshwater ROAs (Cache Slough and West Delta), but careful design of ROAs could reduce the suitability of habitat for IAV. In addition, implementation of *CM13 Invasive Aquatic Vegetation Control* has the potential to limit IAV in the ROAs (Appendix 5.F, Section F.2). Expansion of tidal habitat is assessed to give a moderately high positive change for longfin smelt eggs (score = 3), with moderately low certainty (score = 2).

The utility of the Cache Slough and West Delta ROAs would be enhanced by the implementation of conservation measure *CM13 Invasive Aquatic Vegetation Control*. IAV is not expected to become established in Suisun Marsh because of higher salinities in this area. Although longfin smelt rarely inhabit the south Delta (DFG 20 mm survey), restoration in this area could provide additional spawning habitat in the future. The presence of IAV, abundance of nonnative predators, and water quality issues may preclude major expansion of the distribution of longfin smelt into the south Delta in the future unless habitat restoration can restore a suite of suitable habitat characteristics in this area. Because it seems unlikely that at current population abundance levels longfin smelt are limited by the availability of spawning habitat, expansion of this habitat is expected to have a low benefit to

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the population in the near-term. This benefit may increase in the future if the longfin smelt population abundance increases.

A decrease in food resources (principally calanoid copepods) has been hypothesized as a major factor contributing to the observed decline in longfin smelt abundance (Baxter et al. 2010). Mac Nally and coauthors (2010) found some statistical evidence that spring/summer calanoid copepod biomass and summer mysid biomass was linked to annual trends in abundance of longfin smelt in the fall. The decrease in food resources may have been because of factors such as a change in phytoplankton and zooplankton assemblages related to biological invasions (e.g., the invasive clam *Corbula amurensis*) (Winder and Jassby 2011) and anthropogenic factors such as nutrient balance (Dugdale et al. 2007; Glibert et al. 2011). There has been a downward shift in the response of longfin smelt to another important stressor, outflow: the abundance of longfin smelt in the fall midwater trawl survey is lower now than historically for the same outflow, with changes to the relationship related to the *Corbula* invasion and the Pelagic Organism Decline (Baxter et al. 2010). For this effects analysis it is assumed that the quantity of food resources as a stressor for larval longfin smelt has high importance (score = 4, certainty = 3), and for juvenile and adult longfin smelt as a stressor has moderately high importance (scores = 3) with moderately high or low certainty (scores = 3 and 2, respectively).

As described above, the relationship between phytoplankton growth rate and average habitat depth (Lopez et al. 2006) provides an indication of potential food productivity increases in the ROAs as a result of habitat restoration (Appendix 5.E, Section E.5.1.3.1). Results of these analyses suggested a considerable increase in potential primary productivity (Appendix 5.E, Section E.6.2), which may translate into increased food resources for larval and juvenile longfin smelt in the ROAs, as well as export to the pelagic habitats beyond the ROAs. Increased food production under the Plan would be of considerable importance in and adjacent to areas currently inhabited by longfin smelt, such as the lower Sacramento River, west Delta, and Suisun Marsh. However, the direct relationship between primary productivity and food for higher trophic levels is unclear because of the influence of invasive clams, transfer rates, and other factors (Lopez et al. 2006). High production potential in the South Delta ROA would be dependent on export to areas where longfin smelt larvae and juveniles are more likely to occur.

As noted above for delta smelt, a large body of literature supports the hypothesis that restoration of tidal marsh and floodplain habitat will result in increased local food production and export of additional food resources to downstream areas (Jassby and Cloern 2000; Kneib et al. 2008; Opperman 2008). Food production in the West Delta, South Delta, and Suisun Marsh ROAs also may be enhanced by increases in residence time caused by changes in hydrodynamics. The degree to which additional food resources produced in restoration areas will become available to longfin smelt inhabiting pelagic habitats located outside the ROAs is uncertain. Lehman et al. (2010) demonstrated that export of material from Liberty Island in the Cache Slough subregion varied considerably because of tidal action; the area was both a source and a sink of materials during their study.

Like delta smelt, longfin smelt larvae, juveniles, and adults all have the potential to substantially benefit from food produced in the Cache Slough, Suisun Marsh, and West Delta ROAs. Longfin smelt larvae may benefit from transport of food resources produced in tidal marsh areas downstream to the adjacent pelagic habitats in Suisun Bay that they use more extensively as rearing habitat, with actual benefits depending on the rate of conversion from phytoplankton to zooplankton in these areas and the extent to which *Corbula* and competing fish and invertebrates consume the food

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produced. Depending on the distance these food and nutrient resources are transported downstream, food produced in the Yolo Bypass ROA may also provide some benefit to longfin smelt inhabiting the Cache Slough region, lower Sacramento River, and Suisun Bay. The benefit of habitat restoration in the South Delta ROA for longfin smelt and their food resources is uncertain but is likely to be low. It is hypothesized that food may be limiting abundance of longfin smelt, and as such, increases in food can directly benefit longfin smelt abundance.

Habitat restoration is also expected to benefit adult longfin smelt. Adult longfin smelt would be expected to occur in shallow-water tidal environments during spawning, and would experience direct benefits from habitat expansion and food production in the Cache Slough, West Delta and Suisun Marsh ROAs (Appendix 5.E), although direct use of habitat in these ROAs would occur during spawning and is expected to be relatively brief. Adult longfin smelt would benefit from transport of food resources produced in restored tidal marsh areas downstream to the adjacent, deeper pelagic habitats that they prefer as pre-spawning holding areas. Food production in the West Delta and Suisun Marsh ROAs may also be enhanced due to changes in hydrodynamics and subsequent increases in diatom biomass in these areas (Appendix 5.E).

As with delta smelt, of particular concern is the effect of nonnative species such as *Corbula* that forage on zooplankton in reducing flood resources for larval and early juvenile longfin smelt. For example, filter-feeding by clams removes organic carbon, phytoplankton, and zooplankton from the pelagic foodweb and transfers these nutrients to the benthic foodweb where they are no longer available to longfin smelt. Enhancement of the area of shallow-water tidal and channel margin habitat through Plan habitat restoration actions is expected to increase the production of nutrients. Expansion of tidal wetland habitat is expected to contribute to increased production of organic carbon and phytoplankton and to a potential increase in production of zooplankton in the shallow water tidal areas, as well as exported to the pelagic foodweb, that would benefit longfin smelt larval food supplies. To the extent food sources (abundance of suitable zooplankton species) are increased in the Delta and Suisun Bay, there would be a benefit to longfin smelt growth and survival.

There is a balance between the duration of hydraulic residence time and the production of beneficial algae and the production of blue-green algae and microcystis that could have adverse effects on foodweb dynamics in the Delta. In addition, changes in climate in the future would have the potential to result in elevated seasonal water temperatures, particularly in south Delta habitats, that would contribute to unsuitable habitat for longfin smelt and reductions in the areas of the Delta that are suitable for longfin smelt (habitat compression). The design of habitat features, monitoring, and management of hydrodynamic conditions and other factors in the future will be important in reducing uncertainty associated with these conservation measures and their benefits for longfin smelt.

Food produced in the Yolo Bypass ROA may provide some seasonal benefit during periods of winter floodplain inundation and flow recession, depending on the distance that these resources are transported downstream. The benefit of habitat restoration in the South Delta ROA is uncertain but is likely to be relatively low. After consideration of the various factors described above, it is concluded that there would be a moderately high positive change from the Plan on food resources for larval and juvenile longfin smelt (score = 3), with moderately low certainty (score = 2), and it is also concluded that there would be a moderately low positive change from the Plan to food resources for adult longfin smelt (score = 2), again with moderately low certainty (score = 2).

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Overall entrainment of longfin smelt under the BDCP conservation strategy would remain at or less than low levels experienced in the recent past, depending on water year type, because of north Delta diversion operations reducing reliance on south Delta export facilities. Additional minor benefits are expected from decommissioning of agricultural diversions in restoration areas and implementation of an alternative intake for the North Bay Aqueduct. The risk of longfin smelt entrainment and impingement at the north Delta diversions is expected to be very minor based on the implementation of state-of-the-art positive barrier fish screens and the fact that much of the longfin smelt population occurs downstream of the diversions.

Substantial numbers of longfin smelt historically have been entrained at the south Delta export facilities (Rosenfield 2010). Recent operations mandated through the issuance of an incidental take permit by DFG for operations of the south Delta export facilities, in association with the USFWS (2008) OCAP BiOp pumping restrictions to limit entrainment of delta smelt, have reduced entrainment of longfin smelt adults, larvae, and juveniles. Implementation of the BDCP would ensure that these low levels of entrainment continue into the future.

The timing of longfin smelt entrainment is generally from December to March for adults and from March to June (age-0 juveniles) (Appendix 5.B, Section B.4.1.6). Larval longfin smelt are also entrained at the export facilities (e.g., Aasen 2010), although monitoring did not occur until recently. Eggs adhere to the substrate and are not susceptible to entrainment. In light of changes in pumping under the ITP and BiOp, for this effects analysis, it is assumed that entrainment of larval and juvenile longfin smelt is a stressor with moderately low importance (score = 2), with moderately high certainty, and that adult entrainment is a stressor of low importance (score = 1) with moderately high certainty (score = 2).

Results of particle-tracking model simulations for longfin smelt (Appendix 5.B, Section B.4.1.6.1) indicated that overall the magnitude of larval longfin smelt entrainment risk is low under all hydrologic conditions and starting geographic distributions analyzed. In addition, although variable among hydrologic conditions tested, the magnitude of potential entrainment risk at the south Delta SWP and CVP export facilities was typically low with both increases and decreases in entrainment risk among scenarios (Table 5.5-9; Appendix 5.B, Section B.4.1.6.1). Although the number of hydrological scenarios with higher or lower entrainment under the Plan was similar to existing conditions, the magnitude of the difference was greater when entrainment was lower under the Plan (Table 5.5-9). The risk of south Delta entrainment for longfin smelt larvae is greater during years when river and Delta outflows during the late winter and spring are low (generally in dry years). In those years when flows on the Sacramento and San Joaquin Rivers are relatively high and Delta outflows are high, longfin smelt larvae are rapidly transported downstream out of the Delta and into Suisun Bay where their risk of adverse effects from south Delta entrainment is low. It is concluded that overall there is a low positive change to the south Delta entrainment stressor as a result of the Plan for larval longfin smelt (score = 1, certainty = 3).

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Table 5.5-9. Average Difference[1] (Number of Runs in Parentheses) between Existing and Plan Scenarios in Entrainment at South Delta Diversions for Particle-Tracking Runs after (A) 30 Days and (B) 60 Days (%), Late Long Term

	30-Day Particle Tracking		60-Day Particle Tracking	
Starting Distribution	**Higher Entrainment under Plan**	**Lower Entrainment under Plan**	**Higher Entrainment under Plan**	**Lower Entrainment under Plan**
Wetter	0.1 (5)	-1.2 (5)	0.4 (6)	-2.0 (5)
Drier	0.1 (4)	-1.3 (6)	0.6 (5)	-2.4 (6)
Note: Values represent the difference in the percentage of particles reaching the South Delta export facilities. Negative values indicate lower entrainment under the preliminary proposal compared to the EBC.				

Results of the salvage-density method entrainment analysis for longfin smelt (Appendix 5.B, Section B.4.1.6) suggested that there would be around 50% lower entrainment of adult longfin smelt from December to March under the Plan compared to existing conditions, averaged across all water years in the late long term (Table 5.5-10). As noted for delta smelt, such a change in the winter reflects the ability to use the north Delta diversions in the winter and therefore reduce south Delta entrainment. It is concluded that there is a moderately low (score = 2) positive change to this stressor for longfin smelt adults, with moderately high certainty (score = 3). For juvenile longfin smelt, there was relatively little difference in south Delta entrainment averaged across all years between Plan and existing conditions scenarios in the late long term (Table 5.5-10), reflecting the occasionally greater simulated water exports from the south Delta under the Plan relative to existing conditions. It is concluded that there is no change to this stressor for juvenile longfin smelt (score = 0), with moderately high certainty (score = 3).

[***Note to reader:** the values in the table below represent corrected values from those presented in the draft Appendix 5.B, Entrainment. The correction was necessary because of an incorrect normalization of the salvage density numbers, which resulted in very low entrainment numbers in the appendix. The full revised analysis will be presented in the entrainment appendix, including an examination by water year type.*]

Table 5.5-10. Estimated Mean Monthly Entrainment Index (Number of Fish Lost) of Juvenile and Adult Longfin Smelt for Six Model Scenarios at the SWP and CVP Salvage Facilities for All Water Years, Late Long Term

		State Water Project			Central Valley Project		
Life Stage	**Month**	**Existing**	**Plan**	**Difference**	**Existing**	**Plan**	**Difference**
Adult	December	14	12	-2 (-11%)	129	104	-25 (-19%)
Adult	January	1,416	637	-779 (-55%)	88	42	-46 (-52%)
Adult	February	479	177	-302 (-63%)	164	56	-109 (-66%)
Juvenile/adult	March	817	202	-615 (-75%)	465	128	-337 (-73%)
Juvenile	April	35,520	44,606	9086 (26%)	7,865	7,842	-23 (%)
Juvenile	May	233,356	222,904	-10452 (-4%)	11,114	11,032	-82 (-1%)
Juvenile	June	3,750	1,714	-2036 (-54%)	44	23	-21 (-48%)
Note: negative values indicate lower entrainment under the Plan relative to existing conditions.							

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The centerpiece of the Plan's CM1 is implementation of dual conveyance by construction of five intakes (each 700–1,800 feet long, although designs have not been finalized) with 15,000-cfs total water diversion capacity along the Sacramento River (approximately river mile 37–44) in the North Delta subregion. Longfin smelt occur primarily well downstream of this area but also occur in low abundance seasonally in the vicinity of the screens as adults and larvae, based on data from USFWS seine surveys and DFG striped bass egg and larval surveys. Longfin smelt greater than about 15–16 mm SL would be expected to be excluded from entrainment by the proposed screen mesh of 1.75 mm (Turnpenny 1981; Margraf et al. 1985; Young et al. 1997). Similar to delta smelt, for individuals contacting the screens, the potential exists for impingement-related injury and mortality (Swanson et al. 2005). Approach and sweeping velocity criteria for the north Delta intake screens have not been finalized, but approach velocity would be less than 0.33 fps (the criterion for salmonid fry) and may be limited to 0.2 fps (the existing criterion for juvenile delta smelt). Given the relatively low proportion of the longfin smelt population that is likely to occur near the north Delta diversions and the use of state-of-the-art screening technology, it is concluded that implementation of the Plan will represent a low negative effect on larval, juvenile, and adult longfin smelt (score = -1), with moderately low certainty (score = 2). Monitoring of entrainment and impingement would further inform the effect of this stressor following implementation.

As a result of these factors it was concluded that export operations under the BDCP conservation strategy would not result in an adverse effect on longfin smelt compared to existing baseline conditions. If unforeseen changes were to be observed in the future in the geographic distribution of larval longfin smelt, or other factors occur as a result of Plan operations that would increase vulnerability of longfin smelt to entrainment, the Real-Time Response Team would provide the capability to respond immediately and avoid any potential threats to the species that might occur. Based on the limited potential for a population-level effect of entrainment on longfin smelt, the minimal change in entrainment risk at the south Delta export facilities under the BDCP conservation strategy compared to existing baseline conditions, and the potential for real-time responses to potential unforeseen threats to the species, the Plan is not expected to adversely affect entrainment risk for longfin smelt.

There are more than 2,500 water diversions, including agricultural diversions, in the Plan Area (Herren and Kawasaki 2001) (Appendix 5.B, Section B.2.6). Losses of longfin smelt have not been observed at agricultural water diversions in the Plan Area (Cook and Buffaloe 1998; Nobriga et al. 2004). The extent of longfin smelt entrainment is not known. For the purposes of this effects analysis, it was assumed that entrainment at agricultural diversions is a stressor of low importance (score = 1) with moderately high certainty (score = 3) for larval longfin smelt and no effect on juvenile and adult longfin smelt (score = 0, certainty = 3). Particle-tracking modeling suggested that entrainment of longfin smelt larvae at the agricultural diversions would be lower under the Plan than existing conditions as a result of altered hydrodynamics from CM1 (Appendix 5.B, Section B.4.4.2.1). Further, tidal habitat restoration under CM4 was estimated to potentially result in the decommissioning of over 12% of Plan Area agricultural diversions in the late long-term, and the DRERIP (2009) evaluation of previously proposed conservation measures to decommission agricultural diversion suggested a low magnitude effect with low certainty (Appendix 5.B, Section B.4). Given that agricultural diversions are typically greatest during the larval or juvenile phases of the longfin smelt life cycle (Appendix 5.B, Section B.3), it is concluded that there would be a low beneficial change to this stressor from the Plan (score = 1) for larval longfin smelt, with low certainty (score = 1).

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Larval longfin smelt are potentially vulnerable to entrainment losses at the SWP North Bay Aqueduct (NBA) Barker Slough pumping plant (described in Appendix 5.B, Section B.2.5) in the Cache Slough subregion. For this effects analysis, it is considered that entrainment of longfin smelt larvae at NBA under existing conditions is a stressor with low population effect (score = 1; certainty = 4). Implementation of a dual conveyance, with a new Sacramento River alternative intake under the Plan that could be used instead of the Barker Slough intake, would be expected to result in lower entrainment of longfin smelt larvae at NBA than existing conditions. Particle-tracking modeling results that do not account for the change in alternative intake location but focus solely on pumping differences and changes in hydrodynamics because of habitat restoration in the Cache Slough subregion suggested that entrainment of particles would be similar under the Plan and under existing conditions (average reduction of around 1% less particles being entrained, depending on starting distribution) (Appendix 5.B, Section B.4.3.2.1). It is concluded that there would be no change (score = 0, certainty = 3) under the Plan on this stressor for longfin smelt larvae.

Plan conservation measures may lower predation of larval, juvenile, and adult longfin smelt to some small extent; there is low certainty in this conclusion.

The importance of predation to longfin smelt is unclear because little is known of predation rates. There was no evidence for linkages between largemouth bass and trends in longfin smelt abundance when examined by Mac Nally et al. (2010). For this effects analysis it is assumed that predation is of moderately low importance (score = 2) to longfin smelt but with moderately low certainty (score = 2).

As indicated in Appendix 5.F, Section F.3., the Plan may have several effects on predation related to longfin smelt. CM1 may result in added predation pressure at the proposed north Delta diversions, although this is upstream of the primary geographic distribution of longfin smelt. CM15 (Predation Reduction) may reduce predation pressure at key locations such as during the south Delta salvage process (e.g., by predator capture and by increasing numbers of release sites), although many of the sites initially considered under this measure are of greater relevance to migration pathways of juvenile salmonids and have less overlap with the current geographic distribution of longfin smelt. It is concluded that the Plan would result in no significant reduction in predation of longfin smelt larvae, juveniles, and adults (scores = 0), with low certainty (scores = 1).

5.5.2.3 Adverse Effects

Decreased winter-spring outflows under the BDCP conservation strategy have the potential to contribute to appreciable decreases in longfin smelt abundance as a result of reduced larval transport flows and spring habitat quantity and quality for larval and early juvenile longfin smelt in the Suisun Marsh and West Delta subregions.

Even though the magnitude of the relationship between Delta outflow and longfin smelt abundance has decreased in recent years, the relationship is still present (Kimmerer et al. 2009; Sommer et al. 2007; Rosenfield and Baxter 2009; Baxter et al. 2010) and could have population-level implications for longfin smelt. Reduced winter-spring outflow under the BDCP conservation strategy, especially in above normal water years, may modify Delta hydrodynamics that affect transport of longfin smelt larvae to suitable downstream rearing habitat where food is readily available. Specifically, the preliminary proposal operations are estimated to result in lower longfin smelt abundance in the fall (on average 8-10%, with differences between water year types ranging from averages of -1% to -18%), as reflected in subsequent Fall Midwater Trawl and Bay Study indices of longfin smelt abundance (Table 5.5-11), because of lower winter-spring transport flows. Much of this reduction is

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due to lower flows on the Sacramento River downstream of the new north Delta diversions during the late winter and spring months.

Although it is hypothesized that the adverse effect is because of reduced transport flows, other mechanisms may be involved. It should also be noted that other factors besides outflow (e.g., food availability) (Rosenfield and Baxter 2007; Kimmerer et al. 2009) appear to play a major role in the observed decline in longfin smelt population abundance in recent years (Baxter et al. 2010), including the availability of food. It is unlikely that improving transport flows alone will restore longfin smelt population abundance to past levels (M. Nobriga pers. comm.; J. Rosenfield pers. comm.). There is some uncertainty as to whether total winter-spring outflow is the basis for the importance of the mechanism and how this interacts with other factors that may affect longfin smelt abundance, such as food availability.

Nonetheless, considering the potential importance of reduced transport flows to the health, growth, and survival of the larval and subsequently juvenile and adult longfin smelt population, and the potential effect of the BDCP conservation strategy on this stressor, the Plan is estimated to have an adverse effect on longfin smelt survival and abundance because of lower winter-spring transport flows. The mechanism underlying the correlation between outflow (expressed as X2) and longfin smelt abundance is not understood, and it may not reflect larval transport but instead some other relationship. As such, it is concluded that this represents a moderately high negative change on the larval and juvenile life stages as a result of the preliminary operations proposed in the Plan (score = -3, certainty = 2).

Table 5.5-11. Estimated Longfin Smelt Relative Abundance Using X2-Abundance Regressions (Kimmerer et al. 2009) Based on January–June X2, Averaged by Water Year Type in the Late Long Term

Water Year Type	Fall Midwater Trawl			Bay Midwater Trawl			Bay Otter Trawl		
	Existing	Plan	Difference	Existing	Plan	Difference	Existing	Plan	Difference
All	3,678	3,382	-296 (-8%)	7,563	6,838	-725 (-10%)	9,522	8,609	-913 (-10%)
Wet	11,789	11,665	-124 (-1%)	30,604	30,218	-386 (-1%)	38,528	38,042	-486 (-1%)
Above Normal	5,752	4,867	-885 (-15%)	12,937	10,587	-2,350 (-18%)	16,286	13,328	-2959 (-18%)
Below Normal	2,978	2,558	-420 (-14%)	5,872	4,892	-980 (-17%)	7,393	6,159	-1234 (-17%)
Dry	1,626	1,482	-144 (-9%)	2,840	2,540	-300 (-11%)	3,576	3,198	-378 (-11%)
Critical	820	767	-53 (-6%)	1,249	1,153	-96 (-8%)	1,572	1,452	-121 (-8%)

Exposure of longfin smelt to contaminants may occur following restoration under the Plan; exposure to agriculture-related contaminants later in the Plan term may decrease because of restoration of agricultural areas.

It is uncertain to what extent contaminants may have contributed to the current status of pelagic fish species (Brooks et al. 2011). Spawning and early life stages could be affected by elevated concentrations of contaminants during typical winter runoff, but this has not been demonstrated for longfin smelt. The effects of contaminant exposure on longfin smelt eggs have not been evaluated, and lethal and sublethal effect levels are unknown. No bioassay testing has been done with longfin smelt eggs to determine their response to various contaminant concentrations. For the purposes of these analyses, it was assumed that the response of longfin smelt eggs to contaminant exposure

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would be similar to that of delta smelt. There is some evidence that fish embryos are less sensitive to pyrethroids than larvae (Oros and Werner 2005); however, they may be exposed to higher concentrations because they are in direct contact with the substrate where pyrethroids are more concentrated. The population-level effect of exposure of longfin smelt eggs to contaminants is expected to be low, but may be larger if sublethal effects have substantial population-level implications. For the purposes of this effects analysis, it is assumed that contaminants have low effects on longfin smelt larval and juvenile life stages (score = 2), recognizing that there is low certainty in such a designation (score = 1).

The Plan could adversely affect longfin smelt eggs and other life stages through changes in contaminants as a result of changes in water operations (CM1, CM2) and habitat restoration (principally, CM4). Analyses presented in Appendix 5.D, *Contaminants*, suggested that there was low potential for increased contaminant exposure from the Plan and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded that this represents a low adverse change to this stressor for all longfin smelt life stages (score = -1), with low certainty (score = 1).

The greatest potential benefit to reducing localized exposure of longfin smelt to contaminants as a result of reduced application of pesticides and herbicides due to land use changes associated with restoration are expected to occur in the Cache Slough area. Longfin smelt are known to spawn in the Cache Slough region and lower Sacramento River where localized reductions in contaminant loading would be expected to reduce the risk of adverse effects on longfin smelt. Longfin smelt spawn during the late winter and early spring when pesticide and herbicide application is relatively low. Based on the acreages of habitat restored during each implementation period, the relatively wide geographic distribution of potential longfin smelt spawning areas, and the relative reduction in contaminant loading that would be expected to occur over the long termas a result of restoration action on total loading to the Central Valley system, these changes in the potential risk of toxicity effects on longfin smelt would be minimal in the near-term and early long-term and minor in the late long-term. Therefore, based on the potentially low importance of this stressor to the population (Appendix 5.D), and the projected minor reductions in exposure in the Plan Area during the winter and early spring, the BDCP conservation strategy is expected to have a small net positive effect on longfin smelt.

Longfin smelt larvae are may occur in areas such as the Cache Slough subregion and lower Sacramento River where localized reductions in contaminant loading have the potential to reduce the risk of adverse effects on longfin smelt larvae. Adult longfin smelt are present in the Delta primarily during the fall and winter months when pesticide and herbicide application is reduced. Habitat restoration may, however, result in increased exposure to some constituents such as methylmercury that could adversely affect the health of adult longfin smelt directly or indirectly through bioaccumulation and food supplies (Appendix 5.D). The changes in exposure would be minimal in the near-term and early long-term and minor in the late long-term based on the acreages of habitat restored during each implementation period and the period during which adult longfin smelt are present in the Delta. Based on the potentially low importance of this stressor to the population, and the projected minor reductions in exposure with the project, the project is expected to have a small net positive effect on adult longfin smelt exposure to toxics. The net benefit may be larger if sublethal effects of contaminants are important at the population-level.

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In-water construction and maintenance effects of the Plan could affect longfin smelt but would be minimized with careful management.

In-water construction activities at the proposed north Delta intakes (CM1) would be limited to one construction season during the months of June–October (Appendix 5.H). Longfin smelt generally occur well downstream of the construction area, although as noted for impingement/entrainment, some individuals may occur in the vicinity of the proposed intakes. The seasonality of construction suggests that most longfin smelt would have left the area, as spawning would have been largely completed and larvae would have moved downstream. Any longfin smelt present may experience adverse effects from underwater sound (pile driving), entrapment within enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment, suspension of toxic materials), and accidental spills. Habitat would be temporarily and permanently affected by intake construction, although habitat at the intake sites is generally of low quality (steep-sloping, revetted banks). Maintenance dredging may decrease water quality temporarily.

Habitat restoration activities associated with CM4–CM7 may reduce water quality and would be more likely to affect longfin smelt because the activities are closer to the species' main distribution. Breaching levees to create tidal habitat may reduce areas of channel margin, but there would be considerable gains of habitat caused by the breaching. In-water activities associated with *CM14 Stockton Deepwater Ship Channel Dissolved Oxygen Levels, CM15 Predator Control, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* would have little to no effect on longfin smelt because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* would reduce the likelihood of adverse effects on longfin smelt from in-water activities related to construction and maintenance. It is concluded that construction and maintenance associated with the Plan represent a minor adverse effect on longfin smelt life stages with high certainty.

5.5.2.4 Impact of Take on Species

The Plan may result in incidental take of longfin smelt from several mechanisms. The BDCP conservation strategy may affect incidental take of longfin smelt during construction of the proposed on-bank intake facilities in the north Delta, aquatic habitat restoration construction, and through its influence on entrainment at the SWP and CVP diversion facilities. Effects from north Delta intake and habitat restoration construction activities include disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity/suspended sediment levels. These effects, however, would be temporary and are unlikely to have population-level effects on longfin smelt because longfin smelt are rarely documented in the area where the north Delta diversion facilities would be constructed (Moyle 2002) and are only seasonally present in areas where habitat restoration would occur. In addition, BMPs will be used to minimize effects on all protected fish species.

With regard to take at the south Delta diversion facilities, cumulative annual salvage of longfin smelt at the SWP and CVP between water years 1996 and 2009 ranged from approximately 0 to 97,734 individuals, with the highest salvage recorded in 2002. The second highest salvage was in 2001, when 6,642 longfin smelt were salvaged. Salvage has been variable during this period but has been generally lower in recent years (0 to 1,491 fish salvaged annually in 2005 to 2009), potentially a result of the low abundance of longfin smelt during this period, actions implemented as part of the USFWS delta smelt RPAs, court-ordered restrictions on water operations, and actions taken by the Smelt Working Group (U.S. Fish and Wildlife Service 2008). Results of the entrainment analyses

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indicate that the level of take of longfin smelt under the Plan may be similar to that estimated for the baseline conditions. Take of longfin smelt at the south Delta facilities could increase in the future if the population size increases as a result of the Plan or other actions; however, this would not represent an increase in loss as a proportion of the population.

There also may be take of larval longfin smelt at diversions to the NBA, but this take would be reduced by the alternative intake on the Sacramento River. It is anticipated that decreases in entrainment at the south Delta export facilities, NBA Barker Slough pumping plant, and at numerous agricultural diversions that would be decommissioned in tidal habitat restoration areas would more than offset any entrainment and impingement at the proposed north Delta diversion facilities.

Lower outflow in the winter and spring months is estimated under the Plan, based on regression analysis of the response of longfin smelt to changes in Delta outflow and X2, to result in a decrease in transport flows for larval longfin smelt and reduced population abundance of older individuals. Increased food production from shallow-water tidal habitats may offset this potential take of longfin smelt; however, there is uncertainty in the performance of tidal habitat restoration in providing increased food supplies (zooplankton) to the pelagic foodweb.

Construction activity associated with habitat restoration is expected to result in a temporary localized increase in the take of longfin smelt. The magnitude of potential take will vary depending on construction techniques, the location and size of restoration activities, and the seasonal timing of in-water construction activity relative to the life history and seasonal and geographic distribution of various life stages of longfin smelt. Requirements to implement a range of BMPs, including those in CM22, would serve to reduce and avoid potential adverse effects on habitat and incidental take of longfin smelt. Reduction in the application of pesticides and herbicides associated with changes in land use and the elimination of currently unscreened water diversions in the areas where habitat restoration would occur would serve to reduce the take of longfin smelt. Monitoring would be required before construction began to assess the potential for construction and flooding restored habitat areas to resuspend toxic contaminants from soils that then would enter adjacent water bodies as well as the effects of habitat restoration on changes in the bioavailability of chemical contaminants such as methylmercury and the potential effects of contaminant exposure on various life stages of longfin smelt. Consideration in the design and development of aquatic habitat restoration projects would be required to minimize the risk that SAV and other nonnative species would colonize the habitat and that structures, hydrodynamics, and other conditions that would increase the vulnerability of longfin smelt to predation mortality were minimized and avoided to the maximum extent possible.

5.5.2.5 Abundance

Abundance of longfin smelt has the potential to be beneficially affected by the substantial increase in tidal habitat under the Plan. The quantity of suitable habitat in the ROAs would increase greatly and decreases in habitat quality in the ROAs because of climate change may be offset by increased area. Lower outflow in late winter and spring months, however, is predicted to contribute to reduced larval longfin smelt transport and to reduced juvenile and adult abundance unless this adverse effect is offset by increased food production associated shallow-water tidal habitat restoration.

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5.5.2.6 Productivity

The Plan offers the potential to increase productivity of the longfin smelt population principally by increasing food supply within and outside restored areas. However, reduced outflow during late-winter and spring months may adversely affect the transport of larval longfin smelt downstream to suitable rearing habitat and subsequently the abundance of juvenile and adult longfin smelt. Lower outflow may facilitate increases in *Corbula* clam recruitment in the LSZ, which could cause reductions in planktonic organisms that form the basis of the food that longfin smelt eat.

One of the objectives of the BDCP conservation strategy is to reduce the effects of various stressors on the mortality of each of the life stages of longfin smelt. Actions designed to reduce the mortality of the species may include both direct measures and indirect effects. As part of implementing the north Delta diversion operations, productivity may be improved through reduced entrainment at the south Delta diversions. Operation of the north Delta diversions would result in a reduction in south Delta exports in wetter years and associated reductions in OMR reverse flows that would contribute to reducing the risk of longfin smelt entrainment and salvage at the south Delta export facilities on average. In addition, detailed monitoring of the geographic and seasonal distribution of longfin smelt in the Delta, as well as salvage monitoring at the south Delta export facilities, would provide information for use in making real-time decisions regarding export operations to manage and reduce incidental take of longfin smelt.

The effects of environmental factors such as exposure of longfin smelt to seasonally elevated water temperatures in the future in response to climate change can result in a number of adverse effects that include increased metabolic rates and reduced growth and survival of longfin smelt, reduction in habitat suitability and availability, and under severe conditions direct mortality to longfin smelt. Increasing access for longfin smelt to a diversity of habitat areas located upstream in the Sacramento River (Cache Slough), throughout the Delta (channel margin habitats), in the south and eastern Delta, and downstream adjacent to Suisun Bay (Suisun Marsh) offers the species the opportunity to expand their geographic range and to respond to factors such as exposure to elevated water temperatures in the south Delta by moving to more suitable habitats located elsewhere in the Delta. Expansion of the area and diversity of habitats also offers the species the opportunity to diversify life history strategies and to take advantage of a wider range of habitats in response to changing environmental conditions in and among years.

Increased shallow-water habitat because of restoration under the Plan has the potential to contribute to increased export of organic carbon, which may contribute to increased phytoplankton and zooplankton abundance both in the habitat and farther downstream in pelagic habitats occupied by longfin smelt, although there is uncertainty about the performance of shallow-water tidal habitat restoration projects in contributing to the pelagic foodweb of longfin smelt. Increased zooplankton food supplies would contribute to meeting increased metabolic rates of longfin smelt in response to elevated water temperatures as well as increased growth and survival for larval, juvenile, and adult longfin smelt. These actions would contribute to a reduction in direct effects of increased mortality as well as indirect effects of factors such as exposure to seasonally elevated water temperatures in the Delta. Increased food resources would contribute to increased resistance to disease and sublethal effects of contaminants on the health and survival of longfin smelt.

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5.5.2.7 Life History Diversity

Restoration of tidal habitat under the Plan has the potential to contribute to an increase in life history diversity for longfin smelt. One element of the BDCP conservation strategy is to contribute to opportunities for the covered fish species to express a wider range of life history characteristics, contributing to an increase in biological diversity and fitness. Expanding access to suitable habitats located throughout the Delta, as well as reducing the effects of various stressors on the species, is expected to result in greater abundance and greater life history diversity. Restoration of aquatic habitat as part of the BDCP conservation strategy would reflect an expansion of the available habitat for various life stages of longfin smelt as well as habitat diversity in each of the restored areas. Habitat diversity in terms of variable water depths, areas with and without emergent vegetation, variable water velocities, areas inundated tidally and adjacent shallow subtidal area, and areas having various topographic features contribute to complex habitats that support life history diversity as well as diverse habitats for food production, foraging and rearing areas, cover from predators, and spatial heterogeneity within and among habitat areas. Design of the habitat restoration projects would consider hydrologic connectivity among channel and shallow-water areas, ability for species to move among habitats, the size and complexity of habitat, and location in relation to other suitable habitats for longfin smelt. The design of habitats also will consider tidal hydrodynamics in the habitat and avoid areas of high velocity and turbulence where longfin smelt may be more susceptible to predation mortality.

5.5.2.8 Spatial Diversity

Spatial diversity for longfin smelt could increase because of the restoration of significant areas of suitable habitat in the Suisun Marsh and Cache Slough ROAs, where habitat would increase by a factor of three or four. There would be a lesser benefit from the West Delta ROA because of the relatively small size of the ROA, although its position coincides with an important location within the range of the species, along the migration route from downstream rearing areas in the Suisun Bay/Suisun Marsh subregions to upstream spawning areas. Habitat likely to have relatively low suitability would be restored in the South Delta and Cosumnes-Mokelumne ROAs, which would be less likely to benefit longfin smelt. Lower outflow in late winter and spring months under the Plan potentially would decrease the extent of suitable habitat in the existing Suisun Bay and West Delta subregions, reduce larval longfin smelt transport, and result in reduced juvenile and adult longfin smelt abundance.

The BDCP conservation strategy has been designed to implement a phased program of habitat expansion projects that have a diverse distribution throughout the Delta (Appendix 5.E, Section E.4.2.7.2). The restoration areas include the north Delta Cache Slough and Yolo Bypass complex, channel margin habitat in the western Delta, Suisun Marsh, the eastern Delta (Consumes-Mokelumne corridor), and the south Delta. The habitats include tidal marsh, channel margin, floodplain, and riparian areas. The habitat of greatest potential benefit to longfin smelt would be tidal habitat that would encompass an estimated 64,735 acres (Appendix 5.E, Section E.7.1.1), increasing the amount of shallow-water tidal habitat in the Plan Area by 63% from existing conditions by the late long-term. The size of the areas proposed to be enhanced is substantial (large patch size) as well as a substantial increase in restored habitat area compared to existing conditions. The spatial diversity of habitat improvements throughout the Delta offers opportunities for species to select various habitat areas in response to environmental conditions as well as to benefit various species and life stages of covered fish. Expansion of the spatial diversity of habitats serves to increase the resilience of habitats and species to respond to variation in climate and annual and

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interannual variation in hydrologic conditions, and to spatially expand the range of available habitats to reduce the risk of effects on the species in the event that adverse conditions occur in one habitat area. Increasing habitat diversity and complexity is a fundamental strategy in conservation planning and serves to reduce the risk of take on the population dynamics and resilience of the species to adapt and respond to a range of sources of mortality and adverse environmental conditions.

5.5.2.9 Net Effects

Figure 5.5-2 provides a graphical depiction of the relative population-level outcomes, by stressor, for longfin smelt resulting from implementation of the BDCP conservation strategy.

Longfin smelt are currently at very low levels of abundance. The Plan has the potential to provide substantial benefits to each life stage of longfin smelt. The main potential beneficial effect of the Plan is habitat restoration, which will increase considerably the extent of tidal habitat in the Plan Area. Proposed habitat restoration areas are spatially diverse, are adjacent to very important existing areas occupied by longfin smelt (e.g., the Cache Slough subregion), and would provide a range of habitat conditions that would be suitable for longfin smelt spawning and rearing. Expansion of habitat in the Cache Slough and Suisun Marsh subregions in particular may be of particular importance in the late long-term as the species faces increasingly challenging environmental conditions caused by a warming climate and rising sea level, expanding existing aquatic habitat into preserved upland areas. The potential export of food resources from the restoration areas into existing open-water areas inhabited by longfin smelt may be the most important function of habitat restoration. There is uncertainty related to the extent that this may occur and it is likely to be region-specific, e.g., there may be appreciable benefits resulting from export of food from the Suisun Marsh, West Delta, and Cache Slough ROAs and less benefit from the South Delta and Cosumnes-Mokelumne ROAs because they are further from the species' main range. The Cache Slough subregion may receive increased food production from the Yolo Bypass. As also described for delta smelt, although there is uncertainty related to the beneficial effects of tidal habitat restoration in relation to increased food production for longfin smelt, there is potential for considerable beneficial effects. Implementation of the Plan will include deliberate restoration design and management to promote food production and export to areas where longfin smelt occur. While the magnitude of this benefit cannot be quantified because of uncertainties related to the specifics of the restoration site, adaptive management over the period of implementation will aim to yield large food benefits. The anticipated benefits of restoration for longfin smelt will be tested and verified by the BDCP Implementation Office with an initial series of tidal wetland restoration projects in the first 5–10 years of implementation through the adaptive management and monitoring program. Because of the uncertainties in scaling differing Plan effects, it was not possible to conclude with certainty at this time that BDCP restoration would provide the food benefits needed to increase longfin smelt populations. However, the BDCP has the potential to provide a substantial benefit to longfin smelt as a result of the large amount of tidal wetland restoration and the expected food production to support the species.

Other potential benefits from the Plan relative to existing conditions include maintenance of low larval, juvenile, and adult entrainment loss at the south Delta export facilities at levels at or below those that have resulted from pumping restrictions under the USFWS (2008) OCAP BiOp and the DFG Incidental Take Permit for longfin smelt.

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The principal potential negative effect of the Plan on longfin smelt relative to existing conditions is appreciably lower outflow in the late winter and spring months. Results of regression analysis of the historical response of longfin smelt to changes in Delta outflow and X2 location suggest that the reduction in flows for larval transport and rearing habitat would contribute to reduced longfin smelt abundance later in life. It has been noted that decreases in age-class 2 abundance of longfin smelt following the drought of the late 1980s and early 1990s were greater than expected given the decrease in age-class 1, suggesting that survival between the two life stages had decreased, possibly as a result of food limitation (Rosenfield and Baxter 2007: 1589). The existence of such a relationship may complicate the effect of lower survival because of changes in outflow during the early life stages, possibly reducing the potential adverse effect of the Plan on earlier life stages if there is a 'bottleneck' later in life. Nevertheless, a significant winter/spring outflow-fall abundance relationship remains for longfin smelt, although it has changed over time, possibly in relation to food availability (Baxter et al. 2010) and the potential for an adverse effect of the Plan remains. Factors in addition to river transport flows and Delta outflow, such as food availability for larval longfin smelt foraging, are also likely to be important to the population response to conditions that occur under Plan operations. Provision of higher levels of Delta outflow during the late winter and spring, such as occurred in 2011, does not ensure that longfin smelt will respond as predicted by the earlier regression analyses. The benefits of additional food resources for longfin smelt (zooplankton) produced through expansion of aquatic habitat in the Delta is likely also to be a key factor in determining the population response of longfin smelt to environmental and operational conditions that occur in the Delta in the future.

Reduced Delta outflow may decrease LSZ habitat quantity and quality, increasing exposure to less desirable environmental conditions such as reduced downstream transport of larvae and increased distribution of larval and juvenile longfin smelt in the interior Delta. Indirect effects of lower outflow on longfin smelt include the potential for increased abundance of the invasive clam *Corbula* as a result of greater areas of suitable salinity (>2 ppt) in the West Delta subregion; this may increase consumption of primary and secondary productivity that otherwise would form part of the longfin smelt foodweb.

There is uncertainty, however, in the response of longfin smelt abundance to changes in Delta outflow in the future and the effectiveness of tidal marsh and other habitat restoration efforts in providing suitable habitat and food for longfin smelt. Additionally, the export of food to downstream rearing areas may facilitate increased abundance even when larval transport flows (winter outflows) are reduced. However, there is uncertainty regarding how the availability of food and transport flows interact to provide suitable conditions for larval longfin smelt. As described above, restoration would be implemented to maximize potential food benefits in these rearing areas (Suisun Marsh and West Delta), but the magnitude of the benefit cannot be demonstrated. The relationships between food availability, outflow, and abundance are not well established. The BDCP conservation strategy would include extensive monitoring and other methods that would improve understanding of these interactions and inform the design, implementation, and management of habitat restoration projects to benefit longfin smelt and other fish and to reduce and avoid direct and indirect adverse effects of operations or other BDCP conservation strategy actions on the dynamics of the longfin smelt population.

The effects analysis suggested that implementation of a number of conservation measures as part of the BDCP conservation strategy would not result in substantial positive or negative changes in several stressors for longfin smelt, in many cases in a similar manner to delta smelt. As described in Appendix 5.D, *Contaminants*, implementation of the Plan is not expected to change ammonium

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loading, which is an important stressor influencing plankton communities in the Plan Area. *Alternative channels* relates to different migration routes through the Plan Area (e.g., entry to the Central Delta subregion through the Delta Cross Channel and Georgiana Slough) and is more of a concern for juvenile salmonids migrating through the Plan Area that could be affected by *CM16 Nonphysical Fish Barriers*. Longfin smelt occur primarily downstream of proposed nonphysical barrier locations; therefore it was concluded that there would be no effect. The principal passage barriers that longfin smelt may encounter in the Plan Area are the Suisun Marsh salinity control gates, for which changes in operations under the Plan are uncertain and probably of short duration, and therefore they were assumed to have no effect on longfin smelt. Neither channel margin habitat enhancement nor floodplain restoration/increased flooding of the Yolo Bypass under CM2 were concluded to have appreciable effects on longfin smelt in terms of habitat benefits for different life stages (although there may be some minor addition of spawning habitat from channel margin enhancement depending on the location of the enhancement), but the primary potential benefit of shallow-water tidal habitat restoration for longfin smelt is expected to be related to increased export of suitable food resources to the pelagic foodweb. *CM13 Invasive Aquatic Vegetation Control* is focused on IAV treatment in the ROAs and does not address existing IAV outside the ROAs.

Temperature effects of the Plan in relation to existing conditions were not evident in the analyses of the number of days exceeding 20°C (Appendix 5.C, Section C.5.4.3.17 and C.5.4.3.18), a threshold for habitat that the species typically occupies (Moyle 2002). This suggested that climate rather than water operations governed temperature changes in the Plan Area. Climate change could have appreciable effects on longfin smelt by potentially making the spawning season earlier in the year and possibly disrupting its coincidence with other important environmental variables (e.g., day length and flows), as has been suggested for delta smelt (Wagner et al. 2011). The number of days over 20°C would increase into the future. As temperature increases, bioenergetic demands on all life stages of longfin smelt will increase, particularly in the warmer months of the year. Increased bioenergetic demands in response to increased seasonal temperatures in the future would further increase the food requirements of larval, juvenile, and adult longfin smelt.

Turbidity is an important habitat characteristic for delta smelt and may also be important for longfin smelt. It is unclear whether a 40-year average decline in turbidity of 1.6% per year will continue into the future (Cloern et al. 2011). Should such a trend continue, it presumably would decrease longfin smelt habitat quality in the Plan Area. How the Plan may affect turbidity in the late long-term is uncertain. As described in Appendix 5.C, Section C.6.4.6, a number of factors are important, such as whether the ROAs capture sediment that otherwise would have moved to downstream areas, and whether the ROAs have characteristics that are conducive to sediment resuspension (e.g., wind fetch). Thus the ROAs may increase water clarity in the subregions in which they are located because of sediment capture, but themselves may have relatively turbid water because of factors such as wind- and wave-driven resuspension that could be enhanced by careful design of the ROAs. Given the interplay of these effects, at this time no conclusion is made regarding the effects of the Plan on turbidity within the range of longfin smelt.

In conclusion, in relation to existing conditions, the Plan's main beneficial effect for longfin smelt is potentially greater food production from habitat restoration, and the main adverse effect is lower outflow in the late winter and spring, which may limit longfin smelt abundance because of reduced larval transport and other, unknown mechanisms. The benefits to longfin smelt of reduced entrainment, increased habitat availability, and increased food have the potential to positively affect survival and reproduction and may offset potential adverse effects associated with the effects of lower transport flows on larval and early juvenile life stages, particularly if a population bottleneck

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is limiting the longfin smelt population at a later life stage. Any increases in abundance and distribution may maintain or increase biological diversity. Because the main adverse effect of the Plan results in an outcome that is a measure of population abundance, and the main benefit cannot be quantified, it is concluded with low certainty that the Plan has no net effect on the species. The Monitoring and Research Program and Adaptive Management Program would provide the opportunity to address existing uncertainties and alter the Plan to maximize its long-term benefits. The Real-Time Response Team would provide the ability to respond immediately to potential threats to the species that might occur as a result of project operations, unforeseen changes in species distributions, or other factors.

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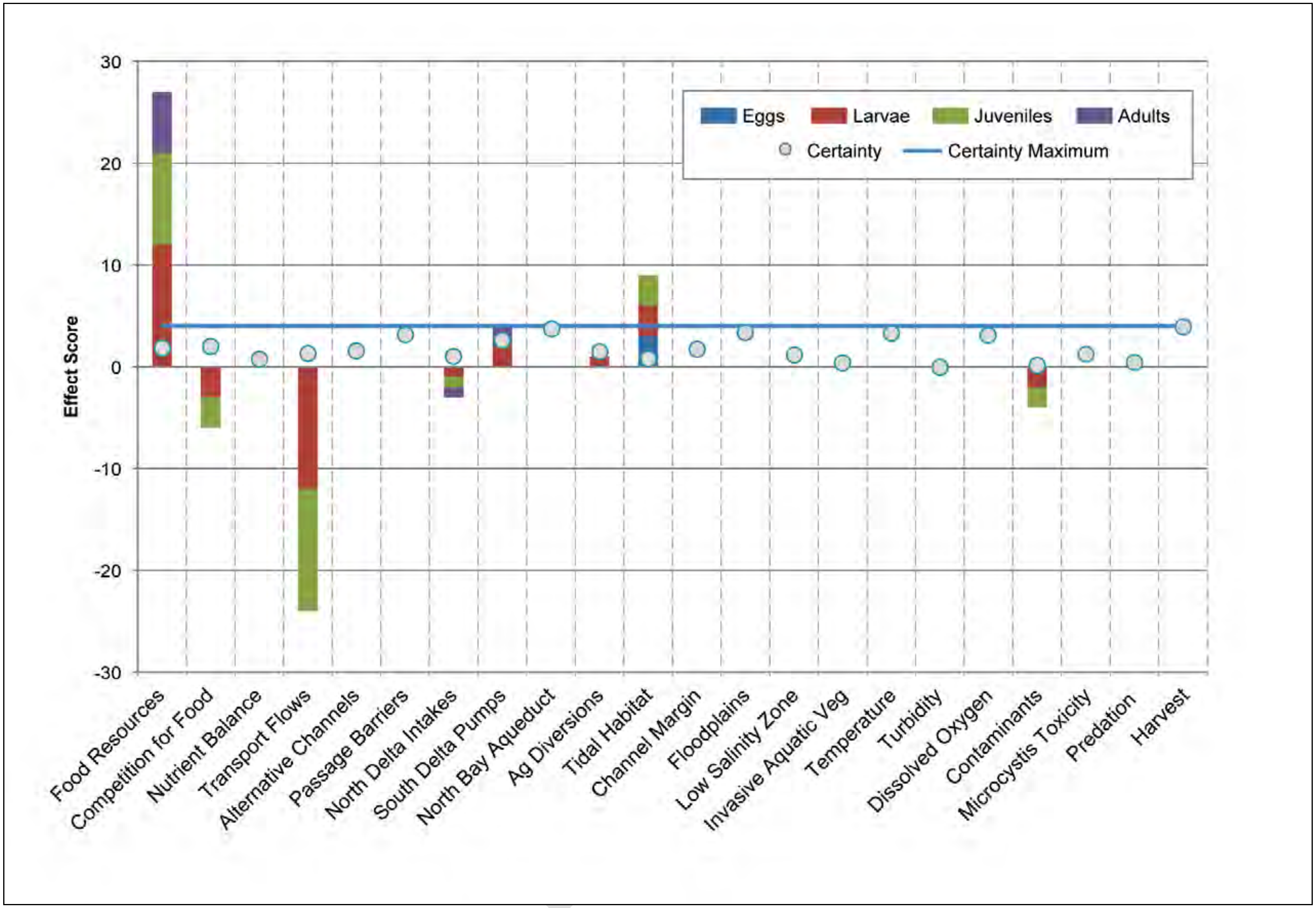

Figure 5.5-2. Effect of the BDCP Conservation Strategy on Longfin Smelt

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5.5.3 Salmonids

Salmon and steelhead (*Oncorhynchus* spp.) are commercially, culturally, and legally important species whose habitat will be affected by the BDCP. Four runs of Chinook salmon (*O. tshawytscha*) along with steelhead (*O. mykiss*) are seasonally present in the BDCP Plan Area (the Delta) and in the BDCP Study Area (Delta plus upstream rivers such as the Sacramento and San Joaquin) and were considered in the effects analysis. For purposes of this discussion, all four runs of Chinook salmon and steelhead will be referred to as *species*. Most of these species are listed under the federal and ESAs (Table 5.5-12).

[***Note to Reader:*** *for this admin draft net effects analysis, salmonids were grouped, but it is recognized that assessing the individual runs may be necessary for subsequent drafts.*]

Table 5.5-12. Status of Central Valley Salmonids with Respect to Federal and Stage Endangered Species Acts

Species	Federal ESA Status	California ESA Status
Winter-run Chinook salmon	Endangered	Endangered
Spring-run Chinook salmon	Threatened	Threatened
Fall-run Chinook salmon	Species of Concern	n/a
Late fall–run Chinook salmon	Species of Concern	n/a
Steelhead	Threatened	n/a

All five species in the Central Valley are much reduced from historical levels (Yoshiyama et al. 1998; Moyle 2002). Fall-run Chinook salmon have been the most abundant species in the Central Valley for many years and have supported much of the California commercial and sport fishery (Lindley et al. 2004). However, a sharp decline in returning fall-run Chinook salmon in the last few years, and the influence of large-scale hatchery production on the genetics of the species (Barnett-Johnson et al. 2007), have prompted concern for these fish as well.

A defining life history feature of these salmonids is that they are anadromous, spawning and rearing in fresh water but spending most of their lives in the ocean prior to migrating back into fresh water to spawn. As a result, the fish species in Table 5.5-12 spend limited and variable amounts of their life history in the BDCP study area. For many species, the majority of the freshwater residency is spent in tributaries above the Delta, and they spend relatively brief periods in the Delta as outmigrating juveniles and returning adults. In contrast, the juveniles of some Chinook salmon species may spend weeks or months rearing in the lower reaches of the rivers and the Delta prior to migrating to coastal marine waters (e.g., fall-run Chinook salmon) (Kjelson et al. 1982). For these reasons, the consideration of BDCP effects is separated into those stressors and BDCP actions that take place in the Plan Area (the Delta, including the full extent of the Yolo Bypass, Suisun Marsh, and Suisun Bay) and stressors and actions that take place in riverine environments, including the Sacramento and San Joaquin Rivers and other tributaries potentially affected by BDCP covered activities.

Anadromous salmonids have complex and variable life histories that have allowed them to inhabit a wide array of habitats and to adapt to variable environmental conditions (MacFarlane and Norton 2002). The timing of adult entry into fresh water is marked by the designation of runs (fall vs. spring-run, for example) that may affect their exposure to the effects of the BDCP. Similarly, the species vary in regard to their juvenile life histories in ways that also affect their exposure to BDCP actions. In particular, two life history patterns are generally recognized that differ in regard to their

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juvenile behavior in addition to other features (Healey 1983, 1994). Ocean-type salmon begin moving downstream soon after hatching and spend periods ranging from days to several months feeding and growing in the river and estuary. Stream-type fish spend up to a year feeding and growing in upriver tributaries near where they were spawned. When smoltification occurs, usually in the spring, stream-type salmon move rapidly downstream and spend a relatively short period in the estuary. In fact, most salmonid populations, especially Chinook salmon, display both life patterns although one type usually predominates in a population. In the Sacramento system especially, both behaviors are present in most populations. The differences in juvenile behavior have important impacts on the assessment of BDCP effects. Ocean-type fish, for example, actively forage for food in shallow-water areas (McLain and Castillo 2010) and likely benefit more from restoration of these types of environments than would stream-type fish that are migrating rapidly through the estuary.

Because of these differences, the effects of BDCP actions are considered for two juvenile behavior patterns termed *foragers* and *migrants*. All outmigrating salmonid species likely display these two behaviors, though a particular behavior probably predominates in populations. Even fish that are fully smolted and bound for the ocean may forage while those fish that are not fully smolted and are actively feeding are still migrating generally downstream toward the ocean, albeit at a slower rate than fully smolted fish. In addition to juvenile foragers and migrants, BDCP effects were evaluated for the egg stage and for adult migrants.

Over the past two centuries the quantity, quality, and availability of habitat for salmonid migration, spawning, and juvenile rearing in the California Central Valley have been substantially reduced as a result of land use changes associated with river regulation, levee construction, channelization, and reclamation of tidal and subtidal wetland and aquatic habitats (Conomos et al. 1985; Logan 1990; National Marine Fisheries Service 1996, 1998, 2009; Yoshiyama et al. 1996, 2001; McEwan 2001; Mesick 2001; Moyle 2002; Williams 2006). These habitat changes have substantially reduced the complexity, heterogeneity, and availability of shallow-water, low-velocity seasonal floodplain, channel margin and intertidal and subtidal wetland and open water habitats that are important migration and juvenile rearing habitats (Sommer et al. 2001a, 2001b; CALFED and National Fish and Wildlife Foundation undated). The reduction in access to these habitats has reduced opportunities for extended juvenile salmonid rearing in the Delta. Therefore, there are reduced opportunities for juvenile salmonids to express a wide range of life history tactics thought to support species resilience under a wide range of environmental conditions (Lindley et al. 2006; Williams 2006; Miller et al. 2010). Historically, the construction of upstream dams reduced access to spawning and rearing habitat as well as changing seasonal hydrology in many Central Valley rivers.

5.5.3.1 Stressor Rankings

This section describes the relative importance of an identified set of stressors on anadromous Chinook salmon and steelhead. As discussed above, stressors are ranked separately for the Plan Area (Delta including the Yolo Bypass) and upstream areas (rivers). In each case, a single ranking of stressors was made that applied to all runs of Chinook salmon and steelhead. While differences in ranking between salmonid species certainly occur, it was concluded that the differences were obscure at the scale of consideration and resolution of stressor differences used in this analysis. Some of the main stressor rankings are summarized below, with additional discussion as necessary in each section of beneficial and adverse effects.

[***Note to Reader:*** *ICF will further investigate the extent to which species-specific rankings for salmonids are appropriate and may adopt such rankings for the public draft BDCP document.*]

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5.5.3.1.1 Delta Stressors on Salmonids

Stressors on salmonids in the Delta were ranked for eggs, foraging juveniles, migrating juveniles, and adults as discussed above (Table 5.5-13). Rankings for stressors on salmonid spawning (egg stage) in the Delta were zero for all stressors because all salmonid spawning occurs upstream in rivers and streams. Delta stressors on adult salmonids were ranked very low because adults spend little time in the Delta as they migrate from the ocean to upriver spawning areas. The summed ranking for foraging juvenile salmonids was the highest of all life stages and appreciably higher than the summed ranks for migrating juvenile salmonids. This is consistent with the fact that foraging juvenile salmonids spend an extended period in the Plan Area compared to migrant smolts and are affected to a larger degree by conditions in the Delta (Williams 2008).

The rationale for ranking of stressors is provided in Table 5.5-13. Across life stages, the top-ranked stressors in order were flow regulation (change in inflow to the Delta), predation, and loss of access to shallow-water tidal wetlands and channel margin habitat. Certainty of these stressor rankings was relatively low, reflecting the relative paucity of studies aimed specifically at evaluating limiting factors for salmonids in the Delta. In most river systems, downstream migration of juvenile salmonids is related to flow, with the spring freshet and flood pulses being important cues for juvenile migration (Quinn 2005; Williams 2008). In the Delta, salmon fry outmigration is related to outflow (Brandes and McLain 2001), while the reduction in spring freshet pulse flows due to regulation appears to impede juvenile salmonid outmigration (Williams 2009; Brandes and McLain 2001). It was concluded that flow should be given a stressor score of 4 for juvenile migrating salmonids because the spring migration of fully smolted juvenile salmonids appears to be especially tied to the spring freshet (Vogel 2011). Flow was given a stressor score of 3 for non-smolted foraging fry that move downstream gradually, feeding as they go, and are less tied to flow pulses (Vogel 2011).

5.5.3.1.2 Riverine Stressors on Salmonids

A separate set of stressors was ranked for salmonids in rivers and streams upstream of the Delta (Table 5.5-14). It is important to note that these stressors do not account for the loss of habitat that resulted from construction of dams in the Sacramento and San Joaquin systems that blocked access to much of the historical habitat, and is generally ranked as the primary cause of diminished returns of most Central Valley salmonids (National Marine Fisheries Service 2009). Tributary dams in the Central Valley have greatly reduced the potential of the system to produce salmonids relative to the intrinsic potential of the system. The list of stressors in Table 5.5-14 also does not include the effect of introgression of hatchery and wild fish that has been identified as an important limiting factor for Central Valley salmonids (National Marine Fisheries Service 2009). Finally, these stressors address salmonids, generally recognizing that there are many watershed-specific issues that affect individual populations of Chinook salmon and steelhead.

The highest summed ranking across stressors was for foraging fry followed by migrant smolts (Table 5.5-14). For both behavior forms the alteration of the normative flow pattern due to regulation was ranked as a major stressor. Juvenile salmonids use flow peaks to signal and assist in downstream migration; reduction of the spring freshet has been shown to negatively affect salmonid survival in the Sacramento system (Brandes and McLain 2001). Other high-ranked stressors included the loss of floodplain habitats and increased water temperature. The value of floodplain habitats to juvenile salmonids in the Central Valley has been well documented (Sommer et al. 2001), and these habitats have been lost through diking, channelization, and flow regulation.

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Table 5.5-13. Population-Level Stressors—Delta Salmonids

Stressor Category	Stressors	Stressor Definitions	Spawned Eggs to Hatching	Fry/ Fingerling Stages Actively Feeding and Growing	Smolted Juveniles Migrating toward the Ocean	Adults Migrating Upstream	Rationale for Stressor Rankings
			Eggs	Foraging Juveniles	Migrating Juveniles	Adults	
Food	Food resources	Quantity and quality of food resources available to life stages	0	3	2	0	Salmon use a wide variety of pelagic, demersal, terrestrial, and drift invertebrates and can shift between prey items. Moyle and coauthors (2008) cite food limitation as a factor for salmon. There are comparatively few studies.
	Competition for food	Decrease in food resources due to competition with other consumers	0	2	2	0	Because of ability of salmon to shift prey base, competition with clams for plankton is unlikely though has not been studied. NMFS BiOp p. 154 highlights *Corbicula* as a problem.
	Nutrient balance	Impact of wastewater treatment plant effluent (for example) and other inputs on Delta food resources	0	1	1	0	It is not thought that salmon fry and juveniles are food-limited because of their ability to shift to a different prey base when mid–water column food sources are limited; therefore, effects of nutrient balance are believed to be low for juveniles.
Water Operations	Transport flows	Change in flow through the Delta as a result of upstream regulation or diversion	0	3	4	2	Salmon fry outmigration related to outflow (Brandes and McLain 2001). Reduction in spring freshet due to regulation has impeded outmigration (Williams 2009; Brandes and McLain 2001). Flow regulation dampens cues that salmonids have adapted to for migration and spawning (Williams 2009).
	Alternative channels	Effect of fish movement into interior Delta through Georgiana Slough and the Delta Cross Channel	0	3	3	0	Juvenile salmonids may enter the interior Delta through channels such as Georgiana Slough, the Delta Cross Channel, and Old River, where survival is appreciably lower (Perry et al. 2010; Newman and Brandes 2010).
	Passage barriers	Structures that may impede or change migration patterns in the region such as the salinity control gates	0	0	0	3	Fremont Weir is a significant barrier for adult migration (DRERIP).

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Stressor Category	Stressors	Stressor Definitions	Spawned Eggs to Hatching	Fry/ Fingerling Stages Actively Feeding and Growing	Smolted Juveniles Migrating toward the Ocean	Adults Migrating Upstream	Rationale for Stressor Rankings
			Eggs	Foraging Juveniles	Migrating Juveniles	Adults	
Water Operations—Entrainment	North Delta entrainment/ impingement[1]	Entrainment and impingement of fish at proposed North Delta intake	0	2	1	0	All juvenile salmon in Sacramento exposed to north Delta intakes. Screening and operations designed with delta smelt in mind, so effects should be low. Fry have less swimming power and so effects should be larger.
	South Delta entrainment	Entrainment at existing South Delta intake	0	2	2	0	It is assumed that the importance of entrainment at the south Delta pumps was greatly diminished by the BiOp Reasonable and Prudent Alternative (RPA).
	North Bay Aqueduct entrainment	Entrainment at North Bay Aqueduct	0	0	0	0	Screened intake to delta smelt standards and therefore not assumed to have an existing effect on salmonids.
	Agricultural diversion entrainment	Entrainment in agricultural and smaller diversions throughout the Delta	0	1	1	0	More than 2,000 unscreened diversions but have small hydrodynamic footprints compared with outflow and tidal flux, so probably minimum impact only on juvenile salmonids (Williams 2009; Nobriga 2004; Moyle and Israel 2005).
Habitat	Tidal habitat	Impact of loss of tidal wetlands in terms of direct habitat for the species	0	4	0	0	Use of tidal wetlands by foraging salmon fry well documented (McLain and Castillo 2009). Stressor score reflects loss of foraging habitat only. Limited information.
	Channel margin	Impact of loss or change in channel margin in terms of direct habitat for the species	0	4	3	0	General loss of channel margin habitat because of levees has affected foraging and migrating juveniles (Williams 2009).
	Floodplains	Impact of loss of area or connectivity to floodplains in terms of direct habitat for the species.	0	4	2	0	Evidence of floodplain rearing by juvenile salmonids increases survival largely because of higher growth (Sommer et al. 2001; Jeffres et al. 2006).
	Low salinity zone	Habitat quantity and quality in the low salinity zone	0	0	0	0	Very little information. However, foraging juvenile salmon are not generally pelagic feeders so would likely not be associated with LSZ.

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Stressor Category	Stressors	Stressor Definitions	Spawned Eggs to Hatching Eggs	Fry/ Fingerling Stages Actively Feeding and Growing Foraging Juveniles	Smolted Juveniles Migrating toward the Ocean Migrating Juveniles	Adults Migrating Upstream Adults	Rationale for Stressor Rankings
	Invasive aquatic vegetation	Shallow water habitat occupied by aquatic vegetation	0	2	1		The proliferation of SAV has occurred since the 1980s and has changed the fish assemblages in nearshore habitats in the Delta (Nobriga and Herbold 2009; Feyrer et al. 2005; Nobriga 2007; Feyrer 2004).
	Temperature	Water temperature	0	1	2	1	Temperature requirements of salmon well documented (e.g., McCullough 2001) though few studies in the Delta. Temperatures during residence times rarely get to levels that decrease survival except during summer. Survival to Chipps Island linked to temperature with 50% survival at 23 degrees Centigrade (Baker 1995); adult Chinook salmon migration rates lower in temperatures above or about 20°C (Goniea et al. 2006).
	Turbidity	Water clarity	0	3	3	0	Turbidity in the regions may be a problem because water can be so clear (Gregory and Northcote 1993; Gregory 1993; Gregory and Levings 1998).
	Dissolved oxygen	Dissolved oxygen	0	0	0	0	Critical values occur only locally (e.g., duck ponds in Suisun, Stockton Deep Water Ship Channel.
Water Quality	Contaminants	Non-biological substances with adverse effects on biota	0	2	2	2	Toxins can inhibit imprinting and homing in juveniles and homing in adults (Williams 2009); it is poorly known whether there may be lethal or sublethal effects.
	Microcystis toxicity	Naturally occurring toxins from algal populations	0	1	0	0	Unlikely that salmon in area during blooms or for prolonged periods of time. Microcystis can affect nutrition and health (Acuna et al. 2012; Lehman 2010).
Predation	Predation	Non-normative consumption of target species by piscivorous species	0	3	3	0	Predation is generally regarded as an important stressor for juvenile salmonids in the Delta (e.g., Vogel 2011).
	Harvest	Human predation on the species in the Delta	0	0	0	1	Harvest, both legal and illegal, of salmon in the Delta assumed generally to be low, although still an issue.

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Stressor Category	Stressors	Stressor Definitions	Spawned Eggs to Hatching Eggs	Fry/ Fingerling Stages Actively Feeding and Growing Foraging Juveniles	Smolted Juveniles Migrating toward the Ocean Migrating Juveniles	Adults Migrating Upstream Adults	Rationale for Stressor Rankings

Note: Stressors are ranked by relative importance on a scale from 0 (unimportant) to 4 (highly important).
LSZ = low salinity zone.
Stressors are ranked by their impact on biological performance of the species under current habitat conditions.
Stressors are attributes of the environment affecting the biological performance of the species.
[1] Presumed impact in the future.

	High degree of scientific certainty, supported by consistent quantitative analysis.
	Appreciable qualitative information supported by general scientific literature.
	Uncertain, conflicting quantitative analysis, limited support in literature.
	Speculative, no quantitative analysis and little applicable literature.

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Table 5.5-14. Population-Level Stressors—River Salmonids

Stressor Category	Stressors	Stressor Definitions	Spawned Eggs to Hatching Eggs	Fry/ Fingerling Stages Actively Feeding and Growing Foraging Juveniles	Smolted Juveniles Migrating toward the Ocean Migrating Juveniles	Adults Migrating Upstream Adults	Rationale for Stressor Rankings
	Food Resources	Quantity and quality of food resources available to life stages	0	1	0	0	Apparently ample food. Resident trout quite robust; few studies.
Water Operations	Flow regulation	Impact of change in timing and magnitude of flow as a result of regulation on behavior (e.g., migrational queues)	0	3	4	1	Salmon fry outmigration related to outflow (Brandes and McLain 2001). Reduction in spring freshet due to regulation has impeded outmigration (Williams 2009; Brandes and McLain 2001). Flow regulation dampens cues that salmonids have adapted to for migration and spawning (Williams 2009).
	Flow-associated habitat	Impact of flow regulation on channel width, stranding, and redd dewatering	2	1	1	0	Flow increases the amount of habitat available for spawning and juvenile rearing, juveniles usually segregate out in habitats by flow velocities (Moyle et al. 2008).
	Channel margin	Loss of channel margin (riprap, riparian, and channel edge)	0	3	2	0	Channel margin habitat provides food, cover from predators, and places for juvenile salmon to rest.
	Floodplain	Connectivity to floodplain habitat	0	3	2	0	Evidence of floodplain rearing by juvenile salmonids increases survival largely because of higher growth (Sommer et al. 2001; Jeffres et al. 2006).
	Channel form and substrate	Loss of channel structure and increase in fine sediment	3	2	0	0	Loss of channel form through channelization and armoring is a source of lost habitat for juvenile salmonids and is reflected in lower growth, i.e., lower survival.
	Temperature	Water temperature	2	2	2	0	Increased temperatures in late spring due to water operations. Survival to Chipps linked to temperature with 50% survival at 23 degrees Centigrade (Baker 1995).

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Stressor Category	Stressors	Stressor Definitions	Spawned Eggs to Hatching	Fry/ Fingerling Stages Actively Feeding and Growing	Smolted Juveniles Migrating toward the Ocean	Adults Migrating Upstream	Rationale for Stressor Rankings
			Eggs	**Foraging Juveniles**	**Migrating Juveniles**	**Adults**	
	Turbidity	Water clarity	0	0	0	0	Juvenile salmonid feeding increased in moderate turbidities and lowered in very low and very high turbidities. Turbidity in the regions only a problem because water can be so clear (Gregory and Northcote 1993; Gregory 1993; Gregory and Levings 1998).
	Dissolved oxygen	Dissolved oxygen	0	0	0	0	No known instances of problems.
	Passage barriers	Structures that may impede or change migration patterns (does not include existing main dams such as Shasta)	0	1	1	1	Beyond the major rim dams, passage issues are not assessed to be considerable.
	Contaminants	Non-biological substances with adverse effects on biota	0	1	1	0	Toxins can inhibit imprinting and homing in juveniles and homing in adults (Williams 2009).
	Predation	Non-normative consumption of target species by piscivorous species	0	2	2	0	Predation can be high in acoustic tag studies, usually around human-made structures and scour holes (Vogel 2011).
	Harvest	Human predation on the species	0	0	1	2	Most non-marine harvest occurs Sacramento and above.

Note: Stressors are ranked by relative importance on a scale from 0 (unimportant) to 4 (highly important).
LSZ = low salinity zone.
Stressors are ranked by their impact on biological performance of the species under current habitat conditions.
Stressors are attributes of the environment affecting the biological performance of the species.

White	High degree of scientific certainty, supported by consistent quantitative analysis.
Light gray	Appreciable qualitative information supported by general scientific literature.
Dark gray	Uncertain, conflicting quantitative analysis, limited support in literature.
Black	Speculative, no quantitative analysis and little applicable literature.

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Table 5.5-15. Change to Stressors because of the BDCP by Life Stage—Delta Salmonids

		Change to the Stressor for the Life Stage (-4 to 4) because of the BDCP			
Stressor Category	**Stressors**	**Eggs**	**Foraging Juveniles**	**Migrating Juveniles**	**Adults**
Food	Food resources	0	3	3	0
	Competition for food	0	0	0	0
	Nutrient balance	0	0	0	0
Water operations	Transport flows	0	-1	-1	-1
	Alternative channels	0	1	1	0
	Passage barriers	0	0	0	4
Water operations—entrainment	North Delta Intakes impingement	0	-1	-1	0
	South Delta entrainment*	0	3	2	0
	North Bay Aqueduct entrainment	0	0	0	0
	Agricultural diversion entrainment	0	1	1	0
Habitat	Tidal habitat	0	4	0	0
	Channel margin	0	1	1	0
	Floodplains	0	3	3	0
	Low salinity zone	0	0	0	0
	Invasive aquatic vegetation	0	0	0	0
	Temperature	0	0	0	0
	Turbidity**	–	–	–	–
	Dissolved oxygen	0	0	0	0
Water quality	Contaminants	-1	-1	-1	-1
	Microcystis toxicity	0	0	0	0
Predation	Predation	0	1	1	0
	Harvest	0	0	0	1

Notes: Changes to stressors as a result of the Plan are expressed as integers from -4 (high negative change) to 4 (high positive change).

* The scores presented for this change from the BDCP reflect a comparison of the PP to EBC2, which includes the current OMR flow requirements of the USFWS BiOp (2008).

** Changes to turbidity as a result of BDCP implementation are difficult to predict and are likely to vary by ROA and subregion, as discussed in Section 5.3.2.3. At this time no conclusion is made regarding the change to turbidity as a result of Plan implementation.

Stressors are ranked by their impact on biological performance of the species under current habitat conditions.

Stressors are attributes of the environment affecting the biological performance of the species.

(white)	High degree of scientific certainty, supported by consistent quantitative analysis.
(light gray)	Appreciable qualitative information supported by general scientific literature.
(dark gray)	Uncertain, conflicting quantitative analysis, limited support in literature.
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Table 5.5-16. Change to Stressors because of the BDCP by Life Stage—River Salmonids

Stressor Category	Stressors	Change to the Stressor for the Life Stage (-4 to 4) because of the BDCP			
		Eggs	Foraging Juveniles	Migrating Juveniles	Adults
Food	Food resources	0	0	0	0
Water operations	Flow regulation	0	0	0	0
	Flow associated habitat	0	0	0	0
	Channel margin	0	0	0	0
	Floodplain	0	0	0	0
	Channel form and substrate	0	0	0	0
Habitat	Temperature	0	0	0	0
	Turbidity	0	0	0	0
	Dissolved oxygen	0	0	0	0
	Passage barriers	0	0	0	0
Water Quality	Contaminants	0	0	0	0
Predation	Predation	0	0	0	0
	Harvest	0	0	0	0

Notes: Changes to stressors as a result of the Plan are expressed as integers from -4 (high negative change) to 4 (high positive change).
The scores presented for this change from the BDCP reflect a comparison of the PP to EBC2, which includes the current OMR flow requirements of the USFWS BiOp (2008).
Stressors are ranked by their impact on biological performance of the species under current habitat conditions.
Stressors are attributes of the environment affecting the biological performance of the species.

(white)	High degree of scientific certainty, supported by consistent quantitative analysis.
(light gray)	Appreciable qualitative information supported by general scientific literature.
(dark gray)	Uncertain, conflicting quantitative analysis, limited support in literature.
(black)	Speculative, no quantitative analysis and little applicable literature.

5.5.3.2 BDCP Effects on Stressors—Delta Stressors

Changes to stressors as a result of the Plan in relation to existing conditions are summarized in Table 5.5-15 and Table 5.5-16. These changes are discussed in detail below.

5.5.3.2.1 Beneficial Effects

The Plan would greatly expand access to tidal habitat used for juvenile salmonid foraging and would enhance channel margin habitat for foraging and migrating juvenile salmonids.

Tidal areas form important rearing habitat for foraging juvenile salmonids. Studies have shown that foraging salmonids may spend 2–3 months in the Plan Area (e.g., fall-run Chinook salmon [Kjelson et al. 1982], winter-run Chinook salmon [Del Rosario et al. in press]). Loss of tidal habitat because of land reclamation facilitated by levee construction is considered to be a major stressor on juvenile salmonids in the DRERIP conceptual model (Williams 2009). For this effects analysis, it was

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assumed that tidal habitat is a stressor with high importance (score = 4) for foraging salmonid juveniles, with moderately high certainty (score =3). It was assumed that this habitat is not important for other life stages.

Analysis of increases in tidal habitat using the habitat suitability index (HSI) approach (Appendix 5.E, Section E.5.1.2.2) suggested that in the late long-term there may be a quadrupling of habitat units (HUs) in the five ROAs for foraging Chinook salmon (Table 5.5-17) (Appendix 5.E, Section E.6.2). These results were driven by major increases in the Cache Slough ROA (nearly a tripling of HUs to almost 10,000 HUs) (Appendix 5.E, Section E.6.2.3.4), Suisun Marsh ROA (more than a quadrupling of HUs to almost 7,000 HUs) (Appendix 5.E, Section E.6.2.4.4), and West Delta ROA (a two-orders-of-magnitude increase in HUs to almost 2,000 HUs) (Appendix 5.E, Section E.6.2.5.4). These ROAs had relatively high habitat suitability indices (around 0.7 to 0.95). Although there was also some contribution to increases in HUs from the Cosumnes-Mokelumne (Appendix 5.E, Section E.6.2.6.4) and South Delta (Appendix 5.E, Section E.6.2.7.4) ROAs (Table 5.5-17), these ROAs generally had low habitat suitability and as a result, relatively low HUs. This was caused by the assumed low suitability of low-turbidity water for rearing salmonids, as derived from catches of fry-sized fish in Sacramento River trawls (Appendix 5.E, Section E.5.1.2.2).

Restoration of habitat in Suisun Marsh may be of considerable importance during higher outflow years, when Chinook salmon fry may be dispersed farther downstream (Kjelson et al. 1982). Restoration in the Cache Slough ROA would provide important shallow-water, low-velocity habitat, which may be of particular importance in years when the Yolo Bypass floodplain is not inundated (McLain and Castillo 2009). Restoration in the Cache Slough and West Delta ROAs would provide important transition areas from upstream habitats as salmon gradually move downstream prior to ocean migration. Conservation of adjacent upland areas under the Plan would allow expansion of aquatic habitat as sea level rises, benefitting rearing juvenile Chinook salmon. It is concluded that the overall change related to tidal habitat restoration on rearing Chinook salmon juveniles is high (score = 4), with moderately high certainty (score = 3). There is some uncertainty related to how much restored habitats may be reduced in value because of colonization by invasive aquatic vegetation and associated nonnative fish species that may prey on juvenile Chinook salmon or compete for food. CM13 aims to control invasive aquatic vegetation in the ROAs, which may limit predation, but there is uncertainty related to the ability to do so effectively.

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Table 5.5-17. Habitat Units and Habitat Suitability Indices for Rearing (Foraging) Chinook Salmon Juveniles (November–June) Under Existing Conditions and the Plan in the Late Long-Term, Assuming No Sea Level Rise

ROA	Scenario	Habitat Units	Habitat Suitability Index
Cache Slough	Existing	3,546	0.73
	Plan	9,861	0.72
Suisun Marsh	Existing	1,657	0.96
	Plan	6,828	0.95
West Delta	Existing	66	0.71
	Plan	1,909	0.72
Cosumnes-Mokelumne	Existing	0	-
	Plan	270	0.24
South Delta	Existing	4	0.20
	Plan	966	0.20
All	Existing	5,273	
	Plan	19,384	

Channel margin habitat in the Plan Area has been considerably reduced because of the construction of levees and the armoring of their banks with riprap (Williams 2009). For this effects analysis it is assumed that channel margin habitat represents a stressor with high importance for foraging juvenile salmonids (score = 4, certainty = 3) and moderately high importance for migrating juvenile salmonids (score = 3, certainty = 3). Channel margin habitat enhancement (CM6) under the Plan is generally expected to benefit covered salmonids by improving rearing habitat and connectivity along migration corridors. The primary benefit of *CM6 Channel Margin Enhancement* would be an increase in high-quality rearing habitat for juvenile salmonids, in particular Chinook salmon fry, because of enhancement and creation of additional shallow-water habitat that would provide refuge from unfavorable hydraulic conditions and predation, as well as foraging habitat. Most fish research in the Plan Area's channel margin habitat has focused on Chinook salmon fry (e.g., McLain and Castillo 2009; HT Harvey & Associates with PRBO Conservation Science 2010) (Appendix 5.E, Section E.6.4.2). Benefits for larger Chinook salmon migrant juveniles and steelhead may be somewhat less than for foraging Chinook salmon fry, although the habitat may serve an important function as holding areas during downstream migration (Burau et al. 2007), therefore improving connectivity along the migration route. The efficacy of the measure may depend on the lengths of enhanced channel margin habitat and the distance between enhanced areas—that is, there may be a tradeoff between enhancing multiple shorter reaches that have less distance between them and enhancing relatively few longer channel margin habitats with greater distances between them. Enhanced channel margin habitat in the vicinity of the proposed north Delta intakes (upstream, between the intakes, and downstream) would provide resting spots and refuge for fish moving through this area. The 20–40 miles of channel margin enhancement proposed in the Plan Area under CM6 represent approximately 4–8% of the total length in these channels—a relatively small proportion. The extent to which this enhancement will affect fish on a broad scale depends on the change in overall habitat value relative to existing conditions. By targeting areas that have been shown to have poor habitat quality and biological performance coupled with extensive occurrence of covered fish species, it is possible that channel margin enhancement, together with associated restoration activities (e.g., *CM7 Riparian Natural Community Restoration*), may give more than a

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proportional 4–8% increase in overall habitat value. Such locations include the greatly altered reach of the Sacramento River between Freeport and Georgiana Slough, for example. Additional research on existing biological performance (e.g., survival studies in particular reaches for Chinook salmon fry) would complement the existing knowledge regarding habitat value. Monitoring would inform the assessment of the change in habitat value resulting from CM6. There may be some risk to juvenile salmonids associated with use of enhanced channel margin habitat by predatory fish species such as largemouth bass (HT Harvey & Associates with PRBO Conservation Science 2010); this risk would be assessed as part of a monitoring and adaptive management program in order to determine the specific site features that may need to be altered to reduce the risk.

Enhancement of channel margin habitat under CM6 would offset the potential negative effects of reductions in channel margin habitat for juvenile salmonids from construction of the north Delta intakes and differences in water elevation under the Plan compared to existing conditions because of water operations and habitat restoration. Construction of the north Delta diversions in the Sacramento River between Freeport and Walnut Grove would result in the permanent loss of nearly 4 miles of channel margin habitat; however, this habitat generally has low value for salmonids (no emergent vegetation, relatively steeply sloping banks, little overhead cover, and riprapped banks) (Appendix 5.H, Section H.6.1.4). The analysis of potential changes in inundation frequency for riparian and wetland benches because of changes in water elevation caused by operations of the north Delta diversions (CM1) and changes in tidal amplitude because of tidal habitat restoration (CM4) showed several main patterns (Appendix 5.C, Section C.5.4.2). Inundation frequency of lower-elevation wetland benches would be similar or greater under the Plan, whereas inundation of higher-elevation riparian benches generally would be somewhat less or similar under the Plan, although there is considerable variability. Channel margin enhancement under CM6 would allow consideration of potential changes in water elevation under the Plan in order to maximize the beneficial effects on juvenile salmonids and other species.

It is concluded that there is a low positive change to the channel margin stressor for juvenile salmonids (score = 1, certainty = 3). The low score mostly reflects the relatively limited spatial extent of CM6, but it is recognized that there may be relatively more benefit than the score suggests depending on the locations that are chosen for enhancement.

The potential food benefits of proposed tidal marsh (CM4), channel margin (CM6), floodplain (CM5), and riparian restoration (CM7) for salmonids and other species are analyzed in Appendix 5.E. Food is produced in restored habitat as phytoplankton and zooplankton, benthic and terrestrial insects, and through detritus produced by breakdown of aquatic and terrestrial vegetation. Its value to salmonids is determined by the amount of time that each salmonid life stage spends in the particular restoration area. Restored tidal marsh habitats will add complex channel networks that will provide benefits to juvenile salmon at both the primary and secondary food levels. Marsh plants will add POM to primary and secondary foodwebs, which has been shown to be important to juvenile salmon in the Columbia River Estuary (Maier and Simenstad 2009). Intertidal marshes also will contribute food resources from terrestrial components and the benthos to juvenile salmon. Channel margin habitat will increase the amount of shallow-water habitat along migration corridors, thus increasing the amount of foraging area in littoral habitats. Studies of littoral habitats in the Pacific Northwest have found that sub-yearling juvenile Chinook salmon feed primarily on amphipods (*Corophium* spp.), dipteran insects, and some zooplankton (*Daphnia* spp.), with a shift in diet from insects to amphipods and larval fish as juveniles increase in length and move toward the estuary mouth (McCabe et al. 1986 and Bottom and Jones 1990 as cited in Lott 2004).

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Increased inundation of floodplain habitat will create rearing habitat that will enhance the growth of juvenile salmon through the production of food resources (chironomids, zooplankton, and terrestrial insects), which has been shown to increase survival (Sommer 2001; Jeffres 2008). Riparian habitat, although not directly providing habitat, does provide important services and food resources that make their way into channel margins and floodplains, primarily when riparian areas are inundated with flooding flows. Riparian vegetation is a source for organic material (e.g., falling leaves), insect food, and woody debris. This debris is an important habitat and food source for fish and aquatic insects (Opperman 2005). Juvenile Chinook salmon rely predominantly on zooplankton and chironomids, with some amphipods derived from channel margin habitat and other littoral sources (Grimaldo et al. 2009). Salmonids also benefit from contributions of the riparian community to the aquatic foodweb, in the form of terrestrial insects and leaf litter that enter the water.

It is concluded that there would be a moderately high increase (score = 3) in food resources for foraging and migrant juvenile salmonids with moderately high certainty (score = 3).

Overall entrainment loss of juvenile salmonids under the Plan generally would be appreciably lower than under existing conditions because the north Delta diversion operations reduce reliance on south Delta export facilities. Reduced entrainment occurs in the majority of years under wetter conditions, whereas in dry and critical water years overall entrainment is increased relative to that under current conditions.

A major component of the BDCP conservation strategy is a switch from export pumping solely in the south Delta to dual conveyance, including both north and south Delta diversions. It is anticipated that this would maintain entrainment levels of juvenile salmonids at or below the levels seen in recent years with the implementation of the NMFS (2009) OCAP BiOp. Appreciable losses of juvenile salmonids have occurred historically at the south Delta export facilities, although relatively few estimates of the proportion of the population entrained have been made. Based on examination of data from tagged hatchery-origin smolts, Kimmerer (2008) estimated that losses of Chinook salmon may have been up to 10% at high rates of south Delta export pumping but noted considerable uncertainty in the estimates because prescreen losses due to predation and other factors are difficult to quantify. Nobriga and Cadrett (2001) used ratios of wild and hatchery-origin steelhead and known numbers of steelhead released from hatcheries to estimate that less than 0.1% to almost 1% of juvenile steelhead may have been salvaged at the south Delta export facilities in 1997–2000. Estimates of wild-origin winter-run Chinook salmon take at the south Delta export facilities as a percentage of the juveniles entering the Delta have ranged from less than 0.1% in 2007 to over 5% in 2001 (Llaban pers. comm.). The NMFS (2009) OCAP BiOp for listed salmonids and green sturgeon is similar to the USFWS (2008) OCAP BiOp for delta smelt in that it includes export pumping restrictions to limit entrainment during important juvenile migration months. For this effects analysis, it is assumed that the entrainment stressor under existing conditions for foraging and migrating juvenile salmonids is of moderately low importance (score = 2, certainty = 3).

The salvage-density method provided a relatively straightforward assessment of potential entrainment changes at the south Delta facilities as a result of changes in export pumping under the Plan (Appendix 5.B, Section B.3.4), albeit one that does not provide an estimate of the proportion of the population that is entrained. Based on modeled changes in pumping, entrainment of juvenile salmonids at the SWP/CVP south Delta export facilities would be lower under the Plan than under existing conditions. The salvage-density method suggested that in the late long-term, juvenile steelhead entrainment would decrease substantially overall (greater than 50% decrease across all water years), with decreases occurring mostly in wet (greater than 80%), above normal (around

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60%), and below normal years (greater than 50%); entrainment of juvenile steelhead in dry and critical years generally would be similar under the preliminary proposal to existing biological conditions (Table 5.5-18) (Appendix 5.B, Section B.4.1.1.1). This reflects a greater proportion of export pumping at the north Delta diversions in wetter years and relatively more export pumping at the south Delta diversions in drier years (Appendix 5.B, Section B.3.1). Winter-run Chinook salmon had modeled changes very similar to steelhead (Table 5.5-18) (Appendix 5.B, Section B.4.1.1.1) because of the assumed similar timing of migration through the Delta based on historical patterns of salvage (Appendix 5.B, Sections B.4.1.1.1 and B.4.2.1.1). Entrainment of juvenile spring-run Chinook salmon was estimated to be somewhat lower under the preliminary proposal than under existing biological conditions averaged across all water years (Table 5.5-18) (Appendix 5.B, Section B.4.1.3.1). The salvage-density method results for spring-run Chinook salmon suggested that substantial decreases in entrainment in wet years under the preliminary proposal (around 60%, but with larger numbers of fish) contrasted with appreciable increases in below normal (50–90%) and dry years (50–80%), albeit with lower numbers of fish estimated to be entrained in the latter year types. These results reflect relatively greater pumping during April–May at the south Delta export facilities (Appendix 5.B, Section B.2.2), which is the main period of entrainment (Appendix 5.B, Section B.4.1.3.1). The general similarity in emigration timing of juvenile fall-run Chinook salmon to spring-run Chinook salmon resulted in similar salvage-density results (Table 5.5-18) (Appendix 5.B, Section B.4.1.4.1): overall modestly reduced entrainment losses (less than 30%) under the Plan compared to existing biological conditions that was driven largely by substantial decreases in entrainment in wet years when more export pumping shifts to the north Delta intakes. As described in Appendix 5.B, there is difficulty in reliably assigning spring-run and fall-run Chinook salmon to race based on length because of the considerable overlap in emigration timing; the numbers of fish estimated to be entrained are likely to be overestimated for spring-run Chinook salmon (i.e., many of those fish in reality would have been fall-run Chinook), but the relative difference in entrainment between scenarios (existing and Plan) are assumed to be representative. The salvage-density method results for late fall–run Chinook salmon suggested decreased entrainment under the preliminary proposal by 30–40% across all water years relative to existing biological conditions, with this pattern again being driven largely by considerable decreases in wet years, but the differing seasonality of emigration meant that increases in entrainment under the Plan were not generally evident in any of the water-year types (Table 5.5-18) (Appendix 5.B, Section B.4.1.4.1).

The Delta Passage Model estimated the percentage of Chinook salmon smolts (greater than 70 mm fork length) salvaged at the south Delta export facilities (Appendix 5.B, Section B.3.7) expressed in relation to the overall percentage survival of smolts through the Delta. This analysis suggested that salvage as a percentage of through-Delta survival generally would decrease for all runs of Chinook salmon, with some variability in individual years (Table 5.5-19). In considering the results of the salvage-density method, which includes all sizes of juvenile salmonids observed historically at the south Delta salvage facilities and therefore may be more representative of rearing fish, and the Delta Passage Model, which considers only Chinook salmon smolts, it is concluded that there may be differences in changes to the south Delta entrainment stressor between different covered salmonids. For steelhead, it is concluded that there is a moderately high positive change (score = 3) with moderately low certainty (score = 2) based on the salvage-density method. For winter-run Chinook salmon, it is concluded that there is a moderately high positive change for rearing fish (score = 3, certainty = 2) based on the salvage-density method and a moderately low positive change for migrating fish (score = 2, certainty = 2) based on the Delta Passage Model. For spring-run Chinook salmon, it is concluded that there is a low positive change for rearing fish (score = 1, certainty = 2) based on the salvage-density method and a moderately low positive change for migrating fish (score

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= 2, certainty = 2) based on the Delta Passage Model. For late fall–run Chinook salmon, all individuals are assumed to be migrants, and so based on results of both the salvage-density method and the Delta Passage Model, it is concluded that there is a moderately low positive change (score = 2, certainty = 2). For fall-run Chinook salmon (populations not differentiated), it is concluded that there is a low positive change for rearing and migrating fish (score = 1, certainty = 2).

[***Note to Reader:*** *to illustrate the net effects approach, the above scores have been combined for all salmonids to give positive change of 2; ICF intends to update these scores as appropriate for the different runs once the differences in stressor importance for the runs has been established.*]

Table 5.5-18. Difference in Entrainment Loss of Juvenile Salmonids between Plan and Existing Conditions at the SWP/CVP South Delta Export Facilities in the Late Long-Term, as Estimated with the Salvage-Density Method

Water Year Type	Winter-Run Chinook Salmon	Spring-Run Chinook Salmon	Late Fall–Run Chinook Salmon	Fall Run Chinook Salmon	Steelhead
Wet	-10282 (-87%)	-59788 (-65%)	-3722 (-63%)	-89608 (-70%)	-5352 (-85%)
Above Normal	-5239 (-78%)	-737 (-2%)	-207 (-37%)	-5733 (-17%)	-9227 (-69%)
Below Normal	-3403 (-50%)	3651 (51%)	-11 (-20%)	953 (7%)	-5662 (-51%)
Dry	-262 (-8%)	8576 (49%)	7 (6%)	6345 (30%)	-108 (-2%)
Critical	-74 (-7%)	1094 (11%)	-31 (-20%)	-3280 (-9%)	139 (3%)
All Years	-4069 (-60%)	-5389 (-14%)	-692 (-37%)	-15044 (-27%)	-6381 (-58%)

Notes:
Negative Values indicate lower entrainment under the Plan compared to Existing biological conditions.
Values for Chinook salmon are based on normalized salvage density (Appendix 5.B, Section B.3.4.2).

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Table 5.5-19. Entrainment (% Salvage Divided by % Survival through the Delta, expressed in %) of Chinook Salmon Smolts at the SWP/CVP South Delta Export Facilities in the Late Long-Term, as Estimated with the Delta Passage Model

	Winter-Run		Spring-Run		Late Fall–Run		Sacramento River Fall-Run		San Joaquin River Fall-Run		Mokelumne River Fall-Run	
Water Year	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**
1975 (W)	0.8	0.6	0.4	0.1	0.7	0.7	0.2	0.2	5.5	4.3	1.0	2.4
1976 (C)	1.2	1.0	0.4	0.4	0.8	0.7	0.2	0.2	4.8	4.7	1.7	2.0
1977 (C)	0.2	0.2	0.2	0.2	0.5	0.3	0.2	0.2	3.4	3.1	0.9	0.8
1978 (AN)	0.1	0.1	0.4	0.0	0.6	0.3	0.3	0.1	4.2	1.6	4.7	2.0
1979 (BN)	0.8	0.7	0.8	0.2	1.3	0.6	0.3	0.5	5.2	5.2	1.0	3.6
1980 (AN)	0.3	0.3	0.3	0.1	1.2	0.4	0.2	0.3	3.7	3.6	1.2	2.5
1981 (D)	0.7	0.5	0.3	0.3	0.8	0.6	0.2	0.3	4.1	5.0	1.0	1.9
1982 (W)	0.2	0.0	0.3	0.0	0.5	0.4	0.4	0.1	4.5	1.0	10.4	0.9
1983 (W)	0.4	0.0	0.1	0.0	1.1	0.4	0.2	0.0	3.0	0.8	4.6	0.5
1984 (W)	0.3	0.0	0.7	0.1	0.5	0.1	0.3	0.3	5.3	4.1	1.9	3.5
1985 (D)	1.1	1.3	0.3	0.3	0.8	1.2	0.2	0.2	4.3	4.6	1.4	2.0
1986 (W)	0.3	0.5	1.2	0.1	0.9	0.7	0.6	0.3	6.7	3.2	1.8	1.7
1987 (D)	0.7	0.5	0.2	0.2	0.5	0.7	0.1	0.2	4.0	5.2	1.2	2.6
1988 (C)	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	3.9	3.5	2.0	2.1
1989 (D)	0.3	0.2	0.1	0.1	0.6	0.4	0.1	0.1	4.3	3.3	0.8	0.5
1990 (C)	0.3	0.3	0.2	0.2	0.7	0.4	0.2	0.2	3.6	3.6	1.1	1.3
1991 (C)	0.2	0.1	0.1	0.2	0.4	0.3	0.2	0.3	4.2	4.7	1.7	2.5
Average	0.5	0.4	0.4	0.2	0.7	0.5	0.3	0.2	4.4	3.6	2.3	1.9

[***Note to reader:*** *the expression of Delta Passage Model salvage percentage as a percentage of overall through-Delta survival percentage was made in response to agency comment on the draft Appendix 5.B Entrainment; all such updates will be included in the revised Appendix 5.B.*]

As noted by Vogel (2011:93–94), there does not appear to be much evidence of agricultural diversions having an appreciable adverse effect on covered salmonids in the Plan Area. Only two Chinook salmon were collected during agricultural diversion sampling over several days in 1993–1995 by Cook and Buffaloe (1998). Although agricultural diversions are numerous, their main period of use (summer) (Appendix 5.B, Section B.3) generally has low overlap with the occurrence of covered salmonids. For this effects analysis it is assumed that entrainment at agricultural diversions is a stressor with low importance for foraging and migrating juvenile salmonids (score = 1), with moderately low certainty (score = 2). Decommissioning of agricultural diversions in lands restored as tidal habitat under CM4 would reduce the number of unscreened diversions in the Plan Area (Appendix 5.B, Section B.4.4.3.1). Because there is little evidence that entrainment at agricultural diversions is a major issue for juvenile salmonids, it is concluded that this represents a small positive change (scores = 1) for all salmonid species, with low certainty (score = 1), reflecting the lack of study of the issue. Changes to the NBA Barker Slough pumping plant and its proposed alternative intake on the Sacramento River are concluded to represent no change to this stressor for

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salmonids because the intake is currently screened and would remain so in the future, at both locations.

The Plan would change the configuration and operation of Fremont Weir and the Yolo Bypass and restore a considerable extent of south Delta floodplain, which would increase floodplain availability and usage and improve conditions for juvenile and adult salmonids.

Loss of access to floodplain habitat in the Plan Area because of levee construction is a major stressor to juvenile salmonids (Williams 2009). The benefits of the Yolo Bypass to improved growth of juvenile salmonids are well-documented (Sommer et al. 2001).

For this effects analysis, it considered that floodplain habitat availability is a stressor of high importance for foraging salmonids (score = 4, certainty = 3) and a stressor of moderately low importance (score = 2, certainty = 2) for migrating individuals because there may be some benefit from floodplains as an alternative migration pathway.

The Plan considerably increases the inundated area in the Yolo Bypass, which is expected to increase food production and shallow-water, low-velocity rearing area for juvenile salmonids during winter and early spring (Figure 5.5-3). The increase in area occurs primarily in wetter water years with small increases in dry and critical years. There is a small risk of juvenile salmonid stranding as a result of increased Yolo Bypass inundation, although the DRERIP (2009) evaluation of Yolo Bypass operations under the Plan assessed the benefits of increased inundation to considerably outweigh this potential effect (Appendix 5.C, Section C.5.4.1.2).

Survival through the Delta for smolt-sized Chinook salmon, including entry into the Yolo Bypass, was assessed with the Delta Passage Model (Appendix 5.C, Section C.5.3.1.3). For the modeling, the Yolo Bypass migration route was assumed to have relatively high survival (80%), although there is a lack of information for smolt-sized fish that will be addressed by future analysis. Use of the Yolo Bypass route through the Delta reduces the risk of entering the relatively low-survival interior Delta through Georgiana Slough or the DCC. The proportion of smolts entering the Yolo Bypass in the late long-term was greatest for winter-run Chinook salmon (almost 9.5% under the Plan versus around 7% for existing conditions), followed by spring-run (6% versus 4%); the proportions of fall-run and late fall–run Chinook salmon entering the bypass were low under the Plan and existing conditions. It is possible that the Delta Passage Model may be underestimating the number of fish entering the Bypass because it assumes a fixed migration period and does not reflect potential benefits of entry below 4,000 cfs. The relatively good survival assumed through the Yolo Bypass is based on studies conducted on fish smaller than smolts, and the assumption will require refinement in the future based, for example, on monitoring studies of acoustically tagged smolts in the Yolo Bypass. Under CM5, considerable acreage of floodplain habitat would be restored in the south Delta subregion, which would benefit salmonids emigrating from the San Joaquin River watershed. Based on these considerations, the benefits of the Plan for floodplain habitats was rated a moderately high positive change (Score = 3) for both foraging and migrating juvenile salmonids with a moderately low certainty (Score = 2).

[***Note to Reviewers:*** *Results of the revised Delta Passage Model runs will be included in the forthcoming revised Appendix 5.C,* Flows, Passage, Salinity, and Turbidity. *ICF is continuing to develop a tool to assess the potential benefits of increased Yolo Bypass flooding for rearing juvenile Chinook salmon, which will further inform conclusions about the benefits of increased Yolo Bypass inundation.*]

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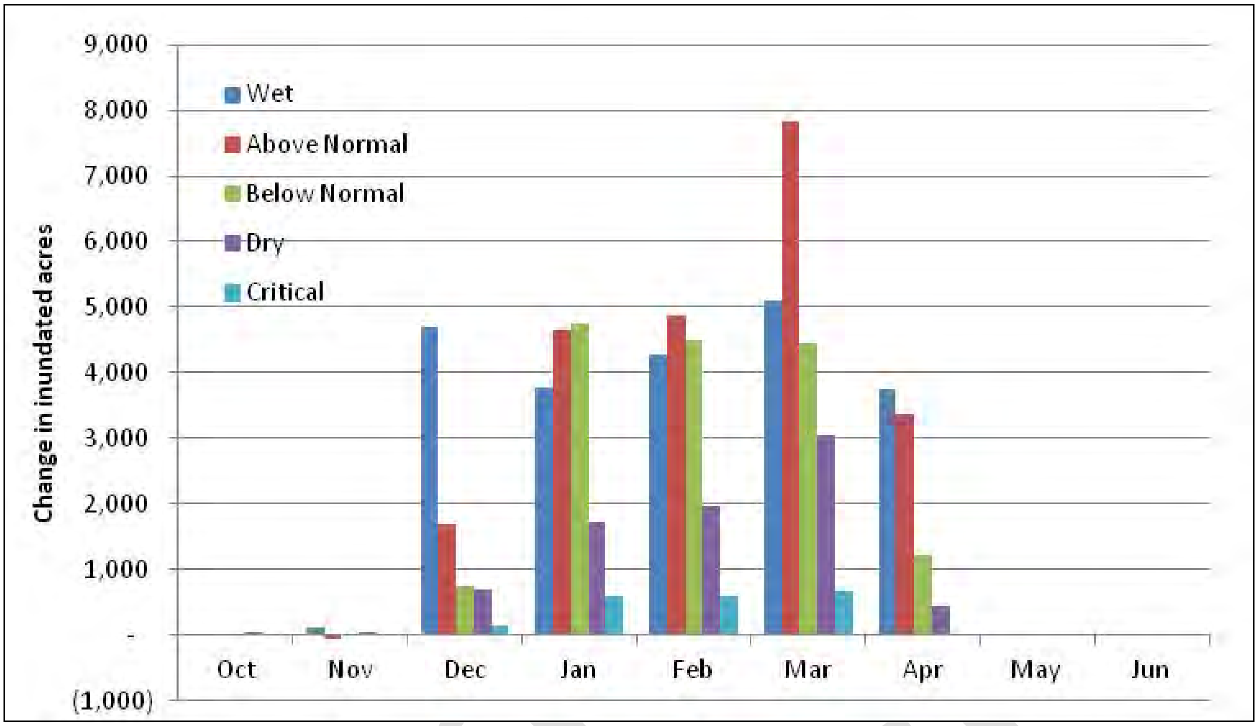

Figure 5.5-3. Average Change in Inundated Acres (0–6.5 Feet) in the Yolo Bypass under Existing and Plan Conditions in the Late Long-Term, by Water-Year Type

Adult salmonids entering the Yolo Bypass can become trapped at the Fremont Weir and face mortality or considerable delay (Williams 2006:116; Harrell and Sommer 2003:94).

Adults entering the downstream end of the Yolo Bypass migrate upstream a considerable way before encountering the Fremont Weir. The weir presently has limited adult fish passage, and fish can be trapped or must migrate back downstream and reenter the Sacramento River to continue their upstream migration. The impediment to upstream migration can be quite severe but only affects those fish entering the Yolo Bypass. Based on these considerations, the stressor of passage barriers was rated moderately high (score = 3) with a high degree of certainty (score = 4).

The suite of actions proposed to improve adult fish passage as part of *CM2 Yolo Bypass Fisheries Enhancement* would benefit Sacramento River basin adult salmonids by reducing stranding and delay in the Yolo Bypass (Appendix 5.C, Section C.5.3.1.7). The efficacy of the passage improvements at the Fremont Weir and other locations in the Yolo Bypass (e.g., Lisbon Weir) cannot be estimated, but will be monitored, and adjustments will be made through adaptive management. Resulting improvements in migration may vary by year type as a result of differing inundation frequencies and volumes. The DRERIP (2009) evaluation of improved passage at Fremont Weir suggested that the benefits of increased passage would greatly outweigh potential risks (e.g., increased stranding as a result of increased attraction in the bypass). Accordingly, it is concluded for this effects analysis that this action represents a moderately high positive change to Delta passage (score = 3) for adult salmonids as a result of the Plan, with moderately high certainty (score = 3).

Nonphysical fish barriers (CM16) have the potential to inhibit juvenile salmonids from entering the interior Delta, therefore potentially increasing through-Delta survival.

The stressor of alternative channels refers to potential entry into the interior Delta by juvenile salmonids through channels such as Georgiana Slough, the DCC, and Old River. Fish can be drawn into these routes by flow, in which case, they enter the interior Delta where survival generally has been shown to be lower than when remaining on the river mainstems (Perry et al. 2010; Brandes and McLain 2010). The importance of alternative channels into the interior Delta and the need to discourage their use by juvenile salmonids was recognized in the NMFS (2009) OCAP BiOp, which requires that engineering solutions be investigated to lessen the issue. Such engineering solutions may include physical or nonphysical barriers. For this effects analysis it is assumed that the stressor of alternative channels has moderately high importance (score = 3, certainty = 3) for foraging and migrating juvenile salmonids.

Under CM16, juvenile Chinook salmon and steelhead have the potential to benefit from nonphysical barriers at important channel divergences leading to the interior Delta such as Sacramento River–Georgiana Slough and San Joaquin River–Old River because they have moderately good hearing abilities and are likely to respond to the main barrier stimulus (the acoustic signal, which is augmented by strobe lights and enclosed within a bubble curtain) and good swimming abilities (Appendix 5.C, Section C.5.3.1.4). As such, these barriers could be an effective tool for precluding juvenile salmonids from entering the interior Delta, where mortality may be higher than in the main channels of the Sacramento and San Joaquin Rivers. The results of the Delta Passage Model suggested that survival through the Delta could be increased by around 2–4% if the barriers had a high 80% deterrence such as observed at the head of Old River in 2009's pilot study (Bowen et al. 2009). The effectiveness of nonphysical barriers will depend on the water velocity characteristics in the vicinity of the barrier and on the extent to which predatory fish may congregate along the barrier and prey on juvenile salmonids. Given the modest potential for increased survival, the experimental nature of this conservation measure, and the need for considerable associated research and monitoring, it is concluded that there would be a low positive change (score = 1) in the alternative channels stressor for juvenile salmonids, with low certainty (score = 1).

Should upstream migrating adult salmonids migrate up Georgiana Slough or Old River during a nonphysical barrier deployment period, there may be potential for impedance or migration delay. The ability to swim under the barriers would depend on how deep the water column is; deeper areas require the nonphysical barrier to be higher up in the water column so that the integrity of the bubble curtain is maintained. Such areas would have greater potential for adult salmonids to swim beneath the bubble curtain than shallower areas, where the bubble curtain may be near the substrate. Monitoring, research, and adaptive management of the conservation measure will assess the risk to adult salmonids from delay at nonphysical barriers.

The Plan has the potential to reduce predation on juvenile salmonids, with considerable uncertainty to be addressed with monitoring and adaptive management

NMFS (2009) ranked predation as a stressor of high importance to the decline of Central Valley Chinook salmon and steelhead. Vogel (2011) reported results from radio-tagging studies that indicated high levels of predation on salmonids at numerous hot spots such as sharp channel bends, deep scour holes, narrow levee breaches, diversion pump structures, and other artificial structures such as bridges, docks, pipelines, and more natural structural elements like downed trees. For the purposes of this effects analysis, predation of juvenile salmonids in the Delta was scored moderately high (score 3, certainty = 3).

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Several different conservation measures have the potential to influence predation of juvenile salmonids under the Plan (Appendix 5.F, Section F.5.3.1). *CM1 Water Facilities and Operation* has potential beneficial effects (reduction of predation associated with entrainment at the south Delta export facilities; see entrainment discussion above) and adverse effects (reduced flows below the north Delta diversions, leading to increased predation risk during migration; concentrations of predators at the north Delta diversions). A bioenergetics model (Appendix 5.F, Section F.3.2.1) was used to estimate the percentage of migrating Chinook salmon juveniles entering the Plan Area that might be consumed by striped bass occurring in the vicinity of the north Delta diversions. This analysis suggested that considerably less than 1% of Chinook salmon juveniles potentially would be preyed upon, although there is appreciable uncertainty in the parameters used in the model. The uncertainty associated with these estimates would be addressed with targeted research and adaptive management during implementation of the Plan. *CM2 Yolo Bypass Fisheries Enhancement* provides greater access to the Yolo Bypass migration route and therefore may result in reduced predation relative to the Sacramento River route, where predation is relatively high (see discussion above for Yolo Bypass entry). Implementation of habitat restoration measures (CM4–CM6) in association with IAV removal (CM13) has considerable potential to increase the amount of shallow-water habitat available for salmonid rearing while minimizing the amount of habitat for predatory fish. Care must be taken when designing levee breaches at restoration sites to avoid creation of locations where predators may congregate and exploit tidal fluxes of prey, including juvenile salmonids (Vogel 2011:120). Decommissioning of water diversion structures in ROAs also would decrease predatory fish habitat (Vogel 2011:116). Predator control (CM15) would identify and target predation hot spots for predatory fish capture or alteration of habitat to enhance juvenile salmonid survival. There are few Plan Area studies for which predator control effectiveness can be predicted and there is considerable uncertainty around this measure (Appendix 5.F, Section F.5.3.1.4). Results from a recent predator study on the lower Mokelumne River suggested that positive changes to juvenile salmonid survival could be achieved but that success would depend on a sustained effort (Cavallo et al. in press), as is proposed under the Plan. The effectiveness of Plan predation reduction efforts would be assessed with targeted research and monitoring. Nonphysical fish barriers (CM16) are intended to benefit juvenile salmonids by altering migration routes to avoid the relatively low-survival interior Delta (see above). Although uncertain, there may be adverse effects from predatory fish aggregating along the barrier structure and preying on juvenile salmonids, a phenomenon that would be addressed with targeted research and adaptive management.

It is concluded that there would be a low positive change to predation (score = 1) for rearing and migrating juvenile salmonids under the Plan, but with low certainty (score = 1) for the aforementioned reasons.

The Plan would help reduce illegal harvest of adult salmonids.

Illegal harvest reduction (CM17) under the Plan would decrease poaching of covered salmonids. The Plan will provide funding over its term to increase the enforcement of fishing regulations in the Plan Area and upstream tributaries in order to reduce illegal harvest of covered salmonids. Funds will be provided to hire and equip 17 additional game wardens and five supervisory and administrative staff in support of the existing field wardens assigned to the Delta-Bay Enhanced Enforcement Project (DBEEP) over the term of the Plan; this represents nearly a tripling of the existing 10-warden squad. It is hypothesized that enhanced enforcement on poaching would reduce mortality, and potentially increase population sizes, of Chinook salmon (all races) (Bay-Delta Oversight Council

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1995; Williams 2006) and steelhead (California Department of Fish and Game 2007b, 2007c, 2008d; Moyle et al. 2008). In the mainstem Sacramento River, the existing effects of poaching are hypothesized to be already low as the majority of fishing activities occur by boat, with access largely limited to a relatively small number of boat launching facilities spread over a large distance of river (Vogel 2011). Recreational boating is popular throughout the Sacramento River, so poaching during daylight would be highly visible to the public and expected to have only a small effect on salmonids. Nighttime poaching undoubtedly occurs, and increased enforcement could reduce its effect on overall fish mortality. Spring-run Chinook salmon may experience the greatest benefit, for they are more susceptible to poaching than other runs because of oversummer holding in tributaries such as Butte Creek, where holding adults are relatively easy to locate by poachers. The magnitude of benefits of this measure is expected to vary inversely with the population size of each covered species (Bay-Delta Oversight Council 1995; Begon et al. 1996; Futuyma 1998; Moyle et al. 2008). It is concluded that there would be a low positive change (score = 1) to the harvest stressor for adult salmonids, with low certainty (score = 1) because little is known of the current extent of illegal harvest.

5.5.3.2.2 Adverse Effects

Operation of the proposed north Delta diversions under the Plan has the potential to adversely affect juvenile salmonid survival through contact with the screens, predation, and reduced downstream flows.

As described above under Stressor Rankings, flow is an important stressor affecting salmonid juveniles and adults. Juvenile salmonids migrating down the Sacramento River may encounter the five intakes proposed for construction and operation under the Plan. The expectation is that no juvenile salmonids would be impinged on these intakes because fish would be large enough (greater than 30 mm standard length) (Appendix 5.B, Section B.4.2.1.1) to be excluded from entrainment by the proposed screen mesh of 1.75 mm, which would be expected to exclude fish with a typical salmonid body size of below 15 mm (Turnpenny 1981; Margraf et al. 1985). For individuals physically contacting the screens, there may be some potential for impingement-related injury and mortality, although these effects were not related to any measured criterion such as screen contact rate in laboratory studies by Swanson et al. (2004). It is uncertain the extent to which the relatively benign environment of the laboratory studies can inform a field-based situation. As noted for other species, approach and sweeping velocity criteria for the north Delta intake screens have not been finalized, but approach velocity would be less than 0.33 fps (the criterion for salmonid fry) and may be limited to 0.2 fps (the existing criterion for juvenile delta smelt). It is concluded that there would be a low adverse effect on juvenile salmonids (score = -1) as a result of contact and impingement with the north Delta diversions, with moderately low certainty (score = 2). This score does not include consideration of potential predation near the intakes, discussed further below. Monitoring of impingement and targeted studies of juvenile salmonid behavior in relation to the intake screens would further inform the effect of this stressor following implementation. It is not anticipated that there would be any adverse effects of the north Delta diversions on adult salmonids with respect to impingement.

[***Note to reader:*** *ICF intends to incorporate detailed methods and results for the north Delta intakes entrainment and impingement analysis in Appendix 5.B,* Entrainment*, for the public draft. Additional modeling of potential hydraulic characteristics by DWR is being undertaken and may further inform this analysis.*]

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Salmonids migrating down the Sacramento River past Rio Vista generally would experience lower migration flows through the Delta because of the north Delta diversions compared to existing conditions. It is important to emphasize that CM1 includes bypass flow criteria that would be managed in real time to minimize adverse effects of diversions at the north Delta intakes on downstream-migrating salmonids. Juvenile salmonids migrating down the Sacramento River often do so in pulses that are triggered by increases in flows. For example, it has been observed that pulses of winter-run Chinook salmon juveniles are caught in large numbers at Knights Landing (just upstream of the Plan Area) rotary screw traps when flows on the Sacramento River at Wilkins Slough increase to more than 400 cubic meters per second (around 14,000 cfs) (Del Rosario et al. in press). CM1 would account for such changes in flows and the associated pulses of fish by monitoring fish presence at locations such as Knights Landing and adjusting to low-level pumping as necessary. Low-level pumping consists of total north Delta diversions of up to 6% of river flow for flows greater than 5,000 cfs and not more than 300 cfs at any intake. Following the initial pulse flows, schedules of post-pulse flows would be applied depending on flows in the river at the time.

There was considerable variability in migration flows simulated from CALSIM-II between different water-year types and months during the juvenile salmonid winter-spring downstream migration periods. The difference between the Plan and existing conditions averaged across all water years in the late long-term main October–June juvenile salmonid migration period ranging from nearly 40% less flow (November) to 25% more (October) (Table 5.5-20). During January–May, the main period of juvenile migration and rearing, the Plan had average flows around 10–20% less at Rio Vista (Table 5.5-20).The results of the Delta Passage Model suggested that through-Delta survival of Chinook salmon smolts was similar under the Plan compared to existing biological conditions (Table 5.5-21) (Appendix 5.C, Section C.5.3.1.3). The observed patterns represented tradeoffs between positive and negative changes from the Plan relative to the existing biological conditions, e.g., the positive effect of greater Yolo Bypass passage versus the negative effect of lesser flows on the Sacramento River. Salmonids entering the Plan Area from the San Joaquin River would experience little difference in migration flows, as estimated from flows at Vernalis (Table 5.5-21). It is concluded that there is a low negative change (score = -1) to flows through the Delta for foraging and migrating salmonids, although without specific relationships between survival and flow, this conclusion has moderately low certainty (score = 2).

Potential predation effects at the North Delta diversions could occur if predatory fish aggregated along the screens as has been observed at other long screens in the Central Valley (Vogel 2008). Such effects were discussed above in the context of the overall potential reduced for predation under the Plan because of the conservation strategy.

[***Note to reader:*** *ICF is reviewing how best to assess through-Delta survival for salmonids not addressed by the Delta Passage model, i.e., steelhead and non-smolt Chinook salmon*.]

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Table 5.5-20. Average Monthly Flows (Cubic Feet per Second) by Water-Year Type for Sacramento River at Rio Vista Estimated from CALSIM II, Late Long-Term

Month	Water-Year Type	Existing	Plan	Difference
Jan	W	78,551	72,415	-6136 (-7.8%)
	AN	42,919	37,439	-5480 (-12.8%)
	BN	19,991	18,693	-1298 (-6.5%)
	D	14,927	14,703	-224 (-1.5%)
	C	12,601	10,822	-1780 (-14.1%)
	AVG	39,721	36,443	-3279 (-8.3%)
Feb	W	89,989	83,061	-6928 (-7.7%)
	AN	55,363	50,658	-4705 (-8.5%)
	BN	29,442	25,747	-3696 (-12.6%)
	D	19,422	17,247	-2175 (-11.2%)
	C	11,956	11,812	-143 (-1.2%)
	AVG	47,675	43,660	-4015 (-8.4%)
Mar	W	68,663	61,586	-7077 (-10.3%)
	AN	48,513	41,050	-7463 (-15.4%)
	BN	19,562	15,626	-3936 (-20.1%)
	D	17,679	14,726	-2953 (-16.7%)
	C	10,684	9,981	-703 (-6.6%)
	AVG	37,655	32,895	-4759 (-12.6%)
Apr	W	38,422	32,024	-6398 (-16.7%)
	AN	21,855	16,986	-4868 (-22.3%)
	BN	14,207	12,777	-1430 (-10.1%)
	D	10,299	10,550	252 (2.4%)
	C	7,816	7,883	67 (0.9%)
	AVG	21,211	18,291	-2920 (-13.8%)
May	W	20,046	14,306	-5739 (-28.6%)
	AN	14,948	11,801	-3147 (-21.1%)
	BN	9,355	9,443	88 (0.9%)
	D	8,564	9,032	468 (5.5%)
	C	5,554	5,350	-204 (-3.7%)
	AVG	12,833	10,641	-2192 (-17.1%)
Jun	W	11,418	8,002	-3416 (-29.9%)
	AN	9,220	7,583	-1637 (-17.8%)
	BN	7,241	6,703	-538 (-7.4%)
	D	6,335	5,820	-516 (-8.1%)
	C	4,513	4,020	-493 (-10.9%)
	AVG	8,257	6,657	-1600 (-19.4%)

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Month	Water-Year Type	Existing	Plan	Difference
Jul	W	12,181	7,996	-4185 (-34.4%)
	AN	12,927	8,132	-4795 (-37.1%)
	BN	11,357	6,831	-4526 (-39.8%)
	D	10,307	5,916	-4391 (-42.6%)
	C	6,596	4,453	-2143 (-32.5%)
	AVG	10,921	6,842	-4079 (-37.4%)
Aug	W	8,650	3,826	-4824 (-55.8%)
	AN	9,648	5,174	-4474 (-46.4%)
	BN	8,753	4,224	-4529 (-51.7%)
	D	7,417	4,505	-2912 (-39.3%)
	C	3,615	3,157	-458 (-12.7%)
	AVG	7,806	4,142	-3664 (-46.9%)
Sep	W	21,199	3,165	-18034 (-85.1%)
	AN	12,832	3,359	-9473 (-73.8%)
	BN	6,197	3,158	-3039 (-49%)
	D	3,644	3,477	-167 (-4.6%)
	C	2,996	3,630	634 (21.1%)
	AVG	10,896	3,329	-7567 (-69.5%)
Oct	W	8,287	8,615	328 (4%)
	AN	7,207	8,846	1639 (22.7%)
	BN	6,976	9,224	2248 (32.2%)
	D	5,727	7,496	1769 (30.9%)
	C	4,969	9,015	4046 (81.4%)
	AVG	6,858	8,566	1708 (24.9%)
Nov	W	15,879	10,636	-5243 (-33%)
	AN	12,156	6,298	-5858 (-48.2%)
	BN	9,071	4,870	-4200 (-46.3%)
	D	8,061	5,178	-2883 (-35.8%)
	C	5,565	4,346	-1219 (-21.9%)
	AVG	10,946	6,898	-4048 (-37%)
Dec	W	40,431	38,576	-1855 (-4.6%)
	AN	19,936	19,338	-598 (-3%)
	BN	14,049	13,609	-440 (-3.1%)
	D	11,687	11,385	-302 (-2.6%)
	C	7,186	7,752	566 (7.9%)
	AVG	21,753	21,019	-734 (-3.4%)

Note: Negative differences indicate lower values under the Plan. Existing includes Fall X2 flow requirements for USFWS (2008) OCAP BiOp.

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Table 5.5-21. Through-Delta Survival Estimates for Chinook Salmon Smolts in the Late Long-Term, as Estimated with the Delta Passage Model

	Winter-Run		Spring-Run		Late Fall–Run		Sacramento River Fall-Run		San Joaquin River Fall-Run		Mokelumne River Fall-Run	
Water Year	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**	**Existing**	**Plan**
1975 (W)	18.7	18.5	24.0	21.1	16.2	13.1	23.7	17.3	14.2	14.2	14.5	10.7
1976 (C)	12.9	12.9	13.2	13.3	12.8	14.0	13.8	14.0	12.8	13.6	7.1	6.9
1977 (C)	15.8	13.9	12.5	12.4	11.4	11.4	12.1	12.3	12.6	13.3	10.6	11.3
1978 (AN)	33.9	32.2	25.5	22.7	13.7	13.6	17.4	15.9	16.1	16.2	4.8	5.8
1979 (BN)	18.5	17.6	14.8	14.4	13.0	14.2	15.2	13.9	14.1	14.0	13.6	10.7
1980 (AN)	32.5	34.1	18.5	18.4	13.3	14.4	14.9	13.9	14.2	14.1	11.6	9.7
1981 (D)	20.8	20.7	15.9	15.7	14.6	14.6	14.3	14.5	13.8	14.2	13.5	11.6
1982 (W)	36.5	38.1	36.0	36.9	21.7	20.4	23.7	21.4	18.6	18.7	6.8	9.0
1983 (W)	38.6	40.8	33.6	35.8	23.0	21.9	27.3	26.6	19.6	19.7	11.2	15.6
1984 (W)	30.9	30.7	17.8	17.8	25.6	24.9	13.7	13.3	14.4	14.3	7.8	7.0
1985 (D)	16.7	16.1	16.5	16.7	17.1	15.5	16.3	16.5	13.7	14.1	8.5	7.8
1986 (W)	27.9	27.7	18.3	18.6	13.7	15.0	14.5	14.6	14.7	14.7	13.5	12.9
1987 (D)	17.6	16.9	15.6	16.3	12.9	11.6	15.3	15.1	12.4	12.9	8.4	7.3
1988 (C)	20.4	19.6	11.7	11.7	14.6	15.0	10.2	10.2	12.7	13.5	6.1	5.9
1989 (D)	16.3	16.8	22.0	21.6	13.0	13.2	18.2	18.6	11.7	12.6	13.3	14.4
1990 (C)	16.1	15.7	15.7	15.7	12.4	13.8	14.7	14.4	12.9	13.5	9.2	8.8
1991 (C)	15.1	15.2	15.3	14.3	11.0	11.6	10.7	10.4	11.6	12.2	6.3	6.0
Average	22.9	22.8	19.2	19.0	15.3	15.2	16.2	15.5	14.1	14.5	9.8	9.5

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Sacramento River attraction flows for migrating adult salmonids would be lower from operations of the north Delta diversions under the Plan.

Sacramento River flows downstream of the proposed north Delta intakes generally would be lower under Plan operations relative to existing conditions, with differences between water-year types because of differences in the relative proportion of water being exported from the north Delta and south Delta facilities. As assessed by DSM2 fingerprinting analysis, the average percentage of Sacramento River–origin water at Collinsville, where the Sacramento and San Joaquin Rivers converge in the West Delta subregion, was always slightly lower under the Plan than for existing conditions (Appendix 5.C, Section C.5.3.1.8). In the late long-term, the average percentage of Sacramento River water was 3% less under the Plan for steelhead than under existing conditions (64% compared to 67%) (Appendix 5.C, Table C.5.3-107), 4% less for winter-run and late fall–run Chinook salmon (67% compared to 71%) (Appendix 5.C, Tables C.5.3-109 and C.5.3-114), 6% less for spring-run Chinook salmon (64% compared to 70%) (Appendix 5.C, Table C.5.3-109), and 8% less for fall-run Chinook salmon (59% compared to 67%) (Appendix 5.C, Table C.5.3-112). The effects of flow reduction in the lower reach of the Sacramento River on the attraction and upstream migration of adult salmonids are uncertain. Flows in the lower Sacramento River are influenced by tidal hydrodynamics, which may also affect adult attraction and migration. Olfactory cues have been shown to be important in guiding adult salmonids to upstream spawning habitat (Hasler and Scholz 1983; Quinn 2005). For example, adult sockeye salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). This may indicate that differences estimated for salmonids covered under the Plan would not be of considerable importance, although this is uncertain.

Adult salmonid attraction/migration flows at the upper part of the West Delta subregion (Sacramento River at Rio Vista) were lower under the Plan than flows under existing conditions with varying differences by water-year type. The general pattern was for lower flows in wetter water years and similar or slightly greater flows in drier years. The relative difference in December–February average flows between scenarios generally was 5–8% less under the Plan in all except critical water years (which were little different) for winter-run and late fall–run Chinook salmon (Appendix 5.C, Section C.5.3.1.8). For spring-run Chinook salmon adults, the difference in April–May flows was more than 20% less in wet and above normal years and similar in other water-year types. Steelhead and fall-run Chinook salmon have upstream migration periods that include the fall months, and there are periods of considerably lower migration flows (particularly during September) in wet and above normal water years as a result of the inclusion of the USFWS (2008) OCAP BiOp Fall X2 requirement for delta smelt under existing conditions. September is assumed to be the beginning of the steelhead migration period that lasts for several months until March, whereas for fall-run Chinook salmon it was assumed that September and October were the primary months; October flows on average are higher under the Plan. The differences between the Plan and existing conditions are lower when compared to the baseline that does not include the Fall X2 requirement (EBC1). In considering the results of the DSM2 fingerprinting results and the CALSIM flow analyses, it is concluded with moderately low certainty (score = 2) that there would be no negative change (score = 0) of lower Sacramento River flows under the Plan for upstream migrating adult winter-run and late fall–run Chinook salmon; a low negative change for spring-run Chinook salmon and steelhead (scores = -1); and a moderately low (score = -2) negative change on fall-run Chinook salmon. The low certainty in these conclusions would be informed by monitoring and targeted research under the Plan (e.g., examining migration success of tagged adult Chinook salmon under different flow regimes), with any adverse effects being addressed by adaptive management.

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[***Note to Reader:*** *because this admin draft effects analysis is not separating out different species of salmonids, the scores above for adult salmonids have been generalized to give a change score for all adult salmonids of -1 with certainty of 2 in the net effects table; future analyses will likely provide separate conclusion by salmon run and species*.]

Attraction flows in the West Delta subregion near the confluence of the Sacramento and San Joaquin Rivers for adult upstream migrating salmonids from the Sacramento River generally were modeled to be lower under the Plan than under existing conditions because of the implementation of dual conveyance and the associated north Delta diversions. Reduced exports in the south Delta under the Plan generally would increase the proportion of water in the West Delta subregion originating from the San Joaquin River (Appendix 5.C, Section C.5.3.1.8; steelhead, Table C.5.3-108; spring-run Chinook salmon, Table C.5.3-111; fall-run Chinook salmon, Table C.5.3-113). The potential change in olfactory cues (expressed as percentage of water at Collinsville made up by the San Joaquin River as estimated from DSM2 fingerprinting analysis) generally was several times greater under the Plan than under existing conditions for steelhead, and fall-run and spring-run Chinook salmon (spring-run Chinook salmon were analyzed to account for the intended reintroduction of the race to the San Joaquin River as a result of the San Joaquin River Restoration Program). However, the San Joaquin River contribution to percentage of water at the confluence was still low (less than 10%), so it is concluded that this does not represent a significant change in olfactory cues.

In-water construction and maintenance effects of the Plan could affect salmonids but would be minimized with careful management.

As described for other species, in-water construction activities at the proposed north Delta intakes (CM1) would be limited to one construction season during the months of June–October (Appendix 5.H). The construction area is directly on the main migration route for Sacramento River salmonids (winter-run, spring-run, fall-run, and late fall–run Chinook salmon; and steelhead). The seasonality of construction is intended to minimize adverse effects, although there remains potential for some salmonids to enter the area during construction (Appendix 5.H, Section H.6.1). These include late migrants of adult spring-run Chinook salmon and juvenile fall-run Chinook salmon, and early migrants of steelhead as well as juvenile late fall–run Chinook salmon. Construction in September and October would overlap much of the main adult fall-run Chinook salmon migration period. Any salmonids present may experience adverse effects from underwater sound (pile driving), entrapment within enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment, suspension of toxic materials), and accidental spills. Habitat would be temporarily and permanently affected by intake construction, although habitat at the intake sites is generally of somewhat low quality (steep-sloping, revetted banks with no emergent vegetation and little overhead cover). Maintenance dredging also may decrease water quality temporarily. Habitat restoration activities associated with CM4–CM7 may contribute to reduced water quality. Breaching of levees to create tidal habitat may reduce areas of channel margin, but there would be considerable gains of habitat caused by the breaching. In-water activities associated with other *CM14 Stockton Deepwater Ship Channel Dissolved Oxygen Levels, CM15 Predator Control, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* would have little to no effect on salmonids because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* would reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on juvenile and adult salmonids. It is concluded that construction and maintenance associated with the Plan represent a minor adverse effect on salmonid juveniles and adults with high certainty.

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The Plan would contribute to a reduction in salmonid exposure to contaminants in the late long-term, although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration.

The Plan could adversely affect salmonid life stages occurring in the Plan Area through changes in contaminants as a result of changes in water operations (CM1, CM2) and habitat restoration (principally, CM4). Analyses presented in Appendix 5.D, *Contaminants*, suggested that there was low potential for increased contaminant exposure from the Plan, and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded that this represents a low negative change to this stressor for juvenile and adult salmonids in the Plan Area (scores = -1), with low certainty (score = 1).

5.5.3.3 BDCP Effects on Stressors—Riverine Stressors

As described below under the Net Effects discussion, changes to salmonid riverine stressors upstream of the Plan Area generally were not assessed to occur. There were two exceptions that are described below.

[***Note to Reader:*** *For the present net effects analysis, the two scores below are not included in the net effects write-up. This will be revisited for the public draft net effects analysis.*]

5.5.3.3.1 Beneficial Effects

Juvenile salmonid migration flows in the Feather and American Rivers generally would be greater under the Plan than under existing conditions.

CALSIM flow modeling suggested that there may be relatively more flow (up to around 30% more) under the Plan than under existing conditions for juvenile steelhead, spring-run Chinook salmon, and fall-run Chinook salmon in the Feather River (Appendix 5.C, Section C.5.3.1.8). It is concluded that these differences represent small positive changes to steelhead, spring-run Chinook salmon, and fall-run Chinook salmon (scores = 1) but with low certainty (score = 1) because the relationship between migration success and flow has not been studied for these species or rivers.

5.5.3.3.2 Adverse Effects

Winter-run Chinook salmon would have greater potential for redd dewatering and lower-weighted usable spawning area under the Plan; the OBAN life cycle model also suggested adverse effects on winter-run Chinook salmon from upstream effects on flow and water temperature; uncertainty will be addressed with adaptive management

Although results of various analyses of potential upstream effects of the Plan's operations did not show appreciable differences for winter-run Chinook salmon, there was evidence that redd dewatering (SacEFT analysis) (Appendix 5.C, Section C.6.2.1.2) was slightly greater under the Plan than under existing conditions: risk of dewatering was classified as good in 29% of years for existing conditions in the late long-term compared to 24% of years for the Plan. Weighted usable area for spawning was assessed to be lower under the Plan: in the late long-term, 32% of years were classified as good for existing conditions compared to 23% of years for existing conditions (Appendix 5.C, Section C.6.2.1.2). Based on these results, it is concluded that there is moderately low negative change to the flow-associated habitat for winter-run Chinook salmon eggs (score = -2, certainty = 3).

The results of OBAN life-cycle modeling suggested that there may be adverse effects on winter-run Chinook salmon from the Plan, as judged by differences in escapement between Plan and existing conditions (Figure 5.5-4; Table 5.5-22). A clear pattern that emerges is that conditions become worse as a result of climate change in the future, as shown by decreases in escapement. There is an additional adverse effect from the Plan. Note that there is considerable variability in the annual estimates of escapement from each scenario, which lends some uncertainty to the results (see Figure 5.5-5 for an example year, 1985) (Appendix 5.G, Section G.7-5). The differences are driven by relatively higher July–September water temperatures during the egg/alevin life stage and relatively lower August–November minimum monthly flow, under the Plan relative to existing conditions. These differences appear to be attributable to the fact that this is a comparison to EBC2, which includes a Fall X2 action. Based on the results of OBAN, it is concluded that there is a moderately high negative change (score = -3) to upstream temperature (for eggs) and flow (for foraging juveniles) for winter-run Chinook salmon eggs, with moderately low certainty (score = 2) because of the variability in model results. Potential adverse effects on winter-run Chinook salmon would be addressed with adaptive management.

Differences in modeled escapement of winter-run Chinook salmon using the IOS model were primarily a result of random differences in ocean harvest between Plan and existing conditions scenarios (Appendix 5.G, Section G.7.2.1); there was little difference attributable to changes as a result of the Plan.

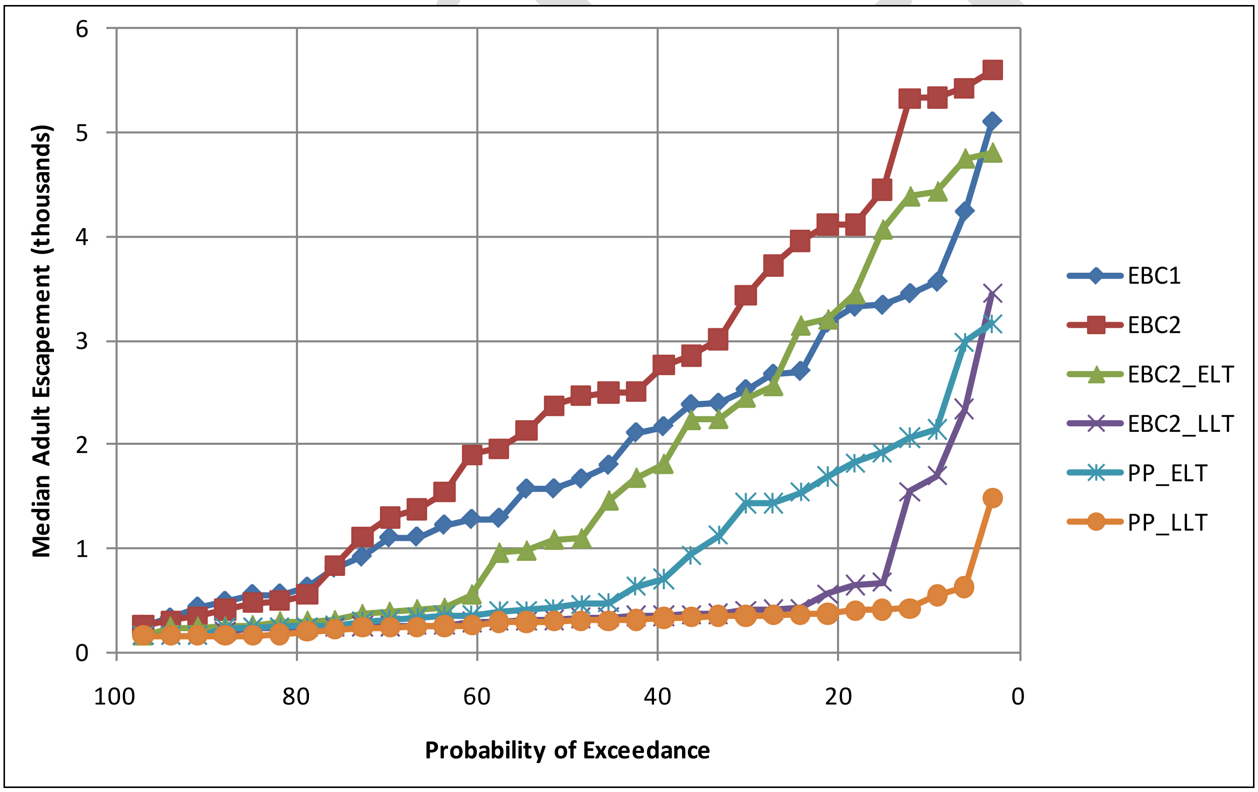

Figure 5.5-4. Exceedance Plot of Median Annual Adult Escapement Predicted by OBAN for Each Model Scenario

[***Note to Reader:*** *OBAN and IOS modeling is being refined for the public draft effects analysis.*]

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Table 5.5-22. Differences (Percent Differences) in Mean Median Annual Adult Escapement between Pairs of Model Scenarios, Late Long-Term (PP_LLT vs. EBC2_LLT)

Water Year Type	Difference
Wet	-220 (-44%)
Above Normal	-390 (-43%)
Below Normal	-460 (-48%)
Dry	-20 (-7%)
Critical	-240 (-44%)
All	-230 (-40%)
Note: negative values indicate lower escapement under the Plan.	

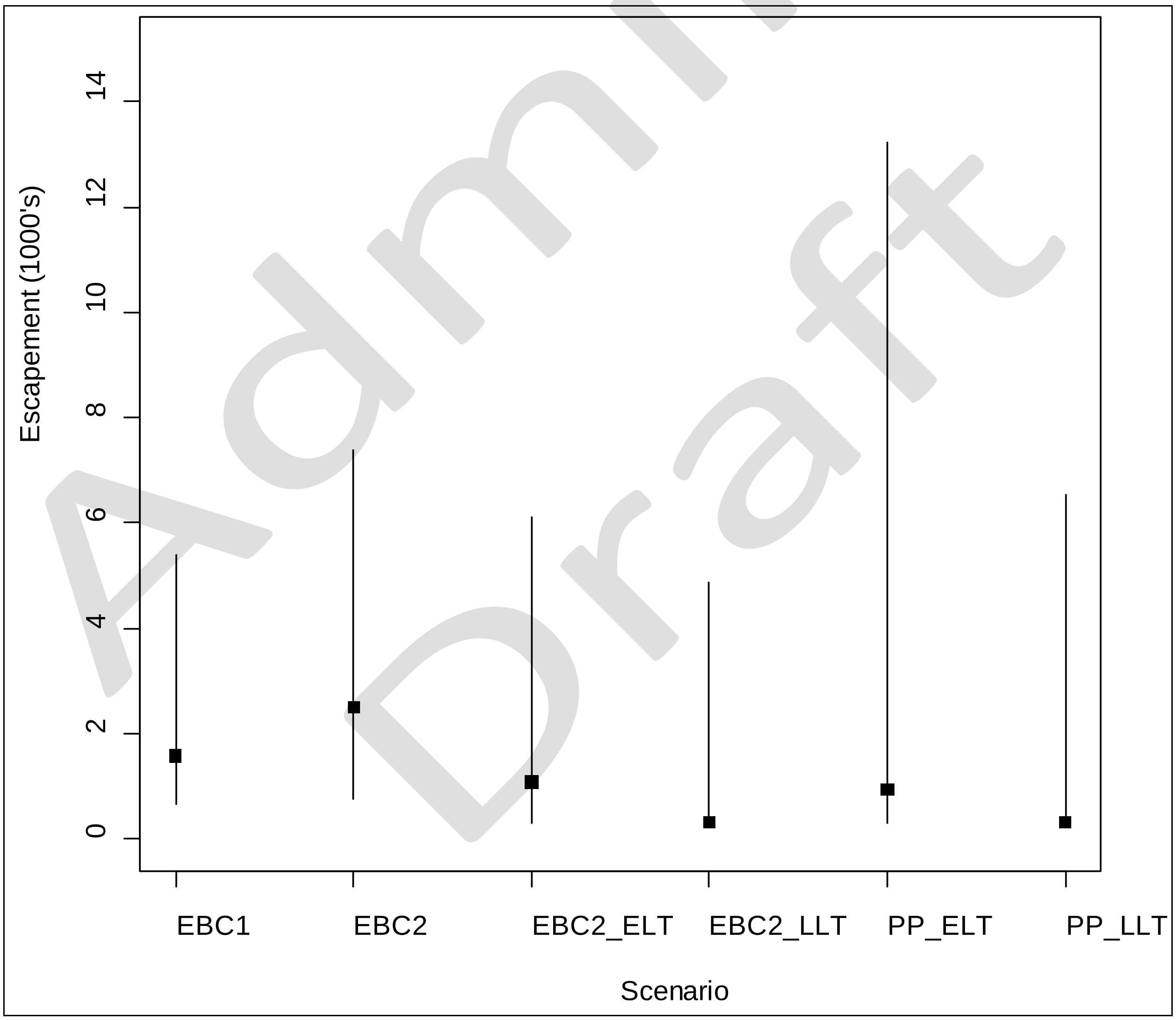

Figure 5.5-5. Median and Central 0.90 Probability Interval (5–95% Range) of Winter-Run Escapement in 1985 Predicted by OBAN for Each Model Scenario

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Egg mortality for spring-run Chinook salmon in the Sacramento River potentially would be somewhat higher under the Plan relative to existing conditions; refinements to reservoir operations may address this issue.

The Reclamation Egg Mortality model suggested that there would be a 5–10% increase in egg mortality of spring-run Chinook salmon under Plan operations relative to existing biological conditions in wet, above normal, and below normal water years. This increase was a result of simulated increased water temperatures during fall months, particularly September. However, results of the SacEFT and SALMOD models, which account for flow, temperature, and other variables in the upper Sacramento River, predict that spawning habitat conditions will not be different (SALMOD) or will be improved (SacEFT) under the Plan compared to existing biological conditions. Should this effect occur, refinements in reservoir operations and coldwater pool management, including real-time management, which CALSIM cannot model, may reduce this effect, but this has not been evaluated using the hydrologic and water temperature simulation models. Given that the great majority of spring-run Chinook salmon do not use the Sacramento River for spawning (DFG GrandTab 2011), it is concluded conservatively that there is a small negative change to temperature for spring-run Chinook salmon eggs as a result of the Plan (score = -1) with moderately low certainty (score = 2).

5.5.3.4 Impact of Take on Species

The Plan may result in incidental take of salmonids from several mechanisms. Construction and maintenance at the proposed north Delta intakes, restoration sites, conservation hatcheries, and nonphysical barriers may result in a number of adverse effects on salmonids, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (see Appendix 5.H, *Aquatic Construction Effects*). These effects, however, would be temporary and are unlikely to be considerable on salmonids because a number of measures would be taken, including timing of in-water work to minimize potential adverse effects on juvenile salmonids. As a result, there would be minimal impact of take from these activities.

In relation to existing conditions, the Plan would reduce overall entrainment of salmon as a result of dual conveyance. Use of the south Delta pumps would be reduced in wetter water years in favor of the north Delta intakes, which will be designed to limit impingement and mortality of juvenile salmonids. During dry and critical water years, however, the use of the north Delta intakes is much reduced or eliminated leading to possibly higher levels of entrainment in those years relative to existing conditions.

Lower outflow from the Sacramento River could modify inflow patterns in such a way as to impede homing and upstream migration of adult salmonids relative to current conditions. This impact is not quantifiable, however, and would need to be evaluated through research and adaptive management. Reduced flows downstream of the north Delta diversions also may result in an adverse effect.

5.5.3.5 Abundance

Abundance of salmonids in the Central Valley is controlled to a great degree by conditions outside the BDCP Plan Area, primarily by conditions in the Pacific Ocean where salmonids spend the majority of their life cycle. Nonetheless, improving Delta conditions is key to the recovery of Central Valley salmonids (NMFS 2008 [OCAP BiOp]). Habitat restoration under the BDCP substantially increases the amount of shallow tidal habitat that is used for foraging by juvenile salmonids. As

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discussed above, this action would greatly increase the number of HUs for juvenile salmonids and would result in relatively high habitat suitability for foraging juvenile salmonids. The benefits for migrating juvenile salmonids would be less. However, all juvenile salmonids engage in both foraging and migrating behavior to varying degrees. As a result populations that enter the estuary in a more advanced state of smoltification still would receive some benefit from habitat restoration.

5.5.3.6 Productivity

The Plan offers the potential to increase survival and productivity of the salmonids. Restoration of tidal habitats, channel margin, and floodplain habitats would increase food supply and substantially increase habitat for foraging juvenile salmonids and increase overall productivity of the Delta for salmonids. Lower overall entrainment across most water years as a result of dual conveyance, along with use of nonphysical barriers at alternative channels, would improve through-Delta survival of juvenile salmonids. However, lower Sacramento River outflow below the north Delta intakes may adversely affect homing and adult upstream migration, although this has not been studied and would require targeted research and adaptive management. Lower flows in the lower Sacramento River also may affect juvenile downstream migration, although real-time monitoring of downstream migration pulses would aim to adjust operations when juvenile salmonids are most abundant.

5.5.3.7 Life History Diversity

Life history diversity is a reflection of the underlying spatial and temporal diversity in survival conditions encountered by salmonid populations across their life histories. A diversity of habitat conditions in the Plan Area should add to the tendency of salmonids to develop a diversity of life histories. Channelization of the Delta along with flow regulation have reduced overall environmental diversity encountered by salmonids in the Plan Area. Restoration of tidal habitat and other habitats under the Plan has the potential to contribute to an increase in life history diversity for salmon by expanding the diversity of depths and nearshore conditions, which would enhance juveniles exhibiting foraging and migrating behavior. This would increase population resiliency in the face of normal environmental variation and may enhance survival with future climate change.

5.5.3.8 Spatial Diversity

Habitat restoration under the BDCP greatly expands the area of suitable foraging habitat in the Delta. It increases the number of habitat “patches” in which salmonid populations can thrive. The value of spatial diversity is that it provides alternative habitats, the value of which may wax and wane over time because of natural and anthropogenic conditions but always ensuring that suitable habitat pathways exist to maintain the populations over time (Lindley et al. 2007). Increased access to the Yolo Bypass would augment the use of this important alternative migratory pathway. Diversity of suitable habitat must occur across the entire life history and is not controlled solely by conditions in the Delta. Nonetheless, the expansion of suitable habitat for juvenile salmonids across the Plan Area should contribute to the development of greater spatial diversity of Central Valley salmonid populations. Spatial diversity potentially would increase because of the restoration of significant areas of suitable habitat in the Suisun Marsh and Cache Slough ROAs, where habitat would increase several-fold. There would be a lesser benefit from the West Delta ROA because of the relatively small size of the ROA, although its position coincides with an important location within the range of the species, along the migration route from upstream spawning and rearing areas to the ocean. Tidal habitat with relatively low suitability would be restored in the South Delta and Cosumnes-Mokelumne ROAs, which would be less likely to benefit salmonids, but which may be of

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some value. The considerable extent of floodplain restoration proposed for the South Delta subregion would enhance spatial diversity for salmonids emigrating from the San Joaquin watershed.

5.5.3.9 Net Effects

Figure 5.5-6 provides a graphical depiction of the relative population-level outcomes, by stressor, for salmonids resulting from implementation of the Plan. Although there are differences in life histories of each of the species, including the seasons in which they occur in the study area, all runs of Chinook salmon and steelhead are grouped in this net effects discussion because the effects of the conservation strategy occur primarily in the Delta where all of the species have the potential to be affected at a relatively similar magnitude. In general it is concluded that the positive aspects of the BDCP appreciably outweigh the negative aspects in regard to salmon and that the net effect of the Plan is beneficial to Central Valley salmonids.

The Plan would increase considerably the amount of shallow-water tidal habitat that will benefit juvenile salmonids as they forage. Restoration of tidal habitat under CM4 will appreciably increase the amount of tidal habitat in the Delta. Restoration should provide a large quantity of habitat with conditions suitable for foraging salmon in Suisun Marsh, Cache Slough, and West Delta ROAs. Restored habitat in the South Delta and Cosumnes-Mokelumne ROAs is less suitable but also should provide some benefit to foraging salmonids. Juvenile salmonids forage in shallow-water habitat where they eat a variety of planktonic and benthic prey (McLain and Castillo 2009). This type of habitat would be provided by BDCP restoration, so there is good reason to believe that this restoration will provide an appreciable direct habitat benefit for foraging salmonids.

The Plan also restores channel marsh and floodplain habitats that provide direct habitat benefits for foraging and migrating juvenile salmonids. In particular, CM2 enhances conditions in the Yolo Bypass, which has been shown to be a highly beneficial habitat for juvenile salmonids (Sommer et al. 2001). The BDCP provides improved adult and juvenile salmonid passage at Fremont Weir, increases the inundation period of the bypass, and enhances habitat conditions across the bypass itself.

In addition to the direct habitat benefits, restoration of tidal areas should augment the Delta foodweb and potentially enhance pelagic food supply. This would benefit both foraging and migrating juvenile salmonids. Production of phytoplankton is greatest in shallow-water areas, and restored shallow-water habitats have been shown to enhance phytoplankton production in many cases (Jassby and Cloern 2000). Restoration of habitats and the increase in inundation of the Yolo Bypass should enhance feeding conditions for juvenile salmonids as well.

The Plan would increase through-Delta survival of juvenile salmonids by decreasing exports from the south Delta facilities in most years. The BDCP should maintain entrainment at levels comparable to that under the BiOp, which is an appreciable reduction compared to pre-BiOp conditions. The new north Delta intakes are designed with screens and approach velocities that should minimize impingement of juvenile salmonids.

A potential adverse effect of the Plan on Central Valley salmonids is the reduction in flow downstream of the north Delta diversions on the Sacramento River. Use of dual conveyance means that water is exported directly from the Sacramento River, reducing outflow. At the same time, reduction in exports from the south Delta will increase outflow from the San Joaquin River. The combined action would modify the flow balance and mixture between the two water sources. The

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reduction in outflow in the Sacramento River during the fall adult migration period along with the possible change in olfactory signals due to the change in flow mixture could result in delay or otherwise inhibit the upstream migration. The certainty of this adverse effect is low, however, but should be monitored and evaluated during implementation.

For winter-run Chinook salmon, the analysis indicated the potential for appreciable changes in upstream spawning and rearing habitat as a result of changed operations. These changes to flow and temperature may add to climate change–related effects on this species, although climate change effects are substantially greater, and adaptive management could address the Plan's contribution.

While the engineering and design criteria for the north Delta intakes are intended to prevent impingement and other mortality of juvenile salmonids, the conservative approach is to expect some negative impact of operation of pumping facilities of this size and the resulting change in hydrodynamics, channel form, and structure, including possible increased opportunities for predators.

Contaminant effects caused by changed hydrograph and by restoration and construction activities are expected to be low. They show up as a larger adverse impact on Figure 5.5-6 because they have the potential to affect all salmonid life stages except for eggs.

An extensive assessment of potential effects from modeled differences in reservoir operations under the Plan relative to existing conditions generally found that once climate change had been factored out, there was little evidence of adverse effects from the Plan on covered salmonid species (Appendix 5.C, Section C.5.2; summarized in Sections C.6.2.1–C.6.2.3). Spawning and egg incubation, fry and juvenile rearing habitat, and adult holding flows therefore generally were not adversely affected in the mainstem rivers (Sacramento River and San Joaquin River) and tributaries (Trinity River, Clear Creek, Feather River, American River, and Stanislaus River) that are part of the SWP and CVP Central Valley operations. In some cases, different results were seen for various life stages. For example, the SacEFT model estimated that winter-run Chinook salmon fry/juvenile rearing habitat in the Sacramento River would be classified as good in 17–20% more years under Plan operations relative to existing conditions, whereas juvenile stranding risk was classified as good in 20–26% fewer years under Plan operations relative to existing conditions (Appendix 5.C, Section C.5.2.1.2). The potential adverse effect on winter-run Chinook salmon from flow and temperature effect and spring-run Chinook salmon eggs in the Sacramento River was discussed above under Adverse Effects. Climate change may have important consequences for covered salmonids, but the effects of the Plan are assessed generally not to exacerbate climate change effects, with the main exception of winter-run Chinook salmon discussed above.

Although the Plan generally is not expected to change water temperatures in the study area, climate change is predicted to result in increasingly difficult conditions for salmonids in the future. Climate change–induced temperature increase coupled with naturally stressful habitats near the southern edge of salmonids' range make California's salmonids particularly vulnerable (Katz et al. 2012). It is predicted that climate changes will influence how, when, and where precipitation falls, which will significantly alter salmonid habitat. Lower baseline flows will increase temperatures, especially in the summer and fall, as the result of lower snowpack accumulation. Spring-run and winter-run Chinook salmon are particularly vulnerable because as adults as they must oversummer before spawning. Using modeling techniques, Thompson and others (2011) found that spring-run Chinook salmon in Butte Creek were unlikely to survive climate change even when changes in water operations were made that would provide more water for fish. A qualitative assessment of Central

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Valley salmonids covered by the Plan suggested that spring-run, winter-run, and late fall–run Chinook salmon would be vulnerable to climate change in all watersheds they inhabit, steelhead would be vulnerable in most watersheds inhabited (with possible refuges present), and fall-run Chinook salmon would be vulnerable in portions of the watershed that they inhabit (with their ocean-type life history resulting in a lower risk from warming tributaries because they tend to leave during cooler months) (Moyle et. al. 2008).

As with upstream flow-related habitat effects, flows during migration periods generally were not modeled to be greatly different under the Plan in relation to existing conditions (Appendix 5.C, Section C.5.3.1.8; summarized in Section C.6.2.4). Of all the rivers in the Plan study area, only the Feather and American Rivers showed notable differences between Plan and existing flows, when accounting for climate change. For fall-run Chinook salmon adult migration flows (September and October) in these rivers, there were considerable differences between Plan and existing conditions in different water-year types that resulted in little overall difference: flows were appreciably lower on average during wet and above normal years but greater in drier years (Appendix 5.C, Section C.5.3.1.8). This was to a great degree influenced by the Fall X2 action included in the late long-term modeling. Within the Feather River, there were some instances of flows being increased under the Plan for juvenile steelhead and spring-run and fall-run Chinook salmon, as described above under Beneficial Effects.

Covered salmonid species may benefit from reduced operations of the Suisun Marsh salinity control gates (CM1), although there is some uncertainty related to the frequency of the changes and to what extent the gates delay adult salmonids under existing conditions (Appendix 5.C, Section C.5.3.1.5). Funding for construction, operation, and maintenance of the Stockton Deepwater Ship Channel aeration facility into the future would ensure maintenance of the pilot facility's benefits for San Joaquin River watershed adult salmonids that migrate upstream during low DO periods (Appendix 5.C, Section C.5.3.1.6). This may be of particular importance to spring-run Chinook salmon that are to be restored to the San Joaquin River as part of the San Joaquin River Restoration Program. The potential positive effects of changes to the Suisun Marsh salinity control gates and the Stockton Deepwater Ship Channel facility are assumed for this effects analysis to be captured under the moderately high positive effect associated with passage improvements at Fremont Weir (see above).

Water temperature was examined at the subregional scale in the Plan Area, and there was little difference between existing conditions and the Plan for the number of days within the suboptimal, optimal, supraoptimal, and lethal ranges for salmonids (Appendix 5.C, Section C.5.4.3). As noted above, climate change is a driver that will have increasing importance for the species into the future. DO also was found to be similar between existing conditions and the Plan (Appendix 5.C, Section C.5.4.4).

As described for delta and longfin smelt, there is uncertainty about the nature of changes in turbidity that may result from implementation of the Plan (Appendix 5.C, Section C.5.4.6). Turbidity in newly restored areas may be relatively high as a result of factors such as water depth and wind fetch resuspending sediments, whereas turbidity outside the restored areas could be affected by restoration areas capturing sediment that otherwise would have moved downstream. Because of these uncertainties, at the present time no conclusion is made regarding the change to turbidity as a result of the Plan.

In conclusion, the magnitude of benefits of the Plan for Central Valley salmonids at the population level cannot be quantified with certainty. Nonetheless, it is concluded with moderate certainty that

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the overall net effect of the Plan is a positive change that has the potential to increase the resiliency and abundance of Central Valley salmonids relative to their condition under the current environment. The Plan should contribute to recovery of the species and may help Central Valley salmonids cope with expected climate change and the ongoing threats to recovery and even perpetuation of salmonid populations. Katz and coauthors (2012) point to the likelihood of extinction of many California salmon populations. Increasing air and water temperatures as well as a general shift in hydrologic regime (rain-dominated rather than snow-dominated) will increase stresses to Central Valley salmonids regardless of the BDCP. However, as noted above, there are potential adverse effects on winter-run Chinook salmon from differences in reservoir operations that appear to exacerbate the effects of climate change (with climate change being the main driver of change over time). The Plan does not directly address the main effects of climate change (i.e., increased temperature) but, by expanding habitat, increasing habitat diversity, and increasing the number of productive habitat patches in the Delta, the Plan may lead to more robust salmon populations with the resiliency and diversity necessary to cope with a changing environment.

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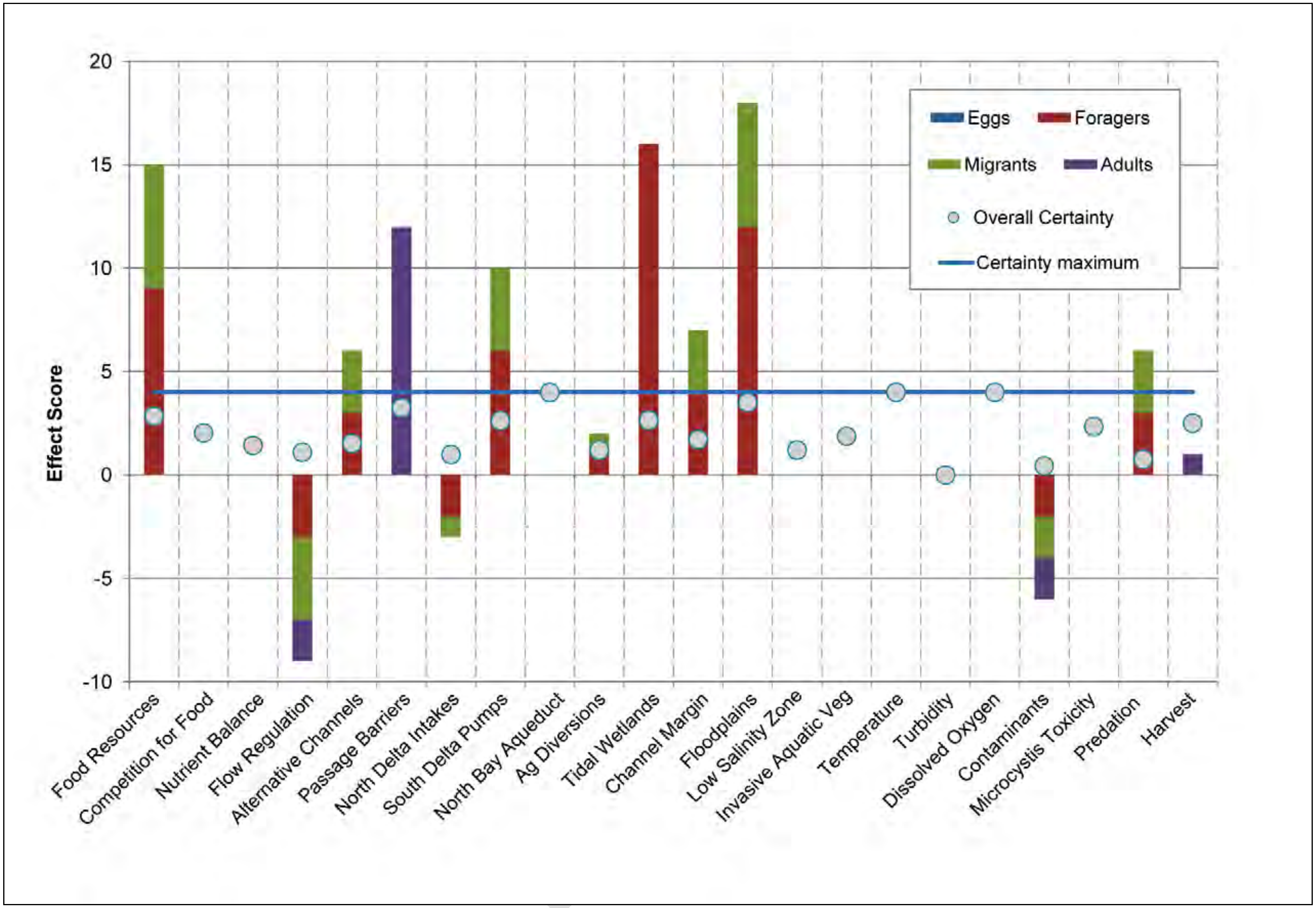

Figure 5.5-6. Effect of the BDCP Conservation Strategy on Salmonids

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5.5.4 Splittail

The Sacramento splittail is a large (up to 40 cm standard length [SL]) cyprinid native to California and is the only surviving member of its genus (Moyle 2002). The species is endemic to the San Francisco estuary and its associated watershed. Its range entirely encompasses the Plan Area, reaching to Mud Slough on the San Joaquin River and the Red Bluff Diversion Dam on the Sacramento River (Feyrer et al. 2005). There are also genetically distinct populations inhabiting the Napa and Petaluma Rivers and marshes (Baerwald et al. 2005). Splittail abundance is strongly related to hydrologic conditions, with wet years typically producing much stronger year classes than dry years (Sommer et al. 1997). Consequently, splittail abundance varies greatly from year to year. In 1999, following a 6-year drought, Sacramento splittail was listed as threatened under the ESA. However, the ruling was remanded in 2003, after a return to wet conditions in the late 1990s that resulted in record abundance indices for the species (Sommer et al. 2007).

Splittail can live 5–8 years and tolerate a wide range of water quality conditions, including salinity, temperature, and DO levels (Moyle et al. 2004). Adult splittail occur predominantly in Suisun Marsh but also inhabit other brackish water marshes in the San Francisco estuary, as well as the fresher Delta. While in these areas, splittail feed on a wide variety of invertebrates and detritus. In the spring, when California's Central Valley experiences large amounts of snowmelt runoff, adult splittail will move onto inundated floodplains in the valley to spawn. The Yolo Bypass provides the largest spawning area. After they spawn, the adult fish return to their marsh habitats. The eggs, which are laid on submerged vegetation, begin to hatch in 3 to 7 days, and the larval fish grow at an accelerated rate in the warm and food-rich environment of the floodplain (Moyle et al. 2004). They develop into juveniles about a month after hatching. When the juveniles reach a size of about 30–40 mm total length (TL), they begin moving off of the floodplain and downstream into areas similar to those inhabited by the adults (Feyrer et al. 2006). Their emigration peaks in May and June (Feyrer et al. 2005). The juveniles rear in the marsh habitats for 2 to 3 years before becoming sexually mature.

A detailed species account of Sacramento splittail is presented in Appendix 2.A. Stressors on the splittail population in the Plan Area are presented in Table 5.5-23 together with scores for the magnitude of importance, the certainty of the importance, and a brief description of the rationale for the scores. More detail is presented on the rationale for the importance of different stressors to splittail as necessary in the sections below. Expected effects of the Plan on these stressors is presented in Table 5.5-24.

The principal potential beneficial and adverse effects of the BDCP conservation strategy on stressors important to the Sacramento splittail population are described in sections below and listed in Table 5.5-23 and Table 5.5-24. There are other potentially important stressors listed in the tables that affect other fish species but not splittail, or that the Plan is not expected to affect. As described in Appendix 5.D, *Contaminants*, ammonium and copper, both of which can have direct toxic effects on fish as well as effects on the foodweb, are not expected to change as a result of the Plan. The stressor *alternative channels* relates to different migration routes through the Plan Area (e.g., entry to the East Delta subregion through the Delta Cross Channel and Georgiana Slough) and is principally of concern for juvenile salmonids migrating through the Plan Area. The LSZ has not been associated with distribution of splittail, probably because they are less pelagic than the other fish and have wide salinity tolerance (Moyle et al. 2004). *CM13 Invasive Aquatic Vegetation Control* is focused on IAV treatment in the ROAs and as such does not address existing IAV outside the ROAs. The Plan is not expected to affect DO levels and would have minor effects on water temperatures, whereas

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splittail are tolerant of broad ranges of DO levels and water temperatures (Young and Cech 1996). Splittail typically inhabit shallow, turbid water (Moyle et al. 2004), but importance of turbidity to splittail has not been studied. Passage barriers of most types are expected to have little effect on splittail, although information to confirm this is lacking. The late-winter and spring operational period of the Suisun Marsh salinity control gates overlaps the period of adult splittail spawning migrations from Suisun Marsh, but the gates, which operate 10 to 20 days per year, are believed to delay fish migrations by a few days at most (Appendix 5.C, Section C.6.3.1.5) and therefore are expected to have a negligible effect on the splittail population.

In evaluating the effects of the BDCP conservation strategy on splittail, it is important to distinguish between total effects and per capita effects. Because of several habitat enhancement measures, the Plan is expected to increase the abundance of splittail, especially the early life stages. Consequently, the number of splittail at risk from a stressor would increase even if the Plan had no effect on the stressor. However, the risk to any one splittail, i.e., the per capita risk, would remain unchanged. This distinction will be particularly important in evaluating stressors that affect mortality rates, such as entrainment and stranding.

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Table 5.5-23. Population-Level Stressors—Sacramento Splittail

Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching Eggs	Hatch to Fully Developed Fins and Air Bladder Larvae	Actively Feeding and Growing Juveniles	Sexually Mature and Migrating Fish Adults	Rationale for Stressor Rankings
Food	Food Resources	Quantity and quality of food resources available to life stages	0	0	2	3	Reduction of *Neomysis* because of *Corbula* invasion has likely had some effect, but splittail switched to feeding on *Corbula* (Moyle et al. 2004; Feyrer et al. 2003). There is no evidence of reduced splittail abundance following invasion (Kimmerer 2002)
	Competition for food	Decrease in food resources due to competition with other consumers	0	0	2	2	Reduction of *Neomysis* because of competition with *Corbula* for phytoplankton may have caused reduced growth rate and fecundity (Moyle et al. 2004; Feyrer and Baxter 1998), but there is no evidence of reduced abundance (Kimmerer 2002).
	Nutrient balance	Impact of wastewater treatment plant effluent (for example) and other inputs on delta food resources	0	0	2	0	Several authors draw links between ammonium concentrations in delta and phytoplankton species composition and amount that may affect zooplankton community (Glibert et al. 2011; Dugdale et al. 2007; Jassby et al. 2008). Effect on splittail minimal because of timing and spatial distribution—the most zooplankton-dependent life stages on floodplain are not affected.
Water Operations	Flow Regulation	Change in flow through the delta as a result of upstream regulation or diversion	1	1	0	1	No direct information—presume effect similar to salmon fry outmigration (Brandes and McLain 2001), but less important. For eggs, larvae, and adults effect related to availability of spawning habitat (and for adults, flow triggering upstream migration; Harrell and Sommer 2003).
	Alternative channels	Effect of fish movement into Interior Delta through Georgiana Slough and the Delta Cross Channel	0	0	0	0	DS generally occur downstream of these diversions though FWS seining data indicates some presence of adults in this area.
	Passage Barriers	Structures that may impede or change migration patterns within the region such as the salinity control gates	0	0	1	1	Barriers in Tule Canal, e.g., Lisbon Weir. SMSCG. South Delta barriers, etc. Limited information.

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Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching Eggs	Hatch to Fully Developed Fins and Air Bladder Larvae	Actively Feeding and Growing Juveniles	Sexually Mature and Migrating Fish Adults	Rationale for Stressor Rankings
Water Operations—Entrainment	North Delta Intakes	Entrainment and impingement of fish at proposed North Delta intake[1]	0	1	1	0	Splittail eggs and larvae rarely found in vicinity of proposed intakes, but some may be flushed from floodplain at high flows. Presumption is that screening and operations will minimize impacts to splittail, which are strong swimmers (Young et al. 1999).
	South Delta Pumps	Entrainment at existing South Delta intake	0	0	2	1	Salvage numbers typically high in wet years, when YOY production is also high. There is no evidence that entrainment affects splittail abundance (Sommer et al. 1997)
	North Bay Aqueduct	Entrainment at North Bay Aqueduct	0	0	1	0	Currently low impact; small diversion; screened; little evidence of entrainment.
	Ag Diversions	Entrainment in agricultural and smaller diversions throughout the delta	0	0	1	0	Currently low impact; small diversions; larger ones screened; little evidence of entrainment.
Habitat	Tidal habitat	Impact of loss of tidal habitat in terms of direct habitat for the species	1	1	3	3	Abundant populations existed under habitat conditions similar to current (e.g. 1960s–1980s). Spawning and larval rearing in tidal wetlands is limited.
	Channel Margin	Impact of loss or change in channel margin in terms of direct habitat for the species	1	1	3	1	Abundant populations existed under habitat conditions similar to current (e.g. 1960s–1980s). Spawning and rearing in channel margin habitat potentially important in dry years (DRERIP—Kratville 2008).
	Floodplains	Impact of loss of area or connectivity to floodplains in terms of direct habitat for the species.	4	4	0	2	Abundant populations existed under physical habitat conditions similar to current (e.g. 1960s–1980s, but changes in flow could affect floodplain habitat availability (DRERIP—Kratville 2008)
	LSZ	Habitat quantity and quality in the Low Salinity Zone	0	0	0	0	LSZ and salinity have not been associated with distribution of splittail, probably because they are less pelagic than the other fish and have wide salinity tolerance (Moyle et al. 2004).

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Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching **Eggs**	Hatch to Fully Developed Fins and Air Bladder **Larvae**	Actively Feeding and Growing **Juveniles**	Sexually Mature and Migrating Fish **Adults**	Rationale for Stressor Rankings
	SAV	Shallow water habitat occupied by aquatic vegetation	0	0	2	1	The proliferation of SAV has occurred since the 1980s and has changed the fish assemblages in nearshore habitats in the Delta (Nobriga and Herbold 2009). May increase predator habitat (DRERIP—Kratville 2008; Nobriga and Feyrer 2007).
	Temperature	Water temperature	2	2	0	0	Splittail are tolerant of a broad range of water temperatures (Young and Cech 1996), but temperature likely affects spawning and growth (Feyrer et al. 2006). Small recent changes due to climate change.
	Turbidity	Water clarity	0	0	2	2	Splittail typically inhabit shallow, turbid water (Moyle et al. 2004), but importance of turbidity to splittail not studied.
	Dissolved Oxygen	Dissolved oxygen	0	0	0	0	Splittail tolerate low DO levels (Young and Cech 1996).
Water Quality	Contaminants	Non-biological substances with adverse effects to biota	1	2	1	0	Evidence of selenium toxicity, but population significance unknown (Stewart et al. 2004). Hg exposure on YB floodplain likely, but as for salmon (Henery et al. 2010), level may be subtoxic.
	Microcystis toxicity	Naturally occurring toxins from algal populations	0	0	1	0	Effect minimal because of timing and spatial distribution—food web of most sensitive life stages on floodplain not affected.
Predation	Predation	Non-normative consumption of target species by piscivorous species	1	2	2	1	Predation by striped bass and large-mouth bass has been documented, but intensity relatively low (Nobriga and Feyrer 2007; Thomas 1967).
	Harvest	Human predation on the species in the delta	0	0	0	0	Reduction of *Neomysis* because of *Corbula* invasion has likely had some effect, but splittail switched to feeding on *Corbula* (Moyle et al. 2004; Feyrer et al. 2003). There is no evidence of reduced splittail abundance following invasion (Kimmerer 2002).

Note: Stressors are ranked by relative importance on a scale from 0 (unimportant) to 4 (highly important).
LSZ = low salinity zone.
Stressors are ranked by their impact on biological performance of the species under current habitat conditions.
Stressors are attributes of the environment affecting the biological performance of the species.
[1]Assumed stressor in the future.

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Stressor Category	Stressors	Stressor Definition	Spawned Eggs to Hatching	Hatch to Fully Developed Fins and Air Bladder	Actively Feeding and Growing	Sexually Mature and Migrating Fish	
			Eggs	Larvae	Juveniles	Adults	Rationale for Stressor Rankings

	High degree of scientific certainty, supported by consistent quantitative analysis.
	Appreciable qualitative information supported by general scientific literature.
	Uncertain, conflicting quantitative analysis, limited support in literature.
	Speculative, no quantitative analysis and little applicable literature.

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Table 5.5-24. Change to Stressors because of the BDCP by Life Stage—Sacramento Splittail

Stressor Category	Stressors	Change to the Stressor for the Life Stage (-4 to 4) Because of BDCP			
		Eggs	Larvae	Juveniles	Adults
Food	Food resources	0	4	4	4
	Competition for food	0	0	-1	-1
	Nutrient balance	0	0	0	0
Water operations	Transport flows	0	0	0	0
	Alternative channels	0	0	0	0
	Passage barriers	0	0	3	3
Water operations—entrainment	North Delta entrainment/impingement	0	-1	0	0
	South Delta entrainment	0	0	2	3
	North Bay Aqueduct entrainment	0	0	0	0
	Agricultural diversion entrainment	0	0	1	0
Habitat	Tidal habitat	4	4	4	4
	Channel margin	1	1	1	1
	Floodplains	4	4	0	4
	Low salinity zone	0	-1	-1	-1
	Invasive aquatic vegetation	0	0	1	1
	Temperature	0	0	0	0
	Turbidity*	–	–	–	–
	Dissolved oxygen	0	0	0	0
Water Quality	Contaminants	-1	-1	0	0
	Microcystis toxicity	0	0	-1	-1
Predation	Predation	0	0	1	1
	Harvest	0	0	0	0

Note: Changes to stressors as a result of the Plan are expressed as integers from -4 (high negative change) to 4 (high positive change).

The scores presented for this change from BDCP reflect a comparison of the PP to EBC2, which includes the current OMR flow requirements of the USFWS BiOp (2008).

Stressors are ranked by their impact on biological performance of the species under current habitat conditions.

Stressors are attributes of the environment affecting the biological performance of the species.

* Changes to turbidity as a result of BDCP implementation are difficult to predict and are likely to vary by ROA and subregion, as discussed in Section 5.3.2.3. At this time no conclusion is made regarding the change to turbidity as a result of Plan implementation.

[1] Presumed impact in the future.

(white)	High degree of scientific certainty, supported by consistent quantitative analysis.
(light gray)	Appreciable qualitative information supported by general scientific literature.
(dark gray)	Uncertain, conflicting quantitative analysis, limited support in literature.
(black)	Speculative, no quantitative analysis and little applicable literature.

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5.5.4.1 Beneficial Effects

Inundated floodplain habitat enhancement (CM2) and restoration (CM5), and restoration of tidal wetland habitat (CM4) and channel margin habitat (CM6) are expected, with a high degree of certainty, to benefit the Sacramento splittail population. CM2 is expected to increase the frequency, duration, and surface area of Yolo Bypass inundation, resulting in substantial increases in availability of inundated floodplain habitat to splittail, particularly in dry years. CM5 would restore up to 10,000 acres of new seasonally inundated floodplain in wet years. CM4 would increase the amount of tidal habitat in the Plan Area, substantially increasing suitable habitat for juvenile and adult splittail. CM6 would restore and enhance 20 miles of channel margin habitat in the Delta, primarily benefitting juvenile and adult splittail during their migrations. These measures also would increase food resources for local consumption and potentially export surpluses to the Delta. Several factors create uncertainty regarding the potential benefits of the measures, including flows needed to trigger migration of adults to the Yolo Bypass, and potential effects of colonization by predatory fish, invasive aquatic vegetation, and invasive mollusks on habitat value.

The most important stressor of the egg, larval, and pre-emigrating juvenile life stages of the splittail population is a limited availability of habitat for spawning and the rearing of larvae and young juveniles, especially in dry years when floodplains are not inundated (Sommer et al. 1997, 2007; Moyle et al. 2004; Feyrer et al. 2006). Abundance of young splittail is almost always high in years of extensive and prolonged floodplain inundation. Inundation of the Yolo Bypass, the largest floodplain in the Central Valley, is especially effective in providing habitat for splittail (Sommer et al. 1997; Feyrer et al. 2006). Because of its high importance to splittail, the availability of floodplain habitat is given a score of 4 for the early life stages (Table 5.5-23). Adult splittail forage primarily in Suisun Marsh (Sommer et al. 2007; Moyle et al. 2004), but they also forage on the floodplain for a period prior to spawning, and this foraging may affect their fecundity and post-spawning survival (Moyle et al. 2004). Floodplain habitat therefore is given a score of 2 for adult splittail. After emigrating from their natal habitats, juvenile splittail derive no direct benefit from the floodplain habitats. The certainty scores for the ranking of floodplain habitat are high (score = 4) for all the life stages.

CM2 Yolo Bypass Fisheries Enhancement is expected, with a high degree of certainty, to increase the frequency, duration, and surface area of Yolo Bypass inundation, resulting in substantial increases in splittail weighted habitat area (Table 5.5-25). The weighted habitat area is an index of habitat suitability index (HSI)-weighted inundated floodplain surface area on the Yolo Bypass suitable for splittail spawning and rearing that was estimated by computer modeling (Appendix 5.C, Section C.4.4.2.1). An important modeling assumption was that the benefit of greater splittail habitat area is realized only if inundation persists at least 30 days, the estimated time needed for development to the juvenile stage that emigrates from the floodplain (Sommer pers. comm.). In the model, floodplain habitat enhancement was quantified only after 30 days of continuous inundation, as indicated by results of hydrologic modeling. The habitat model results indicate that the BDCP conservation strategy would result in increases in splittail weighted habitat area on the Yolo Bypass ranging from about 60% in wet water-year types to almost 300% in below normal years (Table 5.5-25). The relative size of increases are greatest for dry and critical years (Appendix 5.C, Figure C.6.4-3), but percentages cannot be computed for these water-year types because splittail weighted habitat area was estimated to be zero under existing conditions. Because of the large positive effect of CM2 on splittail spawning and rearing habitat availability, a score of 4 was assigned to the BDCP effect on this stressor for all life stages except the older juveniles (Table 5.5-24). The certainty scores are high (score = 4) for all life stages.

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Table 5.5-25. Splittail Weighted Habitat Area in Yolo Bypass for Existing Biological Conditions and the BDCP Conservation Strategy by Water-Year Type, and Increases with the Plan

Water Year Type	Existing	Plan	Difference (% Difference)
Wet	1,662	2,645	983 (59%)
Above normal	1,139	1,911	772 (68%)
Below normal	124	490	366 (296%)
Dry	0	15	15 (NA)
Critical	0	5	5 (NA)

Some uncertainty exists regarding the level of flow from the bypass that is sufficient to trigger spawning migration by splittail adults (Appendix 5.E, Section E.6.2.3.3), but the Plan includes monitoring, research, and adaptive management to identify refinements in operations as needed to further increase spawning habitat availability. Therefore, a score of 4 was given to the certainty of effects.

CM2 is also expected to reduce the per capita risk of stranding on the Yolo Bypass, although the total level of stranding likely would increase because of the expected increase in number of young splittail present. The measure would modify structures at selected locations on Tule Canal and the Toe Drain, such as Lisbon Weir, that are believed to impede fish passage currently. Several factors are expected to contribute to a reduced stranding risk. Most important is the increased duration of inundation, which increases the time available for young splittail to develop sufficiently to emigrate from the floodplain. In addition, CM2 includes a number of actions designed, in part, to reduce stranding and improve fish passage, such as grading; modifying berms, levees, and water control structures; and reworking agricultural delivery channels and the Tule Canal/Toe Drain (Appendix 5.C, Section C.6.4.1.2). Although stranding and fish passage are not considered to be major factors for splittail under existing conditions (Sommer et al. 2008; Feyrer et al. 2004) (Appendix 5.C, Section C.6.4.1.2), the expected reduction in the stranding rate and improved passage would result in even greater benefit to splittail from CM2. Because CM2 is expected to substantially increase splittail inundated floodplain habitat availability, especially in dry years, and because the importance of this habitat to the abundance and productivity of the splittail population is high, the effect of the Plan on inundated floodplain habitat is expected to be highly beneficial to the splittail population (score = 4).

CM5 Seasonally Inundated Floodplain Restoration will restore up to 10,000 acres of new inundated floodplain habitat (Appendix 5.E, Section E.0.1). However, the floodplain inundation will occur only during large storm events and typically in wet years, when much greater acreages of inundated floodplain habitat are already available in the system. The main benefit of this conservation measure for splittail is increased habitat diversity. The importance of habitat diversity to splittail and the effect of the Plan on habitat diversity are discussed below in Sections 5.5.4.4 and 5.5.4.6.

After their first few weeks in their natal habitats, juvenile splittail emigrate to tidal wetland habitats in the Delta and Suisun Bay. The juveniles and adults rear in these habitats until the adults are ready to spawn. However, despite the importance of tidal wetland habitat for older juveniles and adults, its availability has little effect on population abundance in most years. As previously described, the abundance of splittail year classes is determined largely by the availability of inundated floodplain habitat for spawning and rearing. However, if the tidal wetland habitat becomes limited, as may occur following the production of a large year class in a wet year, increased availability of this habitat potentially would improve growth and survival of older juveniles and adults, ultimately resulting in more adult fish and thereby sustaining the benefits of increased young-of-year (YOY) production through the entire life cycle. An increase in the number of adult fish is expected to increase genetic diversity of the splittail population. Because of its value to juvenile and adult splittail, and the potential importance of growth and survival in these life stages to sustaining high production following wet years, the increased tidal wetland habitat is given an importance score of 3 (Table 5.5-23).

CM4 Tidal Natural Communities Restoration would result in large surface areas of tidal wetland habitat in the late long-term, especially in the Cache Slough, Suisun Marsh, and the South Delta ROAs (Table 5.5-26). These areas constitute greater than fourfold increases from existing conditions (Appendix 5.E, Section E.3.1.1). The benefits would be greatest to adult and juvenile splittail, but younger life stages could benefit as well. Cache Slough and Suisun Marsh are especially important habitat areas (Appendix 5.E, Sections E.6.2.3.3 and E.6.2.4.3). The Cache Slough area receives most of the young splittail emigrating from the Yolo Bypass, resulting in heavy use, whereas Suisun Marsh is the most important rearing habitat destination for juvenile splittail and foraging habitat for adults. Analysis of juvenile and adult splittail habitat suitability in the ROAs demonstrated that the South Delta ROA would provide the greatest number of habitat units for both juveniles (Table 5.5-27) and adults (Table 5.5-28). However, because Cache Slough and Suisun are especially important habitat areas for splittail, the restoration in these ROAs is expected to provide greater benefit to splittail. Nonetheless, the increased habitat in the South Delta ROA would increase habitat diversity, adding to the robustness and genetic diversity of the splittail population (Section 5.5.4.6). Because of the large increases in splittail tidal wetland habitat area and diversity expected to result from the Plan, this effect is given a score of 4 (Table 5.5-24). The high potential importance of tidal wetland habitat to the splittail population (Table 5.5-23) and the large increase in the amount of habitat resulting from the Plan combine to produce a high score for the BDCP effect on the species (Figure 5.5-7).

Table 5.5-26. Estimated Surface Areas of Subtidal Habitat in the Late Long-Term for Several Depth Intervals in the Tidal Marsh Restoration ROAs

Depth Interval (below MLLW)	Restoration Opportunity Area, Surface Areas (acres)					
	Cache Slough	Suisun Marsh	Mokelumne-Cosumnes	South Delta	West Delta	East Delta
0 to 1 feet	1,352	2,256	848	2,391	126	164
1 to 2 feet	1,006	3,512	638	2,782	118	434
2 to 3 feet	1,067	2,053	279	2,930	112	257
3 to 4 feet	1,023	1,658	122	2,169	112	35
4 to 10 feet	2,413	547	115	677	429	20
>10 feet	560	31	16		58	0
Total	7,421	10,057	2,018	10,949	955	910
MLLW = mean lower low water.						

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Table 5.5-27. Estimated Juvenile Sacramento Splittail HSI Depth Values and Habitat Units for Several Depth Intervals in the Tidal Marsh Restoration ROAs

Depth Interval (below MLLW)	Juveniles HSI Values	Cache Slough	Suisun Marsh	Mokelumne -Cosumnes	South Delta	West Delta	East Delta
0 to 1 feet	0.4	541	902	339	956	50	66
1 to 2 feet	0.4	402	1,405	255	1,113	47	174
2 to 3 feet	1	1,067	2,053	279	2,930	112	257
3 to 4 feet	1	1,023	1,658	122	2,169	112	35
4 to 10 feet	0.7	1,689	383	81	474	300	14
>10 feet	0.4	224	12	6		23	
Total		4,946	6,414	1,082	7,642	645	545
MLLW = mean lower low water.							

Table 5.5-28. Estimated Adult Sacramento Splittail HSI Depth Values and Habitat Units for Several Depth Intervals in the Tidal Marsh Restoration ROAs

Depth Interval (below MLLW)	Adults HSI Values	Cache Slough	Suisun Marsh	Mokelumne -Cosumnes	South Delta	West Delta	East Delta
0 to 1 feet	0.2	270	451	170	478	25	33
1 to 2 feet	0.2	201	702	128	556	24	87
2 to 3 feet	0.7	747	1,437	195	2,051	78	180
3 to 4 feet	0.7	716	1,161	85	1,518	78	25
4 to 10 feet	1	2,413	547	115	677	429	20
>10 feet	0.7	392	22	11	0	41	0
Total		4,740	4,320	704	5,281	675	344
MLLW = mean lower low water.							

Splittail may spawn in tidal wetlands, but the degree to which such spawning occurs is not well known. If used for spawning, this habitat, which unlike inundated floodplain habitat is available in dry years, would improve the ability of the splittail population to withstand extended periods of drought (Appendix 5.E, Sections E.6.4.4.1).

Juvenile splittail use channel margin habitat during their downstream migrations from natal habitats, and the adults use this habitat during their spawning migrations. An unknown fraction of the Sacramento River juveniles migrate upstream to rear in off-channel habitats in the upper Sacramento River and migrate to the Delta and Suisun Marsh the following year (Moyle et al. 2004; Feyrer et al. 2005). Channel margin habitat also is used for spawning and rearing, which may be important in dry years when inundated floodplain habitat is unavailable. Because channel margin habitat is especially important to juvenile splittail, this habitat is given a stressor importance score of 3 (Table 5.5-23).

CM6 Channel Margin Enhancement is expected to enhance 20 linear miles of channel margin habitat in the Plan Area, which constitutes about 4–8% of the existing habitat. The measure is directed at improving habitat conditions for covered fish species along Delta channel banks by improving channel geometry and restoring riparian, marsh, and mudflat habitats along levees. All of the

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locations planned for channel margin habitat improvement (Appendix 5.E, Section E.4.4) are migration corridors for emigrating YOY splittail and all are currently leveed, frequently including riprap. Depending on the quality of the restored habitat, some emigrating juvenile splittail could be expected to rear in channel margin habitat for extended periods. The habitat also could be used for spawning in dry years. Because the percentage of existing habitat proposed for enhancement is relatively small, the effect is given a BDCP effect score of 1 (Table 5.5-24).

Little information exists regarding food-resource limitation of splittail. Reduction of the *Neomysis*, a major prey item of juvenile and adult splittail, that resulted from competition with *Corbula* following its invasion of the estuary in the 1980s, may have caused reduced growth rate and fecundity of splittail (Moyle et al. 2004; Feyrer and Baxter 1998), but there is no evidence that splittail abundance was affected (Kimmerer 2002). Because of these considerations, food resources are given a stressor importance score of 2 for juvenile and adult splittail (Table 5.5-23).

Increases in inundated floodplain habitat are expected to increase foodweb resources for larval and early juvenile splittail because these resources are dependent on habitat availability (Appendix 5.E, Section E.6.3). However, detailed information on the requirements and expected availabilities of habitats of the food resource species is not available, so the Plan effects on food resource availability for splittail larvae and early juveniles are considered identical to the effect on floodplain habitat, and the benefit of the increased food resources is rated as 4 (Table 5.5-24). The certainty score is moderately high (score = 3).

Potential effects of the Plan on the foodweb resources of Delta habitats other than the floodplains, including the tidal wetland and channel margin habitats inhabited by older juvenile and adult splittail, have been analyzed with respect to the phytoplankton-based foodweb. Analysis of the potential increase in phytoplankton growth rate as a function of average habitat depth (Lopez et al. 2006) was used as an indication of potential food productivity increases in the ROAs as a result of habitat restoration (Appendix 5.E, Section E.5.1.3.1). This suggested a considerable increase in potential primary productivity (Table 5.5-29) (Appendix 5.E, Sections E.6.2.3.1, E.6.24.1, E.6.2.5.1, E.6.2.6.1, E.6.2.7.1), which may translate into increased food resources for juvenile and adult splittail in the ROAs, as well as export beyond the ROAs. Increased food production under the Plan would be of considerable importance in and adjacent to areas currently occupied by splittail, (Cache Slough, West Delta, and Suisun Marsh ROAs; there was estimated to be more than a threefold increase in primary productivity in these ROAs (Table 5.5-29). A large body of literature supports the hypothesis that restoration of tidal marsh and floodplain habitat will result in increased local food production and export of additional food resources to downstream areas (Jassby and Cloern 2000; Kneib et al. 2008; Opperman 2008). Food production in the West Delta and Suisun Marsh ROAs also may be enhanced by increases in residence time caused by changes in hydrodynamics. The degree to which additional food resources produced in restoration areas will become available to splittail outside the ROAs is uncertain. Lehman and coauthors (2010) demonstrated that export of material from Liberty Island in the Cache Slough subregion varied considerably because of tidal action; the area was both a source and a sink of materials during their study. Careful design of the restored aquatic habitats and monitoring would aim to reduce or avoid the adverse effects of colonization by benthic organisms including invasive clams such as *Corbula* and *Corbicula*, but the ability to limit colonization is uncertain. Restoration designs could be refined through adaptive management as new restoration areas are developed. After consideration of the various factors described above, it is concluded that there would be a moderately high positive benefit of the Plan on food resources for juvenile and adult splittail (score = 3), with moderately low certainty (score = 2).

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Table 5.5-29. Depth-Averaged Phytoplankton Growth Rate and Prod-Acres for Existing Conditions and the Plan in the Late Long-Term, Assuming No Sea Level Rise

Restoration Opportunity Area	Scenario	Phytoplankton Growth Rate	Prod-Acres
Cache Slough	Existing	0.60	4,526
	Plan	0.85	13,858
Suisun Marsh	Existing	0.69	4,018
	Plan	0.92	13,089
West Delta	Existing	0.76	293
	Plan	0.74	2,907
Cosumnes-Mokelumne	Existing	0.00	0
	Plan	1.06	3,116
South Delta	Existing	1.14	98
	Plan	1.12	15,892
All	Existing		8,935
	Plan		48,862

Notes:
Existing conditions is EBC2 (U.S. Fish and Wildlife Service [2008] OCAP BiOp with Fall X2 requirements included, i.e., the 2-ppt near-bottom salinity isohaline [X2] located no farther upstream than 74 km and 81 km from the Golden Gate Bridge in falls of wet and above normal years, respectively).
Prod-acres are the product of phytoplankton growth rate and acreage.

Overall entrainment of splittail would be lower under the Plan because of north Delta diversion operations reducing reliance on south Delta export facilities, but entrainment under existing conditions has a minor effect on the splittail population.

Large numbers of YOY splittail are entrained at the SWP and CVP south Delta facilities in wet years, when abundance of splittail is high, while entrainment numbers are much lower in dry years when abundance is less. From 1980 to 2009, entrainment at the south Delta facilities ranged from 931 in 2007 (dry year) to 5.4 million in 2006 (wet year). Most of the entrained fish are juveniles, but adults also are entrained. Past studies have found no evidence that entrainment of splittail significantly affects population abundance (Sommer et al. 1997; Moyle et al. 2004). Nevertheless, the high level of juvenile entrainment in wet years has a potential to reduce year class production. Therefore, entrainment is considered to be of moderately low importance (score = 2) to the splittail population (Table 5.5-23).

As previously noted, it is important to distinguish between total entrainment and the rate of entrainment (per capita entrainment) when evaluating the effect of the Plan on entrainment of splittail. This distinction is reflected in the very different results obtained from two different modeling techniques that were used to estimate entrainment (represented by salvage) of splittail. The results of the analysis using the Delta inflow method indicate that the Plan would result in a large reduction in splittail entrainment, while the results of the analysis using the days of Yolo Bypass inundation method indicate that the Plan would increase entrainment. Both methods account for splittail abundance in analyzing the effect of the Plan on entrainment so as to account for the very large effect of abundance on total entrainment. The Delta inflow method uses inflow as a proxy for splittail abundance, based on the observed correlation between historical inflow and salvage density (Appendix 5.B, Section B.3.4.5.1), while the days of inundation method uses days of

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Yolo Bypass inundation as a proxy for abundance, based on the observed correlation between days of inundation and salvage density (Appendix 5.B, Section B.3.4.5.2). The Plan is expected to have a much smaller effect on Delta inflow than on days of Yolo Bypass inundation. Consequently, estimates of entrainment are more directly related to exports when using the inflow method than when using the days of inundation method. As discussed in Appendix 5.B (Section B.4.1.7.1), as a result of this difference, the inflow method more closely estimates per capita entrainment, whereas the days of inundation method more closely estimates total entrainment.

As shown by the results of the two methods for estimating entrainment (Appendix 5.B, Section B.4.1.7.1), the Plan is expected to result in a substantial increase in total entrainment of juvenile splittail at the south Delta facilities, but the increase is entirely due to the expected increase in YOY abundance because of increased floodplain habitat (Appendix 5.B, Section B.4.1.7.1). The per capita rate of entrainment, which better represents entrainment as a proportion of the population, is expected to decline about 40% for juvenile splittail and about 65% for adults. Entrainment of splittail at the screened new north Delta intakes is expected to be negligible. Based on these results, the Plan is considered to have a moderately low beneficial effect (score = 2) on entrainment of juvenile splittail and a moderately high beneficial effect (score = 3) on adult entrainment (Table 5.5-24). The certainty scores are moderately high (score = 3) for both life stages.

The BDCP conservation strategy is expected to result in a substantial reduction in wet year (per capita) entrainment losses because diversions at the SWP and CVP facilities will be greatly reduced and little entrainment of splittail at the screened new north Delta intakes and other diversions is expected. A reduction of entrainment in wet years is not expected to significantly affect population abundance because production of the YOY in wet years is so high that even the large entrainment losses have little effect on total abundance. A large reduction in dry year entrainment, when YOY abundance is low, likely would benefit the population, but as noted, numbers entrained in dry years are low under existing conditions. However, reduced entrainment in wet years potentially would result in increased spawning stock, especially because Plan habitat restoration measures are expected to increase availability of rearing and foraging habitat for juveniles and adults, as previously discussed.

Plan conservation measures may lower predation of juvenile and adult splittail to a small extent although the magnitude of this benefit is uncertain.

The importance of predation to splittail is unclear because almost nothing is known of predation rates. Nobriga and Feyrer (2007) found only three splittail in the stomachs of 1,172 predators in surveys in the Delta conducted March through October 2001 and 2003, but this low rate may have resulted from low local abundance of splittail or habitat conditions that reduced splittail predation risk. For this effects analysis it is assumed that predation on splittail is of low (score = 1) or moderately low importance (score = 2) (Table 5.5-23), with low certainty (score = 1 or 2).

The Plan may have several effects on predation. Habitat restoration measures potentially would affect predation on splittail, but the effect is highly uncertain. Changes in water operations under CM1 are expected to result in a lower proportion of the splittail population being entrained at the south Delta export facilities, which in turn would reduce exposure to predation, particularly in the CCF (such losses are captured within the calculations of changes in entrainment loss discussed above). In contrast, the north Delta intakes potentially would result in added predation pressure. The striped bass bioenergetics model for predation on juvenile salmon was used, with modifications, to estimate effects on YOY splittail at the north Delta intakes. The model estimated a

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large number of splittail consumed by striped bass, but the level of predation relative to the size of the splittail population, i.e., the per capita rate of predation, is unknown, so the effect on the splittail population could not be determined. The Plan would reduce flow in the lower Sacramento River below the new intakes, which is expected to result in increased predation on emigrating YOY splittail. CM2 potentially would minimize the proportion of splittail subjected to predation at the north Delta intakes. Most of the splittail produced on the Yolo Bypass, the most important spawning habitat of splittail (Feyrer et al. 2006), migrate downstream via the Cache Slough area and enter the Sacramento River downstream of the north Delta intake locations. As a result, these fish would not be exposed to predators inhabiting the intake structures. Assuming CM2 resulted, as expected, in an increased proportion of the splittail population being produced on the Yolo Bypass, exposure to predation at the intake would be minimal. *CM15 Predation Control* may reduce predation pressure at key locations such as during the south Delta salvage process (e.g., by predator capture, by increasing numbers of release sites) (Appendix 5.F, Section F.3.4.5). It is concluded that the Plan would lead to a small reduction in predation of juvenile and adult splittail (scores = 1), with low certainty (scores = 1) (Table 5.5-24).

5.5.4.2 Adverse Effects

Increased exposure of splittail to contaminants may occur following habitat restoration and enhancement under the Plan; exposure to some contaminants may decrease later in the Plan term because of reduced agricultural production.

Contaminants that potentially affect the splittail population include methylmercury, pyrethroids, and selenium, but little is known about their effects under current conditions. Some aspects of splittail biology put them at increased risk of exposure to contaminants, and other aspects put them at reduced risk. Aspects that increase risk include their relatively long lives, leading to greater bioaccumulation, and their benthic feeding habitats, which bring them into contact with potentially contaminated sediments and prey. On the other hand, all life stages of splittail feed at a relatively low trophic level, so biomagnification is likely not as important for splittail as for many other fish species. Major spawning and rearing areas for splittail, such as the Yolo Bypass and Cache Slough, occur in areas of high methylmercury concentrations. Spawning often occurs on inundated agricultural fields treated with pesticides (Teh et al. 2005). Selenium is found at high concentrations in *Corbula* living in Suisun Bay and Suisun Marsh, where the clams are an important prey item of splittail, and has produced documented toxic effect in splittail (Stewart et al. 2004). Maternal transfer of selenium by spawning females adversely affects the embryo stage, which is especially susceptible to selenium toxicity. Larvae on the Yolo Bypass are especially vulnerable to methylmercury because of high levels of mercury loading. Because larvae consume potentially contaminated prey organisms, they are more susceptible to methylmercury poisoning than the embryos (Alvarez et al. 2006). Henery and coauthors (2010) compared methylmercury in Chinook salmon confined in the Yolo Bypass with those from the Sacramento River and found that the fish that reared in the Yolo Bypass accumulated 3.2% more methylmercury than fish held in the nearby Sacramento River. However, only two of the 199 salmon sampled had tissue concentrations that exceeded the whole-body threshold level for potentially important sublethal effects. Reduced survival of splittail larvae on the Yolo Bypass as a result of contaminant exposure potentially would result in reduced abundance of the splittail population and a lower spawning stock. A lower spawning stock potentially reduces genetic diversity and increases the vulnerability of the population to environmental stressors. For this effects analysis, contaminants were assigned an

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importance score of 2 for larvae, 1 for eggs and juveniles, and 0 for adults (Table 5.5-23). Certainty scores were low (score = 1) for all life stages.

Habitat restoration and enhancement measures of the Plan, especially CM4 and CM2, have the potential to increase exposure of splittail to contaminants. Restoration activities likely will mobilize contaminants, especially methylmercury, but any such effect should be localized, short-lived, and of low magnitude (Appendix 5.D, Section D.1). Restoration and enhancement also could affect the average exposure of splittail to contaminants by altering the spatial distribution of the population. CM2 and CM4 are likely to increase the proportion of the splittail population using the Yolo Bypass and Cache Slough, both of which have relatively high levels of methylmercury in sediments, and thereby increasing the average exposure of the population to this contaminant. *CM12 Methylmercury Management* would help minimize potential negative effects. The Plan is not expected to increase levels of selenium in splittail because concentrations are not expected to increase in major foraging areas of adult splittail, such as Suisun Bay (Appendix 5.D, Section D.6.2.2). Analyses presented in Appendix 5.D, *Contaminants*, suggest that there is a low potential for increased contaminant exposure from the Plan and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. For the purposes of this effects analysis, it is assumed that the Plan would have low effects on exposure of splittail to contaminants (score = -1 for eggs and larvae and score = 0 for juveniles and adults) (Table 5.5-24), with moderately low certainty (score = 2).

In-water construction and maintenance effects of the Plan could affect splittail but would be minimized with CM 22 and other standard measures.

In-water construction activities at the proposed north Delta intakes (CM1) would be limited to one construction season during the months of June–October (Appendix 5.H). Generally, most splittail have emigrated well downstream of the construction area by this time (Appendix 2.A). Any splittail remaining in the area could experience adverse effects from underwater sound (pile driving), entrapment in enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment and suspension of toxic materials), and accidental spills. Habitat would be temporarily and permanently affected by intake construction, although habitat at the intake sites is generally of low quality (steep-sloping, revetted banks). Maintenance dredging may decrease water quality temporarily. Habitat restoration activities associated with CM4–CM7 temporarily may cause reduced water quality in the immediate area of disturbance and could affect splittail because the activities would occur within the species' main distribution. Breaching levees to create tidal habitat may reduce areas of channel margin, but there would be considerable gains of habitat caused by the breaching. In-water activities associated with *CM14 Stockton Deepwater Ship Channel Dissolved Oxygen Levels, CM15 Predator Control, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* would have little to no effect on splittail because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* would reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on splittail. It is concluded that construction and maintenance associated with the Plan represent a minor adverse effect on splittail, with high certainty.

5.5.4.3 Impact of Take on Species

The BDCP conservation strategy is expected to result in take of splittail from continued entrainment at the CVP and SWP south Delta facilities and as a result of construction activities. Construction and maintenance at the proposed north Delta intakes, restoration sites, conservation hatcheries, and

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nonphysical barriers may result in a number of adverse effects on splittail, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil and elevated turbidity levels (see Appendix 5.H, *Aquatic Construction Effects*). These actions, however, would have temporary effects unlikely to adversely affect splittail because the population is mostly well downstream of the area where the main in-water activities (construction of north Delta diversion facilities) would be located during the time of year the construction would occur. Avoidance and minimization measures are expected to further reduce or eliminate any such take (Appendix 5.H). Take from these construction and enhancement activities therefore would be minimal.

Historically, take levels of splittail at the south Delta pumping facilities have been related to abundance. Entrainment has been high in wet years because of high production of young splittail on inundated floodplains, such as the Yolo Bypass. Once the north Delta intake facilities begin operating, take, as a proportion of the splittail population, is expected to decline substantially because diversions at the south Delta facilities will be much reduced and entrainment at the north Delta intakes is expected to be negligible because of the state-of-the-art fish screen facilities. The Plan could increase the total take numbers for splittail if the abundance of splittail throughout the Delta increased to the point that many more splittail were put at risk of entrainment in the south Delta. Take levels relative to the size of the splittail population, however, would be reduced, and therefore the effect of the take on the population would be reduced. It is anticipated that decreases in entrainment at the south Delta export facilities, NBA Barker Slough pumping plant, and at numerous agricultural diversions that would be decommissioned areas as a result of the Plan would more than offset any entrainment and impingement at the proposed north Delta diversion facilities.

5.5.4.4 Abundance

A number of studies have concluded that splittail abundance is determined largely by the availability of inundated floodplain habitat, which adult splittail use for spawning and larvae and young juveniles use for rearing (Sommer et al. 1997, 2007; Moyle et al. 2004; Feyrer et al. 2006). Abundance of YOY splittail is almost always high in years of extensive and prolonged floodplain inundation. Inundation of the Yolo Bypass, the largest floodplain in the Central Valley, is especially effective at providing habitat for splittail (Sommer et al. 1997; Feyrer et al. 2006). CM2 would increase the frequency, duration, and surface area of Yolo Bypass inundation, resulting in substantial increases in habitat availability. These increases are especially high (on a percentage basis) in dry years (see Section 5.5.4.1 above). Consequently, the Plan is expected to have the largest effect on splittail YOY abundance during dry years, when YOY abundance is very low under current conditions. Some uncertainty exists regarding the level of flow from the bypass that is sufficient to trigger spawning migration by the splittail adults (Harrell and Sommer 2003), but the BDCP conservation strategy includes monitoring, research, and adaptive management to identify refinements in operations to further increase spawning habitat availability. All other effects of the Plan on the splittail population are expected to be secondary to the effect of CM2. CM5 will add 10,000 acres of new floodplain habitat in the south Delta in the late long-term, but because the new habitat will be inundated only in large storm events, when spawning habitat is currently highly available, and this addition is small relative to existing habitat on the Sacramento River, the effect on population abundance from CM 5 is expected to be minor (Appendix 5.E, Section E.4.3).

CM4 and CM6 would increase availability of tidal wetland and channel margin habitat. Because the abundance of splittail year classes is determined largely by the availability of inundated floodplain habitat for spawning and rearing, availability of tidal wetland and channel margin habitat has little

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effect on population abundance in most years. However, if these habitats become limiting, as may occur following the production of a large year class in a wet year, increasing their availability potentially would improve growth and survival of older juveniles and adults, ultimately resulting in a greater abundance of adult fish.

5.5.4.5 Life History Diversity

The Sacramento splittail population is known to exhibit life history diversity in the timing and location of spawning habitat and habitat for rearing of young juveniles. The main factors that affect the timing of spawning include annual variations in hydrology and water temperature (Feyrer et al. 2006). The location of spawning and rearing habitat is determined largely by hydrology and the availability of inundated floodplain habitat. However, such potentially important life history variations as the upstream migration of juvenile splittail for overwinter rearing in river margin habitats (Appendix 2.A) and suspected spawning in tidal wetlands are less well understood (Moyle et al. 2004; Feyrer et al. 2005).

Habitat measures that expand the geographic distribution of the splittail habitats, including CM4, CM5, and CM6, are expected to increase habitat and biological diversity, including a potential increase in life history diversity. Habitat conditions can be expected to vary over any geographic range in response to varying environmental conditions. Thus, by providing habitat over an extended geographic range, the chances of providing suitable habitat conditions for splittail are increased, and providing greater diversity in habitat conditions can be expected to result in greater biological diversity, including greater life history diversity.

5.5.4.6 Productivity

The Plan offers the potential to increase productivity of the splittail population principally by increasing food supply within and outside of the Yolo Bypass and restored tidal wetland areas. Reducing entrainment by implementation of dual conveyance could contribute to increased productivity of the juvenile and adult stages as well. However, potential increases in exposure to contaminants and reduced food resources as a result of increased competition from invasive clams potentially would reduce growth and survival, although such reductions likely would be minor.

5.5.4.7 Spatial Diversity

The BDCP conservation strategy is expected to increase the spatial and temporal diversity of the splittail population by expanding the array of suitable habitat areas. CM4, CM5, and CM6 would greatly expand the geographic range of suitable spawning, rearing, and migration habitat for splittail in the Delta and Suisun Marsh. Habitat measures that expand the geographic distribution of the splittail habitats are expected to increase habitat diversity resulting in greater biological, and life history diversity and thereby increase the ability of the population to withstand environmental stress factors. Habitat conditions vary over any geographic range, in response to varying environmental conditions. Thus, providing habitat over an extended geographic range increases the chances of providing suitable habitat conditions for splittail, and providing greater diversity in habitat conditions can be expected to result in greater biological diversity. Increasing spatial diversity of habitats also potentially would reduce the risk of catastrophic loss from environmental stress factors, including new species introductions, major water quality degradation, and drought.

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The increased spatial diversity of habitats that would result from the Plan would include location-specific benefits. Each of the channel margin enhancement locations proposed in CM6 provides benefits for splittail associated with a major spawning area. The proposed enhancements on the Sacramento River and Sutter and Steamboat Sloughs would benefit splittail migrating to and from the Sacramento River, including the Sutter Bypass spawning area. The proposed enhancements on the Mokelumne River would benefit splittail from the Cosumnes River floodplain, and the proposed enhancements on the San Joaquin River would benefit splittail from the San Joaquin River floodplain. No channel margin habitat restoration is proposed for locations downstream of the Yolo Bypass/Cache Slough complex, which is the most important splittail production region in the valley. However, this region is relatively close to Suisun Bay and Marsh, the ultimate destination for most of the emigrating YOY splittail.

Restoration in the South Delta ROA also potentially would provide location-specific benefits. The ROA would be located between upstream spawning and rearing habitat areas in the San Joaquin River and the major splittail habitat downstream in Suisun Marsh.

5.5.4.8 Net Effects

Sacramento splittail abundance has been highly variable, which has produced inconsistent findings concerning its regulatory status. As described above, the species was listed as threatened in 1999 (U.S. Fish and Wildlife Service 1999) following a sharp decline in YOY abundance during a 6-year drought (Sommer et al. 2007), but the listing was remanded in 2003 after the population rebounded in response to a series of wet years (U.S. Fish and Wildlife Service 2003). The variability in abundance of the splittail population stems from the strong effect of hydrologic variability on YOY production. Wet years with high river flow and extensive floodplain inundation produce large splittail year classes, while dry years produce much smaller year classes. The abundance of splittail populations is determined largely by the availability of inundated floodplain habitat, which is used for spawning and rearing of larvae and young juveniles.

Splittail are well-adapted to take advantage of the highly variable availability of inundated floodplain habitat that is characteristic of the Central Valley. They are long-lived (5–8 years) (Moyle et al. 2004), highly fecund (up to 100,000 eggs per female (U.S. Fish and Wildlife Service 2010) and able to spawn in more than one year, which allows the population to withstand periods of drought and then rebound quickly when inundated floodplain habitat becomes available in a wet year. Because of their longevity, splittail can withstand normal droughts, but a severe drought of more than about 7 years potentially would threaten the species' survival (U.S. Fish and Wildlife Service 2010). The risk of such a severe drought may increase with climate change.

The BDCP conservation strategy is expected to have a positive effect on the abundance, productivity, and diversity of splittail populations and to reduce the risks to its survival. As a result of CM2, the most important benefit to splittail will be to increase the frequency, duration, and surface area of inundated floodplain habitat on the Yolo Bypass, especially in dry years (Appendix 5.C, Section C.6.4.1.1). This benefit is expected to increase population abundance and reduce the risk to the population of an extended drought. Although the level of flow needed to stimulate spawning migrations is unknown, this uncertainty will be reduced through the adaptive management process. BDCP conservation measures CM4 and CM6 will increase availability of tidal wetland and channel margin habitat, respectively, and potentially further increase the availability of dry-year spawning and rearing habitat (Appendix 5.E, Sections E.2.3.3, E.2.4.3, and E.6.4.4.1). However, the degree to which splittail spawn in such habitats in the Delta is uncertain. The habitat measures likely will

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benefit splittail foodweb resources, thereby adding to the benefits of the increased habitat availability (Appendix 5.E, Section E.6.2.3.3).

CM4, CM5, and CM6 will increase the geographic distribution of splittail habitat, which is expected to result in increased habitat diversity and ultimately in greater biological diversity of the population. CM4 and CM6 also will increase total habitat availability for older juvenile and adult splittail and their foodweb resources, as well as increase the geographic distribution of habitat (Appendix 5.E, Section 5.4.8.3.7). The greater habitat availability is expected to increase numbers of spawning adults, especially following wet years, when high YOY production potentially results in a limited availability of rearing and foraging habitat for the juveniles and adults. Enlarging the spawning stock potentially would increase biological diversity and enhance the population's capacity to withstand environmental stress factors. These potential benefits of the Plan may be reduced if nonnative competitors and predators colonize the new habitats in large numbers, but the Plan includes conservation measures to control SAV and predation in the ROAs. Additionally, the BDCP Adaptive Management and Monitoring and Research Programs will be used to minimize these adverse effects.

The BDCP conservation strategy will greatly reduce per capita entrainment of splittail from reduced diversions at the CVP and SWP facilities. This reduction is unlikely to affect overall abundance of splittail populations, as demonstrated by the lack of correlation between entrainment and abundance of splittail (Sommer et al. 1997; Moyle et al. 2004). However, reduced diversions potentially would result in an enlarged spawning stock, especially if BDCP habitat restoration measures increased availability of rearing and foraging habitat for juveniles and adults. As previously discussed, an enlarged spawning stock potentially would increase the population's genetic diversity.

The Plan is expected to result in a small increase in the existing stress on splittail from exposure to methylmercury, which could reduce abundance of the population and a lower spawning stock. Methylmercury is not believed to affect splittail at the population level (U.S. Fish and Wildlife Service 2010), and the likelihood of adverse effects resulting from the Plan is low.

The net change in predation on the splittail population resulting from the Plan conservation measures and covered activities that create and remove predator habitat is highly uncertain.

In conclusion, the overall effect of the BDCP conservation strategy on splittail would be to increase the abundance, productivity, and diversity of the species and improve the species' chances for survival. The Plan adequately mitigates the impacts of the covered activities and contributes to recovery of the species.

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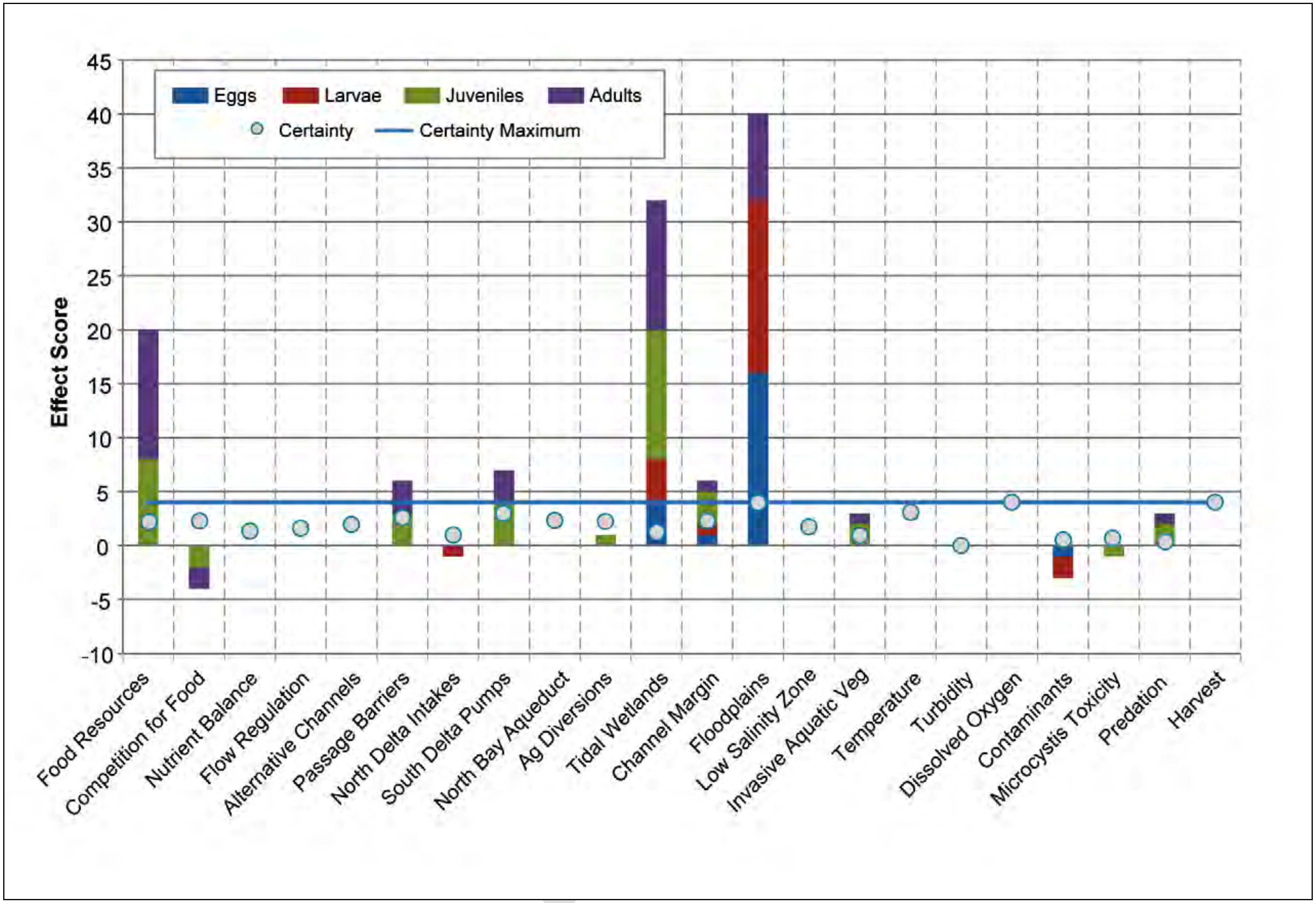

Figure 5.5-7. Effect of the BDCP Conservation Strategy on Sacramento Splittail

5.5.5 White and Green Sturgeon

White and green sturgeon are long-lived species that use the San Francisco estuary as a migration corridor, feeding area, and juvenile rearing area. Individuals have been observed throughout the Plan Area, including Suisun Bay and the Yolo Bypass. The abundance of white sturgeon in the Central Valley has declined from an estimated 114,000 adults in 1994 to 10,000 adults in 2005 (Bland 2006). DFG (2002) estimated that green sturgeon abundance in the Bay-Delta estuary ranged from 175 to more than 8,000 adults between 1954 and 2001 with an annual average of 1,509 adults. White sturgeon spawn in the Sacramento, Feather, and San Joaquin Rivers, and possibly the Stanislaus River, during late winter and spring (February through May). Green sturgeon spawn in the Sacramento River and the Feather River during January through May. Individuals from both species spend the majority of their lives in brackish portions of the estuary in deep water, although a small number of individuals dwell in the ocean (Moyle 2002; Surface Water Resources, Inc. 2004; Welch et al. 2006).

There are several stressors on white and green sturgeon at each life stage. Water temperature is considered important and potentially limiting for all life stages of white sturgeon (Israel et al. 2009) and green sturgeon (Israel and Klimley 2008). Elevated water temperatures can reduce the suitability of spawning habitat and white sturgeon egg and embryo development and survival.

Spring flows in wetter years may be the single most significant factor for white sturgeon year class strength (Kohlhorst et al. 1991; Fish 2010). Although the mechanism is unknown, it is hypothesized that higher flows may help disperse young sturgeon downstream, provide increased freshwater rearing habitat, increase spawning activity cued by higher upstream flows, increase nutrient loading into nursing areas, or increase downstream migration rate and survival through reduced exposure time to predators (Anadromous Fish Restoration Program 1995; Israel pers. comm.). As for white sturgeon, Sacramento River outflow in wetter years may be the single most significant factor for a successful green sturgeon year class.

Entrainment of juvenile white and green sturgeon upstream and throughout the Delta has the potential to reduce their local abundance. Entrainment of juvenile sturgeon in agricultural diversions is considered extremely low and is not a limiting factor on the population. Entrainment of juvenile sturgeon at the south Delta pumping facilities, however, is considered an important stressor for this life stage.

Although the bioavailability of toxics in the Delta region may influence individuals within the sturgeon population, relative to other factors (e.g., spring outflow), their effect does not appear to limit the population size or structure. The most significant effects of toxins on sturgeon stem from their accumulation in adults (primarily maternal body burden), which is then transferred to the eggs. At sufficient levels, toxins can result in the deformation and mortality of eggs, embryos, and larvae (Kroll and Doroshov 1991). Increases in metal levels in benthic food resources (Presser and Luoma 2000) likely will elevate concentration in juvenile, subadult, and adult sturgeon tissue.

DO is important for sturgeon occurrence and habitat use throughout Bay-Delta habitats. Juvenile white and green sturgeon occur year-round within some portion of all subregions analyzed for DO conditions. Depressed levels of DO (<5 mg/L) can lead to increased stress levels, reduction in temperature tolerance, decreased feeding activity, and elevated mortality in sturgeon (Crocker and Cech 1997; Secor and Nkilitschek 2001; Israel and Klimley 2008; Israel et al. 2009).

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Historical reclamation of wetlands and islands has reduced and degraded suitable in- and off-channel rearing habitat for white and green sturgeon. Furthermore, the channelization and hardening of levees with riprap has reduced in- and off-channel intertidal and subtidal rearing habitat as well as seasonal inundation of floodplains. The reclamation, channelization, and riprapping of Delta marshes and waterways likely has reduced primary food sources for juvenile and adult sturgeon, including benthic organisms such as clams and shrimp.

Upstream migration barriers for adult sturgeon in the Plan Area include Fremont Weir and the DCC on the Sacramento River, and the Stockton Deep Water Ship Channel in the San Joaquin River. The Fremont Weir acts as a barrier for adults that enter the Yolo Bypass during bypass inundation. DCC gate closures occur during the winter and early spring months during sturgeon migration. Gate closures completely block juvenile and adult sturgeon migration. When the gates are open, Sacramento River water flows into the central Delta providing migration cues. It is likely that attraction to flows passing into the central Delta from the Sacramento River causes migration delays and straying of sturgeon, as it does to Chinook salmon (CALFED Science Program 2001; McLaughlin and McLain 2004).

Harvest of white sturgeon is thought to have a substantial adverse effect on the local population (Beamesderfer et al. 2007), particularly through the illegal harvest of gravid females (Schwall pers. comm.). Likewise, illegal harvest is thought to have a substantial adverse effect on the local population of green sturgeon (Israel and Klimley 2008). Because of the long-lived, late-maturing life history and low population estimates, both white and green sturgeon are particularly susceptible to threats from overfishing (Musick 1999; Israel and Klimley 2008; Israel et al. 2009).

5.5.5.1 Beneficial Effects

***CM17 Illegal Harvest Reduction* is expected to reduce poaching pressure on white and green sturgeon and reduce mortality of reproductive adults.**

Implementation of *CM17 Illegal Harvest Management* is expected to reduce poaching pressure on white and green sturgeon, which would reduce mortality of reproductive adults, especially of females, and lead to improved white sturgeon productivity (Appendix F.5). Because of the long-lived, late-maturing life history, low population estimates, and infrequent reproduction of sturgeon, the overall effect of this conservation measure is expected to have a moderate benefit for white sturgeon. Additionally, the BDCP is expected to improve passage of sturgeon at the Fremont Weir, reducing the ease with which they can be illegally harvested from this area.

The Plan is predicted to have positive effects on flow rates during white and green sturgeon egg incubation in the Feather River.

Flow rates during white sturgeon egg incubation (February through May) are expected to be 7% to 26% higher on average under the Plan in the Feather River (Appendix 5.C, Table C.5.2-103 and Table C.5.2-104).

Flow rates under the Plan during the green sturgeon egg incubation period (March through August) are predicted to be 4% to 24% greater than under existing conditions, although flows are predicted to be 23% to 34% lower in July and August. Overall, benefits to green sturgeon eggs as a result of increased March through June flows are expected to at least offset the adverse effects of reduced July and August flows.

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***CM2 Yolo Bypass Fisheries Enhancements* will substantially improve passage for white and green sturgeon and *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* will improve passage for white sturgeon with smaller benefits to green sturgeon.**

CM2 Yolo Bypass Fisheries Enhancements includes a number of actions to reduce fish passage impediments in the Yolo Bypass, including the addition of sturgeon ramps in the vicinity of the Fremont Weir (Appendix 5.C, Section C.5.3). The proposed revisions to the operations of the DCC would direct more water originating in the Sacramento River toward San Francisco Bay and not toward the south Delta where entrainment risk is higher. As a result, it is presumed that pre-spawn adult sturgeon would be better able to detect the origin of upstream cues under the Plan. This measure also is expected to facilitate downstream migration of white sturgeon toward the estuarine and marine habitats of Suisun and Grizzly Bays rather than toward the inner Delta, including the CCF. Improving the design of the Fremont Weir (CM2) would reduce poaching of sturgeon stranded in the stilling basin below the weir after water recedes.

Under *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels,* the Plan would increase DO concentrations and improve the habitat conditions for immigrating adults and emigrating juveniles in the Stockton Deep Water Ship Channel (Appendix 5.C, Section C.5.3). The continued and potentially expanded use of oxygen aerators under the Plan is expected to reduce the number of DO violations, resulting in a decreased migration barrier and potential increase in migratory movements of juvenile and adult sturgeon using this region. It is uncertain whether this localized benefit would be sufficient to result in a beneficial effect at the population level. Because their presence in the San Joaquin watershed is believed to be minor, green sturgeon will benefit less from CM14 than white sturgeon.

Habitat restoration may provide habitat and food benefits to juvenile and adult white and green sturgeon, although there is high uncertainty in this assertion.

Tidal habitat restoration under CM 4 may create permanent year-round rearing habitat for juvenile white and green sturgeon, although there is low certainty in this assertion (Appendix 5.E). Tidal habitat restoration is expected to produce food and export food that may indirectly benefit sturgeon in the form of increased epibenthic organisms such as amphipods, mysids, bay shrimp, and bivalves, including the introduced clams, *Corbula* and *Corbicula*. Further, sturgeon are expected to benefit from the transfer of increased production in restored marshes to benthic mudflat prey species. These benefits are likely to vary among ROAs because of differences in substrate types and available food preferences. *CM5 Seasonally Inundated Floodplain Restoration* may provide a small benefit to sturgeon in the form of habitat and food benefits. *CM7 Riparian Natural Community Restoration* may provide an incremental food benefit to sturgeon through insect drop.

Although little is known about the use of channel margin habitat by white and green sturgeon, the DRERIP evaluations reported that there may be some rearing benefit from channel margin enhancement under CM 6. Channel margin enhancement may increase the availability and quality of resting habitat for migrating adults by increasing channel margin complexity (e.g., woody material) that provides refuge from high flows. However, the benefits of this increased resting habitat are uncertain because of a lack of research on this topic in adult anadromous fishes.

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***CM2 Yolo Bypass Fisheries Enhancement* is predicted to provide food downstream in the Delta because of increased flooding frequency and duration.**

Increased flooding in the Yolo Bypass will increase the frequency and magnitude of export of dissolved organic matter (DOM), particulate organic matter (POM), and microorganisms from the bypass to provide food downstream in the Delta for delta smelt, longfin smelt, Chinook salmon, steelhead, splittail, and green and white sturgeon.

***CM15 Predator Control* is expected to provide modest benefits to white and green sturgeon while these species are within vulnerable size ranges.**

There may be some modest benefit to white and green sturgeon through predator control, at least while these species are within a size range vulnerable to predation risk. Their risk is expected to diminish as they grow beyond the optimal prey size for piscivorous fish in the Delta.

Entrainment of white and green sturgeon at south Delta pumps under the Plan will be substantially reduced in wetter water years and moderately reduced in drier water years. The negligible reductions in entrainment in agricultural diversions are not expected to affect sturgeon.

Juvenile sturgeon entrainment risk is expected to be substantially reduced under the Plan as a result of reductions in exports at south Delta pumps (Appendix 5.B). The greatest reductions in entrainment of white (42% to 45% annual average difference) and green (56% to 58% annual average difference) sturgeon would occur in wetter water years (wet and above normal), although moderate reductions in entrainment (white, 12% to 13% annual average difference; green, 7% to 10% annual average difference) are predicted in drier water years (below normal, dry, and critical) (Appendix 5.B, Figure B-78 through Figure B-85 and Table B-232 through Table B-239). Entrainment of sturgeon in agricultural diversions is so rare under existing conditions that reductions in the number of diversions due to changed land use under the Plan are not expected to affect sturgeon entrainment. In the north Delta, very little entrainment and impingement of sturgeon eggs, larvae, and juveniles is expected to occur, although state-of-the-art fish screens and low approach velocities would further minimize the risk for entrainment and impingement.

***CM13 Invasive Aquatic Vegetation Control* is predicted to improve the quality and quantity of habitat for important prey resources for white and green sturgeon.**

CM13 Invasive Aquatic Vegetation Control is designed to control nonnative submerged aquatic vegetation (SAV) and floating aquatic vegetation (FAV) (which degrade habitat for covered species and enhance habitat for invasive species) in subtidal habitats restored under BDCP tidal habitat restoration actions (Appendix 5.F). The control of SAV and FAV and the restoration of native aquatic plant communities in treated areas are expected to increase the quantity and quality of habitat suitable for some prey resources (such as crustaceans, annelids, bivalves, fish, and midges) important to white and green sturgeon.

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5.5.5.2 Adverse Effects

The Plan would reduce April and May Delta outflow, which has been correlated with year class strength of white sturgeon, in some water year types. However, the Plan would maintain upstream spring flows in the Sacramento River, which has been correlated with recruitment of a given year class.

The reproductive success of white sturgeon is greatest in wet and above normal water years when spring flows are high (Kohlhorst et al. 1991; Fish 2010). There are 0% to 42% reductions in the ability of the Plan to meet Anadromous Fish Restoration Program (AFRP) Delta outflow thresholds for green and white sturgeon (Appendix 5.C, Table C.5.3-127). Because historical Delta outflow is highly correlated with Delta inflow and not correlated with exports, the mechanism driving the relationship between Delta outflow and year class strength correlation may be caused by upstream flows or Delta outflow, but there is insufficient evidence to discern the actual cause or causes.

February through May flow targets in the Sacramento River at Wilkins Slough and Verona also established by the AFRP were unaffected by the Plan (Appendix 5.C, Table C.5.3-125 and Table C.5.3-126), suggesting that patterns in year class recruitment would be unchanged.

Taken together, these two findings suggest that there may be a small adverse effect on white sturgeon year class strength.

Average transport or migration flows for white sturgeon juveniles and green sturgeon larvae and juveniles in the Sacramento and Feather Rivers are predicted to be lower under the Plan. Flows in the San Joaquin River are not expected to be affected by the Plan.

Average instream flows during the white sturgeon juvenile migration period (June through September) are expected mostly to decline in the Sacramento and Feather Rivers under the Plan (Appendix 5.C, Section C.5.3). Average monthly flows during July through September are predicted to be 17% to 37% lower than existing conditions in the Sacramento River and 23% to 52% lower in the Feather River, although there is high variability among water-year types around these monthly averages. Average June flows, however, are predicted to be 14% greater under the Plan in the Sacramento River and 20% to 24% higher in the Feather River.

Average instream flows during the green sturgeon larval transport (August through October) and juvenile migration (August through June) periods are expected mostly to decline in the Sacramento and Feather Rivers under the Plan (Appendix 5.C, Section C.5.3). Average flows during the larval transport period under the Plan are expected to be 4% to 69% lower than existing conditions in August and September, although flows are predicted to be 3% lower to 20% higher in October. Average flows during the juvenile migration period are expected to be generally lower during August through September and November only and predicted to be generally similar or up to 24% higher in other months (October and December through June).

5.5.5.3 Impact of Take on Species

Historical entrainment of juvenile white and green sturgeon is based on salvage. Salvage during water years 1996–2008 ranged from 12 to 805 white sturgeon and 0 to 252 green sturgeon (California Department of Fish and Game unpublished data). The effects analysis indicates that the BDCP is expected to substantially reduce average annual salvage by approximately 40 to 60%. The proposed BDCP Real Time Response Team's management of operations and adaptive management coupled with monitoring and improved entrainment risk models should allow improved avoidance

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and minimization of take at the export facilities. Should white and green sturgeon respond to BDCP conservation actions as predicted and small net increases in the population result, entrainment of juveniles at the south Delta facilities could increase, but at a proportionally lower rate relative to the population size.

Take at north Delta diversion facilities is predicted to be negligible because of the size of white and green sturgeon at the time they would be near the facilities, the very small area of influence of the diversions due to the high sweeping to approach velocity ratio, and the efficiency of the fish screens.

Take of sturgeon associated with construction of the north Delta intakes is expected to be minimal because avoidance and minimization measures (e.g., work windows, spill prevention) will eliminate nearly all take.

5.5.5.3.1 Abundance

The BDCP is expected to contribute to a small positive effect on the abundance of white and green sturgeon. There is a small benefit of reduced entrainment due to a large reduction in south Delta exports, and entrainment in the north Delta associated with new intake facilities will be minimized with state-of-the-art-screens and protective operations. Increased predation associated with the north Delta diversions will have a small adverse effect on sturgeon abundance. Habitat restoration may provide habitat and food benefits to juvenile and adult white and green sturgeon, although there is high uncertainty in this assertion. Reduced illegal harvest of white and green sturgeon will allow higher survival. Passage improvements in the Yolo Bypass under CM2 are expected to reduce trapping of adult sturgeon in the stilling basin and, consequently, reduce poaching.

5.5.5.3.2 Productivity

The small expected increases in white and green sturgeon abundance are predicted to contribute to increased production of these species. In particular, reductions in passage barriers for adults and illegal harvest of gravid females are expected to contribute directly to improving productivity of the species because the probability of successfully reaching spawning habitat is improved over existing conditions. In addition, possible improvements in food availability in the Delta due to habitat restoration are expected to increase the size and, therefore, fecundity of adult spawners. Year class strength of white sturgeon may be adversely affected by reductions in Delta outflow during spawning periods, although this relationship is uncertain, and upstream correlates of year class strength would not be affected by the Plan.

5.5.5.3.3 Life History Diversity

Improvements in passage under the Plan will improve the life history diversity of white and green sturgeon. In addition, habitat restoration may allow an increase in rearing and resting habitat for both sturgeon species.

5.5.5.3.4 Spatial Diversity

Spatial diversity of white and green sturgeon may improve within the Delta if suitable habitat is restored in areas currently thought to be unsuitable for sturgeon inhabitance, such as the south Delta ROA. Spatial diversity in spawning and rearing habitat upstream of the Delta is expected to be maintained under the Plan.

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5.5.5.4 Net Effects

White and green sturgeon face a number of stressors that may limit their abundance in the Central Valley. The Plan will affect several of these stressors but will not affect several others. The Plan is predicted to have negligible (<5% difference) effects on water temperatures during egg, larval, and juvenile presence for white sturgeon and during egg, larval, juvenile, and adult presence for green sturgeon (Appendix 5.C, Section C.5.2). The Plan is expected to have negligible effects on instream flows during larval periods for white and green sturgeon in the Sacramento, Feather, and San Joaquin Rivers (Appendix 5.C, Section C.5.2). In addition, there are no predicted effects of the Plan on water temperatures and spawning habitat during adult presence or on adult immigration flows (Appendix 5.C, Section C.5.3).

The Plan is not expected to increase effects of contaminants on white and green sturgeon, although there is low certainty in these conclusions because of a lack of understanding of contaminant dynamics and biological effects (Appendix 5.D). The increase in methylmercury production expected from habitat restoration is predicted to increase accumulation in sturgeon tissue, although still at levels lower than that required to elicit an adverse effect. Despite regular consumption of overbite clams, sturgeon are not likely to be affected by increases in selenium because of the distance from the selenium source area, the upper San Joaquin River. Localized and short-term increases in copper and pesticide (pyrethroids, organophosphate pesticides, and organochlorine pesticides) concentrations are predicted near ROAs, although these increases are not expected to result in increased effects on sturgeon because of their ephemeral and localized nature. There will be no effect of the Plan on ammonia concentration and, therefore, no effect on sturgeon.

In-Delta water temperature threshold exceedances during juvenile and adult white and green sturgeon presence would not be affected by the Plan in any ROA (Appendix 5.C, Section C.5.4.3). Threshold exceedances under the Plan are all similar to those under existing conditions. Most effects on in-Delta water temperatures are predicted to be a result of climate change.

There are no conservation measures that will affect legal harvest of white sturgeon, although harvest is an important stressor to sturgeon. Further, because there is no legal harvest of green sturgeon, there will be no effect of the Plan.

Based on the results of this analysis, the Plan is expected to provide small population-level benefits to both white and green sturgeon. The positive effects of the Plan on illegal harvest, habitat restoration, food production, passage, entrainment in the south Delta, and predation are expected to outweigh the adverse effects of the Plan on Delta outflow and transport flows because, as described above, there is uncertainty of the mechanism for the relationship between outflow and year class strength. This relationship could be driven by either outflows or upstream flows, or a combination but may change with implementation of the north Delta intakes. Results of this analysis show that outflow generally decreases, but upstream flows generally stay the same, resulting in uncertainty about whether there will be effects on year class strength. Nonetheless, the magnitude of the beneficial changes of the Plan is greater than the magnitude of adverse effects over the Plan implementation period. Therefore, the Plan is expected to avoid jeopardy and contribute to the recovery of both species through improvements in abundance, productivity, life history diversity, and spatial diversity in the Delta.

Based on the limited knowledge of sturgeon biology and ecology, there is low certainty in these conclusions. The Monitoring and Research Program and Adaptive Management Program will provide the opportunity to address this uncertainty and alter the preliminary proposal to maximize

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its long-term benefits. The Real-Time Response Team would provide the ability to respond immediately to potential threats to the species that might occur as a result of project operations, unforeseen changes in species distributions, or other factors.

5.5.6 Pacific and River Lamprey

Because very little is known about river lamprey, much of this discussion uses information about Pacific lamprey. Where known, differences are noted. Pacific lamprey spend the majority of their 9- to 12-year lifespan upstream: 5 to 7 years as eggs and rearing ammocoetes and up to 1 year as pre-spawn adults (Moyle 2002). River lamprey spend 3 to 5 years of their 6- to 7-year lifespan upstream (Moyle 2002). The remainder of their lifespan is spent in the ocean, except during the periods when they migrate upstream to spawn and downstream toward the ocean after rearing upstream. A number of stressors have been identified that affect upstream life stages of both species. Passage barriers include dams, culverts, water diversions, tidal gates (Klamath-Siskiyou Wildlands Center et al. 2003; Luzier et al. 2009). Adult lamprey have difficulty passing over ladders designed for passage of other species (Kostow 2002). Outmigrating ammocoetes and macropthalmia may have difficulty in traditional spill gates because they migrate in deeper water than salmonids (Moursund et al. 2003). Based on existing literature, passage barriers are predicted to be moderately important to lamprey with low certainty. Redd dewatering and ammocoete stranding as a result of rapid changes in streamflows (Streif 2007; Luzier et al. 2009) are predicted to be highly important with low certainty. Dredging associated with channel or screen irrigation maintenance or mining (Luzier et al. 2009) is predicted to be moderately important with low certainty. Chemical poisoning and contaminants in the silty substrate inhabited by ammocoetes (Kostow 2002; Haas and Ichikawa 2007; Bettaso and Goodman 2008) are predicted to be of minor importance with low certainty. Elevated water temperatures (higher than 22°C) lead to significant egg and ammocoete deformation and mortality (Meeuwig et al. 1999). This stressor is predicted to be highly important with low certainty. Harvest has not been well-studied but could affect a large proportion of pre-spawning and spawning adults (Luzier et al. 2009; Moyle et al. 2010). There are currently no regulations on the harvest of lamprey in California (69 FR 77158). This stressor is expected to be moderately important with low certainty. Predation of eggs and ammocoetes by birds, mammals, and other fish species (Luzier et al. 2009), particularly nonnative species, is expected to be moderately important with low certainty.

For this analysis, macropthalmia were classified as all emigrating lamprey from upstream to the ocean. Pacific and river lamprey macropthalmia migrate downstream during winter-spring, likely in association with high flow events (Moyle 2002). Downstream transport flows are a major driver of outmigrating macropthalmia (Luzier et al. 2009). This stressor is expected to be moderately important with low certainty. The duration of time that macropthalmia spend in the Delta is thought to be short (<1 month), indicating that exposure to in-Delta stressors is small relative to stressors of other life stages. Such in-Delta stressors include: (1) predation associated with structures, particularly the new north Delta intakes; (2) entrainment at North Delta Intakes and south Delta pumps and at agricultural diversions; and (3) passage barriers, including the Stockton Deep Water Ship Channel and Fremont Weir. These in-Delta stressors are predicted to be of minor importance, with low certainty, because the time migrating macropthalmia spend in the Delta is short compared to time spent upstream and in the ocean by other life stages.

Although there are no data on the amount of time that adults from the Central Valley spend in the ocean, individuals from British Columbia spend 3 to 4 years in the ocean (Moyle 2002). River

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lamprey adults are thought to spend 3 to 4 months in the ocean (Moyle 2002). There are three primary stressors on adult lamprey: ocean conditions, passage impediments, and upstream attraction flows. The most important stressor is likely ocean conditions, which may affect host/prey populations (Luzier et al. 2009), although there is low certainty in this assertion. Because the BDCP conservation strategy will not affect Pacific or river lamprey downstream of Suisun Marsh or in the Pacific Ocean, the adult life stages will be affected by the Plan only during the upstream migration period and the pre-spawning and spawning periods, both of which are thought to be much less important to the species than the ocean rearing and growth phase.

The BDCP conservation strategy would not affect upstream predation of Pacific or river lamprey eggs and ammocoetes, effects of increased temperature on egg and ammocoetes, or net adverse effects on downstream migration flows of Pacific lamprey macropthalmia.

Because upstream temperatures change little as a result of the BDCP conservation strategy, the Plan would have a minimal effect on water temperatures that would increase either the presence of nonnative fish predators or their bioenergetic demands. Therefore, this stressor would not be affected by the Plan.

The effect of the Plan on Pacific and river lamprey egg exposure to elevated water temperature is small and inconsistent in the Sacramento, Trinity, American, and Stanislaus Rivers. In the upper Feather River and all other rivers, there are small and inconsistent effects of the Plan on exposure of Pacific (Appendix 5.C, Table C.5.2-52, Table C.5.2-54, Table C.5.2-75, Table C.5.2-77) and river (Appendix 5.C, Table C.5.2-53, Table C.5.2-55, Table C.5.2-76, Table C.5.2-78) lamprey eggs to elevated water temperatures compared to existing conditions. In the lower Feather River (below Thermalito Afterbay), a moderate increase in exposure of Pacific and river lamprey eggs due to the BDCP is predicted. The effects of climate change are nearly always larger than the effects of the BDCP.

Exposure of Pacific lamprey ammocoetes to elevated upstream water temperatures due to the BDCP are predicted to vary widely among and within rivers (Appendix 5.C, Table C.6.5-60, Table C.5.2-61). The effect varies from a 0% to 27% decrease in exposure in the Sacramento River, 37% decrease to 21% increase in the Trinity River, 100% decrease to 20% increase in the Feather River, and 0% to 4% decrease in the American River, and show no change in the Stanislaus River. Likewise, effects of exposure of river lamprey ammocoetes to elevated upstream water temperatures due to the BDCP are predicted to vary widely among and within rivers (Appendix 5.C, Table C.6.5-62, Table C.5.2-63). The effect varies from a 25% decrease to 80% increase in exposure in the Sacramento River, 46% decrease to 30% increase in the Trinity River, 100% decrease to 150% increase in the Feather River, and 11% decrease to 80% increase in the American River, and show no change in the Stanislaus River. Overall, there is expected to be no net effect on Pacific or river lamprey ammocoetes attributable to exposure to elevated water temperature. The effect of climate change on water temperature is predicted to be generally larger than the effect of the BDCP.

There are no biologically meaningful changes in downstream migration flows for Pacific and river lamprey under the Plan in the Feather River (Appendix 5.C, Table C.5.3-133 through Table C.5.3-136), San Joaquin River (Appendix 5.C, Table C.5.3-9 and Table C.5.3-10), American River (Appendix 5.C, Table C.5.3-137 through Table C.5.3-140), and Stanislaus River (Appendix 5.C, Table C.5.3-141 and Table C.5.3-142), although there are small to moderate (1% to 10%) increases in downstream flows in the upper Sacramento River (Appendix 5.C, Table C.5.3-119, Table C.5.3-120). In addition, the BDCP is predicted to cause small to moderate (4% to 13%) decreases in the Sacramento River flows downstream of the diversions during macropthalmia downstream migration (Appendix 5.C,

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Table C.5.3-1 and Table C.5.3-2). Overall, there are no net adverse effects on downstream migration flows for Pacific or river lamprey macropthalmia under the Plan.

5.5.6.2 Beneficial Effects

Except in the Feather River, upstream river flows are expected to fluctuate such that they dewater redds or strand ammocoetes under the BDCP at a frequency the same as or lower than under existing conditions.

There are small to moderate reductions in the dewatering risk of Pacific and river lamprey redds predicted in the Sacramento and American Rivers due to the BDCP (Appendix 5.C, Table C.5.2-56 and Table C.5.2-57). Redd dewatering risk in the Trinity and Stanislaus Rivers is not predicted to be affected by the Plan (<5% difference). Redd dewatering risk in the Feather River is predicted to increase moderately with the Plan. The proportions of the overall Pacific and river lamprey population that are found in the Feather River are not known. The effects of climate change are nearly always larger than the effects of the Plan.

Effects of the Plan on Pacific and river lamprey ammocoete stranding are predicted to be highly variable among and within upstream rivers. Effects on Pacific lamprey are predicted to range, depending on time period, location in river, and flow reduction, from a 14% decrease to 12% increase in the Sacramento River (Appendix 5.C, Figure C.5.2-151, Figure C.5.2-153, Table C.5.2-64, Table C.5.2-66), 3% decrease to 11% increase in the Trinity River (Figure C.5.2-189, Table C.5.2-79), 18% decrease to 32% increase in the Feather River (Figure C.5.2-309, Table C.5.2-125), and 15% decrease to 11% increase in the American River (Figure C.5.2-352, Figure C.5.2-354, Table C.5.2-138, Table C.5.2-140) and show no change in the Stanislaus River (Figure C.5.2-413, Table C.5.2-154). Effects on river lamprey are predicted to range, depending on time period, location in river, and flow reduction, from a 3% decrease to 7% increase on river lamprey ammocoete stranding in the Sacramento River (Figure C.5.2-152, Figure C.5.2-154, Table C.5.2-65, Table C.5.2-67), 5% decrease to 18% increase in the Trinity River (Figure C.5.2-190, Table C.5.2-80), 32% decrease to 18% increase in the Feather River (Figure C.5.2-310, Table C.5.2-126), and 11% decrease to 24% increase in the American River (Figure C.5.2-353, Figure C.5.2-355, Table C.5.2-139, Table C.5.2-141) and show no change in the Stanislaus River (Figure C.5.2-414, Table C.5.2-155). Overall, there is expected to be no net effect on ammocoete stranding by Pacific or river lamprey in upstream rivers.

The BDCP is expected to reduce Pacific and river lamprey entrainment at south Delta export facilities and in agricultural diversions.

The BDCP is expected to reduce sources of entrainment for Pacific and river lamprey through reduction in south Delta exports (Appendix 5.B, Table B-241, Table B-242, Figure B-86) and reducing the demand of in-Delta agricultural diversions because of changed land use associated with habitat restoration conservation measures. In addition, any new entrainment at the north Delta intakes is expected to be minimized by operations and state-of-the-art fish screens.

Pacific and river lamprey macropthalmia and adult passage at the Stockton Deep Water Ship Channel and the Fremont Weir is expected to be considerably improved as a result of BDCP conservation measures.

Pacific and river lamprey passage through the Stockton Deep Water Ship Channel is expected to improve because of aeration technology (ICF International 2010) under CM14, which will largely eliminate the DO sag in the channel. Fremont Weir fish ladders that use existing lamprey passage

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technology from the lower Columbia River (e.g., Moser et al. 2002) and the newest available information (e.g., Daigle et al. 2005; Magie et al. 2007; Moser and Mesa 2009; Moser et al. 2011) are expected to allow efficient passage of lamprey adults from the Yolo Bypass to the Sacramento River (CM2). Additional sculpting of the Yolo Bypass landscape is expected to further reduce stranding of lamprey macropthalmia and adults on the floodplain.

Upstream adult attraction flows from the San Joaquin River are predicted to increase substantially in the Delta, although there is low certainty that Pacific and river lamprey adults are attracted to chemical cues.

Because the new north Delta export facilities will reduce the need to export from the south Delta, the proportion of San Joaquin River flow that composes west Delta/confluence water will increase substantially during adult immigration of Pacific lamprey (53% to 62% increase, on average) (Appendix 5.C, Table C.5.3-115), and river lamprey (300% to 584% increase, on average) (Appendix 5.C, Table C.5.3-116), potentially improving attraction flows of adult lamprey toward the San Joaquin River. In the Sacramento River, because of new north Delta export facilities, there will be small (7% to 8% reduction, on average) reductions in attraction flows during the Pacific lamprey upstream migration period and moderate (10% to 15% reduction, on average) reductions in attraction flows during the river lamprey migration period. However, there are mixed evidence and low certainty that olfactory cues drive patterns in upstream lamprey migration to specific streams and rivers (Hatch and Whiteaker 2010). Low site fidelity is further supported by the small genetic diversity of Pacific lamprey from British Columbia to California (Goodman 2006).

5.5.6.3 Adverse Effects

Predation of Pacific and river lamprey macropthalmia at the north Delta intake is expected to increase under the BDCP, although predator control will somewhat offset this increase.

Due to changes in hydrology and an increase in hiding spots for predatory fish, predation of Pacific and river lamprey macropthalmia is expected to increase as a result of north Delta intakes. Predator control will somewhat offset this increase. Predator control efforts at other hot spots in the Delta are expected to have negligibly positive effects on predation of lamprey.

5.5.6.4 Impact of Take on Species

The SWP/CVP is expected to continue to take Pacific and river lamprey individuals at south Delta export facilities. Annual historical (water years 1996–2008) take of Pacific and river lamprey combined ranged from 8 to 1,704 individuals at the SWP facility and 168 to 13,230 individuals at the CVP facility. Although there are no population estimates available to determine whether this represents a large proportion of the population, it is unlikely given the relatively large number of individuals caught in trawls that sample only a very small proportion of the water column (U.S. Fish and Wildlife Service unpublished data). Trawls between 1995 and 2010 captured an average of approximately 250 individuals per year, which represent 2 to 15% of the salvage at SWP and CVP facilities combined. This suggests that take is having a negligible effect on the overall populations of Pacific and river lamprey because trawls operate for a small portion of time in a small portion of the river. Further, the BDCP is expected to reduce take at the south Delta by approximately 50% based on reductions in south Delta exports. As populations of lamprey increase with implementation of the BDCP, it is expected that take will increase proportionally. This is expected to be offset somewhat by

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real-time operations management coupled with monitoring and improved entrainment risk models that will allow greater avoidance and minimization of take in the future.

Take at north Delta diversion facilities is predicted to be negligible because of the size at which lamprey emigrate (average length = 127 mm), the very small area of influence of the diversions due to the high sweeping to approach velocity ratio, and the efficiency of the fish screens.

Take associated with construction of the north Delta intakes is expected to be minimal because avoidance and minimization measures (e.g., work windows, spill prevention) will eliminate nearly all take.

5.5.6.4.1 Abundance (Acres of Suitable Habitat, Habitat Restoration)

The BDCP is expected to contribute to a small positive effect on the abundance of Pacific and river lamprey. There is a small benefit of reduced entrainment due to a large reduction in south Delta exports, and entrainment in the north Delta associated with new intake facilities will be minimized with state-of-the-art-screens and protective operations. Increased predation associated with the north Delta diversions will have a small adverse effect on lamprey abundance. Because Pacific and river lamprey are thought to spend very little time rearing in the Delta, habitat restoration will have a limited effect on population abundance.

5.5.6.4.2 Productivity

Productivity of Pacific and river lamprey is not expected to be affected overall by the BDCP. Small increases and decreases in water temperature and upstream spawning and rearing habitat conditions due to the BDCP are not expected to affect lamprey productivity at a population level.

5.5.6.4.3 Life History Diversity

Life history diversity of Pacific and river lamprey is expected to be maintained by the Plan. Improved passage through and increased frequency and duration of inundation in the Yolo Bypass are expected to increase lamprey use of the Yolo Bypass as a migration pathway. However, genetic diversity is currently low for Pacific lamprey, likely due to high straying and gene flow among populations that homogenize the genetics of the populations from British Columbia to the California coast (Goodman 2006). Therefore, existing genetic diversity is expected to be maintained under the Plan. Genetic diversity of river lamprey is unknown, although if similar to Pacific lamprey, it would also be maintained by the Plan. Because Pacific and river lamprey rear in the Delta for very short periods, changes in the composition and diversity of habitat types associated with habitat restoration in the Delta are expected to have minimal effects on life history diversity.

5.5.6.4.4 Spatial Diversity

Spatial structure of Pacific lamprey is complicated, and small local populations likely have been lost prior to implementation of the Plan (Moyle et al. 2010). Spatial structure of river lamprey is largely unknown, although the species is thought to spawn in all major upstream tributaries. The Plan would contribute to maintaining existing spatial structure and may improve San Joaquin River populations by improving attraction flows if Pacific and river lamprey adults use olfactory cues to navigate upstream. In addition, reduced passage impediments in the Yolo Bypass and Stockton Deep Water Ship Channel are expected to increase the spatial diversity of the overall population.

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5.5.6.5 Net Effects

Knowledge of the relative effects of different stressors on Pacific lamprey is very limited, and even less is known about river lamprey. Because of the amount of time spent upstream by Pacific and river lamprey, upstream stressors will affect upstream individuals for a longer duration than oceanic and in-Delta stressors. Likewise, stressors affecting adults in the ocean are likely to have prolonged effects on individuals relative to in-Delta stressors. However, the population-level effect of a stressor on an individual adult is much larger than the population-level effect of a stressor on an individual egg or ammocoete because an individual adult has a higher reproductive value than younger life stages. Based on this logic, existing literature, and best professional judgment, it was concluded that upstream water temperatures and ammocoete stranding are likely the most important stressors to the Pacific and river lamprey populations. In addition, Moyle and coauthors (2010) indicate that climate change is an important stressor to the species because of its predicted effect on increased water temperature and alteration of flows.

Overall, despite high uncertainty based on a deficiency of available scientific knowledge of lamprey biology and ecology, the effects analysis found that the Plan will provide a small net benefit to both Pacific and river lamprey. There are small net positive effects on Pacific lamprey eggs and ammocoetes, small positive effects on macropthalmia, and marginal positive effects on adults. There are no net effects on river lamprey eggs and ammocoetes and marginal positive effects on macropthalmia and adults. Benefits to both lamprey species are expected to be higher for individuals that spawn in the San Joaquin River watershed than for those that spawn in the Sacramento River watershed because of higher attraction flows, but the effect of flows on adult migration is highly uncertain. If monitoring during BDCP implementation indicates methods to improve conservation, conservation measures would be adaptively managed to improve conditions for both species of lamprey. The effects of climate change on upstream flows and water temperatures are expected to be mostly adverse and offset some of the predicted benefits of the Plan. Although the net benefits of the Plan to lamprey are relatively small and localized, they are in proportion to the relatively small fraction of the species' life cycle that occurs in the Delta and could be affected (negatively or positively) by BDCP covered activities. Therefore, the small net benefit of the Plan will contribute to the conservation of both species by substantially improving passage in specific locations (Fremont Weir and Stockton Deep Water Ship Channel) and by reducing entrainment in the south Delta.

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5.5.7.1 Personal Communications

Israel pers. comm.

Llaban pers. comm.

M. Nobriga pers. comm.

J. Rosenfield pers. comm.

Schwall pers. comm.

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5.6 Effects on Covered Wildlife and Plant Species

This section provides the results of the effects analysis for covered wildlife and plant species. Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*, describes the methods used for this analysis. The maximum allowable habitat loss for each species is provided in Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*, and Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*. The indirect effects related to disturbance adjacent to covered activities are quantified in Table 5.6-2a, *Indirect Effects, Wildlife*, and Table 5.6-2b, *Indirect Effects, Plants*. The net effects on modeled habitat for each species are quantified in Table 5.6-1a, *Net Effects, Wildlife*, and Table 5.6-1b, *Net Effects, Plants*. Table 5.6-4, *Covered Plant Species Occurrences, Effects, and Conservation Requirement*, quantifies the covered plant occurrences to be affected and conserved through BDCP covered activities, including conservation measures.

5.6.1 Riparian Brush Rabbit

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the riparian brush rabbit. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the riparian brush rabbit includes 38 vegetation associations within the valley/foothill riparian natural community and adjacent grasslands. The vegetation associations were selected based on a review of understory and overstory composition from Hickson and Keeler-Wolf (2007) and species habitat requirements. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of adversely affected habitat for riparian brush rabbit, to the extent information was available, included size and degree of isolation of habitat patches, proximity to recorded species occurrences, and adjacency to conserved lands.

5.6.1.1 Adverse Effects

5.6.1.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 63 acres[1] of riparian habitat (2% of riparian habitat in the Plan Area) and 175 acres of associated grassland habitat (6% of grassland habitat in the Plan Area) for the riparian brush rabbit (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in permanent habitat loss include conveyance facilities construction, tidal natural communities restoration, and floodplain restoration. The effects are described below for each covered activity.

[1]Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Conveyance Facility Construction

This activity will result in the permanent loss of approximately 5 acres of riparian habitat and 131 acres of associated grassland habitat for the riparian brush rabbit (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*) in Conservation Zone 8. The riparian habitat that will be removed is of low quality for the riparian brush rabbit: it consists of several small, isolated patches surrounded by agricultural lands northeast of Clifton Court Forebay. The associated grasslands are also of low quality for the species: they consist of long, linear strips that abut riparian habitat, but extend several miles from the riparian habitat and therefore provide few if any opportunities for adjacent cover. Trapping efforts conducted for the riparian brush rabbit in this area were negative (Endangered Species Recovery Program 2010).

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 15 acres of habitat and 18 acres of associated grassland habitat for the riparian brush rabbit (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). in the South Delta ROA in Conservation Zone 7. The riparian habitat that would be removed consists of relatively small and isolated patches along canals and irrigation ditches surrounded by agricultural lands in the Union Island and Roberts Island areas, and several small patches along the San Joaquin River. The habitat that would be removed is not adjacent to any existing conserved lands, and is several miles north and northeast of the northernmost riparian brush rabbit record located northeast of Paradise Cut (Williams et al. 2002). Although the final footprint for tidal natural communities restoration will differ from the hypothetical footprint, the measures described in Appendix 3.C, *Avoidance and Minimization Measures,* require that tidal natural communities restoration avoid removal of any habitat occupied by the riparian brush rabbit.

Floodplain Restoration

Levee construction associated with this activity will result in the permanent removal of approximately 43 acres of riparian habitat and 26 acres of associated grassland habitat for the riparian brush rabbit (Table 5.6-1a *Maximum Allowable Habitat Loss, Wildlife*). in Conservation Zone 7. The quality of this habitat for riparian brush rabbit is high: although it consists of small patches and narrow bands of riparian vegetation, these areas are in proximity to, or contiguous with, habitat with recorded occurrences of riparian brush rabbit. The hypothetical footprint for levee construction overlaps with one occurrence record for riparian brush rabbit, south of the Interstate 5/Interstate 205 interchange.

Although the final floodplain restoration design will differ from the hypothetical footprint used for this effects analysis, restoration of the river floodplain in Conservation Zone 7 will be targeted in the general area of the riparian brush rabbit population. Through monitoring and adaptive management described in Section 3.6, *Adaptive Management and Monitoring Program*, and the measures described in Appendix 3.C, *Avoidance and Minimization Measures*, the Implementation Office will ensure that riparian brush rabbit habitat permanently removed as a result of floodplain restoration does not exceed the amount estimated based on the hypothetical footprint.

5.6.1.1.2 Periodic Inundation

Floodplain restoration is the only covered activity expected to result in periodic inundation of riparian brush rabbit habitat.

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Floodplain Restoration

This activity will periodically inundate approximately 264 acres of riparian habitat (9% of riparian habitat in the Plan Area) and 423 acres of associated grassland habitat (14% of associated grassland habitat in the Plan Area) for the riparian brush rabbit. The area between existing levees that will be breached and the newly constructed setback levees will be inundated through seasonal flooding. The potentially inundated areas consist of high-quality habitat for the species: although they consist of small patches and narrow bands of riparian vegetation, many of these areas are in proximity to, or contiguous with, habitat with recorded occurrences of riparian brush rabbit.

Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian brush rabbits occupy these areas and cannot escape flood waters. One recorded occurrence of riparian brush rabbit (Williams et al. 2002), just west of Stewart Road in Mossdale, is in the area that would be seasonally flooded based on the hypothetical restoration footprint.

The adverse effects of periodic inundation on the riparian brush rabbit will be minimized through construction and maintenance of flood refugia to allow riparian brush rabbits to escape inundation, as described under Section 5.6.1.2, *Beneficial Effects*.

5.6.1.1.3 Construction-Related Effects

Construction-related effects on the riparian brush rabbit include short- and long-term temporary habitat loss as a result of grading and ground disturbance, construction-related injury or mortality, and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or the specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Grading and ground disturbance associated with conveyance facility construction, Yolo Bypass fisheries enhancement, and floodplain restoration levee construction will temporarily remove approximately 35 acres of riparian habitat (0.6% of riparian habitat in the Plan Area) and 33 acres of associated grassland habitat (0.6% of associated grassland habitat in the Plan Area) for the riparian brush rabbit. Conveyance facility construction will temporarily remove 13 acres of modeled grassland habitat for riparian brush rabbit in Conservation Zones 6 and 8, adjacent to and north of Clifton Court Forebay: this is low-quality habitat for the species based on its fragmented nature and the low likelihood that the species is present in this area. Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 35 acres of modeled habitat that is high quality based on habitat patch size and proximity to recorded occurrences in Conservation Zone 7.

Temporarily disturbed areas will be restored as riparian habitat within 1 year following completion of construction and management activities. Although the effects are considered temporary, several years may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. Most of the riparian vegetation within the species' range in the Plan Area is early to mid-successional, and this species prefers riparian scrub that is early successional; therefore, the replaced riparian vegetation is expected to meet habitat requirements for the riparian brush rabbit within the first few years after the initial restoration activities are complete.

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Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 3 acres of grassland habitat for this species (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). in Conservation Zone 8. Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown. However, the riparian brush rabbit is not likely to be present in the area of effect based on a lack of occurrences in Conservation Zone 8 and recent negative survey results (Endangered Species Recovery Program 2010).

Construction-Related Injury or Mortality

Water conveyance facility construction is not likely to result in injury or mortality of individual riparian brush rabbits because the species is not likely to be present in the areas that would be affected by this activity, based on live trapping results (Endangered Species Recovery Program 2010). Tidal natural communities restoration will not result in injury or mortality of the riparian brush rabbit because tidal natural communities restoration projects will be designed to avoid occupied riparian brush rabbit habitat (Appendix 3.C, *Avoidance and Minimization Measures*). Activities associated with construction of setback levees for floodplain restoration could result in injury or mortality of riparian brush rabbits: however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance adjacent to construction activities could temporarily affect the use of 208 acres of modeled riparian brush rabbit riparian habitat (7% of riparian habitat in the Plan Area) and 129 acres of associated grassland habitat (4% of riparian habitat in the Plan Area) (Table 5.6-2a, *Indirect Effects, Wildlife*). These construction activities will include water conveyance construction, tidal natural communities restoration construction, construction and subsequent maintenance of transmission lines, and construction of setback levees. Water conveyance construction will potentially affect 112 acres of adjacent riparian habitat and 4 acres of associated grassland habitat: this construction will occur in Conservation Zone 8, and the riparian brush rabbit is not known from this zone; therefore, the potential for adverse noise and visual effects from conveyance facility construction will be minimal. Tidal natural communities restoration construction will potentially affect 51 acres of adjacent riparian habitat and 50 acres of associated grassland habitat for this species: however, adverse effects on the species are unlikely because tidal natural communities restoration projects will be sited to avoid areas occupied by riparian brush rabbit (Appendix 3.C, *Avoidance and Minimization Measures*). The activity most likely to result in noise and visual disturbance to riparian brush rabbit is the construction of setback levees, which will take place in Conservation Zone 7, where the species is known to occur. These adverse effects will be minimized through the measures described in *Appendix 3.C, Avoidance and Minimization Measures.*

The use of mechanical equipment during construction might cause the accidental release of petroleum or other contaminants that would affect the riparian brush rabbit in adjacent habitat, if the species is present. The potential for this adverse effect will be avoided and minimized through best management practices (BMPs) described in Appendix 3.C, *Avoidance and Minimization Measures*.

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5.6.1.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Facilities operation and maintenance activities are not expected to adversely affect the riparian brush rabbit.

Habitat Enhancement and Management

Enhancement and management actions in riparian brush rabbit habitat within the reserve system may include invasive plant removal, planting and maintaining vegetation to improve and sustain habitat characteristics for the species, and creating and maintaining flood refugia. Injury or mortality of riparian brush rabbit will be avoided by these activities as described in Appendix 3.C, *Avoidance and Minimization Measures*. Although these activities may result in harassment of riparian brush rabbits through noise and visual disturbance, adverse effects will be minimal, if any.

Other Indirect Effects

The BDCP covered activities and conservation measures will have no other indirect effects on the riparian brush rabbit.

5.6.1.1.5 Impact of Take on Species

Populations of the riparian brush rabbit are known to have occurred historically in riparian forests along the San Joaquin and Stanislaus Rivers and some tributaries to the San Joaquin River (U.S. Fish and Wildlife Service 1998). One population estimate within this historical range was approximately 110,000 individuals (U.S. Fish and Wildlife Service 1998). As a result of habitat loss and fragmentation, the species has since been reduced to populations in only two areas: an approximately 258-acre patch in Caswell Memorial State Park on the Stanislaus River, immediately southwest of the Plan Area; and several small, isolated or semi-isolated patches totaling approximately 270 acres along Paradise Cut and Tom Paine Slough and channel of the San Joaquin River in the south Delta, within the Plan Area. The Plan Area consists of a large proportion of the species' total range (Figure A-15a in Appendix 2.A, *Covered Species Accounts*). Conservation within the Plan Area is therefore important to the long-term survival and recovery of this species.

There are 5,997 acres of modeled riparian brush rabbit habitat in the Plan Area, consisting of 2,894 acres of riparian habitat and 3,103 acres of associated grassland habitat. The effects on riparian brush habitat are shown in Table 5.6-3a *Net Effects, Wildlife,* and described above. Many of these effects will be in areas that are not likely to be occupied by the species (Conservation Zone 8) or will result from tidal natural communities restoration that will be designed to avoid occupied habitat. Periodic flooding is not expected to adversely affect the species because flood refugia will be constructed and maintained to allow riparian brush rabbit to escape flood waters. Effects most likely to result in take of the riparian brush rabbit are permanent habitat removal (43 acres of riparian and 26 acres of associated grassland habitat) and temporary habitat removal (35 acres of riparian and 20 acres of associated grassland habitat) as a result of levee construction for floodplain restoration.

Based on the rarity and narrow range of this species, and the large proportion of the species' range in the Plan Area, take resulting from BDCP covered activities has the potential to adversely affect the long-term survival and recovery of the species. However, the BDCP's beneficial effects on the

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species, described below, are expected to offset potential adverse effects of habitat loss and contribute to the long-term survival and recovery of the species in the Plan Area.

5.6.1.2 Beneficial Effects

The BDCP Implementation Office will restore at least 5,000 acres and protect at least 750 acres of valley/foothill riparian natural community, a portion of which is expected to consist of suitable riparian brush rabbit habitat. At least 1,000 acres of valley/foothill riparian natural community in the reserve system will be maintained as early to mid-successional vegetation with a well-developed understory of shrubs, providing the dense understory required for suitable riparian brush rabbit habitat. Fluvial processes within restored floodplains will further contribute to the maintenance of early-successional habitat suitable for the riparian brush rabbit.

Assuming the restored and protected riparian natural community will provide suitable riparian brush rabbit habitat proportional to the amount that exists within this natural community in the Plan Area, and estimated 808 acres of suitable riparian habitat will be restored and 300 acres of suitable habitat will be protected (Table 5.6-3a, *Net Effects, Wildlife*). However, to ensure that a sufficient amount of the restored and protected valley/foothill riparian natural community specifically benefits the riparian brush rabbit, the Implementation Office will protect at least 200 acres of occupied riparian brush rabbit habitat (as a component of the 750-acre protection commitment) and restore or create at least 300 acres of riparian habitat (as a component of the 5,000-acre riparian restoration/creation commitment) that meets the ecological requirements of the riparian brush rabbit . The restored habitat will be within or adjacent to existing occupied habitat, or in areas that facilitate connectivity between occupied and other suitable habitat, to facilitate species dispersal and genetic interchange between populations.

In addition to restoration and protection of riparian habitat for the riparian brush rabbit, the Implementation Office will protect, and, if necessary, create or restore grasslands adjacent to suitable riparian vegetation in upland areas that seldom flood or are outside the floodplain levees. These grasslands are expected to provide additional foraging opportunities for the riparian brush rabbit and upland refugia during flood events. The Implementation Office will also create and maintain mounds in restored and protected riparian areas that are designed specifically to provide flood refugia for riparian brush rabbit (Endangered Species Recovery Program 2010).

5.6.1.3 Net Effects

Full implementation of the BDCP will result in a minimum 651-acre (11%) increase of suitable riparian habitat for riparian brush rabbit in the Plan Area (Table 5.6-3a, *Net Effects, Wildlife*), and a minimum 1,424-acre (315%) increase in protected riparian habitat for this species. This estimate only takes into account the riparian areas that will be restored specifically for the riparian brush rabbit, and the protected riparian areas that consist of occupied habitat. Additional areas within the 5,000 acres of restored and 750 acres of protected valley/foothill riparian natural community are expected to provide suitable habitat for this species. In addition, the reserve system created will facilitate connectivity between occupied and other suitable habitat, to facilitate species dispersal and genetic interchange between populations.

The habitat that will be lost as a result of covered activities includes areas in Conservation Zones 6 and 8 that are fragmented, isolated, and unlikely to support the species, and areas in Conservation Zone 7 that provide high-quality habitat for the species. The 300 acres of restored and 200 acres of

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protected riparian brush rabbit habitat will be of a high quality, and will either be occupied or contiguous with occupied habitat, in areas that contribute to population expansion and species recovery. Restoration and protection of adjacent grasslands and creation and maintenance of upland refugia are expected to protect the species from loss of individuals that could otherwise result from seasonal flooding in restored floodplains. The BDCP is expected to result in a net benefit to riparian brush rabbit.

All the near-term loss of riparian brush rabbit habitat will result from conveyance facility construction, and this will occur in an area not likely to be occupied by the species. Habitat loss in Conservation Zone 7, in areas known or likely to be occupied, will occur during the early long-term and late long-term implementation periods. Riparian restoration will be phased to minimize temporary habitat loss (Chapter 6, *Plan Implementation*).

Overall, the BDCP will provide a substantial net benefit to the riparian brush rabbit through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the riparian brush rabbit.

5.6.2 Riparian Woodrat

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the riparian woodrat. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants,* and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model used to assess effects for the riparian woodrat consists of selected plant alliances from the valley/foothill riparian natural community, geographically constrained to the south Delta portion of the BDCP area (Conservation Zone 7), south of State Route (SR) 4 and Old River Pipeline along the Stanislaus, San Joaquin, Old, and Middle Rivers. Valley/foothill riparian areas along smaller drainages (Paradise Cut, Tom Paine Slough), and some larger streams in the northern portion of Conservation Zone 7 were excluded from the riparian woodrat habitat model due to a lack of trees or riparian corridors that were too narrow. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the riparian woodrat, to the extent that information is available, include habitat patch size and connectivity.

5.6.2.1 Adverse Effects

5.6.2.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 46 acres[2] of habitat (2% of the habitat in the Plan Area) for the riparian woodrat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in adverse effects on the riparian woodrat include tidal natural communities restoration and seasonally inundated floodplain restoration. Seasonally inundated floodplain restoration is expected to result in the majority (41 acres; 89%) of the permanent habitat loss.

[2] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 5 acres of riparian brush rabbit habitat in the South Delta ROA for the riparian woodrat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of low quality, consisting of a small, isolated patch surrounded by agricultural lands. The measures described in Appendix 3.C, *Avoidance and Minimization Measures*, require that tidal natural communities restoration avoid removal of any habitat occupied by the riparian woodrat. Because the estimates of habitat loss due to tidal inundation are based on projections of where restoration may occur, actual habitat loss is expected to be lower because sites will be selected to minimize effects on riparian woodrat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 41 acres of riparian woodrat habitat in Conservation Zone 7 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The quality of this habitat for riparian woodrat is moderate. Although the habitat consists of small patches and narrow bands of riparian vegetation and no riparian woodrats have detected in Conservation Zone 7, the riparian patches are in proximity to each other along the San Joaquin River. There are two species occurrences immediately south of Conservation Zone 7, one of which is less than 1.5 mile from the southernmost patch of riparian habitat potentially affected by levee construction.

The final floodplain restoration design will differ from the hypothetical footprint used for this effects analysis. However, through monitoring and adaptive management described in Section 3.6, *Adaptive Management and Monitoring Program*, and the measures described in Appendix 3.C, *Avoidance and Minimization Measures*, the Implementation Office will ensure that riparian brush rabbit habitat permanently removed as a result of floodplain restoration does not exceed the amount estimated based on the hypothetical footprint. Habitat loss is expected to be lower than 41 acres because sites will be selected and restoration designed to minimize effects on the riparian woodrat.

5.6.2.1.2 Periodic Inundation

Seasonal flooding as a result of floodplain restoration is the only covered activity expected to result in periodic inundation of riparian woodrat habitat.

Floodplain Restoration

Floodplain restoration will result in periodic inundation of up to 202 acres of riparian woodrat habitat (9% of the riparian woodrat habitat in the Plan Area). The area between existing levees that will be breached and the newly constructed setback levees will be inundated through seasonal flooding. The potentially inundated areas consist of moderate-quality habitat for the species. Although the habitat consists of small patches and narrow bands of riparian vegetation and no riparian woodrats have detected in Conservation Zone 7, the riparian patches are in proximity to each other along the San Joaquin River and there are two species occurrences immediately south of Conservation Zone 7, one of which is less than 1 mile from the southernmost patch of riparian habitat potentially affected by levee construction.

Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian woodrats occupy these areas and cannot escape flood waters. The adverse effects of periodic inundation on the riparian woodrat will be minimized through construction and maintenance of

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flood refugia to allow riparian brush rabbits to escape inundation, as described under Section 5.6.2.2, *Beneficial Effects*.

5.6.2.1.3 Construction-Related Effects

Construction-related effects on the riparian woodrat include long-term, temporary habitat loss as a result of grading and ground disturbance, construction-related injury or mortality, and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or the specific nature of the effect.

Temporary Habitat Loss (Long-Term)

Levee construction will temporarily remove approximately 33 acres of riparian woodrat habitat (1.5% of total habitat in the Plan Area). Temporarily disturbed areas will be restored as riparian habitat within 1 year following completion of construction and management activities. Although the effects are considered temporary, the replaced riparian vegetation will likely take over a decade to develop suitable oak overstory for the species. As described in Appendix 3.C, *Avoidance and Minimization Measures*, floodplain restoration projects in Conservation Zone 7 will be designed to minimize the removal of mature oaks in areas providing suitable habitat for the riparian woodrat.

Construction-Related Injury or Mortality

Tidal natural communities restoration will not result in injury or mortality of riparian brush rabbit because tidal natural communities restoration projects will be designed to avoid occupied riparian woodrat habitat (Appendix 3.C, *Avoidance and Minimization Measures*). Activities associated with construction of setback levees for floodplain restoration could result in injury or mortality of riparian woodrats; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.2.1.4 Effects of Ongoing Activities

The only ongoing effects on the riparian woodrat are those potentially resulting from habitat enhancement and management activities.

Enhancement and management actions in riparian brush rabbit habitat within the reserve system may include invasive plant removal, planting and maintaining vegetation to improve and sustain habitat characteristics for the species, and creating and maintaining flood refugia. Injury or mortality of riparian woodrat will be avoided by these activities as described in Appendix 3.C, *Avoidance and Minimization Measures*. Although these activities may result in harassment of riparian brush rabbits through noise and visual disturbance, adverse effects will be minimal, if any.

5.6.2.1.5 Impact of Take on Species

There are three extant California Natural Diversity Database (CNDDB) riparian woodrat occurrences rangewide, none of which are in the Plan Area. The current known range of the species is confined to a small area in northern San Joaquin County immediately south of the Plan Area, with the nearest known extant occurrence approximately 1.5 to 2 miles to the southeast of Conservation Zone 7, in Caswell State Park. An additional extant population might occur just outside the Plan Area, near

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Vernalis along the San Joaquin River, although there have been no sightings of the species at this location since the 1970s (Williams and Kilburn 1992). Based on the proximity of these occurrences, the riparian woodrat potentially occurs in suitable habitat in the Plan Area, in Conservation Zone 7, or could occupy this area in the future.

Full implementation of the BDCP will result in permanent loss of up to 46 acres (2% of the habitat in the Plan Area), temporary loss of 33 acres (1.5% of the habitat in the Plan Area), and periodic inundation of up to 202 acres (9% of the habitat in the Plan Area) of habitat for the riparian woodrat. Take of riparian woodrat resulting from BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- There are no riparian woodrat occurrences in the Plan Area.
- The habitat that will be removed consists of small patches that are of moderate quality for the species.
- The habitat that will be removed permanently is a small proportion of the total habitat in the Plan Area (2%).
- Avoidance and minimization measures will be implemented to avoid injury or mortality of riparian woodrats, and to minimize loss of occupied habitat.
- Floodplain restoration will be designed to provide flood refugia so that flooding will not adversely affect any riparian woodrats that occupy restored floodplains.

5.6.2.2 Beneficial Effects

The BDCP Implementation Office will restore at least 5,000 acres and protect at least 750 acres of valley/foothill riparian natural community, a portion of which is expected to occur in Conservation Zone 7 and consist of suitable riparian woodrat habitat. Assuming the restored and protected riparian natural community will provide suitable riparian woodrat habitat proportional to the amount that exists within this natural community in the Plan Area, and estimated 602 acres acres will be restored and 90 acres protected that provide suitable riparian habitat for this species. To ensure that a sufficient amount of the restored and protected valley/foothill riparian natural community specifically benefits the riparian woodrat, the Implementation Office will restore and maintain at least 300 acres of riparian habitat that meets the ecological requirements of the riparian woodrat (e.g., dense willow understory and oak overstory) and that is adjacent to or facilitates connectivity with existing occupied or potentially occupied habitat. The Implementation Office will also create and maintain mounds in restored and protected riparian areas that are designed specifically to provide flood refugia for riparian woodrat (Endangered Species Recovery Program 2010).

5.6.2.3 Net Effects

Full implementation of the BDCP will result in a minimum 556-acre (26%) increase of habitat for the riparian woodrat in the Plan Area, and at least a 689-acre (682%) increase of riparian woodrat habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*). The habitat that will be lost as a result of covered activities is of low to moderate quality, consisting of small patches, some of which are isolated and surrounded by agricultural lands and others of which are in proximity to other riparian patches along the San Joaquin River. Habitat potentially removed in the southernmost portion of Conservation Zone 7 as a result of floodplain restoration is of higher quality for the riparian woodrat because it is closer to riparian woodrat occurrences to the south. The habitat that will be restored will be high-quality habitat that will be managed specifically to maintain suitable habitat components for the riparian woodrat. At least 300 acres of suitable habitat for the species will be restored as part of the 5,000 acres of restored valley/foothill riparian habitat. Additional restored valley/foothill riparian habitat is likely to be suitable habitat for riparian woodrat. Some portion of the 750 acres of protected valley/foothill riparian forest is also expected to be suitable for riparian woodrat. Although there are no records of occurrences of the riparian woodrat in the Plan Area, habitat restoration in Conservation Zone 7, in the vicinity of occurrences south of the Plan Area, will increase opportunities for northward expansion of the species into the Plan Area.

Overall, the BDCP will provide a substantial net benefit to the riparian woodrat through the net increase in available habitat, and net increase of habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the riparian woodrat.

5.6.3 Salt Marsh Harvest Mouse

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the salt marsh harvest mouse. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions.* The habitat model used to assess effects for the salt marsh harvest mouse includes two habitat types: wetland habitat and upland habitat. The model for wetland habitat includes tidal brackish emergent wetland and managed wetland with a minimum patch size of 1 acre that is within Suisun Marsh and the portion of the Delta between Chipps Island and the western edge of Sherman Island (but not including Sherman Island; see Appendix 2.A, *Covered Species Account*). The model for upland habitat includes grasslands and vernal pool complexes within 150 feet of wetland edges in the modeled area. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the salt marsh harvest mouse, to the extent that information is available, include suitability of vegetation, habitat sustainability, and habitat contiguity.

5.6.3.1 Adverse Effects

5.6.3.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up to 4,287 acres[3] of habitat (24% of the habitat in the Plan Area) for the salt marsh harvest mouse (Table 5.6-1a, *Maximum Allowable Effects, Wildlife*). The only covered activity resulting in adverse effects on this species is tidal natural communities restoration, described below.

[3] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Tidal Natural Communities Restoration

This activity will result in the loss of approximately 2,736 acres[4] wetland habitat (19% of wetland habitat in the Plan Area) and 808 acres of upland habitat (22% of upland habitat in the Plan Area) for the salt marsh harvest mouse. Of the 2,736 acres of wetland habitat lost, approximately 2,707 acres will convert from wetland habitat to aquatic areas (below the mean lower low water line) that will not provide suitable habitat for the species, and approximately 29 acres (less than 1% of total habitat in the Plan Area) will be desiccated as a result of tidal dampening and will convert from wetland habitat to suitable upland habitat for the species. The loss of 808 acres upland habitat will reduce supplemental foraging areas and the loss of upland refugia for salt marsh harvest mice during high tide events.

Tidal natural community restoration throughout the Plan Area will all occur by year 40 in roughly even amounts for every 5-year period until year 40 (Chapter 6, *Implementation*). Tidal natural communities restoration requirements for Suisun Marsh do not have specific deadlines, so restoration there may occur at any time during the first 40 years of the permit term. However, adverse effects on salt marsh harvest mouse and other tidal marsh covered species will be minimized through careful phasing of tidal marsh restoration in Suisun Marsh to ensure that salt marsh harvest mouse populations are able to find refuge in suitable habitat near restoration sites (Appendix 3.C, *Avoidance and Minimization Measures*).

The 2,707 acres of wetland habitat that are predicted to convert to tidal perennial aquatic habitat is a subset of the 3,479 acres of salt marsh harvest mouse aquatic habitat that will be inundated as a result of tidal natural communities restoration. The remainder of the 3,479 acres of wetland that will be tidally inundated is expected to continue to provide wetland habitat value for the species.

The salt marsh harvest mouse habitat that will be affected by tidal natural communities restoration in Suisun Marsh is of relatively low quality compared with modeled habitat in Suisun Marsh that is not planned for restoration. The tidal brackish emergent wetland to be inundated, based on the hypothetical footprint, consists of scattered patches of suitable pickleweed-dominated marsh within a matrix of less suitable marsh dominated by bulrushes and other reed-like vegetation.

5.6.3.1.2 Periodic Inundation

No periodic inundation effects on the salt marsh harvest mouse will occur as a result of BDCP covered activities.

5.6.3.1.3 Construction-Related Effects

Construction is not expected to result in loss of salt marsh harvest mouse habitat other than that described in in Section 5.2.1.1. *Permanent Habitat Loss, Conversion, and Fragmentation.* All staging and other temporary construction-related work areas for tidal natural communities restoration will either be on areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above.

[4] This is less than the amount of wetland habitat that overlaps with the hypothetical footprint for tidal restoration. However, some of the tidally restored area will remain as wetland habitat for the species: 2,736 represents the areas that will convert from suitable habitat to unsuitable aquatic areas or upland habitat.

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Construction-Related Injury or Mortality

The operation of equipment for construction could result in injury or mortality of salt marsh harvest mice, if present. However, as described in Appendix 3.C, *Avoidance and Minimization Measures*, no motorized equipment will be used to remove vegetation in salt marsh harvest mouse habitat. Restrictions on the use of motorized equipment, biological construction monitoring, and other measures will be implemented to ensure that salt marsh harvest mice occupying the construction area will be able to leave and escape to suitable adjacent habitat. Temporary exclusion fences will be installed to ensure that mice do not reenter work areas during construction.

Petroleum or other contaminant spills from construction equipment, drilling operations, or other activities could also affect salt marsh harvest mice, if present, and their habitat. BMPs described in Appendix 3.C, *Avoidance and Minimization Measures* will minimize the potential for this effect.

Indirect Construction-Related Effects

Noise and visual disturbance within 100 feet of construction activities could temporarily affect the use of 154 acres (0.8%) of modeled salt marsh harvest mouse habitat (Table 5.6-2a, *Indirect Effects, Wildlife).*

5.6.3.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing operation and maintenance activities are not expected to result in adverse effects on the salt marsh harvest mouse. Ongoing water operations are expected to change salinity levels but this is expected to have a beneficial effect on salt marsh harvest mouse, as described below in Section 5.6.3.2, *Beneficial Effects*.

Habitat Enhancement and Management

Habitat enhancement and management activities in salt marsh harvest mouse habitat could result in temporary habitat disturbance or removal, and noise and disturbance related effects to adjacent habitat, but adverse effects, if any, are expected to be minimal. Injury or mortality of salt marsh harvest mouse as a result of habitat enhancement and management will be avoided as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

Exposure to methylmercury is known to affect mammals and thus potentially could adversely affect the salt marsh harvest mouse. Tidal wetlands are known to produce methylmercury as are the managed wetlands that currently support the species' habitat and that will be restored to tidal wetlands. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Currently, it is unknown if or how much of the sediment-derived methylmercury enters the food chain or what tissue concentrations are harmful to the salt marsh harvest mouse. The potential adverse effects associated with any increased exposure are considered low because methylmercury occurs naturally in the habitats in which the species has evolved, because the species is relatively low in the food chain, and because the species' short life span (1 year) likely precludes it from bioaccumulating mercury to lethal levels. This potential adverse effect will be minimized with the

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implementation of *CM12 Methylmercury Management*, which is expected to reduce the effects of potential increases in levels of methylmercury resulting from BDCP tidal habitat restoration actions.

5.6.3.1.5 Impact of Take on Species

The salt marsh harvest mouse is endemic to the salt marshes of San Francisco, San Pablo, and Suisun Bays. The species today potentially occupies an area representing 15% of the habitat it historically occupied in this area (Dedrick 1989). Suisun Marsh, in the Plan Area, includes roughly 20% of the range-wide population of the salt marsh harvest mouse and is identified as a recovery unit in the recovery plan for this species (U.S. Fish and Wildlife Service 2001). The Plan Area is therefore important to the long-term survival and recovery of the salt marsh harvest mouse.

Tidal natural communities restoration will result in the permanent loss or conversion of up to 24% of the salt marsh harvest mouse habitat in the Plan Area (4,287 acres). While some of the affected area is likely to remain as tidal brackish emergent wetland that is suitable for the species, and most of the affected area will be restored to suitable tidal brackish emergent wetland habitat over time, the temporal habitat loss has the potential to adversely affect the salt marsh harvest mouse population in Suisun Marsh.

The draft recovery plan for salt marsh harvest mouse describes a recurrent dilemma: the species often occupies diked wetlands, an anthropogenic habitat. Tidal marsh restoration is often accomplished by breaching levees and converting diked nontidal marsh currently occupied by salt marsh harvest mouse populations to tidal wetlands, their historic condition. Conversion of these subsided areas requires sedimentation and accretion over time to restore marsh plains, resulting in a prolonged period (sometimes a decade or more) in which resident mice populations are displaced by uninhabitable aquatic areas (U.S. Fish and Wildlife Service 2001).

Take of the salt marsh harvest mouse through tidal natural communities restoration activities implemented by the BDCP has the potential to adversely affect the survival and recovery of the salt marsh harvest mouse. The removal of up to 25% of the species' habitat in the Plan Area may diminish the salt marsh harvest mouse population in the Plan Area and result in reduced genetic diversity, thereby putting the local population at risk of local extirpation due to random environmental fluctuations or catastrophic events. This effect is expected to be greatest if large amounts of habitat are removed at one time in Suisun Marsh and are not effectively restored for many years, and if there are no adjacent lands with salt marsh harvest mouse populations to recolonize restored areas. However, as described in Section 5.6.3.2, *Beneficial Effects*, below, measures will be implemented to ensure that the salt marsh harvest mouse population in the Plan Area is not adversely affected in this manner, and that the long-term benefits of tidal natural communities restoration outweigh the short-term adverse effects of these actions.

5.6.3.2 Beneficial Effects

The BDCP Implementation Office will restore at least 4,800 acres of tidal brackish emergent wetland natural community in Suisun Marsh that will provide suitable habitat for the salt marsh harvest mouse. Of the 4,800 acres, at least 1,000 acres will be restored in the Western Suisun/Hill Slough Marsh Complex and 1,000 acres in the Suisun Slough/Cutoff Slough Marsh Complex, in 150-acre or greater patches that provide viable habitat areas for the salt marsh harvest mouse habitat consistent with the draft tidal marsh recovery plan (U.S. Fish and Wildlife Service 2010). The BDCP Implementation Office will also protect and enhance at least 1,500 acres of managed wetlands in the Grizzly Island Marsh Complex to provide suitable habitat for salt marsh harvest mouse consistent

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with the salt marsh harvest mouse recovery plan (U.S. Fish and Wildlife Service 2001). Upland transitional areas will be protected adjacent to restored tidal lands to accommodate sea level rise, and additional grasslands will be protected or restored to provide upland refugia for the salt marsh harvest mouse during high tide events.

In order to ensure that temporal loss as a result of tidal natural communities restoration does not adversely affect the salt marsh harvest mouse population, restoration in Suisun Marsh will be carefully phased over time to offset adverse effects of restoration as it occurs, ensure that short-term population loss is relatively small and incremental, and maintain local source populations to recolonize newly restored areas. The salt marsh harvest mouse population will be monitored during the phasing process and adaptive management will be applied to ensure maintenance of Suisun Marsh population as described in Chapter 6, *Implementation*.

Water salinity in Suisun Marsh is generally expected to increase as a result of water operations and operations of salinity control gates to mimic a more natural water flow. This will likely encourage the establishment of tidal wetland plant communities tolerant of more saline environments, which should be favorable to salt marsh harvest mouse because its historical Suisun Marsh habitat is brackish tidal marsh. However, the degree to which salinity changes in all tidal channels and sloughs in and around Suisun Marsh is highly variable, and harvest mouse response to these changes may be variable as well.

5.6.3.3 Net Effects

Full implementation of the BDCP will result in at least a 513-acre (3%) increase of habitat for salt marsh harvest mouse in the Plan Area, and at least 2,275 acres (15%) increase of salt marsh harvest mouse habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

The tidal brackish emergent wetland that will be lost as a result of covered activities is of low to moderate habitat quality for the salt marsh harvest mouse in that the suitable pickleweed-dominated marsh occurs in numerous scattered patches within a matrix of less suitable marsh dominated by bulrushes and other reed-like vegetation. The habitat that will be restored and protected will consist of large blocks of contiguous tidal brackish emergent wetland that has a greater proportion of pickleweed-dominated vegetation suitable for the species. This will provide greater habitat connectivity and greater habitat quality and quantity, with is expected to accommodate larger populations and to therefore increase population resilience to random environmental events and climate change. The managed wetland habitat that will be converted to tidal brackish emergent wetland habitat is not a sustainable habitat type because of the potential for catastrophic flooding associated with subsided lands, known levee instability, and projected sea level rise, in addition to the intensive management required of these lands (U.S. Fish and Wildlife 2010).

Although tidal natural communities restoration will remove occupied habitat and displace existing salt marsh harvest mice from the restored areas over the short term, these areas will be converted to high-quality habitat for the species that will provide lasting, long-term benefits to the species. The effects of temporal loss on the population will be minimized through monitoring and phasing to mitigate loss as it occurs and to protect adjacent source populations for subsequent recolonization into newly restored areas.

Overall, the BDCP will provide a substantial long-term net benefit to the salt marsh harvest mouse through the increase in available high-quality and sustainable habitat in large, connected blocks, and

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an increase in the protected status of this habitat. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the salt marsh harvest mouse.

5.6.4 San Joaquin Kit Fox

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the San Joaquin kit fox. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model used to assess effects for the San Joaquin kit fox includes grasslands and vernal pool complex in the area south and west of SR 4 from Antioch to Old River and in the vicinity of Clifton Court Forebay, as described further in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the San Joaquin kit fox, to the extent that information is available, include size and connectivity of habitat patches.

5.6.4.1 Adverse Effects

5.6.4.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 163 acres[5] of habitat (3% of the habitat in the Plan Area) for the San Joaquin kit fox (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Conveyance facility construction is the only covered activity resulting in San Joaquin kit fox habitat loss.

Conveyance Facility Construction

This activity will result in the permanent removal of 163 acres of modeled kit fox habitat in Conservation Zone 8, adjacent to Clifton Court Forebay. This habitat is of low quality as it is composed of fragmented patches of grassland surrounded by agricultural lands.

5.6.4.1.2 Periodic Inundation

No periodic inundation effects on San Joaquin kit fox will occur as a result of BDCP covered activities.

5.6.4.1.3 Construction-Related Effects

Potential construction-related effects on the San Joaquin kit fox include long-term temporary habitat loss from establishment and use of borrow and spoil areas, construct-related injury or mortality, and temporary construction-related indirect effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

[5] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Temporary Habitat Loss (Long Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in the long-term removal of approximately 151 acres of grassland habitat for this species in Conservation Zone 8 (Table 5.6-1a ,*Maximum Allowable Habitat Loss, Wildlife*). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown. This habitat, in the vicinity of Clifton Court Forebay, is of low quality as it is composed of fragmented patches of grassland surrounded by agricultural lands.

Construction-Related Injury or Mortality

During construction activities, construction equipment could result in the injury or mortality of San Joaquin kit foxes if individuals are present; however, no injury or mortality of kit fox is expected to occur because foxes will likely avoid the increased activity and noise related to the construction activities. Preconstruction surveys will be conducted and if kit fox dens are found, measures will be implemented to ensure the injury or mortality is avoided, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbances within 250 feet of construction activities could temporarily affect the use of 113 acres (2%) of modeled San Joaquin kit fox habitat (Table 5.6-2a, *Indirect Effects, Wildlife*). Given the remote likelihood of active kit fox dens in the vicinity of the conveyance facility, the potential for this effect is low and will further be minimized with the implementation of seasonal no-disturbance buffers around occupied dens, if any, and other avoidance and minimization measures as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.4.1.4 Effects of Ongoing Activities

The only ongoing BDCP activities expected to affect the San Joaquin kit fox are those associated with habitat enhancement and management.

Habitat Enhancement and Management

A variety of habitat management actions to be implemented to enhance wildlife values on protected lands may result in localized ground disturbances that could temporarily remove small amounts of San Joaquin kit fox habitat in Conservation Zone 8. Ground-disturbing activities such as removal of nonnative vegetation and road and other infrastructure maintenance activities are expected to have minor effects on available kit fox habitat. Management activities could result in the injury or mortality of San Joaquin kit foxes if individuals are present in work sites or if dens occur in the vicinity of habitat management work sites. Noise and visual disturbances could also affect San Joaquin kit fox use of the surrounding habitat. These effects are expected to be minor, and will be minimized with implementation of the worker awareness training, monitoring, avoidance of active kit fox dens, and BMPs described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.4.1.5 Impact of Take on Species

The southwestern portion of the Plan Area (Conservation Zone 8) overlaps with the northernmost extent of the San Joaquin kit fox's range-wide distribution. The San Joaquin kit fox was originally found throughout most of the San Joaquin Valley in Central California, but is now found only on the edges of the San Joaquin Valley from southern Kern County up to Alameda, Contra Costa, and San

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Joaquin Counties on the west and up to Stanislaus County on the east, and a few populations exist in the valley floor. When the San Joaquin kit fox was added to the endangered species list in 1967, there were no known extant occurrences in San Joaquin County or northward. In the 1970s, however, surveys revealed that the range of the kit fox extended northward beyond Tracy to Contra Costa County (Jensen 1972; Clark et al. 2002). Relatively few San Joaquin kit foxes have been found in the northern portion of their range within the last few decades, despite a number of surveys (Hall 1983; California Department of Fish and Game 1983; Bell 1994; Smith et al. 2006; Clark et al. 2007).

The northern range of the San Joaquin kit fox (including the Plan Area) was most likely marginal habitat historically and has been further degraded due to development pressures, habitat loss, and fragmentation (Clark et al. 2007). CNDDB (2009) reports eight occurrences of San Joaquin kit foxes along the extreme western edge of the Plan Area within Conservation Zone 8, south of Brentwood. However, Clark et al. (2007) provide evidence that a number of CNDDB occurrences in the northern portion of the species' range may be misidentification of coyote pups as kit fox. Smith et al. (2006) suggest that the northern range may possibly be a population sink for the San Joaquin kit fox.

The loss of 163 acres of kit fox habitat in Conservation Zone 8 is not expected to adversely affect the long-term survival and recovery of the San Joaquin kit fox for the following reasons.

- The affected habitats are composed of naturalized grassland in a highly disturbed or modified setting.
- Potentially suitable habitat areas to be lost are located in the northernmost extent of the species' range, in an area where kit foxes seldom occur, and which has marginal value for the long-term survival and recovery of the species.
- The proportion of the species' range to be affected is small in comparison to the species' range-wide distribution.

5.6.4.2 Beneficial Effects

With full implementation of the BDCP, at least 1,000 acres of grassland will be protected in Conservation Zone 8, where the San Joaquin kit fox is most likely to occur if present in the Plan Area. Additionally, a portion of the 2,000 acres of grassland restoration will likely occur in Conservation Zone 8. Because kit fox home ranges are large (ranging from around 1 to 12 square miles; see Appendix 2.A, *Covered Species Accounts*), habitat connectivity is key to the conservation of the species. Grasslands will be acquired for protection in locations that provide connectivity to existing protected breeding habitats in Conservation Zone 8 and to other adjoining kit fox habitat within and adjacent to the Plan Area. Connectivity to occupied habitat adjacent to the Plan Area will help ensure the movement of kit fox to larger habitat patches outside of the Plan Area in Contra Costa County. Grassland protection will focus in particular on acquiring the largest remaining contiguous patches of unprotected grassland habitat, which are located south of SR 4 in Conservation Zone 8 (Appendix 2.A, *Covered Species Accounts*). This area connects to over 620 acres of existing habitat that was protected under the East Contra Costa County HCP/NCCP. Grasslands in Conservation Zone 8 will also be managed and enhanced to increase prey availability and to increase mammal burrows, which could benefit the San Joaquin kit fox by increasing potential den sites, which are a limiting factor for the kit fox in the northern portion of its range.

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5.6.4.3 Net Effects

Full implementation of the BDCP will result in at least 163 acres (3%) decrease of habitat for the San Joaquin kit fox, and at least 906 acres increase (142%) of San Joaquin kit fox habitat in protected lands.

Full implementation of the BDCP will result in the permanent loss of 163 acres of modeled San Joaquin kit fox habitat and the protection of at least 1,000 acres of grasslands providing habitat for the San Joaquin kit fox in Conservation Zone 8 (Table 5.6-3a, *Net Effects, Wildlife*), resulting in an 142% increase in protected grasslands suitable for the San Joaquin kit fox in Conservation Zone 8. Additional grassland in this area will be restored as a component of the 2,000 acres of grassland restoration. The modeled habitat that will be lost as a result of covered activities consists of small, fragmented patches that are surrounded by cultivated lands and that are unlikely to be used by this species. The grasslands that will be protected and restored and that provide suitable habitat for the San Joaquin kit fox will consist of large, interconnected areas in Conservation Zone 8 that will connect with protected San Joaquin kit fox habitat to the west in the East Contra Costa County HCP/NCCP Plan Area. Connectivity to occupied habitat adjacent to the Plan Area will help ensure the movement of kit foxes to larger habitat patches outside of the Plan Area in Contra Costa County.

Overall, the BDCP will provide a substantial net benefit to the San Joaquin kit fox, if the species occurs in the Plan Area, through the increase in habitat in protected status, and management and monitoring of habitat to support the species. Therefore, the BDCP will contribute to the recovery of the San Joaquin kit fox.

5.6.5 Suisun Shrew

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the Suisun shrew. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model for the Suisun shrew identifies suitable habitat (minimum 1-acre mapping unit) in the Plan Area as all pickleweed-dominated natural seasonal wetlands and sedge and bulrush-dominated tidal brackish emergent wetlands located in Suisun Marsh only. Managed wetlands and low marsh habitat dominated by sedges have been excluded from the model. Secondary habitats generally provide only a few ecological functions such as foraging (low marsh and managed wetlands) or extreme high tide refuge (upland transition zones), while primary habitats provide multiple functions, including breeding, effective predator cover, and quality forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix A, Species Accounts. Factors considered in assessing the quality of affected habitat for the Suisun shrew, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.5.1 Adverse Effects

5.6.5.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up to 1,279 acres of habitat (36% of the habitat in the Plan Area) for the Suisun shrew (Table 5.6-1a, *Maximum Allowable*

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Habitat Loss, Wildlife). The only covered activities that will adversely affect this species are those associated with tidal natural communities restoration, as described below.

Tidal Natural Communities Restoration

This activity is expected to result in tidal inundation of 865 acres of primary and 96 acres of secondary Suisun shrew habitat, and desiccation of 318 acres of primary and 0 acres of secondary habitat. Although the actual tidal natural communities restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for Suisun shrew.

The 865 acres of primary habitat to be tidally inundated consists of emergent wetland that is already tidally inundated. Approximately 51 (6%) of the 865 acres are expected to convert to tidal perennial aquatic natural community (areas of tidal marsh below the mean lower low water line), which is unsuitable for the species. The remaining 814 acres (94%) are expected to remain as tidal brackish emergent wetland, with an unknown portion of this to convert to unsuitable low marsh and the rest to remain as primary habitat for Suisun shrews. The 814 acres (27% of the existing habitat) represents a maximum but unquantified overestimate, of the amount of Suisun shrew habitat that will be lost due to tidal inundation.

Desiccation resulting from change in the upper marsh tidal prism, is expected to result in conversion of approximately 318 acres of primary tidal brackish emergent wetland habitat to secondary upland habitat. The conversion of primary habitat to secondary habitat is considered a reduction in habitat function as the tidal brackish emergent wetlands provide many more ecological functions (e.g., breeding, foraging, cover from predators) than the upland grassland habitats (e.g., extreme tide refugia) to which they will convert. The conversion of secondary wetland habitat to secondary upland habitat is not considered a loss as both habitat types provide only limited habitat value to the Suisun shrew.

5.6.5.1.2 Periodic Inundation

No periodic inundation effects on the Suisun shrew will occur as a result of BDCP covered activities.

5.6.5.1.3 Construction-Related Effects

Construction is not expected to result in loss of Suisun shrew habitat other than that described in in Section 5.2.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. All staging and other temporary construction-related work areas for tidal natural communities restoration will either be in areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of Suisun shrews. Risk would be greatest during extreme high tides when shrews may move to higher and drier lands where they might come in contact with upland construction activities. Disturbance, injury, or mortality to Suisun shrews will be avoided or minimized as described further in Appendix 3.C, *Avoidance and Minimization Measures*. Minimization measure include passive removal of shrews in the proximity of construction activity by removing shrew cover habitat within 50 feet of construction using nonmechanized hand tools. Further, construction will be avoided during extreme

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high tide events when upland encounters with shrews are highest. Finally, barrier fences constructed to exclude salt marsh harvest mice from construction sites will also exclude shrews.

Indirect Construction-Related Effects

Noise and visual disturbance within 100 feet of construction activities could temporarily affect the use of 244 acres of Suisun shrew habitat adjacent to these activities (Table 5.6-2a, *Indirect Effects, Wildlife*). Tidal natural communities restoration construction activities may include grading, filling, contouring, and other ground-disturbing operations.

5.6.5.1.4 Effects of Ongoing Activities

The only ongoing BDCP activities expected to affect the Suisun shrew are those associated with habitat enhancement and management.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management that are intended to maintain and improve habitat functions in the protected habitats for Suisun shrew and other covered species, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury, or mortality of Suisun shrews, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable, but will be minimized with implementation of Suisun shrew avoidance and minimization measures described in Appendix 3.C. *Avoidance and Minimization Measures*.

Other Indirect Effects

Increased exposure to methylmercury associated with tidal natural communities restoration will potentially indirectly affect the Suisun shrew. Section 3.4.13, *CM12 Methylmercury Management,* describes the process by which tidal natural communities restoration may increase methylmercury levels in wetlands in the Plan Area. For short-lived small mammals such as shrews, mercury bioaccumulation is generally not of concern because the species feeds low on the food chain and generally does not live long enough to bioaccumulate toxic concentrations of mercury except when they occur in highly toxic sites. Toxic concentrations of methylmercury have been found in the kidneys of shrews that inhabit contaminated sites and forage on earthworms and other prey that live within contaminated sediments (Talmage and Walton 1993; Hinton and Veiga 2002). Hays (1990) found Suisun shrews to eat mostly isopods and amphipods, two aquatic prey types less likely to harbor methylmercury concentrations compared to a benthic organism (e.g., polychaetes). Further, the Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that restored tidal wetlands will generate less methylmercury than the existing managed wetlands to be restored. Measures described in Section 3.4.13, *CM12 Methylmercury Management* are expected to reduce the effects of methylmercury resulting from BDCP tidal natural communities restoration.

5.6.5.1.5 Impact of Take on the Species

The Suisun shrew is endemic to the tidal marshes of Suisun Bay. Approximately half of the range of this subspecies of ornate shrew occurs in Suisun Marsh, reflecting the importance of the Plan Area to the subspecies. There are 15 CNDDB/DHCCP occurrences through the species' range, of which five extant occurrences are in the Plan Area (33%). The hypothetical footprint for BDCP activities

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overlaps with three of these occurrences, all within Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the Suisun shrew, the Plan Area supports 3,505 acres of suitable habitat, most (86%) of which is tidal brackish emergent wetland (3,006 acres). Of the total habitat, up to 1,279 acres of modeled habitat (36%) will be affected by tidal natural communities restoration. Some of the 961 acres of inundation effects may result in long-term temporary losses as some portion of the inundated areas would eventually develop into marsh conditions favored by this mammal. These losses of Suisun shrew habitat are not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- The amount of habitat to be restored (4,800 acres) greatly exceeds the amount lost (1,279 acres).
- Habitat removal will be sequenced with tidal habitat restoration to minimize adverse effects on habitat abundance.

5.6.5.2 Beneficial Effects

The BDCP Implementation Office is expected to restore or create approximately 4,800 acres of tidal brackish emergent wetland natural community in Conservation Zone 11 (CM4). Tidal wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural gradient extending from subtidal to the upland fringe. The habitat and ecosystem functions of tidal brackish emergent wetland will be maintained and enhanced over the term of the BDCP (CM11). Much of the restored tidal brackish emergent wetland will meet the primary habitat requirements of the Suisun shrew, including mid- and high-marsh vegetation with dense, tall stands of pickleweed cover. Nonnative predators will be controlled as needed to reduce predation and help maintain species abundance (CM11). Restoration will be sequenced and oriented in a manner that minimizes any temporary, initial loss of habitat and habitat fragmentation. These BDCP restoration actions will improve habitat conditions for the Suisun shrew and enhance the long-term viability of this species in the Plan Area.

Water operations associated with BDCP actions intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal habitat restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed (*Sarcocornia*), an outcome expected to benefit the Suisun shrew.

5.6.5.3 Net Effects

Full implementation of the BDCP will result in at least a 3,617-acre (121%) net increase in primary habitat for Suisun shrews, and at least 5,417 acres increase (27%) of Suisun shrew habitat in protected lands. (Table 5.6-3a, *Net Effects, Wildlife*). The potential take of Suisun shrew as a result of permanent and temporary habitat loss and indirect effects is not expected to adversely affect the long-term survival or recovery of this species. Avoidance and minimization measure described in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to specifically protect Suisun shrews from disturbance and avoid injury or mortality. Tidal habitat restoration actions will primarily affect managed wetlands that provide low-quality habitat for the Suisun shrew, and

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restoration will be phased to ensure that the local shrew population is not adversely affected. Much of the restored tidal brackish emergent wetland will meet the primary habitat requirements of Suisun shrew, including mid- and high-marsh vegetation with dense, tall stands of pickleweed cover. Habitat management and enhancement, and control of nonnative predators as needed, will further benefit the species.

Overall, the BDCP will provide a substantial net benefit to the Suisun shrew through the increase in primary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the Suisun shrew.

5.6.6 Townsend's Big-Eared Bat

This section describes the adverse, beneficial, and net effects of the BDCP covered activities and conservation measures on the Townsend's big-eared bat. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants* ,and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model used to assess effects for the big-eared bat includes roosting habitat and primary and secondary foraging habitat. Modeled roosting habitat consists of valley/foothill riparian natural community and vegetation alliances dominated by oaks, eucalyptus, or other tree species. Modeled primary foraging habitat consists of valley/foothill riparian natural community. In Suisun Marsh and Yolo Basin, modeled secondary foraging habitat consists of all the nonriparian natural community types. In the Delta, secondary foraging habitat consists of cultivated lands, alkali seasonal wetland complex, vernal pool complex, grasslands, managed wetlands, nontidal and tidal freshwater emergent wetland, and tidal perennial aquatic natural communities. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Although Townsend's big-eared bats have not been documented in the Plan Area, most of the Plan Area provides potential foraging habitat for the species.

5.6.6.1 Adverse Effects

5.6.6.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up 237 acres of roosting habitat (3% of roosting habitat in the Plan Area) and up to 12,919 acres[6] of foraging habitat (1.6% of the foraging habitat in the Plan Area) for the Townsend's big-eared bat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife)*. Covered activities resulting in permanent loss or conversion of Townsend's big-eared bat habitat include conveyance facility construction, Fremont Weir/Yolo Bypass improvements, floodplain restoration, nontidal marsh restoration, and conservation hatcheries facilities.

Conveyance Facility Construction

This activity will result in the permanent removal of 4,096 acres of Townsend's big-eared bat habitat (0.3% of total bat habitat in the Plan Area), including 6 acres of roosting habitat, 17 acres of primary

[6] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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foraging habitat, and 4,073 acres of secondary foraging habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of an estimated 1,253 acres of Townsend's big-eared bat habitat (0.16% of total bat habitat in the Plan Area), including 80 acres of roosting habitat, 145 acres of primary foraging habitat, and 1,028 acres of secondary foraging habitat for Townsend's big-eared bat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of an estimated 2,227 acres of Townsend's big-eared bat secondary foraging habitat (0.3% of the secondary foraging habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

Conservation Hatcheries Facilities

This activity will result in the permanent loss of up to 35 acres of secondary foraging habitat for Townsend's big-eared bat in the Plan Area (<0.1% of total secondary foraging habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

5.6.6.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions, this activity will periodically inundate 31 acres of roosting habitat for the Townsend's big-eared bat. Potential roosting trees in periodically inundated areas could be adversely affected by flooding. Inundation will not adversely affect foraging habitat for the species.

Floodplain Restoration

This activity will periodically inundate an estimated 169 acres of roosting habitat for the Townsend's big-eared bat (2% of the roosting habitat in the Plan Area). Potential roosting trees are likely to be retained within seasonally flooded areas, although high velocity flooding could uproot trees. Seasonal flooding will not adversely affect foraging habitat for the species.

5.6.6.1.3 Construction-Related Effects

Construction-related effects on the Townsend's big-eared bat include short- and long-term temporary habitat loss, injury or mortality, and indirect noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction-related effects will result in short-term temporary loss of 4,134 acres of habitat (0.5% of the total habitat in the Plan Area) for the Townsend's big-eared bat, including 90 acres of roosting, 637 acres of primary foraging, and 3,407 acres of secondary foraging habitat (Table 5.6-1a,

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Maximum Allowable Habitat Loss, Wildlife). Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 1,600 acres of secondary foraging habitat for Townsend's big-eared bat (0.2% of secondary foraging habitat in Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss*, *Wildlife*). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to the Townsend's big-eared bat if hibernacula or maternity sites are destroyed. Preconstruction surveys will be conducted and if hibernacula or maternity sites are detected, no construction or disturbance of the structure or within 500 feet of the structure will occur while bats are present, as described further in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance within 500 feet of construction activities could temporarily affect the use of 492 acres of modeled roosting habitat for the Townsend's big-eared bat (7% of total roosting habitat in the Plan Area) (Table 5.6-2a, *Indirect Effects*, *Wildlife*). However, no construction-related activity will occur within 500 feet of a maternity site or hibernaculum while bats are present, as described further in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.6.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

The operation and maintenance of BDCP facilities are not expected to adversely affect the Townsend's big-eared bat.

Habitat Enhancement and Management

Noise and visual disturbances during implementation of riparian habitat management actions could result in temporary disturbances that, if Townsend's big-eared bat roost sites are present, could cause temporary abandonment of roosts. This effect will be minimized with implementation of the avoidance and minimization measures as described in Chapter 3, *Conservation Strategy*.

Other Indirect Effects

Increased exposure to methylmercury associated with tidal natural communities restoration will potentially indirectly affect Townsend's big-eared bat. Section 3.4.13, *CM12 Methylmercury Management* describes the process by which tidal natural communities restoration may increase methyl mercury levels in wetlands in the Plan Area. Mercury has been found in high concentrations in some bat species, such as the Indiana bat. Many bat species forage heavily on aquatic insects, which might result in rapid bioaccumulation (Biodiversity Research Institute 2012). However, Townsend's big-eared bats feed primarily on moths and may not be subject to the same methylmercury pathways as other bat species. Measures described in Section 3.4.13, *CM12*

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Methylmercury Management, are expected to reduce the effects of methylmercury resulting from BDCP tidal natural communities restoration.

5.6.6.1.5 Impact of Take on Species

The western subspecies of Townsend's big-eared bats occur throughout most of western North America from British Columbia to central Mexico, as far east as South Dakota and Texas to the Edwards Plateau (Hall 1981; Kunz and Martin 1982). The Townsend's big-eared bat ranges widely in the western United States and the Plan Area represents a very small proportion of the species' range. No Townsend's big-eared bats have been documented in the Plan Area. However, this is likely due to a lack of surveys; the species is known to occur at nearby Central Valley locations and could be present in the Plan Area (Appendix 2.A, *Covered Species Accounts*).

BDCP covered activities will result in the permanent loss or conversion of up to 237 acres of roosting habitat (3% of roosting habitat in the Plan Area) and up to 12,919 acres of habitat (2% of the foraging habitat in the Plan Area) for the Townsend's big-eared bat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The take resulting from BDCP implementation is not expected to result in an adverse impact on the species' long-term survival for the following reasons:

- The species is widely distributed, and the Plan Area represents a small proportion of the species' entire range.
- BDCP covered activities will result in loss or conversion of a very small proportion of the species' habitat in the Plan Area.
- Construction activities will avoid disturbance of maternity sites or hibernacula, if found
- The species likely occurs in the Plan Area in low numbers, if at all.

5.6.6.2 Beneficial Effects

Creation and protection of natural communities and establishment of a large, interconnected reserve system will provide potential foraging and roosting habitat, and will maintain and increase the quality of suitable habitat for the Townsend's big-eared bat in the Plan Area. The BDCP will protect at least 31,000 acres of natural communities in the Plan Area potentially used by the Townsend's big-eared bat. The 72,809 acres of restored or created natural communities, including at least 65,000 acres of tidally influenced natural communities, will also provide high-quality foraging habitat for this species, assuming that primary productivity increases and results in and increase in insect prey for the species. Protection of at least 750 acres and restoration of at least 5,000 acres of valley/foothill riparian habitat will also provide potential roosting habitat for the Townsend's big-eared bat.

The significant decline in Townsend's big-eared bat populations throughout the species' range is largely attributed to loss or disturbance of hibernacula and roost sites. No maternal roosts or hibernacula will be disturbed while bats are present, and any unavoidable loss of maternal roosts or hibernacula (after the bats have left at the end of the breeding season or hibernation) will be offset with a functionally equivalent roost or hibernaculum within 10 miles. Maternal roosts or hibernacula that occur on reserve lands will be protected.

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5.6.6.3 Net Effects

Full implementation of the BDCP will result in an estimated 26,390 acres (3%) increase of habitat for the Townsend's big-eared bat, and at least 49,835 acres increase (29%) of Townsend's big-eared bat habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*). Restored foraging habitats will primarily replace agricultural lands. Restored habitats are expected to be of higher function than habitat removed because the production of flying insect prey species is expected to be higher in restored wetlands and uplands on which application of pesticides will be reduced relative to affected agricultural habitats.

Overall, the BDCP will provide a substantial net benefit to the Townsend's big-eared bat through the increase in foraging habitat quality and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the Townsend's big-eared bat.

5.6.7 California Black Rail

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures on the California black rail. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumption*. The modeled primary habitat for this species includes tidal brackish emergent wetland and tidal freshwater emergent wetland in Suisun Marsh and the Delta west of Sherman Island, and instream islands and White Slough Wildlife Area in the central Delta. Primary habitat is dominated by pickleweed, bulrush, and cattail, but also includes riparian communities on the small channel islands in the Delta. Secondary habitat includes low marsh, upland transitional areas, and managed wetlands. The minimum mapping unit is 0.5 acre. Secondary habitats generally provide only a few ecological functions such as foraging (low marsh and managed wetlands) or extreme high tide refuge (upland transition zones), while primary habitats provide multiple functions, including breeding, effective predator cover, and quality forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Species Accounts*. Factors considered in assessing the quality of affected habitat for the California black rail, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.7.1 Adverse Effects

5.6.7.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up to 6,195 acres of habitat (23% of the habitat in the Plan Area) for the California black rail (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The only covered activities that will adversely affect this species are those associated with tidal natural communities restoration, as described below.

Tidal Natural Communities Restoration

This activity is expected to result in tidal inundation of 1,278 acres of primary habitat (33% of primary habitat in the Plan Area) and 4,538 acres of secondary habitat (20% of secondary habitat in the Plan Area) for the California black rail. This activity will also result in the desiccation of 379 acres of primary habitat. Although the actual tidal natural communities restoration effects are

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likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the California black rail.

The 1,278 acres of primary habitat to be tidally inundated consists of emergent wetland that is already tidally inundated. An unknown proportion of the 1,278 acres is expected to convert to tidal perennial aquatic natural community, which is unsuitable for the species, while the remainder will remain, or develop into, suitable habitat for California black rails. However, because the amount of habitat that will convert to nonhabitat is unknown, the entire 1,278 acres are treated as habitat loss for the purpose of establishing take limits (recognizing that this is an overestimate of the true amount of loss). Further, most of the 4,538 acres of secondary habitat (nearly all managed wetland) that would be lost to inundation will, in reality, be restored to tidal brackish emergent wetland that will provide primary habitat functions such as breeding. Finally, the tidal natural communities restoration will be phased over a 40-year period to ensure recovery of some areas before initiating restoration actions in other areas.

Desiccation resulting from change in the upper marsh tidal prism is expected to result in conversion of approximately 379 acres of primary tidal brackish emergent wetland habitat and 0 acres of secondary managed wetland habitat to secondary upland habitat for the California black rail. The conversion of primary habitat to secondary habitat is considered a loss as the tidal brackish emergent wetlands provide many more ecological functions (e.g., breeding, foraging, cover from predators) than the upland grassland habitats (e.g., refugia) to which they convert. The conversion of secondary wetland habitat to secondary upland habitat is not considered a loss as both habitat types provide only limited ecological value.

5.6.7.1.2 Periodic Inundation

Flooding of Fremont Weir/Yolo Bypass Inundation

Flooding of Yolo Bypass will result in the periodic inundation of 51 acres of modeled habitat (98% of which is secondary habitat) for the California black rail (5% of the 1,182 acres of modeled habitat in the bypass area). There are no records for California black rails in the Yolo Bypass, although the extent to which this area has been surveyed for California black rails is unknown and the species is not conspicuous. Therefore, the species is potentially present in the Yolo Bypass. Periodic inundation does not result in permanent habitat loss and should not prevent use of the bypass by future rail populations.

Floodplain Restoration

Planned floodplain restoration in Conservation Zone 7 will probably not affect California black rails because neither the known range nor modeled habitat of this species overlaps with this activity.

5.6.7.1.3 Construction-Related Effects

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management that are intended to maintain and improve habitat functions in habitats for the California black rail and other covered species, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury, or mortality of California black rails, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are

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currently not quantifiable, but will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

Construction-Related Injury or Mortality

Operation of construction equipment, or contamination from petroleum or other chemical spills, could result in injury or mortality of California black rails. Risk would be greatest to eggs and nestlings susceptible to land-clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. Injury or mortality will be avoided by establishing 700-foot no-disturbance buffers during the breeding season, as described in Appendix 3.C, *Avoidance and Minimization Measures.*

Indirect Construction-Related Effects

There are 488 acres of primary habitat and 26 acres of secondary habitat (2% of all existing habitat) within the vicinity of proposed construction areas that could be indirectly affected by construction activities. Construction activities associated with tidal natural communities restoration include grading, filling, contouring, and other ground-disturbing operations, with the potential to cause noise, dust, and visual disturbance up to 500 feet from the construction edge. If construction occurs during the nesting season, these indirect effects could result in the loss or abandonment of nests, and mortality of any eggs and/or nestlings. This is especially important given that 95% of the habitat indirectly affected is primary habitat for this species. However, as described in Appendix 3.C, *Avoidance and Minimization Measures*, preconstruction surveys of potential breeding habitat will be conducted within 700 feet of project activities, and a 700-foot no-disturbance buffer will be established around any territorial call-centers during the breeding season, or construction will be avoided altogether if breeding territories cannot be accurately delimited.

5.6.7.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird-power line strikes, which could result in injury or mortality of the California black rail. The potential for this risk, however, is considered minimal based on the bird's low-altitude flight behaviors and likely low abundance near the proposed power line corridors. Transmission line poles and towers also provide perching substrate for raptors, which could result in increased predation pressure on local black rails. Of the proposed permanent and temporary transmission lines, approximately 3 kilometers of lines intersect or occur within 100 meters of modeled black rail habitat, all within Conservation Zones 5 and 6. This is expected to have few adverse effects on the black rail population, if any.

Methylmercury

Increased exposure to methylmercury associated with tidal natural communities restoration will potentially indirectly affect Suisun song sparrow. Section 3.4.13, *CM12 Methylmercury Management,* describes the process by which tidal natural communities restoration may increase methylmercury levels in wetlands in the Plan Area. Concentrations of methylmercury known to cause reproductive effects in birds have been found in blood and feather samples of San Francisco Bay black rails (Tsao et al. 2009). Because they forage directly in contaminated sediments, California black rails may be especially prone to methylmercury contamination. Restoration of marshlands might increase

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methylation of mercury where it was to increase the anaerobic conditions necessary for methylation (Appendix 5.D, *Contaminants*). However, the Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands (due to more flushing to prevent anaerobic environments), perhaps reducing the overall risk. Currently, it is unknown how much of the sediment-derived methylmercury enters the food chain in Suisun Marsh or what tissue concentrations are actually harmful to the California black rail. Measures described in Section 3.4.13, *CM12 Methylmercury Management* are expected to reduce the effects of methylmercury resulting from BDCP tidal natural communities restoration.

5.6.7.1.5 Impact of Take on the Species

The range of the California black rail extends throughout portions of California and Arizona, with populations in the Delta, San Francisco Bay, Central Valley, and southern California (Salton Sea and lower Colorado River). The Plan Area represents about 20% of the range-wide distribution of the black rail in California. In the Plan Area, the species occupies suitable habitat in the extreme western Delta and Suisun Marsh. There are 232 CNDDB occurrences through the species' range, or which 40 extant occurrences (17%) are in the Plan Area. The hypothetical footprint for BDCP activities overlaps with seven of these occurrences, all within Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the California black rail, the Plan Area supports 26,439 acres of suitable habitat, most (67%) of which is lower-quality managed wetland (17,739 acres). Of this, up to 6,195acres of modeled habitat (23%) will be affected by tidal natural communities restoration. These effects will primarily occur in managed wetland (4,502 acres) that provides marginal habitat for this species; about 1,279 acres affected are higher-quality tidal brackish habitat. Some of the 5,816 acres of inundation effects may be construed as a long-term temporary loss as some portion of the inundated areas would eventually restore to marsh conditions favored by this bird. These losses of California black rail habitat are not expected to adversely affect the long-term survival and recovery of the species because for the following reasons.

- Most of the permanently removed habitat is managed wetland that provides marginal quality habitat for the species.
- The amount of primary habitat lost (1,657 acres) is much less than the 4,800 acres of tidal brackish marsh and 3,924 acres of tidal freshwater marsh habitat to be restored in the Conservation Zones currently with known occurrences of the species.

Habitat removal will be sequenced with tidal habitat restoration to minimize adverse effects on habitat abundance.

5.6.7.2 Beneficial Effects

The BDCP Implementation Office will restore or create at least 4,800 acres of tidal brackish emergent wetland natural community in Conservation Zone 11, and 3,924 acres of tidal freshwater emergent wetland in Conservation Zones 4, 5, and 6 (West Delta and Cosumnes-Mokelumne ROAs). An additional 12,076 acres of tidal freshwater marsh restoration is planned in Conservation Zones 1, 2, 3, and 7 where there are no current records for California black rails but they may be present but undetected, or they may expand into these areas with future restoration. Tidal wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural

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gradient extending from subtidal to the upland fringe. The habitat and ecosystem functions of tidal wetlands will be maintained and enhanced over the term of the BDCP. Much of the restored tidal marsh will meet the primary habitat requirements of the California black rail, including development of mid- and high-marsh vegetation with dense, tall stands of pickleweed and bulrush cover in Suisun Marsh and expanded freshwater marshes in the riparian zones of the Delta. Nonnative predators will be controlled as needed to reduce nest predation and help maintain species abundance. Tidal habitat restoration actions will primarily affect managed wetlands that provide lower-quality habitat for the California black rail. Restoration will be sequenced and oriented in a manner that minimizes any temporary, initial loss of habitat and habitat fragmentation. These measures will improve habitat conditions for the California black rail and enhance the long-term viability of this species in the Plan Area.

Water operations associated with BDCP actions intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal habitat restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed, an outcome expected to benefit the California black rail.

5.6.7.3 Net Effects

Full implementation of the BDCP will result in at least an estimated 7,122-acre (184%) net increase (8,724-acre gain and 1,278-acre loss) in primary habitat for California black rails in Conservation Zones 4, 5, 6, and 11, which they are known to currently occupy (Table 5.6-3a, *Net Effects, Wildlife*). Taking into account the potential tidal freshwater habitat (12,076 acres) that would be restored in Conservation Zones 1, 2, 3, and 7, which they have not been found in, the amount of restored habitat increases dramatically. The 6,140 acres of both primary and secondary habitat that will be lost as a result of covered activities are primarily (73%) lower-quality managed wetland, while the 8,724 acres of habitat that will be restored will be higher-quality tidal brackish and freshwater marsh. The take of the California black rail as a result of permanent and temporary habitat loss and other direct and indirect effects is not expected to result in an adverse effect on the long-term survival or recovery of this species. California black rail avoidance and minimization measures will be implemented to specifically protect black rail nest sites and avoid injury or mortality to adults, nestlings, and eggs (Appendix 3.C, *Avoidance and Minimization Measures*).

Overall, the BDCP will provide a substantial net benefit to the California black rail through the increase in primary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the California black rail.

5.6.8 California Clapper Rail

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the California clapper rail. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions.* The habitat model for this species includes tidal brackish emergent wetland with a minimum patch size of 1.6 acres within Suisun Marsh and the Delta as far as the western edge of Sherman Island. Primary habitat is tidal brackish emergent wetland dominated by pickleweed. Upland transitional areas, the Delta, and all tidal brackish marsh

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habitats dominated by sedges and bulrushes (low marsh) are considered secondary. Managed wetlands and narrow strips of sedges and bulrushes were excluded from the model. Secondary habitats generally provide only a few ecological functions such as foraging (low marsh) or high tide refuge (upland transition zones), while primary habitats provide multiple functions including breeding, effective predator cover, and quality forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts*. Factors considered in assessing the quality of affected habitat for the California clapper rail, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.8.1 Adverse Effects

5.6.8.1.1 Permanent Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 959 acres of habitat (15% of the habitat in the Plan Area) for the California clapper rail (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). BDCP covered activities that will adversely affect modeled California clapper rail habitat only include tidal natural communities restoration actions.

Tidal Natural Communities Restoration

Tidal This activity is expected to result in tidal inundation of 59 acres of primary and 889 acres of secondary California clapper rail habitat, and desiccation of 11 acres of primary habitat. Although the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for California clapper rail.

The 59 acres of primary habitat to be tidally inundated consists of emergent wetland that is already tidally inundated. An unknown proportion of the 59 acres is expected to convert to tidal perennial aquatic natural community, which is unsuitable for the species. Although the remainder will remain as, or develop into, primary habitat for the California clapper rail, the entire 59 acres are treated as habitat loss for the purpose of establishing take limits because the proportion that will not be converted cannot be determined at this time. The 889 acres of secondary habitat that will be inundated is low marsh that is primarily used by this species for foraging only.

Desiccation as a result of change in the upper marsh tidal prism is expected to result in conversion of approximately 11 acres of primary wetland habitat for California clapper rail to secondary upland habitat. The conversion of primary habitat to secondary habitat is considered a loss as the tidal brackish emergent wetlands lost provide many more ecological functions (e.g., breeding, foraging, cover from predators) than the upland grassland habitats (e.g., refugia) it will convert to. The conversion of secondary wetland habitat to secondary upland habitat is not considered a net loss as both habitat types provide only limited ecological value.

5.6.8.1.2 Periodic Inundation

No periodic inundation effects on the California clapper rail will occur as a result of BDCP covered activities.

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Construction-Related Effects

Construction is not expected to result in loss of California clapper rail habitat other than that described in in Section 5.2.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation.* All staging and other temporary construction-related work areas for tidal natural communities restoration will either be on areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of California clapper rails. Risk would be greatest to eggs and nestlings susceptible to land clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. However, nest sites will be avoided during the nesting season as described in Appendix 3.C. *Avoidance and Minimization Measures.*

Indirect Construction-Related Effects

Construction activities related to tidal restoration are expected to result in temporary indirect effects on 810 acres of California clapper rail habitat adjacent to these activities. Tidal natural community restoration construction activities include grading, filling, contouring, and other ground-disturbing operations, with the potential to cause noise, dust, and visual disturbance up 500 feet from the construction edge. If construction occurs during the nesting season, these indirect effects could result in the loss or abandonment of nests, and mortality of any eggs and/or nestlings. However, 87% (702 acres) of the habitat lost is secondary low marsh rarely used by this species for nesting, and there are approximately 108 acres of breeding habitat in the vicinity of proposed construction areas. As described in Appendix 3.C, *Avoidance and Minimization Measures*, preconstruction surveys of potential breeding habitat will be conducted within 700 feet of project construction activities, and a 700-foot no-disturbance buffer will be established around the territorial call centers during the breeding season, or construction during the breeding season will be avoided altogether if breeding territories cannot be accurately delimited.

Other Indirect Effects

Increased exposure to methylmercury associated with tidal restoration could indirectly affect the California clapper rail. *CM12 Methylmercury Management* describes the process by which tidal restoration may increase methylmercury levels in wetlands in the Plan Area. Concentrations of methylmercury known to be toxic to bird embryos have been found in the eggs of San Francisco Bay clapper rails (Schwarzbach and Adelsbach 2003). Because they forage directly in contaminated sediments, California clapper rails may be especially prone to methylmercury contamination. Tidal restoration of marshlands that increase anaerobic conditions might increase methylation of mercury, leading to increased contamination levels. However, the Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the Plan will generate less methylmercury than the existing managed wetlands, perhaps reducing the overall risk. Currently, it is unknown how much of the sediment-derived methylmercury enters the food chain in Suisun Marsh or what tissue concentrations are actually harmful to the California clapper rail. Measures prescribed for *CM12 Methylmercury Management* are expected to reduce the effects of methylmercury resulting from BDCP tidal natural communities restoration. Despite these measures,

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because of the uncertainty related to methylmercury mobilization from restoration activities and their effects on the California clapper rail, indirect effects on the species are expected.

5.6.8.1.3 Effects of Ongoing Activities

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management may include ground disturbance or removal of nonnative vegetation, which could result in local adverse habitat effects, injury, or mortality of California clapper rails, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable, but will be minimized with implementation of California clapper rail avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.8.1.4 Impact of Take on the Species

The current distribution of the California clapper rail is limited to San Francisco Bay, San Pablo Bay, Suisun Bay, and tidal marshes associated with estuarine sloughs draining into these bays. The range of this subspecies of clapper rail just barely extends into the Plan Area (Suisun Marsh), and the species may use the Plan Area only sporadically and in low densities. For example, surveys conducted by annually from 2002 to 2007 in Suisun Marsh found up to eight birds and as few as no birds each year (California Department of Fish and Game XXXX). Within the Plan Area, the clapper rail occupies suitable habitat in the extreme western Delta and the Suisun Marsh. There are 88 CNDDB/DHCCP extant occurrences of California clapper rail through the species' range, of which 13 (15%) occur in the Plan Area. The hypothetical footprint for BDCP activities overlaps with two of these occurrences, all within Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the California clapper rail, the Plan Area supports 6,597 acres of suitable habitat, most (82%) of which is tidal brackish marsh (5,414 acres). Of this, only 959 acres of modeled habitat (15%) will be permanently removed. These permanent losses will occur almost entirely (99%) in tidal brackish marsh habitat. Some of the 948 acres of inundation loss is temporary losses as some inundated areas would eventually restore to marsh conditions favored by this species. These losses of California clapper rail habitat are not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- The Plan Area represents the edge and a small portion of the species' range, in which its population occurs at low densities.
- The permanent inundation loss (948 acres) is much less than the amount to be restored (4,800 acres).
- Tidal habitat inundated will be sequenced with tidal habitat restoration to minimize adverse temporal and spatial effects on habitat abundance.

5.6.8.2 Beneficial Effects

Full implementation of theThe BDCP Implementation Office will restore or create at least 4,800 acres of tidal brackish emergent wetland natural community in Conservation Zone 11. Tidal wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural gradient extending from subtidal to the upland fringe. The habitat and ecosystem functions of tidal brackish emergent wetland will be maintained and enhanced for native species

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over the term of the BDCP. Much of the restored tidal brackish emergent wetland will meet the primary habitat requirements of the California clapper rail, including development of mid- and high-marsh vegetation with dense, tall stands of pickleweed cover. Nonnative predators will be controlled as needed to reduce nest predation and help maintain species abundance. Restoration will be sequenced and spaced in a manner that minimizes any temporary, initial loss of habitat and habitat fragmentation. These measures will improve habitat conditions for the California clapper rail and enhance the long-term viability of this species in the Plan Area (primarily by converting unsuitable managed wetlands to suitable tidal brackish marsh).

Water operations associated with BDCP actions intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal natural community restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed, an outcome expected to benefit the California clapper rail.

5.6.8.3 Net Effects

Full implementation of the BDCP will result in approximately a 3,347-acre (51%) net increase in habitat for California clapper rails, and at least 3,078 acres increase (16%) of California clapper rail habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*). The take of California clapper rail as a result of permanent and temporary habitat loss and other direct and indirect effects is not expected to result in an adverse effect on the long-term survival or recovery of this species. California clapper rail avoidance and minimization measures (Appendix 3.C, *Avoidance and Minimization Measures*) will be implemented to specifically protect clapper rail nest sites and avoid injury or mortality to adults, nestlings, and eggs.

Overall, the BDCP will provide a substantial net benefit to the California clapper rail through the increase in primary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of California clapper rail.

5.6.9 California Least Tern

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the California least tern. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model used to assess effects for the California least tern identifies suitable foraging habitat as all areas mapped as tidal perennial aquatic. Breeding habitat is not mapped because most of the natural shoreline in the Plan Area that historically provided nesting sites has been modified or removed. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Least terns currently nest on artificial fill adjacent to tidal perennial aquatic habitat in the vicinity of Suisun Marsh and west Delta (Conservation Zone 11), and additional nesting could occur at the edge of tidal perennial waters whenever disturbed or artificial sites mimic habitat conditions sought for nesting (i.e., sandy or gravelly substrates with sparse vegetation). Habitat quality factors used to assess effects on foraging habitat included size and extent of habitat fragmentation, and location in relation to areas where California least terns are most likely to forage (near nesting colonies and relatively coastal).

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5.6.9.1 Adverse Effects

5.6.9.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 65 acres[7] of aquatic habitat (less than 0.1% of the aquatic habitat in the Plan Area) for the California least tern (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in adverse effects on the California least tern include conveyance facility construction and Fremont Weir/Yolo Bypass improvements. Most of the loss results from conveyance facility construction (43% of permanent loss) and desiccation as a result of tidal natural communities restoration (41% of permanent loss).

Conveyance Facility Construction

This activity, including construction and establishment of areas for disposal of muck, will result in the permanent removal of approximately 28 acres (less than 0.1%) of aquatic foraging habitat for the California least tern) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Foraging habitat that will be affected by conveyance facility construction consists of small patches that are located inland of areas where California least terns would normally forage, and does not provide high quality foraging areas for this species.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 7 acres of aquatic foraging habitat for California least tern in Conservation Zone 2 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

While tidal inundation will not result in adverse effects on California least tern, desiccation as a result of change in the tidal prism is predicted to result in the loss of 27 acres of modeled foraging habitat (less than 0.1% of foraging habitat in the Plan Area) for California least tern (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

5.6.9.1.2 Periodic Inundation

Periodic inundation will not result in adverse effects on California least tern foraging habitat.

5.6.9.1.3 Construction-Related Effects

Construction-related effects on the California least tern include short- and long-term temporary habitat loss, potential injury or mortality, and indirect noise and visual disturbance effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction activities will result in temporary loss of approximately 125 acres of aquatic foraging habitat for the California least tern. The habitat will be lost in several locations that are inland of

[7] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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areas where California least terns would normally forage, such as Clifton Court Forebay, and is not near any known nesting colonies. This habitat does not provide high-quality foraging habitat for the California least tern.

Construction-Related Injury or Mortality

California least terns currently nest in the vicinity of potential restoration sites in Suisun Marsh and west Delta area (Conservation Zones 10 and 11). New nesting colonies could establish if suitable nesting habitat is created during restoration activities (e.g., placement of unvegetated fill to raise surface elevations prior to breaching levees during restoration efforts). If nesting occurs where covered actions are undertaken, the operation of equipment for construction, restoration and enhancement could result in injury or mortality of California least terns. Risk of injury or disturbance would be greatest to eggs and nestlings susceptible to land-clearing activities, abandonment of nests and nesting colonies, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. However, injury or mortality will be avoided through planning and preconstruction surveys that follow established protocols to identify nesting colonies and to design projects to avoid locations with least tern colonies, and the provision for 500-foot protective buffers to limit possible adverse effects. Construction activities will avoid injury or mortality of nesting California least terns as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance within 500 feet of construction activities could temporarily affect the use of 3,600 acres (4%) of modeled California least tern aquatic foraging habitat (Table 5.6-2a, *Indirect Effects, Wildlife*). However, noise and visual disturbance is expected to have a minimal effect on California least tern foraging. If least tern nests are found during planning or preconstruction surveys, no construction will take place within 500 acres of active nests as described in Appendix 3.C, *Avoidance and Minimization Measures*.

The use of mechanical equipment during construction may result in the accidental release of petroleum or other contaminants that could affect California least tern and their prey. Implementation of the construction BMPs described in Appendix 3.C, *Avoidance and Minimization Measures*, will minimize the likelihood of such spills occurring. Should a spill occur, implementation of the avoidance and minimization measures will greatly reduce the likelihood that individuals would be impacted.

5.6.9.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Facilities operation and maintenance activities are not expected to adversely affect the California least tern because no facilities requiring ongoing maintenance are planned in the vicinity of modeled habitat.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected habitats, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects and injury or mortality of California least terns, and temporary noise and

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visual disturbance effects if individuals are present in or adjacent to work sites over the term of the BDCP. These potential effects are currently not quantifiable, but are expected to be minimal because few management activities will be implemented in aquatic habitat and because terns are not expected to nest on protected lands. However, surveys will be conducted prior to ground disturbance in any areas that have suitable nesting substrate for California least tern nesting (flat, unvegetated areas near aquatic foraging habitat) and injury, mortality, and noise and visual disturbance of nesting terns, if present, will be avoided as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

Increased exposure to methylmercury associated with tidal natural communities restoration will potentially indirectly affect the California least tern. Section 3.4.13, *CM12 Methylmercury Management*, describes the process by which tidal natural communities restoration may increase methylmercury levels in wetlands in the Plan Area.

Schwarzback and Adelsbach (2003) investigated mercury exposure in 15 species of birds inhabiting the Bay-Delta ecosystem. Among the species studied, the highest concentrations of mercury were found in the eggs of piscivorous birds (terns and cormorants) that bioconcentrate mercury from their fish prey. The very highest concentrations were found in Caspian and Forster's terns, especially those inhabiting South San Francisco Bay. Based on three California least tern eggs collected from Alameda Naval Air Station in the San Francisco Central Bay, concentrations in California least tern eggs were a third (0.3 ppm) those of the eggs of the other two terns. Because of the small sample size, there is a high degree of uncertainty regarding the levels of mercury that may be present in California least tern eggs. If the mercury levels measured at Alameda Naval Air Station are representative of the population in the San Francisco Bay, they are not expected to result in adverse effects on tern hatchlings. Hatching and fledging success were not reduced in common tern eggs in Germany with mercury concentrations of 6.7ppm (Hothem and Powell 2000).

The effects of mercury mobilization and methylation from tidal wetland restoration will be minimized by the implementation of CM12. However, despite these measures, some indirect effects of methylmercury mobilization on the California least tern are expected.

5.6.9.1.5 Impact of Take on Species

The Plan Area constitutes a relatively small portion of the species' total range. The California least tern breeds along the Pacific Coast from San Francisco Bay to Baja California. The nesting range in California is somewhat discontinuous due to the limited availability of suitable estuarine shorelines. Recent statewide surveys estimated between 6,744 and 6,989 breeding pairs in California, with about 85% of the breeding colonies occurring in southern California and only a small percentage (6.3%) occurring in the San Francisco Bay area (Marschalek 2009). Breeding colonies in the San Francisco Bay area have only been reported since about 1970 (U.S. Fish and Wildlife Service 2006). Recently, California least terns have been reported nesting at two sites on artificial fill in the Plan Area: on the eastern edge of Suisun Marsh in the Montezuma Wetland (Conservation Zone 11), and at the Pittsburg Power Plant in Pittsburg (Conservation Zone 10). About 3% (2 of 67) of all occurrence records for the California least tern are from the Plan Area, and the breeding colonies in the Plan Area are small and exhibit low nesting success compared with those outside the Plan Area. In 2010, for example, 23 California least tern pairs and 17 nests were found at the Montezuma Hills

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site, and only 5 young fledged. In comparison, 47 California least tern pairs and 47 nests were found at Napa Sonoma Marsh Wildlife Area, and 85 young fledged at this location.

Based on modeled California least tern habitat, the Plan Area supports 86,231 acres of potentially suitable foraging habitat, represented by the tidal perennial aquatic natural community. Breeding habitat is not mapped because no natural estuarine shoreline areas that could support nesting remain in the Plan Area, although the species nests in small numbers in two locations on artificial fill areas and could potentially nest in similar areas along the perimeter of tidal perennial aquatic habitat. Projects will be designed to avoid sites supporting nesting California least terns. BDCP actions are projected to permanently remove 65 acres (less than 0.1%) and to temporarily remove 125 acres (less than 0.1%) of modeled California least tern foraging habitat in the Plan Area. Loss of modeled foraging habitat in Conservation Zones 10 and 11, where terns currently nest, is limited to an 8-acre permanent loss in Conservation Zone 11.

Although the habitat losses, disturbances, and other BDCP-associated impacts may affect California least terns over the short-term, they are not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- Only a small fraction of the total California least tern population uses the Plan Area.
- The Plan Area is not identified as a management area key to California least tern recovery in the recovery plan for this species (U.S. Fish and Wildlife Service 1990).
- The BDCP will avoid adverse effects on the two sites where small numbers of California least terns currently nest, and will avoid the disturbance of any active nests found in the future during Plan implementation.
- Combined permanent and temporary losses of modeled California least tern foraging habitat represent approximately 0.2% of the available tern foraging habitat in the Plan Area.
- Because of a lack of suitable nesting sites, much of the modeled foraging habitat is likely used by California least terns only during seasonal migrations, if at all.

5.6.9.2 Beneficial Effects

The BDCP Implementation Office will restore or create at least 10,000 acres of tidal perennial aquatic habitat that supports aquatic food production and foraging habitat for the California least tern. Tidal perennial aquatic restoration is expected to substantially increase the primary productivity of fish, increasing the prey base for California least terns. This substantial increase in tidal perennial aquatic foraging habitat will help to offset the historical loss of such habitat in the Plan Area.

5.6.9.3 Net Effects

Full implementation of the BDCP will result in at least a 9,935-acre (12%) increase of habitat for California least tern and at least 9,858 acres increase (55%) of California least tern habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*). Up to 65 acres of tidal perennial aquatic habitat will be permanently lost and 10,000 acres will be restored or created. Tidal perennial aquatic restoration is expected to substantially increase the primary productivity of fish, increasing the prey base for California least terns. Adverse effects on California least tern nest sites will be avoided as described in Appendix 3.C, *Avoidance and Minimization Measures*.

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Overall, the BDCP will provide a substantial net benefit to the California least tern through the increase in extent and quality of available foraging habitat. Therefore, the BDCP will contribute to the recovery of the California least tern.

5.6.10 Greater Sandhill Crane

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures on the greater sandhill crane. The general methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants* and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*, and more specific assessment methods are described below. The habitat model used to assess effects the species includes vegetation and land cover types associated with greater sandhill crane winter roosting and foraging habitat. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the greater sandhill crane, to the extent that information is available, include the relative habitat value of specific crop or land cover types within the crane's winter use area and proximity to known roosting sites.

Effects on greater sandhill crane were calculated using the density index data provided by Ivey (2010). While the effects analysis and the conservation strategy for greater sandhill crane rely on the habitat-based approach used for all covered species, density index data are also useful in examining effects on habitat based on the current distribution of wintering cranes. Seven density zones were established by Ivey (2010) that extend out 6 kilometers from known roosting locations within the crane use area. Zones closest to roosting sites had the greatest density index value. This method of assessing habitat effects assumes that lands closer to roost sites are used more frequently by cranes and thus have higher relative biological value. Both methods are useful because of their different assumptions. The habitat-based approach overestimates occupied habitat but accounts for a changing landscape and a changing crane distribution through time. In contrast, the density index method does not account for changes in conditions or crane distribution through time but provides gradients of habitat quality, allowing more refined estimates of effects on habitat.

Greater sandhill cranes in the Plan Area are almost entirely dependent on privately owned agricultural lands for foraging. Long-term sustainability of the species is thus dependent on providing a matrix of compatible crop types that afford suitable foraging habitat, while sustaining and increasing the extent of other essential habitat elements such as night roosting habitat. The habitat model for the greater sandhill crane (Appendix 2.A, *Covered Species Accounts*) identifies suitable foraging and roosting habitat in the Plan Area as certain agricultural types, specific grassland types, irrigated pastures and hays, and many managed seasonal wetland types. Because agricultural crops and other cover types differ in their value as foraging habitat for greater sandhill crane, the acres of foraging habitat were converted into habitat units by assigning relative foraging habitat values to cover type categories (Table 5.6-4). These habitat units were used to characterize BDCP effects on greater sandhill crane habitat in terms of existing habitat value. The conservation acreages are characterized as a range that represent the minimum and maximum replacement acres that are associated with the habitat value of impacted acres relative to the habitat value of the selected conservation land.

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Table 5.6-4. Assigned Greater Sandhill Crane Foraging Habitat Value Classes for Cultivated Land Crop Types and other Cover Types

Foraging Habitat Value Class	Cultivated Land Crops and other Cover Types	Foraging Habitat Value
Very high	Corn, rice, managed seasonal wetlands	1.0
High	Alfalfa, irrigated pasture, wheat	0.75
Moderate	Other grain crops (barley, oats, sorghum), grasslands	0.5
Low	Other irrigated field and truck crops	0.1
None	Orchards, vineyards, blueberries	0

5.6.10.1 Adverse Effects

5.6.10.1.1 Permanent Habitat Loss, Conversion and Fragmentation

BDCP covered activities will result in the permanent loss, conversion, or fragmentation of up to 6,507 acres[8] (3,810 habitat units) of modeled habitat (3.3% of the habitat units in the Crane Winter Use Area) for the greater sandhill crane (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in adverse effects on the greater sandhill crane include conveyance facility construction, transmission line construction, and tidal natural communities restoration.

Conveyance Facility Construction

This activity will result in the permanent removal of approximately 1,719 acres (1,380 habitat units) of habitat for the greater sandhill crane (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Habitat effects from conveyance construction will occur in Conservation Zones 3, 5, and 6, primarily in areas with relatively low crane use (Ivey pers. comm.).

Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration footprint, this activity will result in the permanent conversion of approximately 4,794 acres (2,431 habitat units) of modeled cultivated lands for the greater sandhill crane in the Cosumnes-Mokelume River and West Delta ROAs to tidal wetland natural community (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

The habitat value index calculations from Table 5.6-5 indicate that of the total 6,507 acres of permanent effects, 1,376 acres (21%) are in the very high (1.0) habitat value category, 1,998 acres (31%) are in the high (0.75) habitat value category, 1,552 acres (24%) are in the moderate (0.5) habitat value category, and 1,581 acres (24%) are in the low (0.1) habitat value category. This indicates that a fairly broad distribution of habitat suitability values would be permanently affected.

[8] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Table 5.6-5. Total Amount of Greater Sandhill Crane Habitat Affected by BDCP Covered Activities and Corresponding Habitat Units

Foraging Habitat Value Class	Cultivated Land Crops and other Cover Types	Foraging Habitat Value	Acres Affected by BDCP Covered Activities	Habitat Units Affected
Very High	Corn, rice, managed seasonal wetlands	1.0	1,376	1,376
High	Alfalfa, irrigated pasture, wheat	0.75	1,998	1,499
Moderate	Other grain crops, grasslands	0.5	1,552	776
Low	Other irrigated field and truck crops	0.1	1,581	159
Totals			6,507	3,810

The permanently affected acres and corresponding habitat units associated with each covered activity type are expressed in Table 5.6-6.

Table 5.6-6. Permanently Affected Acres and Corresponding Habitat Units by Covered Activity Type

Foraging Habitat Value Class	Conveyance Facility Construction		Tidal Natural Community Restoration	
	Acres	Habitat Units	Acres	Habitat Units
Very High (1.0)	1,035	1,035	341	341
High (0.75)	301	226	1,697	1,273
Moderate (0.5)	201	101	1,351	676
Low (0.1)	176	18	1,405	141
Total	1,714	1,380	4,794	2,431

While the habitat-based approach does not differentiate value based on geography (i.e., all similar cover types in the crane use area are considered to have equal value), the density index approach, based on observed use patterns, reveals that BDCP actions primarily remove lower-quality habitat in the crane use area (Table 5.6-7). Approximately 85% of all the affected habitat areas are either outside of the 6-mile radius area or are in the two lowest density categories (greater than 5 kilometers from roost sites). Only 10% of the total affected acres (767 acres) occur within 3 kilometers of roost sites. Other than the 6.7 acres directly affecting a roost site, no impacts occur immediately adjacent (within 1kilometer) of roost sites, and only 15% of the loss occurs within 4 kilometers of roost sites.

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Table 5.6-7. Percent of Effect by Foraging Density Zone[1] using all Effects Combined (Total Affected Acres)[2]

Foraging Density Zone**	**Area Affected (acres)**	**Percentage of Total**
Outside 6km radius	942	12
0.001–0.01	3,296	42
0.01–0.1	2,422	31
0.1–0.2	454	6
0.2–0.4	438	5
0.4–0.6	0	0
1.0–1.2	329	4
1.2–1.4	0	0
Roosting habitat	7	0.09

[1] Includes area outside 6-kilometer plus roosting habitat.
*[2] The total affected acres include all permanent, temporary, borrow/spoil, and roost site effects.
**[3] Foraging density zones follow Ivey (2010).

The estimates of permanent loss of foraging habitat in winter use zones likely overestimate effects on sandhill cranes and are thus conservative. For example, not all agricultural lands in the winter use area are suitable for crane use. Similarly, crane distribution is not uniform within winter use areas, so much of the crane winter use area is unused or underused in any given year. Unpublished data from Ivey (pers. comm.) indicates the areas (foraging density zones) that are most frequently used by greater sandhill cranes. A qualitative review of this crane use data suggests that the majority of effects from BDCP actions will occur in areas of Conservation Zones 4 and 5 that receive the lowest reported crane use.

Effects in Conservation Zone 4 are also associated with tidal wetland restoration activities where low-value cultivated lands are converted to tidal wetlands. To be conservative, these effects are counted as a permanent loss of sandhill crane habitat. However, tidal wetland restoration may in some cases enhance habitat value for cranes. While it is unclear to what extent this community would be used by cranes, in areas where the tidal range is relatively narrow and invertebrate food items are available, freshwater tidal wetlands around the perimeter of and outside of the winter use area may also benefit crane populations in the Plan Area by providing stable foraging areas. Because agricultural uses shift (and thus can shift from a high-value to a low-value or unsuitable crop type), they generally do not provide a stable landscape for foraging. Restored tidal freshwater wetlands in Conservation Zone 4 will include shallow water habitats, berms, and grassland edges and may provide suitable roosting and foraging habitat for greater sandhill cranes. Additional restored tidal freshwater wetlands south of the winter use area may also provide suitable roosting, loafing, and foraging habitat that may facilitate a southward expansion of the wintering range.

Fragmentation of both suitable and occupied habitat is expected to be minimal because the majority of the affected acres are outside of the core occupied portion of the winter use area (based on Ivey's density maps) and because the largest proportion of the effect is associated with tidal restoration. In Conservation Zone 5, loss of modeled habitat occurs along the western edge of the crane winter use area and therefore will not result in fragmentation of traditional crane habitats. In Conservation Zone 4, tidal wetland restoration may occur between the high crane use area of the central Delta and

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the Cosumnes River Preserve. However, conversion to tidal wetlands in this area will not prohibit crane movement or reduce use of these important crane use areas.

5.6.10.1.2 Periodic Inundation

No periodic inundation effects on greater sandhill crane will occur as a result of BDCP covered activities.

5.6.10.1.3 Construction-Related Effects

Construction-related effects on the greater sandhill crane include short-term, temporary effects from water conveyance construction and long-term, temporary effects from establishment of borrow and spoils sites. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction activities are expected to temporarily remove 1,662 acres (1,197 habitat units) from the crane use area, including temporary and long-term temporary effects (Table 5.6-8) and representing approximately 0.8% of the modeled crane habitat in the Plan Area. Nearly all the affected modeled habitat is cultivated land.

Table 5.6-8. Construction-Related Affected Acres and Corresponding Habitat Units by Type of Effect

Foraging Habitat Value Class	Short-Terrm Temporary Effects from Conveyance Facility Construction		Long-Term Temporary Effects from Borrow and Spoils Sites	
	Acres	Habitat Units	Acres	Habitat Units
Very high (1.0)	344	344	472	472
High (0.75)	216	162	16	12
Moderate (0.5)	232	116	131	66
Low (0.1)	142	14	109	11
Total	934	636	728	561

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 728 acres (561 habitat units) of modeled greater sandhill crane winter foraging habitat Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

New transmission lines will increase the risk for greater sandhill crane power line strikes or electrocution. Greater sandhill cranes are susceptible to collision with power lines and other structures during periods of inclement weather and low visibility (Avian Power Line Interaction Committee 1994;, Brown and Drewien 1995; Manville 2005). The existing network of power lines in

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the Plan Area currently poses this risk for greater sandhill cranes. New transmission lines will increase this risk; however, power line siting considers and to the extent possible reduces the risk by designing the project to avoid high-use areas and flight corridors. The risk for bird-power line strikes and/or electrocution will also be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*, including the installation of flight deterrent devices on power lines.

Indirect Construction-Related Effects

Construction-related noise and visual disturbances within 2,600 feet of construction activities could temporarily affect the use of 9,487 acres (4.8%) of modeled greater sandhill crane habitat (Table 5.6-2a, *Indirect Effects, Wildlife*). These construction activities will include water conveyance construction, transmission line construction, and tidal restoration activities.

Noise and visual disturbances during construction of the water conveyance facilities could result in temporary disturbances that affect greater sandhill crane use of approximately 6,952 acres of habitat in the crane use area. In addition, construction of the transmission line could result in the temporary disturbance of up to approximately 515 acres of modeled crane habitat and restoration-related noise and visual effects could result in temporary disturbances of up to an additional 2,020 acres of modeled crane habitat. Noise and visual disturbances during construction of the water conveyance, transmission line facilities, and restoration projects could result in temporary disturbances that affect greater sandhill crane use of the surrounding agricultural lands. These effects would be minimized through implementation of the measures described in Appendix 3.C, *Avoidance and Minimization Measures*, which require set-back buffers from crane use areas during construction.

5.6.10.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Facilities and operations activities within 1,320 feet of construction could permanently indirectly affect 523 acres of modeled greater sandhill crane habitat. Maintenance of the above-ground water conveyance facilities could result in ongoing but periodic post-construction noise and visual disturbances that could affect greater sandhill crane use of surrounding habitat. These effects may include periodic vehicle use along the conveyance corridor, and inspection and maintenance of above-ground facilities. These potential effects will be minimized with implementation of the measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

Exposure to methylmercury is known to affect birds and could adversely affect the greater sandhill crane; the effects of methylmercury production in restored tidal natural communities on greater sandhill crane, however, are not known. Because greater sandhill cranes occur in the Plan Area only during the nonbreeding winter months, because their primary foraging habitats in the Plan Area are cultivated crops, and because the use of restored tidal wetlands by cranes is likely to be limited compared to seasonal managed wetlands, the extent of potential exposure is probably minimal. Implementation of *CM12 Methylmercury Management* is expected to reduce the level of methylmercury that may be produced in restored tidal habitats.

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5.6.10.1.5 Effects Impact of Take on Species

Of the estimated total population of 62,600 greater sandhill cranes, an estimated 8,500 belong to the Central Valley population (Littlefield and Ivey 2000). The Central Valley population breeds from British Columbia to northern California and winters in the Central Valley. A portion of the Plan Area (the Greater Sandhill Crane Winter Use Area) is one of two important greater sandhill crane winter use areas in the Central Valley, the other being the Butte Basin. In the Plan Area, the winter use area includes lands within Conservation Zones 3, 4, 5, and 6, which includes the central Delta and northern Delta east of the Stockton Deep Water Ship Channel, and incorporates nearly all of the lands traditionally used by wintering greater sandhill cranes in the Delta.

BDCP actions are expected to permanently remove up to 6,507 acres (3,810 habitat units) of modeled greater sandhill crane foraging habitat representing 3.3% of total modeled crane foraging habitat in the crane use area, and 6.7 acres of roosting habitat. Approximately 85% of all the affected foraging habitat areas occur outside of the core crane use area (greater than 5 kilometers from traditional roost sites). This and other adverse effects resulting in take are not expected to adversely affect the species' long-term survival and recovery for the following reasons.

- While a substantial number of acres of cultivated lands will be affected, the affected areas represent a small proportion of habitat in the Plan Area, and have relatively low value habitat in the crane use area.
- Adverse effects on crane roost sites is limited to only 6.7 acres and roosts will be protected through implementation of avoidance and minimization measures that include no-disturbance set-backs while cranes are present.

5.6.10.2 Beneficial Effects

The BDCP Implementation office will restore and protect between 3,353 and 4,247 acres with the intent to protect an equivalent habitat value that is permanently removed. Conservation lands will be protected from potential loss or degradation that otherwise could occur with future changes in existing land use (e.g., incompatible crop conversions, urbanization). Restoration and annual maintenance of 320 acres of roosting habitat, the lack of which is a stressor on the species, located near protected foraging habitats is expected to improve the distribution of crane use within the crane use area and ensure the continued availability of roost sites over the term of the BDCP. Finally, some portion of the restored freshwater tidal wetland natural community may provide foraging, loafing, or roosting value to the greater sandhill crane and potentially facilitate the expansion of the crane use area into currently unoccupied areas, particularly in Conservation Zone 7.

5.6.10.3 Net Effects

Full implementation of the BDCP will result in at least 5,957 acres (3%) decrease of habitat for the greater sandhill crane, but at least 2,204 acres increase (6%) of greater sandhill crane habitat in protected lands.

Full implementation of the BDCP will result in a net permanent loss of modeled foraging habitat of between 2,260 and 3,154 acres, but the habitat value on protected acres will be maintained sufficient to fully replace or exceed all lost habitat values. Additional restoration of roosting habitat will increase this essential habitat element in the Plan Area and facilitate use of other modeled foraging habitat areas. The extent of protected foraging and roosting habitat in the Plan Area will

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also increase with full BDCP implementation. The net effect of BDCP actions on the greater sandhill crane are expected to be beneficial based on the following rationale.

- The majority of affected acres do not occur in the core crane use area and are considered lower-value habitat based on use data.
- A large proportion of the crane use area, while modeled as suitable crane habitat, is unoccupied by cranes in any given year.
- Only 3.3% of the total available modeled crane habitat within the crane use area would be permanently removed.
- The agricultural habitat value that will be permanently lost will be replaced in equal proportion through protecting and enhancing other agricultural lands on at least 3,353 acres (the total if all replacement acres are in the highest value class).
- At least 80% of all protected greater sandhill crane habitat will be maintained each year in the highest value land cover type with the remainder in moderate to high value.
- Because agricultural habitat values change over time based largely on economically driven agricultural practices, protecting crane habitat will provide enhanced stability to agricultural habitat value within the crane use area that does not currently exist.
- The creation and management of 320 acres of permanent crane roosting habitat will substantially increase the extent of roosting habitat in the crane use area and facilitate use of surrounding lands that may be currently unoccupied or underused due to the lack of proximity to roost sites.

Overall, the BDCP will provide a net benefit to the greater sandhill crane through the increase in available roosting habitat, the maintenance of existing or enhanced foraging habitat values, and the increase in extent of habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the greater sandhill crane.

5.6.11 Least Bell's Vireo

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the least Bell's vireo. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the least Bell's vireo identifies suitable nesting and migratory habitat as those plant alliances from the valley/foothill riparian modeled habitat that contain a dense shrub component, including all willow-dominated alliances. Although the species may use adjacent nonriparian scrub habitats for foraging or dispersal, nonriparian portions of the Plan Area are primarily in agricultural use and thus unsuitable for least Bell's vireo. Therefore, the habitat model is restricted to riparian vegetation. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the least Bell's vireo, to the extent that information is available, include location in relation to species occurrences and existing protected lands (Categories 1 and 2 open space[9]), and habitat patch size and configuration.

[9] See Section 5.3.5.2 *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories.

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5.6.11.1 Adverse Effects

5.6.11.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 1,032 acres[10] of habitat (7% of the habitat in the Plan Area) for the least Bell's vireo (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in adverse effects on the least Bell's vireo include conveyance facility construction, tidal natural communities restoration, Fremont Weir/Yolo Bypass improvements, and floodplain restoration. A majority (75%) of the permanent loss is from tidal communities restoration.

Conveyance Facility Construction

Construction of all conveyance facilities including transmission lines will result in the permanent removal of approximately 13 acres of least Bell's vireo habitat (less than 0.1% of habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of low quality for the species: it consists of small patches scattered through Conservation Zones 3, 4, 5, 6, and 8, most of which are narrow strips along irrigation and drainage channels. Least Bell's vireo does not likely nest in habitat along the conveyance facility alignment: the alignment was surveyed by DWR biologists in 2009, 2010, and 2011 and although the surveys were not conducted specifically for least Bell's vireo, they occurred during the nesting season when this species is easily detected by its song, if present.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 212 acres of least Bell's vireo habitat (Table 5.6-1a ,*Maximum Allowable Habitat Loss, Wildlife*) in Conservation Zone 2 (1.4% of habitat in the Plan Area). Most of the habitat to be lost is of low to moderate quality: although it is located in and near Category 1 open space, the modeled habitat to be affected in the vicinity of Fremont Weir includes grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation, and there are no least Bell's vireo occurrences near the Fremont Weir.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 778 acres of least Bell's vireo habitat (5% of habitat in the Plan Area) in the Suisun, Cache Slough, Cosumnes, West Delta, and South Delta ROAs (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The majority of the habitat will be lost in Conservation Zones 2 (41%) and 5 (28%), and the remainder is scattered in Conservation Zones 1, 4, 6, 7, 8, and 11. Most of the habitat loss in Conservation Zone 2 is in Cache Slough ROA, around Liberty Island (Category 1 open space), and most of the loss in Conservation Zone 5 is located in the vicinity of Frank's Tract and Brannan Island State Recreation Areas (Category 2 open space). These areas are considered of moderate to high quality because they include relatively large habitat patches in or adjacent to protected lands. The remainder of the habitat loss potentially resulting from tidal natural communities restoration is of low to moderate quality, and is mostly in relatively small patches and narrow strips along drainage channels and

[10] Impact acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual impacts will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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surrounded by agricultural lands. Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on the least Bell's vireo.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 28 acres of least Bell's vireo habitat in Conservation Zone 6 (less than 0.1% of habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of moderate to high quality: although it consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River, some of the patches are adjacent to existing Categories 1 and 2 open space, and some of the patches are within several miles of a breeding occurrence for least Bell's vireo south of the Plan Area. The estimates of habitat loss resulting from floodplain restoration are based on projections of where restoration may occur, but actual habitat loss is expected to be lower because sites will be selected to minimize effects on least Bell's vireo habitat.

5.6.11.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 97 acres of habitat for the least Bell's vireo (0.6% of the habitat in the Plan Area). Although flood frequency will increase in the Yolo Bypass area, the flooding regime is expected to be within the tolerance range for riparian vegetation in the bypass.

Floodplain Restoration

This activity will periodically inundate approximately 147 acres of least Bell's vireo habitat (1.0% of the habitat in the Plan Area). Frequency of flooding will be on the order of once every 5 years in restored floodplain.

Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the least Bell's vireo because flooding is unlikely to occur during the breeding season when vireos could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal.

5.6.11.1.3 Construction-Related Effects

Construction-related effects on the least Bell's vireo include long-term, temporary habitat loss, potential construction-related injury or mortality, and indirect noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Long-Term)

Construction-related effects will temporarily remove 131 acres of habitat for the least Bell's vireo (less than 1% of the habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily removed areas will be restored as riparian habitat within 1 year following

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completion of construction activities. Although the effects are considered temporary, 5 years to several decades may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, restored riparian vegetation can have the habitat structure to support breeding vireos within 3 to 5 years, particularly if the restored vegetation is adjacent to established riparian areas (Kus 2002). Furthermore, most of the riparian vegetation to be temporarily removed in the Plan Area is early- to mid-successional; therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first 5 to 10 years after the initial restoration activities are complete.

Construction-Related Injury or Mortality

Although least Bell's vireo nesting has not been confirmed in the Plan Area, recent occurrences in the Yolo Bypass and south of the Plan Area at the San Joaquin River National Wildlife Refuge suggest that the reestablishment of a breeding population is a possibility over the duration of the BDCP. If the least Bell's vireo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk would be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Injury or mortality to nesting least Bell's vireos will be avoided through preconstruction surveys and establishment of no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance within 1,300 feet of construction activities could temporarily affect the use of 1,071 acres (7%) of modeled least Bell's vireo habitat (Table 5.6-2a, *Indirect Effects, Wildlife*). As described above, there are no nesting records for this species in the Plan Area but recent sightings indicate that the species may become established in the Plan Area during Plan implementation. Indirect noise and visual effects on nesting vireos, if found, will be minimized by establishing 250-foot no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.11.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing facility operation and maintenance will have little, if any, adverse effect on the least Bell's vireo. Noise and visual disturbance within 500 feet of facilities could affect the use of 1 acre (less than .01%) of modeled least Bell's vireo habitat (Table 5.6-2a, *Indirect Effects, Wildlife*).

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected least Bell's vireo habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of vireos, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with measures described in Appendix 3.C. *Avoidance and Minimization Measures*.

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Other Indirect Effects

The BDCP covered activities and conservation measures will have no other indirect effects on the least Bell's vireo.

5.6.11.1.5 Impact of Take on Species

The least Bell's vireo's historical breeding distribution in California once extended from coastal southern California through the San Joaquin and Sacramento Valleys as far north as Tehama County near Red Bluff. The Sacramento and San Joaquin Valleys were considered the center of the species' historical breeding range, supporting 60 to 80% of the historical population (51 FR 16474). Coinciding with widespread loss of riparian vegetation throughout California (Katibah 1984), Grinnell and Miller (1944) began to detect population declines in the Sacramento and San Joaquin Valley region. Surveys conducted in the late 1970s (Goldwasser et al. 1980) detected no least Bell's vireos in the Sacramento and San Joaquin Valleys, and the species was considered extirpated from the region. In 1986, the estimated statewide least Bell's vireo population was approximately 300 pairs (51 FR 16474), and the population was confined to southern California. By 1998, the population had increased to an estimated 2,000 pairs after extensive cowbird trapping efforts (Kus 2002), but the population was confined to southern California. Recent occurrences, however, have suggested a range expansion to the northern extent of the species' historical breeding range, including nest sites reported from the San Joaquin River National Wildlife Refuge adjacent to the Plan Area to the south (Howell et al. 2010) and recent (2010) observations of singing least Bell's vireos at the Yolo Bypass Wildlife Area in Conservation Zone 2. This recent occurrence in the Plan Area represents one of 236 CNDDB occurrences throughout the state. The hypothetical footprint for BDCP activities does not overlap with this occurrence. No confirmation of breeding by vireo has been documented in the Plan Area since at least the 1970s.

Based on modeled habitat for the least Bell's vireo, the Plan Area supports 14,731 acres of potentially suitable nesting and migratory habitat. Of this, up to 1,032 acres of suitable habitat (7% of such habitat in the Plan Area) will be permanently removed, and up to 131 acres of suitable habitat (less than 0.9 of such habitat in the Plan Area) will be temporarily removed. Approximately 224 acres of nesting and migratory habitat (2% of such habitat in the Plan Area) will experience periodic seasonal flooding as a consequence of floodplain restoration and the operation of the Fremont Weir, but this periodic flooding is not expected to affect the least Bell's vireo because flooding is unlikely to occur during the breeding season when vireos could be present, and adverse changes to riparian vegetation from flooding is unlikely. Construction-related activities will avoid direct injury or mortality or indirect noise or visual effects through the measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Take of least Bell's vireo resulting from permanent and temporary habitat loss and other direct and indirect effects is not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- Vireo occurrence is expected to be uncommon in the Plan Area.
- The nesting and migratory habitat to be lost is small relative to the amount of habitat in the Plan Area and the species range throughout California.
- Most of the permanently removed habitat consists of relatively small, fragmented riparian stands that provide low-quality habitat for the vireo.

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5.6.11.2 Beneficial Effects

The BDCP Implementation Office will restore at least 5,000 acres and protect at least 750 acres of valley/foothill riparian natural community, a portion of which is expected to be suitable habitat for the least Bell's vireo. To ensure that a sufficient amount of the restored valley/foothill riparian natural community provides vegetation structure suitable for the least Bell's vireo and other species with similar habitat requirements, the Implementation Office will maintain at least 1,000 acres of the valley/foothill riparian natural community as early- to mid-successional vegetation with dense shrubby understory. Fluvial disturbance within restored floodplains is expected to help maintain this early- to mid-successional vegetation. Riparian systems subject to natural erosional and depositional processes provide conditions conducive to the establishment of dense willow stands preferred by vireos for nesting. These BDCP restoration actions will improve habitat conditions and increase the likelihood for breeding by least Bell's vireo in the Plan Area. Additionally, invasive plants such giant reed and tamarisk that diminish structural diversity and potentially render habitat unsuitable for the least Bell's vireo will be controlled, and this is expected to maintain and enhance vireo habitat. Providing an upland buffer will reduce adverse effects of adjacent land uses. This buffer, which will include transitional uplands adjacent to riparian habitat, will decrease opportunities for encroachment into riparian habitat of domestic pets that are potential predators, and human disturbances such as trampling, nest disturbance, noise and lighting. If a least Bell's vireo population becomes established in the Plan Area and the Implementation Office determines through population monitoring that the population is declining as a result of cowbird parasitism, a cowbird control program will be implemented to maintain the vireo population in the Plan Area.

5.6.11.3 Net Effects

Full implementation of the BDCP will result in at least 3,070 acres (21%) increase of high-quality habitat for the least Bell's vireo, and at least 3,968 acres increase (78%) of the least Bell's vireo habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

The habitat that will be lost as a result of covered activities is of low to moderate quality, consisting primarily of relatively small, isolated patches and narrow strips of riparian vegetation within a cultivated landscape. The restored and protected habitat will consist of large, contiguous areas, at least 1,000 acres of which will be managed to sustain appropriate vegetation structural requirements for the species. Increasing the size and connectivity of the reserve system by acquiring lands adjacent to and between existing protected lands will benefit the yellow-breasted chat by reducing the risks of habitat fragmentation and adverse effects from adjacent lands uses. Restoration, protection, and management of least Bell's vireo habitat in the Plan Area will increase opportunities for a breeding population of least Bell's vireo to become reestablished in this portion of its historical range.

Overall, the BDCP will provide a substantial net benefit to the least Bell's vireo through the net increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the least Bell's vireo.

5.6.12 Suisun Song Sparrow

This section describes the adverse, beneficial, and net effects of the BDCP covered activities , including conservation measures, on the Suisun song sparrow. The methods used to assess these

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effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the Suisun song sparrow identifies primary habitat (minimum mapping unit of 1 acre) as pickleweed-dominated tidal brackish emergent wetland and cattail, rush, and bulrush-dominated tidal freshwater emergent wetland in Suisun Marsh and the Delta west of Sherman Island in the Plan Area. Low marsh habitats dominated by hardstem and California bulrushes, managed wetlands, and upland transitional areas are considered secondary habitat in the model. Secondary habitats generally provide only a few ecological functions such as foraging (low marsh and managed wetlands) or extreme high tide refuge (upland transition zones), while primary habitats provide multiple functions ,including breeding, effective predator cover, and quality forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts*. Factors considered in assessing the quality of affected habitat for the Suisun song sparrow, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.12.1 Adverse Effects

5.6.12.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up to 6,311 acres of primary and secondary habitat (25% of the habitat in the Plan Area) for the Suisun song sparrow (Table 5.6-1a, *Habitat Loss by Covered Activity, Wildlife*). The majority of the effects (76%) will be on low-quality habitat in managed wetlands that will be converted to mostly high-quality tidal brackish emergent wetland habitat for the species. The only BDCP actions that will adversely affect this species are activities associated with tidal habitat restoration in Conservation Zone 11.

Tidal Natural Communities Restoration

Tidal natural communities restoration is expected to result in the tidal inundation of 977 acres of primary and 5,010 acres of secondary Suisun song sparrow habitat, and the desiccation of 324 acres of primary habitat. Although the actual tidal natural communities restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the Suisun song sparrow.

The 977 acres of primary habitat to be tidally inundated consists of emergent wetland that is already under tidal influence. While the deeper portions of this emergent wetland will convert to tidal perennial aquatic habitat unsuitable for song sparrows, the remainder will remain, or develop into, suitable primary or secondary habitat. Because the proportion of the 977 acres that will continue to provide primary habitat for Suisun song sparrows is currently unknown, the entire 977 acres are treated as habitat loss for the purpose of establishing take limits (recognizing this is an overestimate of loss). Further, most of the 5,010 acres of secondary habitat (nearly all managed wetland) that will be inundated will convert to restored tidal brackish emergent wetland that will provide primary habitat functions such as breeding.

Desiccation resulting from change in the upper marsh tidal prism is expected to result in conversion of approximately 324 acres of primary tidal brackish emergent wetland habitat for the Suisun song sparrow to secondary upland habitat. The conversion of primary habitat to secondary habitat is considered a loss as the tidal brackish emergent wetlands provide many more ecological functions (e.g., breeding, foraging, cover from predators) than the upland grassland habitats (e.g., refugia) they

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will convert to. The conversion of secondary wetland habitat to secondary upland habitat is not considered a net loss as both habitat types provide only limited ecological value.

5.6.12.1.2 Periodic Inundation

No periodic inundation effects on the Suisun song sparrow will occur as a result of BDCP covered activities.

5.6.12.1.3 Construction-Related Effects

Construction is not expected to result in loss of Suisun song sparrow other than that described in in Section 5.2.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. All staging and other temporary construction-related work areas for tidal natural communities restoration will either be in areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above.

Injury or Mortality

Operation of construction equipment could result in injury or mortality of Suisun song sparrows. Risk would be greatest to eggs and nestlings susceptible to land clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. However, establishment of a 250-foot no-disturbance buffer around nest sites during construction (Appendix 3.C, *Avoidance and Minimization Measures*) is expected to minimize the potential for injury or mortality of the Suisun song sparrow.

Indirect Construction-Related Effects

Construction activities related to tidal natural communities restoration are expected to result in temporary indirect effects on 860 acres of Suisun song sparrow habitat adjacent to these activities. These construction activities include grading, filling, contouring, and other ground-disturbing operations, with the potential to cause noise, dust, and visual disturbance up to 500 feet from the construction edge. If construction occurs during the nesting season, these indirect effects could result in the loss or abandonment of nests, and mortality of any eggs and/or nestlings. However, preconstruction surveys will be conducted and if an active nest site is present within 250 feet of construction activity, a 250-foot no-disturbance buffer will be established around the nest site during the breeding season, as described further in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.12.1.4 Effects of Ongoing Activities

The only ongoing BDCP activities expected to affect the Suisun song sparrow are those associated with habitat enhancement and management.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected habitats, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury or mortality of Suisun song sparrows, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable, but will be minimized with implementation of Suisun

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song sparrow avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

Increased exposure to methylmercury associated with tidal natural communities restoration will potentially indirectly affect the Suisun song sparrow. Section 3.4.13, *CM12 Methylmercury Management,* describes the process by which tidal natural communities restoration may increase methylmercury levels in wetlands in the Plan Area. Robinson et al. (2011) found toxic levels of methylmercury levels in song sparrow populations from southern San Francisco Bay. Pathways of exposure are probably a consequence of the portion of aquatic snails, amphipods, and insects in their diet (Grenier 2004) and the fact that they occupy small territories year-round. Although Robinson et al. (2011) found but much lower levels of methylmercury from populations near Suisun Marsh (i.e., San Pablo and Simas Creeks), and the Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that restored tidal wetlands will generate less methylmercury than the existing managed wetlands to be restored, Suisun song sparrows that occupy these restored tidal habitats will be subject to potential adverse effects from methylmercury exposure. Measures described in Section 3.4.13, *CM12 Methylmercury Management* are expected to reduce the effects of methylmercury resulting from BDCP tidal natural communities restoration.

5.6.12.1.5 Impact of Take on the Species

The Suisun song sparrow is a subspecies of song sparrow that is endemic to the tidal marshes of Suisun Bay. In the Plan Area, it occupies suitable habitat in the extreme western Delta and the Suisun Marsh. There are 37 CNDDB/DHCCP occurrences through the species' range, of which 23 extant occurrences (62%) are in the Plan area. The hypothetical footprint for BDCP activities overlaps with five of these occurrences, all within Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the Suisun song sparrow, the Plan area supports 25,678 acres of suitable habitat, most (71%) of which is lower-quality managed wetland (18,126 acres). Of this, up to 6,311 acres of modeled habitat (25%) will be affected by tidal natural communities restoration. These effects will primarily occur on managed wetland (4,820 acres or 76% of the effects) that provides marginal habitat for this species; about 1,480 acres affected are higher-quality brackish tidal habitat. Some of the 5,987 acres of inundation effects may be construed as a long-term temporary loss as some portion of the inundated areas would eventually restore to marsh conditions favored by this species. These losses of Suisun song sparrow habitat are not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- Most of the permanently removed habitat is managed wetland that provides marginal quality habitat for the species.
- The amount of primary habitat to be permanently lost (1,301 acres) is much less than the 4,800 acres of tidal marsh habitat to be restored.
- Habitat removal will be sequenced with tidal habitat restoration to minimize adverse effects on habitat and the Suisun song sparrow population.

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5.6.12.2 Beneficial Effects

The BDCP Implementation Office is expected to restore or create approximately 4,800 acres of tidal brackish emergent wetland natural community in Conservation Zone 11 (CM4). Tidal wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural gradient extending from subtidal to the upland fringe. Larger and more interconnected patches of suitable habitat are expected to reduce the effects of habitat fragmentation that exist in Suisun Marsh. This, in turn, is expected to allow increases in the populations of native species, including the Suisun song sparrow. The habitat and ecosystem functions of tidal brackish emergent wetland will be maintained and enhanced for native species over the term of the BDCP. Much of the restored tidal brackish emergent wetland will meet the primary habitat requirements of the Suisun song sparrow, including development of mid- and high-marsh vegetation. Nonnative predators will be controlled as needed to reduce nest predation and help maintain species abundance (CM11). Tidal habitat restoration actions will primarily affect managed wetlands that provide low-quality habitat for the Suisun song sparrow. At Grizzly Island, where unrestored managed wetland will remain, enhancement of 1,500 acres of salt marsh harvest mouse habitat (CM11) will also benefit the Suisun song sparrow, given the similarity in the use of that habitat by the two species. Restoration will also be sequenced (over 40 years) and oriented in a manner that minimizes any temporary, initial loss and fragmentation of habitat. These measures will improve habitat conditions for the Suisun song sparrow and enhance the long-term viability of this species in the Plan Area.

Water operations associated with BDCP actions intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal habitat restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed, an outcome expected to benefit the Suisun song sparrow.

5.6.12.3 Net Effects

Full implementation of the BDCP will result in an estimated 1,202-acre (5%) net decrease in habitat for Suisun song sparrows and at least 829 acre increase (4%) of Suisun song sparrow habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*). The primary and secondary habitat that will be lost as a result of covered activities is primarily (76%) lower quality managed wetland, while the 4,800 acres of habitat that will be restored will be higher quality tidal brackish marsh.

The potential take of Suisun song sparrows in the form of noise and visual disturbance associated with BDCP actions is not expected to adversely affect the long-term survival or recovery of this species. Suisun song sparrow avoidance and minimization measures, as described in Appendix 3.C, *Avoidance and Minimization Measures,* will be implemented to specifically protect song sparrow nest sites and avoid injury or mortality to adults, nestlings, and eggs. Managed wetland management and protection conservation measures (CM11) will also contribute to offsetting Suisun song sparrow losses by enhancing 1,500 acres of salt marsh harvest mouse habitat (also used by Suisun song sparrows) in the Grizzly Island complex. Collectively, these actions will offset the effects of BDCP covered activities and further contribute to the long-term survival and recovery of the Suisun song sparrow.

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Overall, the BDCP will provide a substantial net benefit to the Suisun song sparrow through the increase in high-quality primary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of Suisun song sparrow.

5.6.13 Swainson's Hawk

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the Swainson's hawk. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants* and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*, and more specific assessment methods are described below. The habitat model used to assess effects for the Swainson's hawk includes vegetation and land cover types associated with Swainson's hawk nesting and foraging habitat. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.*

Factors considered in assessing the quality of affected Swainson's hawk habitat, to the extent that information is available, include the relative habitat value of different vegetation and land cover types used as foraging habitat based on structural characteristics and crop management that relate to prey accessibility and availability. Because cultivated crops and other cover types differ in their value as foraging habitat for Swainson's hawks, the acres of foraging habitat were converted into habitat units by assigning relative foraging habitat values to each crop or cover type (Table 5.6-9). These habitat units, representing a habitat value index, were then used to characterize BDCP effects on Swainson's hawk foraging habitat in terms of existing habitat value. The corresponding conservation acreage is characterized as a range that represents the minimum and maximum replacement acres that are associated with the habitat value of acres lost relative to the habitat value of the selected conservation land.

Table 5.6-9. Assigned Swainson's Hawk Foraging Habitat Value Classes for Agricultural Crop Types

Foraging Habitat Value Class	Agricultural Crop Type	Foraging Habitat Value
Very high	Alfalfa hay	1.0
High	Irrigated pasture, other hay crops	0.75
Moderate	Tomatoes, sugar beets, grain crops (wheat, barley, oats), grasslands, managed wetlands, vernal pool grasslands, alkali seasonal wetlands	0.5
Low	Other irrigated field and truck/berry crops	0.25
Very low	Safflower, sunflower, corn, grain sorghum	0.1
None	Orchards, vineyards, rice	0

In addition to the quantitative and qualitative analysis of habitat loss described above, the loss of habitat was also qualitatively reviewed with regard to the geographic location of habitat removed relative to the Swainson's hawk nesting distribution and the effects of possible habitat fragmentation. Because the species is wide-ranging, the loss of large patches of cultivated land foraging habitat as a result of tidal wetland restoration is likely to affect the viability of some local nesting territories. This qualitative analysis also recognizes that the final design for covered activities will likely differ somewhat from hypothetical footprints.

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5.6.13.1 Adverse Effects

5.6.13.1.1 Permanent Habitat Loss, Conversion and Fragmentation

BDCP covered activities will result in the permanent removal or conversion of up to 37,561 acres[11] of habitat (8.3% of the habitat in the Plan Area) for the Swainson's hawk (Table 5.7-1a, *Maximum Allowable Habitat Loss, Wildlife*). This total includes loss of nesting habitat (679 acres) and loss of foraging habitat (36,882 acres). A total of 31,920 acres of foraging habitat loss (not including 4,962 acres resulting from riparian restoration) are also expressed as 18,700 habitat units (Table 5.6-10). Covered activities resulting in adverse effects on Swainson's hawk include conveyance facility construction, transmission line construction, Fremont Weir/Yolo Bypass improvements, tidal natural community restoration, floodplain restoration, nontidal marsh restoration, and conservation hatcheries facilities. Most (72%) of this loss will result from tidal natural communities restoration.

Conveyance Facility Construction

This activity will result in the permanent removal of approximately 2,951 acres of habitat for the Swainson's hawk in Conservation Zones 3, 4, 5, 6, and 8 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This total represents a loss of 2,927 acres (1,249 habitat units) of foraging habitat and 24 acres of nesting habitat for the Swainson's hawk. Effects on foraging habitat occur primarily on cultivated land, in an area with numerous Swainson's hawk occurrences.

Freemont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 1,087 acres of cultivated and riparian natural communities in Conservation Zone 1 for the Swainson's hawk (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This represents a loss of 871 acres (522 habitat units) of foraging habitat and 210 acres of nesting habitat for the Swainson's hawk.

Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration footprint, this activity will result in the permanent removal or conversion of approximately 27,810 acres of cultivated lands, managed wetland, and grassland natural communities in the Yolo Bypass, Cache Slough, Suisun Marsh, West Delta, Cosumnes/Mokelumne River, and South Delta ROAs for the Swainson's hawk (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This total represents a loss of 27,403 acres of foraging habitat (15,962 habitat units [not including loss of foraging habitat from 971 acres of riparian restoration]) and 407 acres of nesting habitat for the Swainson's hawk.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 5,718 acres of primarily cultivated and riparian natural communities in Conservation Zone 7 for the Swainson's hawk (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This total represents a loss of 5,680 acres of foraging habitat (970 habitat units [not including loss of foraging

[11] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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habitat from 3,991 acres of riparian restoration]) and 38 acres of nesting habitat for the Swainson's hawk.

Nontidal Marsh Restoration

Based on nontidal marsh restoration objectives in the giant garter snake conservation strategy, this activity will result in the permanent removal of approximately 400 acres of cultivated natural community in the Conservation Zones 2 and 4 for the Swainson's hawk (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Because specific or hypothetical locations for nontidal marsh restoration have not been identified, these acres could not be assigned a foraging value class and thus were not converted to habitat units.

Conservation Hatcheries Facilities

Based on a preliminary design footprint, this activity will result in the permanent removal of approximately 35 acres of cultivated natural community in Conservation Zone 1 for the Swainson's hawk (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

The largest proportion of the permanent impacts to foraging habitat will result from the loss of 27,728 acres of cultivated lands (16,163 habitat units) (Table 5.6-10). Other natural communities that would be lost include grasslands (2,239 acres), alkali seasonal wetland complex (71 acres), vernal pool complex (87 acres), and managed seasonal wetland (1,587acres). While noncultivated types represent suitable foraging habitat for Swainson's hawks, in the Plan Area they are not primary foraging cover types. This is mostly due to their geographic extent relative to the Swainson's hawk breeding distribution and to the reduced prey accessibility and abundance relative to cultivated lands. The majority of the grassland loss will occur along the western edge of the Plan Area, an area that supports fewer nesting sites and generally receives less use by foraging hawks. The majority of managed wetland loss will occur around Suisun Marsh, an area that, while within the range of the species, supports significantly fewer nest sites and foraging use than other portions of the Plan Area. Thus, the loss of most noncultivated acres is unlikely to affect the distribution and abundance of the Swainson's hawk in the Plan Area.

Agricultural lands provide the primary land cover type for Swainson's hawks in the Plan and the loss and conversion of agricultural lands will have a greater likelihood of affecting the distribution and abundance of the species in the Plan Area. Therefore, while Table 5.6-10 summarizes the majority of modeled habitat that would be affected by BDCP actions, the loss of 27,728 acres of cultivated lands (16,163 habitat units) represents the habitat loss that could adversely affect the species.

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Table 5.6-10. Total[1] Acres of Swainson's Hawk Habitat Permanently Affected and Corresponding Habitat Units

Foraging Habitat Value Class	Agricultural Crops and other Cover Types	Foraging Habitat Value	Acres Affected	Habitat Units	Habitat Units (Cultivated Land)
Very high	Alfalfa hay	1.0	9,198	9,198	9,198
High	Irrigated pasture, other hay crops	0.75	3,606	2,705	2,705
Moderate	Tomatoes, sugar beets, grain crops (wheat, barley, oats), grasslands, managed wetlands, vernal pool grasslands, alkali seasonal wetlands	0.5	10,890	5,445	2,906
Low	Other irrigated field and truck/berry crops	0.25	3,540	885	885
Very low	Safflower, sunflower, corn, grain sorghum	0.1	4,686	469	469
Totals			31,920[1]	18,700	16,163

[1] Foraging habitat loss from riparian restoration, which total 4,962 acres is not included in the calculations because it was not possible to determine precise locations or habitat value class of the affected habitat.

The habitat value index calculations from Table 5.6-9 indicate that a fairly broad distribution of habitat suitability values will be permanently affected, with the majority of the loss consisting of moderate- and low-value habitat.

Historically, Swainson's hawks foraged in grasslands and other open habitats of the Plan Area, and nested within vast areas of riparian forests and oak woodlands. Diking, levee construction, channelization, agricultural conversion, urbanization, and other activities have substantially altered and fragmented their historical habitat. With substantial conversion of the native landscape to support farming operations, Swainson's hawks have shifted their nesting and foraging to include those agricultural lands that provide low, open vegetation for hunting and high rodent prey populations, and nearby remnant trees suitable for nesting. Restoration activities such as grading, filling, contouring, and other ground-disturbing operations may result in permanent habitat loss that further fragments nesting and foraging habitat. This could reduce functions provided by Swainson's hawk habitat until restoration is achieved, a process that could take several years (e.g., grassland foraging areas) to decades (e.g., valley/foothill riparian nesting habitat) to achieve.

Because the species is highly mobile and wide-ranging, habitat fragmentation is not expected to reduce the use of remaining cultivated lands or preclude access to surrounding lands. In this regard, fragmentation will not isolate subpopulations or individual nest sites or result in a barrier to movement. However, the conversion of cultivated lands to tidal wetlands over fairly broad areas within the tidal restoration footprints could result in the removal or abandonment of nesting territories that occur within or near the restoration areas. Depending on the extent and quality of remaining habitat, this could reduce the local nesting population. There are at least 27 Swainson's hawk nest sites that overlap with the hypothetical restoration footprint, suggesting that numerous nest sites could be directly affected by restoration activities.

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5.6.13.1.2 Periodic Inundation

Fremont Weir/ Yolo Bypass Improvements

This activity will periodically inundate 2,072 acres of habitat for the Swainson's hawk, including 1,984 acres of foraging habitat and 88 acres of nesting habitat.

Periodic effects on Swainson's hawks are expected to result from operation of the Fremont Weir and seasonally inundated floodplain restoration. Up to 88 acres of modeled Swainson's hawk nesting habitat will be inundated during operations of the new Fremont Weir gates to increase the frequency and duration of bypass floodplain flows for the benefit of covered fish species. However, increased periodic flooding is not expected to cause any adverse effect on the six nest sites within the inundation area because trees in which nest sites are situated already withstand floods in the area. The increase in inundation frequency and duration is not expected to exceed the tolerance range of riparian trees, and the nests are expected to remain above floodwater levels.

Much of the Yolo Bypass, particularly in the north, is farmed in rice and is therefore not suitable for Swainson's hawk foraging. However, south of Interstate 80, land use in the bypass also includes other agricultural cover types, seasonally managed wetlands, and some grassland, all of which provide foraging habitat value to Swainson's hawks. During years with inundation, affected agricultural and grassland foraging habitats will not be available as foraging habitat until prey populations have reoccupied affected habitats. This will result in a temporary periodic reduction in the availability of 1,984 acres (823 habitat units) of foraging habitat. The full extent of the periodic effect is unknown. While inundation could reduce accessibility to foraging habitats through April, the actual use of these areas would remain limited until prey populations have recovered. In addition, if late Fremont Weir operations were to preclude the planting of some crop types in some years, there could be a further loss of foraging habitat value if the crop type that would have been planted provides greater foraging habitat value than the fallowed fields or substitute crop.

Floodplain Restoration

This activity will periodically inundate 7,332 acres (3,922 habitat units) of modeled Swainson's hawk foraging and 188 acres of nesting habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Floodplain restoration is expected to restore a more natural flood regime and sustain riparian vegetation types that support regeneration of Swainson's hawk nesting habitat.

Foraging habitat that is inundated after Swainson's hawks arrive in the Central Valley in mid-March could result in a periodic loss of available foraging habitat due to the reduction in available prey. Inundated habitats are expected to recover following draw-down and provide suitable foraging conditions until the following inundation period. Thus, this is considered a periodic and short term effect that is unlikely to affect Swainson's hawk distribution and abundance, or foraging use of the Plan Area.

5.6.13.1.3 Construction-Related Effects

Construction-related effects on the Swainson's hawk include short-term, temporary effects from water conveyance construction and levee construction associated with Yolo Bypass improvements and flood plain restoration, and long-term, temporary effects from establishment of borrow and spoils sites.. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the

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extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Construction activities are expected to temporarily remove 2,992 acres (1,314 habitat units) from the Plan Area, including temporary and long-term temporary effects (Table 5.6-1a ,*Maximum Allowable Habitat Loss, Wildlife*) and representing approximately 0.3% of the modeled Swainson's hawk habitat in the Plan Area. Most of the affected modeled habitat is cultivated land.

Temporary Habitat Loss (Short-Term)

Construction-related effects will temporarily disturb 2,037 acres (989 habitat units) of foraging habitat for the Swainson's hawk (Table 5.7-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporary losses will result from water conveyance construction (1,042 acres of foraging habitat) in Conservation Zones 3 through 8, Yolo Bypass fisheries enhancements (100 acres of nesting habitat and 40 acres of foraging habitat) in Conservation Zones 2 and 3, and construction of floodplain restoration levees (31 acres of nesting habitat and 955 acres foraging habitat) in Conservation Zone 7. Temporarily removed areas will be restored to their previous habitat condition within 1 year following completion of BDCP construction and management activities. It is expected that restored habitats will achieve conditions favored by Swainson's hawks for foraging and nesting within several years (e.g., grassland and agricultural areas) to decades (e.g., valley/foothill riparian habitat) following disturbance. Most temporary effects resulting from BDCP actions will affect agricultural and grassland habitats that can be restored relatively quickly to suitable foraging habitat. However, restored riparian habitat will likely require decades before trees attain sufficient size and structure adequate for nesting by Swainson's hawks.

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in the long-term, temporary removal of approximately 955 acres (315 habitat units) of modeled Swainson's hawk foraging habitat in Conservation Zones 4, 5, and 8 (Table 5.7-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

New transmission lines will increase the risk for Swainson's hawk power line strikes and/or electrocution. The existing network of power lines present in the Plan Area currently poses this risk for the Swainson's hawk, and any incremental increase in risk associated with the new power lines is expected to be minor.

Indirect Construction-Related Effects

Construction-related noise and visual disturbances within 1,300 feet of construction activities could temporarily affect the use of 14,650 acres (3.2%) of modeled Swainson's hawk habitat (Table 5.6-3a, *Indirect Effects, Wildlife*). These construction activities will include water conveyance construction, transmission line construction, tidal restoration activities, tidal plain restoration, and Fremont Weir/Yolo Bypass Enhancements.

Swainson's hawks are seasonally abundant across much of the Plan Area wherever adequate nest trees occur within a cultivated landscape that supports suitable foraging habitat. There is a potential for noise and visual disturbances associated with BDCP actions to temporarily displace Swainson's

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hawks and temporarily reduce the use of suitable habitat adjacent to construction areas. Assuming effects up to 0.25 mile from the edge of construction to nest sites and up to 500 feet for foraging birds, noise and visual disturbances could temporarily affect the use of up to 14,650 acres of modeled Swainson's hawk habitat (Table 5.6-3a, *Indirect Effects, Wildlife*). This includes about 1,251 acres of potential nesting habitat and 13,398 acres of potential foraging habitat. Risk of injury or disturbance will be greatest to eggs and nestlings susceptible to land-clearing activities, abandonment of nests, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment.

These adverse effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*, Preconstruction surveys to identify active Swainson's hawk nest sites will be conducted within 0.5 mile of BDCP actions during the breeding season (mid-March through mid-September), no more than 30 days prior to scheduled construction. If an active nest is documented, avoidance and minimization will be achieved by establishing a 0.25-mile buffer around the nest tree in which no construction activity or disturbance is permitted. If removal of a nest tree cannot be avoided, the removal will only occur during the nonbreeding season.

5.6.13.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Facilities and operations activities within 0.25 mile of Swainson's hawk nest sites could affect 4 acres of modeled Swainson's hawk nesting habitat. Maintenance of the above-ground water conveyance facilities could result in ongoing but periodic post-construction noise and visual disturbances that could affect Swainson's hawk use of surrounding habitat. These effects may include periodic vehicle use along the conveyance corridor, and inspection and maintenance of above-ground facilities. These potential effects will be minimized with implementation of the avoidance and minimization measures described in Chapter 3, *Conservation Strategy*.

Habitat Enhancement and Management

Activities associated with habitat enhancement and management intended to maintain and improve habitat functions within protected habitats could result in localized effects on Swainson's hawk habitat, injury or mortality of Swainson's hawks, and temporary noise and disturbance effects over the term of the BDCP. If active nests are located near work sites, disturbance could reduce reproductive success or result in nest failure or abandonment. These effects will be minimized with the implementation of avoidance and minimization measures described in Appendix 3.C. *Avoidance and Minimization Measures*. Over the term of the BDCP, these habitat enhancement and management effects are expected to result in a net benefit because these actions will improve habitat functions for Swainson's hawks and other covered species.

Other Indirect Effects

The BDCP covered activities and conservation measures will have no other indirect effects on the Swainson's hawk.

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5.6.13.1.5 Impact of Take on Species

The Swainson's hawk breeds in the open grasslands, shrub-steppe and agricultural regions of western North America from southern Canada to northern Mexico, and winters primarily in the Pampas region of Argentina. With the conversion of much of the species' historical range to agriculture, the Swainson's hawk has adapted to agricultural landscapes compatible with its foraging needs where suitable nesting habitat is also available. Most nesting Swainson's hawks in California are found in the Central Valley, from Tehama County south to Kern County, an area almost entirely converted to agricultural landscapes. The species is generally found in this area from early March through mid-September. Recent surveys documented more than 2,000 nesting pairs in the Central Valley (Anderson et al. in preparation), with the density of nesting Swainson's hawks in the Yolo/Solano/Sacramento/San Joaquin County area, considered the core of the Central Valley breeding population, higher than anywhere else in the species' range. The population in the Plan Area is also large and widely distributed, with over 400 reported nesting records. At least 300 of these are considered independent nesting territories that are potentially active in any given year, representing about 14% of the statewide population. Within the Plan Area, nesting densities are highest in the northern (north of SR 12) and southern (south of SR 12) portions, areas that support a relative abundance of potential nest sites within an agricultural landscape that is suitable for Swainson's hawk foraging. The hypothetical footprint for BDCP activities overlaps with at least 27 of the documented nest occurrences from the Plan Area. The Plan Area constitutes an important portion of the species' California range.

Based on modeled habitat for the Swainson's hawk, the Plan Area supports 445,236 acres of potentially suitable habitat, including 10,149 acres of nesting habitat and 435,087 acres of foraging habitat. Sustainability of the Swainson's hawk population in the Plan Areas is dependent on providing and maintaining suitable nesting sites interspersed in sufficient acreage of compatible agricultural and grassland landscapes that support abundant, accessible prey. BDCP actions are projected to affect a total of 49,190 acres of foraging habitat (11% of the available habitat) in the Plan Area, and 679 acres (6.6%) of modeled Swainson's hawk nesting habitat. This total includes 36,882 acres (8.2%) of permanent removal (31,920 acres of which is converted to 18,700 habitat units 2,992 acres (1,314 habitat units) of temporary removal; and 9,316 acres (4,745 habitat units) of periodic removal. Assuming the riparian restoration, which is not included in the habitat unit calculations, will replace primarily cultivated land, approximately 3,984 acres (8%) will affect noncultivated foraging cover types, and the remaining 45,206 acres (92%) will affect cultivated foraging cover types.

At least 27 documented occurrence records lie within the hypothetical project footprint, and therefore would presumably be affected by BDCP activities. Many of these records are expected to be long-established nest sites for Swainson's hawks. BDCP actions could remove nest trees and displace breeding pairs from traditional nesting territories if alternate nest sites are not available. Lack of sufficient nest trees is a major factor limiting the distribution and use of the Plan Area by Swainson's hawks, and further losses of nest trees and nesting territories could lead to population declines in the Plan Area. Considering the strategic location of the Plan Area in the core of the Central Valley breeding population, these habitat losses, disturbances, and other identified effects could potentially adversely affect the species' long-term survival and recovery. However, the BDCP's beneficial effects on the species, described below, are expected to offset many of these potential adverse effects and contribute to the long-term survival and recovery of the species in the Plan Area.

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5.6.13.2 Beneficial Effects

The BDCP Implementation Office will restore or create 5,000 acres of valley/foothill riparian forest, restore riparian corridors along 20 miles of stream channel margins, and protect 750 acres of existing valley/foothill riparian forest. Portions of these restored and protected riparian areas are expected to provide nesting structure for Swainson's hawks (i.e., large, mature trees) over the term of the BDCP. Restoration of valley/foothill riparian forest is expected to substantially increase available nest sites in the Plan Area for Swainson's hawk. Conservation measures will also protect 24,647 to 36,344 acres of Swainson's hawk foraging habitat, including a minimum of 8,000 acres of grassland, 1,000 acres of vernal pool and alkali wetland complex, 1,500 acres of managed seasonal wetlands, and annually maintain 15,647 to 27,344 acres of cultivated land compatible as foraging habitat. Swainson's hawk foraging habitat will be managed to support moderate- to high-value cover types and with at least 25% managed as alfalfa hay, the highest value crop types. Management of protected lands will be such that a minimum of 18,700 habitat units are available on conservation lands each year once all acquisition and restoration is completed. Restored habitats (e.g., valley/foothill riparian nesting areas) may require several years to several decades to achieve conditions suitable for nesting by Swainson's hawks; however, there is currently sufficient nesting habitat available in the Plan Area to support a very large and dense nesting population. Restored riparian habitats are designed to provide future nesting habitat in order to increase nesting opportunities during the permit period.

Additional conservation measures are designed to further increase habitat functions for Swainson's hawks by improving habitat diversity in the Plan Area. Because agricultural practices have removed so much of the species' historical nesting habitat, Swainson's hawks often nest in isolated trees, tree rows along field borders or roads, or small clusters of trees in farmyards or at rural residences. Protection and maintenance of these small isolated nesting habitats (CM3, CM11) is essential to sustaining the distribution and abundance of the species in the Plan Area. Agricultural practices have also steadily degraded foraging habitat by removing uncultivated lands and habitat edge that support prey populations. To help retain these important habitat elements within the agricultural matrix, small existing nest sites will be protected and future nesting opportunities will be expanded by planting native trees along roadsides and field borders within protected agricultural lands (CM3, CM11). In addition, remnant noncultivated areas of high wildlife value will be protected within conserved cultivated lands, and new hedgerows will be established along field borders and roadsides to enhance prey populations (CM3, CM11). These conservation efforts will help ensure that Swainson's hawk populations are sustained throughout the protected cultivated landscape and that the long-term viability of the species is enhanced in the Plan Area.

5.6.13.3 Net Effects

The total amount of Swainson's hawk foraging habitat in protected status will increase substantially to between 88,887 and 104,907 acres, representing an increase above existing conditions of between 17% and 39%. The protection of a significant proportion of the species foraging habitat from potential loss or degradation associated with future changes in land use is highly beneficial because most of the species foraging habitat in the Plan Area is currently under private control and managed without consideration of Swainson's hawk habitat needs. Without protection, habitat value for Swainson's hawk would be expected to decline over time. The conserved protected lands will be managed at a significantly higher value than the affected lands.

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Swainson's hawk foraging habitat will be managed such that 15,647 to 27,344 acres of agricultural foraging habitat units are available on conservation lands each year. In addition, 2,450 acres of grassland, vernal pool complex, and alkali seasonal wetland complex will be protected, managed, and available for Swainson's hawk foraging on the reserve system once all acquisition and restoration is completed.

The net effect of BDCP actions on the Swainson's hawk is expected to be minimally beneficial based on the following rationale.

- The extent of nesting habitat protection and restoration will result in significantly greater available nesting habitat in the Plan area than currently exists.
- Protection of foraging habitats will maintain or increase the habitat value of agricultural foraging habitats. Approximately 77% of the habitat to be lost is in the moderate- to low-value categories. Protected lands, however, will be managed as moderate- to very high-value habitat, with at least 25% of all protected lands in the very high value category.
- The extent of protected foraging habitat in the Plan Area will increase from between 17% and 39% above existing conditions depending the habitat value of land protected. The protection of a significant proportion of the species foraging habitat from potential loss or degradation associated with future changes in land use is highly beneficial because most of the species foraging habitat in the Plan Area is currently under private control and managed without consideration of Swainson's hawk habitat needs.
- In a region where compatible agricultural cover types are increasingly being converted to incompatible types, BDCP will increase the extent of protected habitats and manage these habitats to maximize habitat value for Swainson's hawk and other covered species.
- To address the conversion of an estimated 8,630 acres of alfalfa hay to tidal wetlands, between approximately 4,000 and 7,000 acres of alfalfa hay will be maintained each year on protected lands.
- Noncultivated foraging habitats will also be protected in acreages that far exceed loss from BDCP activities. For example, effects on 2,239 acres of grassland are addressed through protection of 8,000 acres and restoration of 2,000 acres of grassland; 71 acres of alkali seasonal wetland and 87 acres of vernal pool complex effects are addressed through protection of 400 acres and 600 acres, respectively; and 1,587 acres of managed seasonal wetlands effects are addressed through protection of 1,500 acres.
- BDCP protected lands will be managed to enhance other important habitat elements that support Swainson's hawk use such as protecting and restoring nesting habitat and creating hedgerows to promote high prey density.

A combination of habitat restoration, creation, protection, and enhancement will be implemented across a matrix of agricultural and natural land cover types to offsets losses of nesting and foraging habitat, and to enhance overall habitat functions over the term of the BDCP. Restoration and creation of at least 5,000 acres of riparian habitat is expected to increase the extent of Swainson's hawk nesting habitat in the Plan Area by 3,295 acres (32 %). Total nesting habitat under protected status will increase by 109%. Additional nesting opportunities will be provided by restoring riparian corridors along 20 miles of stream channels, and by planting, maintaining, and protecting small patches of potential nest trees within conserved cultivated lands that provide foraging habitat for Swainson's hawks.

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Full implementation of the BDCP will result in a decline in the overall extent of Swainson's hawk foraging habitat in the Plan Area by approximately 11%, (including low-value habitat and marginal grassland and seasonal wetland habitats in areas supporting few nesting Swainson's hawks) by about 11%, or 49,190 acres, including 36,882 acres of permanent removal (Table 5.6-4a, *Net Effects*). A relatively large proportion (60%) of the estimated loss of foraging habitat is of moderate-, low-, and very low-value crop types for Swainson's hawk habitat.

In summary, BDCP actions are not expected to have an adverse population-level effect on Swainson's hawk. Although a net reduction to foraging habitat will occur, these losses will be offset by a substantial net increase in protected foraging and nesting habitat, a substantial net increase in the availability of nesting habitat and potential nest sites through restoration, and the improved management of foraging and nesting habitat under protection in ways beneficial to Swainson's hawks. With implementation of these conservation actions, BDCP is expected to sustain the current range and abundance of Swainson's hawk within the Plan Area and provide for potential population and range increases within and adjacent to the Plan Area. In combination, these actions are expected to improve habitat suitability for Swainson's hawks in the Plan Area and contribute toward the long-term survival and recovery of the species.

5.6.14 Tricolored Blackbird

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the tricolored blackbird. The methods used to assess these effects are described in Section 5.2.7 *Effects Analysis for Wildlife and Plants* and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model used to assess effects for the tricolored blackbird considers two primary life requisites – breeding habitat and nonbreeding habitat. Modeled breeding habitat includes bulrush/cattail wetlands and shrub communities that may provided suitable nesting substrate, and adjacent high- quality foraging areas that occur within 5 miles of nesting colonies documented in the Plan Area over the last 15 years. The foraging component includes cultivated lands and noncultivated land-cover types known to support abundant insect populations important in egg formation and rearing of young, such as grasslands, pasturelands (including alfalfa), natural seasonal wetlands, and sunflower croplands. Modeled nonbreeding habitat includes emergent wetlands and shrub stands that provide suitable roosting habitat, as well as cultivated lands and noncultivated habitats that provide vegetable and animal foods sought by tricolored blackbirds during the winter. Outside of the breeding season, tricolored blackbirds are primarily granivores that forage opportunistically across the Plan Area in grasslands, pasturelands, croplands, dairies, and livestock feed lots. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the tricolored blackbird, to the extent that information is available, include habitat patch size, suitability of vegetation, and proximity to recorded occurrences.

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5.6.14.1 Adverse Effects

5.6.14.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up to 41,487 acres[12] of habitat for the tricolored blackbird (8% of the habitat in the Plan Area), including 11,416 acres of breeding habitat and 30,077 acres of nonbreeding habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Most breeding season effects will be on foraging habitat, including 8,436 acres of cultivated lands and 2,904 acres of noncultivated habitats. Loss of nesting habitat is expected to be much smaller, estimated at up to 76 acres. Permanent effects on nonbreeding season habitat will affect 23,256 acres of cultivated lands and 2,217 acres of noncultivated habitats that providing foraging habitat. Losses to roosting habitat for tricolored blackbirds are expected to reach 4,604 acres. Covered activities resulting in adverse effects on tricolored blackbirds include conveyance facility construction, transmission line construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, nontidal marsh restoration, and conservation hatcheries facilities. The effects are described below for each covered activity.

Conveyance Facility Construction

This activity will result in the permanent removal of 648 acres of tricolored blackbird breeding habitat (7 acres of nesting habitat; plus 460 acres of cultivated lands and 181 acres of noncultivated lands suitable for foraging) and 2,737 acres of nonbreeding habitat (6 acres of roosting habitat; 2,711 acres of cultivated and 20 acres of noncultivated lands suitable for foraging) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). These losses are expected to occur in Conservation Zones 3, 4, 5, 6, and 8.

Fremont Weir/Yolo Bypass Improvements

Yolo Bypass fisheries enhancements are expected to permanently remove 613 acres of breeding habitat (11 acres of nesting habitat; plus 448 acres of cultivated lands and 154 acres of noncultivated habitats suitable for foraging) and 243 acres of nonbreeding habitat (8 acres of roosting habitat, 66 acres of cultivated lands and 169 acres of noncultivated habitats suitable for foraging) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).These losses will occur in Conservation Zones 2 and 3.

Tidal Natural Communities Restoration

This activity will result in tidal inundation of approximately 5,470 acres of tricolored blackbird breeding habitat (53 acres of nesting habitat, 3,141 acres of cultivated lands, and 2,276 acres of noncultivated habitats suitable for foraging) and 24,547 acres of nonbreeding habitat (4,588 acres of roosting habitat plus 17,934 acres of cultivated lands and 2,025 acres of noncultivated habitats suitable for foraging) (Table 5.6-1a *Maximum Allowable Habitat Loss, Wildlife*). These habitat losses and conversions would occur in Conservation Zones 1, 2, 4, 5, 6, 7, 8, and 11. An unknown proportion of the 30,017 acres to be inundated is expected to convert to tidal emergent wetland communities that could provide nonbreeding season roosting habitat for tricolored blackbirds,

[12] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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depending on future vegetation density and composition. Because the proportion that will be converted cannot be determined at this time, the entire 30,017 acres are treated as a habitat loss for the purpose of establishing take limits. In addition to these losses, another 18 acres of breeding habitat (7 acres of cultivated lands and 11 acres of noncultivated habitats suitable for foraging) and 953 acres of nonbreeding habitat (all cultivated lands that provide foraging habitat) will be permanently converted to riparian habitat along the upper fringe of the tidal restoration areas (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although considered to be a permanent loss for the purpose of establishing take limits, any areas that develop into riparian scrub-shrub could provide suitable nesting and roosting habitat for tricolored blackbirds. Although the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the tricolored blackbird.

[***Note to Reader:*** *The analysis of habitat loss from restoration activities is conservative because it assumes all restoration results in a permanent loss of breeding or nonbreeding habitat for tricolored blackbird. This overestimates habitat loss because some portion of restoration sites will remain suitable and may increase in habitat quality. The next draft of the effects analysis will refine these estimates and try to account for the portion of restoration projects that is likely suitable for the tricolored blackbird.*]

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of up to 441 acres of tricolored blackbird breeding habitat (4 acres of nesting habitat plus 390 acres of cultivated lands and 47 acres of noncultivated habitats suitable for foraging) and 1,391 acres of nonbreeding habitat (1 acre of roosting habitat plus 1,387 acres of cultivated lands and 3 acres of noncultivated habitats suitable for foraging) in Conservation Zone 7 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). In addition to these losses, another 3,991 acres of breeding habitat (all cultivated lands that provide foraging habitat) will be permanently converted to riparian habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although these restored riparian habitats are counted as a permanent loss, the portion maintained as riparian scrub-shrub (an amount not to exceed 1,000 acres) could provide suitable nesting and roosting habitat for tricolored blackbirds. Although the actual floodplain restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the tricolored blackbird.

Nontidal Marsh Restoration

This activity will result in the permanent removal or conversion of approximately 200 acres of tricolored blackbird breeding habitat (all noncultivated habitats suitable for foraging) and 200 acres of nonbreeding habitat (all cultivated habitats suitable for foraging) in Conservation Zones 2 and 4 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Nontidal marsh restoration is intended primarily to benefit the giant garter snake. Although about two-thirds of the restored marsh will be open water, the remainder will support emergent wetland vegetation that could provide low-quality roosting habitat for tricolors, depending on vegetation density and composition.

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Conservation Hatcheries Facilities

This activity will result in the permanent removal of approximately 35 acres of tricolored blackbird breeding habitat (all noncultivated habitats suitable for foraging) in Conservation Zone 1 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

Permanent loss and fragmentation of tricolored blackbird nesting habitat will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*. Preconstruction surveys will be conducted in known or suitable nesting habitat to identify active tricolored blackbird nesting colonies. Covered activities will be prohibited within 250 feet of an active nesting colony until breeding has ceased. Monitoring will occur to ensure that construction does not adversely affect the nesting colony.

5.6.14.1.2 Periodic Inundation

Yolo Bypass Operations

.Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.2.5-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 1,833 acres of habitat for the tricolor blackbird, including 441 acres of modeled breeding habitat and 1,391 acres of modeled nonbreeding habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Most breeding season effects are on cultivated (390 acres) and noncultivated (47 acres) lands that provide potential foraging habitat for tricolored blackbirds. Only 4 acres of habitats that represent potential nesting structure will be affected. Effects on nonbreeding habitat include cultivated (1,387 acres) and noncultivated (3 acres) lands used for foraging, as well as potential roosting habitats (1 acre). More frequent flooding in the Yolo Bypass is not expected to adversely affect the suitability of emergent wetlands and riparian vegetation that provide nesting and roosting structure for tricolored blackbirds. These actions could prove beneficial if the additional floodwaters extend the duration of inundation in some seasonal wetlands to lengths that become attractive to nesting birds. The extent of suitable foraging habitat in the Yolo Bypass will be temporarily reduced during periods of increased inundation until floodwaters recede and food resources recover.

Floodplain Restoration

This activity will periodically inundate 8,009 acres of habitat for the tricolor blackbird, including 1,812 acres of modeled breeding habitat and 6,196 acres of modeled nonbreeding habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Breeding season effects will be on cultivated (1,427 acres) and noncultivated (355 acres) lands that provide potential foraging habitat for tricolored blackbirds; an estimated 30 acres of potential nesting habitats will be affected. Effects on nonbreeding habitat are primarily expected to affect cultivated lands used for foraging (6,008 acres), with limited losses to noncultivated foraging habitats (30 acres) and to roosting habitat (158 acres). Whenever periodic inundation occurs, suitable foraging habitats in restored floodplains will be unavailable for use by tricolored blackbirds until floodwaters recede and food resources recover. Periodic inundation is not expected to affect tricolored blackbird nesting habitat because most inundation is unlikely to occur during the breeding season.

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5.6.14.1.3 Construction-Related Effects

Construction-related effects on the tricolored blackbird include short-term and long-term, temporary habitat loss as a result of grading and ground disturbance, construction-related injury or mortality, and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the tricolored blackbird are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Grading and ground disturbance associated with conveyance facility construction, Yolo Bypass fisheries enhancement, and floodplain restoration levee construction will temporarily disturb up to 1,633 acres of modeled habitat for the tricolor blackbird (0.3% of the habitat in the Plan Area), including 772 acres of breeding habitat and 891 acres of nonbreeding habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Most breeding season effects will be on foraging habitat, including 509 acres of cultivated lands and 233 acres of noncultivated lands (primarily grassland) that support insect prey vital to egg formation and rearing of young. Temporary removal of nesting habitat is expected to be small, estimated at 30 acres. Temporary disturbance to nonbreeding season habitat will predominately affect cultivated lands (887acres) used by foraging tricolored blackbirds. Limited temporary losses are expected to roosting habitat (3 acres) and noncultivated lands that providing foraging habitat (1 acre). Conveyance facility construction will temporarily remove 61 acres of tricolored blackbird breeding habitat (44 acres of cultivated and 17 acres of noncultivated lands suitable for foraging) and 879 acres of nonbreeding habitat (817 acres of cultivated and 56 acres of noncultivated lands suitable for foraging; 6 acres of roosting habitat), primarily in Conservation Zones 4, 5, and 6. Yolo Bypass fisheries enhancements are expected to temporary disturb 527 acres of breeding habitat, primarily cultivated (296 acres) and noncultivated (203 acres) lands suitable for foraging. Nesting habitat losses will not exceed 28 acres. Most of these losses are expected to occur in Conservation Zone 2. No temporary effects on nonbreeding habitat are expected. Construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 245 acres of tricolored blackbird breeding habitat (predominately cultivated lands suitable for foraging) and 799 acres of nonbreeding habitat (predominately cultivated lands suitable for foraging) in Conservation Zone 7.

Development of the transmission line alternative with the greatest potential effect on the tricolored blackbird will result in the temporary removal of up to 417 acres of cultivated lands, 105 acres of grassland, 25 acres of valley foothill/riparian, 4 acres of managed wetlands, and 1 acre of tidal freshwater emergent wetland natural community, which may include suitable habitat for the tricolored blackbird. Transmission line effects were assessed only for natural communities and not for covered species modeled habitat; therefore, only a portion of the 552 acres is expected to provide suitable habitat for tricolored blackbirds.

Temporarily disturbed areas will be restored to their previous habitat condition within 1 year following completion of construction and management activities. Because most temporary losses to tricolored blackbird habitat will affect agricultural and grassland foraging habitats that can be restored relatively quickly to suitable habitat, the replaced vegetation is expected to meet habitat requirements for tricolored blackbird within the first few years after the initial restoration activities are complete.

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Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water conveyance construction will result in long-term temporary removal of approximately 1,093 acres of tricolored blackbird habitat (0.2% of the habitat in the Plan Area), including 198 acres of breeding season foraging habitat (151 acres of noncultivated lands, primarily grasslands, and 47 acres of cultivated lands), and 894 acres of nonbreeding season foraging habitat (all cultivated lands) for the tricolored blackbird (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Most of these long-term temporary losses will occur in Conservation Zones 4, 5, and 8. Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown. Upon completion of the restoration efforts, the replaced grassland and cultivated lands are expected to provide foraging habitat for tricolored blackbird within the first few years.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of tricolored blackbirds. Risk would be greatest to eggs and nestlings susceptible to land clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. However, establishment of a 250-foot exclusion zone around nest sites during construction and associated monitoring of the nesting colony (Appendix 3.C, *Avoidance and Minimization Measures*) are expected to minimize the potential for injury or mortality of the tricolored blackbird.

Indirect Construction-Related Effects

Construction-associated disturbances (i.e., noise, dust, visual) within 1,300 feet of tricolored blackbird nesting colonies and 500 feet of foraging habitat could temporarily affect the use of up to 15,174 acres (3.1%) of modeled tricolored blackbird habitat, including 4,526 acres of breeding habitat and 10,647 acres of non-breeding habitat (Table 5.6-2a, *Indirect Effects, Wildlife*).

Construction-associated disturbance risk would be greatest to tricolored blackbirds when it occurs during the breeding season. Disturbance near active nesting colonies could lead to increased mortality of eggs and young due to increased exposure of nests to the elements or to predators, the avoidance or reduced use of high value foraging areas, or the abandonment of nests and nesting colonies. However, preconstruction surveys will be conducted in known or suitable nesting habitat to identify active tricolored blackbird nesting colonies. Covered activities will be prohibited within 250 feet of an active nesting colony until breeding has ceased, and monitoring will occur to ensure that construction does not adversely affect the nesting colony, as described further in Appendix 3.C, *Avoidance and Minimization Measures*. Because the area of effect for nesting tricolors can extend up to 1,300 feet from nesting colonies, some disturbance effects may remain even with implementation of the measure. Risk to tricolored blackbirds posed by construction disturbance is greatly reduced during the nonbreeding season when adults and fledged young forage opportunistically across the Plan Area.

Construction activities may result in the accidental release of petroleum or other contaminants that could affect tricolored blackbirds if present. The potential for this adverse effect will be avoided and minimized through BMPs described in Appendix 3.C, *Avoidance and Minimization Measures*.

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5.6.14.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Activities associated with ongoing operation and maintenance of facilities may result in local adverse habitat effects, injury, or mortality of tricolored blackbirds, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable, but will be minimized with implementation of tricolored blackbird avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Habitat Enhancement and Management

Activities associated with implementation of natural communities enhancement and management that are intended to maintain and improve habitat functions within protected habitats for tricolored blackbirds and other covered species, such as ground disturbance or removal of nonnative vegetation, may result in local adverse habitat effects, injury or mortality of tricolored blackbirds, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable, but will be minimized with implementation of tricolored blackbird avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.14.1.5 Other Indirect Effects

Transmission Lines

New transmission lines will increase the risk for bird-power line strikes, which could result in injury or mortality of tricolored blackbirds. Strike risk is greatest during the winter when large mixed-species flocks of blackbirds forage opportunistically across the Delta. The existing network of transmission lines in the Plan Area currently poses this risk for tricolored blackbirds, and any incremental risk associated with the new power line corridors is expected to be low. Transmission line poles and towers also provide perching substrate for raptors, which could result in increased predation pressure on local tricolored blackbirds.

Methylmercury

Increased exposure to methylmercury associated with tidal natural communities restoration could potentially affect tricolored blackbirds that nest near tidal restoration sites and feed in restored tidal wetlands. Section 3.4.13, *CM12 Methylmercury Management* describes the process by which tidal restoration may increase methylmercury levels in wetlands in the Plan Area. Concentrations of methylmercury known to cause adverse reproductive effects in birds have been found in San Francisco Bay black rails (Tsao et al. 2009) and clapper rails (Schwarzbach and Adelsbach 2003), species that may be especially prone to methylmercury contamination because they forage directly in contaminated tidal sediments. Susceptibility of breeding tricolored blackbirds to methylmercury exposure is likely low because tidal wetlands are not expected to be a major foraging area for the species. Furthermore, the Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands, perhaps reducing the overall risk. Currently, it is unknown how much of the sediment derived methylmercury enters the food chain in the Plan Area or what tissue concentrations are actually harmful to tricolored blackbirds. Measures described in Section 3.4.13, *CM12 Methylmercury*

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Management are expected to reduce the effects of methylmercury resulting from BDCP tidal natural communities restoration.

5.6.14.1.6 Impact of Take on Species

The tricolored blackbird is a colonial nesting passerine that is largely restricted to California. More than 95% of the California breeding population of tricolored blackbird occurs in the Central Valley (Kyle and Kelsey 2011). Breeding also occurs in the foothills of the Sierra Nevada south to Kern County, the coastal slopes from Sonoma County to the Mexican border, and sporadically in the Modoc Plateau. The Plan Area constitutes a relatively small portion of the species' total range. While the overall range of the tricolored blackbirds is largely unchanged since the 1930s (Neff 1937; DeHaven et al. 1975; Beedy et al. 1991; Hamilton 1998), large gaps now exist in the species' former range. Surveys during the 1990s (Hamilton et al. 1995; Beedy and Hamilton 1997; Hamilton 2000) indicated a significant declining trend in California populations since the 1930s, and a particularly dramatic decline since 1994. Statewide surveys conducted during the 2000s indicated some recovery from the recent (1999) population low; however, the population increases have primarily been limited to the San Joaquin Valley and the Tulare Basin (Kyle and Kelsey 2011).

Although there are few reported historical occurrences of tricolored blackbirds nesting within the Plan Area (Neff 1937; Beedy et al. 1991; California Department of Fish and Game 2011), more recent surveys have documented occasional nesting colonies along the fringe of Suisun Marsh, in the Yolo Bypass, and along the southwestern perimeter of the Plan Area (University of California Davis n.d.). While breeding colonies are uncommon, the Delta is recognized as a major wintering area for the species (Hamilton 2004, Beedy 2008).

There are approximately 491,438 acres of modeled tricolored blackbird habitat in the Plan Area (over 55% of the Plan Area), consisting of 129,962 acres of breeding habitat and 361,476 acres of nonbreeding habitat. Full BDCP implementation will result in the permanent loss of 11,416 acres of breeding habitat (8.8%) in the Plan Area, including 76 acres of nesting habitat and 11,340 acres of foraging habitat. BDCP implementation will also result in loss of 30,077 acres of nonbreeding habitat (6.1 %) in the Plan Area, including 4,604 acres of roosting habitat and 25,473 acres of foraging habitat.

Take resulting from this permanent habitat loss and other adverse effects as described above and shown in blackbird (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*) is not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- Very little loss of nesting structure (up to 76 acres) will occur.
- Most of the loss of breeding and nonbreeding habitat will be to cultivated lands that are abundant throughout the Plan Area, so the loss due to covered activities is not expected to substantially affect the population in the Plan Area.
- The effect of periodic inundation on breeding and non-breeding habitat is expected to be minor.
- Most temporary effects will affect cultivated lands and grassland habitats that can be restored relatively quickly to suitable foraging habitat.
- The Plan Area represents a very small proportion of the species statewide range.

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5.6.14.2 Beneficial Effects

The BDCP Implementation Office will protect at least 20,000 acres of cultivated lands in agricultural reserves (CM3), a large portion of which is expected to be suitable foraging habitat for the tricolored blackbird. At least 11,400 acres (57%) will be in crop types that are of at least moderate value to tricolored blackbirds during the nonbreeding season when birds forage widely across the Plan Area, while 5,100 to 7,600 acres will be maintained in crop types of high to very high quality foraging value for breeding tricolored blackbirds. High-quality cultivated lands for nesting tricolored blackbirds include those in proximity to nesting habitat (within 5 miles) that support large insect populations vital to egg formation and rearing of young, such as pasturelands, alfalfa and other hay crops, and some croplands such as sunflower. The actual amount of protected cultivated lands will be determined during implementation.

In addition to these cultivated lands, the Implementation Office will also restore and protect noncultivated habitats, portions of which are expected to provide tricolored blackbird foraging habitat. Habitats beneficial to tricolored blackbirds include grasslands (8,000 acres protected, CM3; 2,000 acres restored, CM8), alkali seasonal wetlands (150 acres protected, CM3), and vernal pool complexes (600 acres protected, CM3; restoration of all affected acreage in Conservation Zones 1, 8 or 11 to achieve no net acreage loss, CM9). All of these communities are known to support large insect populations, a vital food resource for successful reproduction. In addition, protected grasslands will be managed to increase insect prey through techniques such as grazing practices and avoiding use of pesticides (CM11). Those conservation lands that lie within a few miles of active nesting colonies will provide high quality foraging areas to support breeding tricolors, while all areas may be used opportunistically by tricolors during other times of the year.

To successfully maintain or increase breeding by tricolored blackbirds in the Plan Area, the Implementation Office will protect and manage 50 acres of occupied or recently occupied tricolored blackbird nesting habitat located in close proximity to high quality foraging habitat. Tricolors are highly dependent on disturbance events to maintain suitable nesting conditions at nesting colony sites. To sustain nesting habitat characteristics, bulrush/cattail emergent vegetation will be subject to periodic management (e.g., burning, mowing, discing) to ensure that young, actively growing stands preferred by tricolored blackbirds for nesting are maintained over the term of the BDCP.

Actions taken by the BDCP Implementation Office will also benefit roosting by tricolored blackbirds in the Plan Area. At least 65,000 acres of tidally influenced natural communities will be restored or created (CM4), portions of which will provide suitable nonbreeding roosting habitat for tricolored blackbirds. Tidal restoration sites will incorporate hydrologic and elevation gradients that provide for a diversity of inundation characteristics and plant composition. Areas of tidal emergent wetlands that support tall or dense vegetation, such as cattails and bulrushes, will be suitable as roosting habitat for tricolored blackbirds. These BDCP conservation efforts will improve habitat conditions for tricolored blackbirds and enhance the long-term viability of this species in the Plan Area.

5.6.14.3 Net Effects

Full implementation of the BDCP will result in up to a 9,376-acre (7.2%) decrease in breeding habitat for the tricolored blackbird, although the amount of breeding habitat in protected status will increase by at least 1,483 acres (Table 5.6-3a, *Net Effects, Wildlife*). Breeding habitat losses primarily affect lands suitable for foraging, particularly cultivated lands. A net increase in habitat suitable for nesting (360 acres) will occur. Because nesting by tricolored blackbirds is dependent on periodic

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disturbance to retain favorable vegetative structure (at least in optimal bulrush/cattail wetland nesting stands), the amount of modeled breeding habitat suitable for use by tricolored blackbirds in any given year is variable. Under the BDCP, management for tricolored blackbirds will ensure that at least 50 acres of suitable emergent wetland nesting structure is maintained at all times, in close association with high-quality foraging habitats that support abundant insect populations necessary for high reproductive success. Although the overall amount of foraging habitat will decline, foraging habitat under protective status will increase by 4,287 acres under the BDCP. In addition, 5,100 acres of cultivated lands in agricultural reserves will be maintained in crop types that provide high- to very high-quality foraging habitat for breeding tricolored blackbirds in any given year. These increases in protected foraging habitat, managed to provide for optimal foraging conditions, will offset the decline in breeding season foraging habitat for tricolored blackbirds.

Full implementation will also result in up to a 25,656-acre (7.1%) decrease in nonbreeding habitat for the tricolored blackbird, although the amount of nonbreeding habitat in protected status will increase by at least 16,264 acres (Table 5.6-3a, *Net Effects, Wildlife*). Again, most of the nonbreeding season habitat decline involves lands suitable for foraging (a decrease of 25,460 acres), primarily cultivated lands (a decrease of 23,250 acres). A much smaller decline in roosting habitat (1,196 acres) is estimated, however, replacement of this loss is expected as part of tidal restoration efforts (an undetermined portion of the 65,000 acres of restored tidal land will support bulrush/cattail emergent wetlands suitable as roosting habitat for tricolored blackbirds). The net declines in non-breeding foraging habitat for the tricolored blackbird will be offset by a 13,927-acre increase in foraging habitat that is protected under the BDCP. Furthermore, at least 11,400 acres of cultivated lands in agricultural reserves will be maintained in crop types that provide a moderate of higher quality foraging value for non-breeding tricolored blackbirds in any given year, 50% of which will be of high or very high value. These increases in protected foraging habitats, managed to provide for moderate of higher foraging conditions, will offset the decline in nonbreeding season foraging habitat for the tricolored blackbird.

About half of the losses in tricolored blackbird habitat will occur in the NT and early LT periods, with the remaining losses during the LLT period. Tidal restoration efforts account for about 70% of these permanent habitat losses, and primarily involve lands suitable for foraging during the breeding and non-breeding seasons. The BDCP Implementation Office will secure, protect, and manage lands suitable as breeding and nonbreeding habitat for the tricolored blackbird as part of the reserve design requirements for this species.

The potential take of tricolored blackbird as a result of permanent and temporary habitat loss and indirect effects, is not expected to adversely affect the long-term survival or recovery of this species. Tricolored blackbird avoidance and minimization measure, as described in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to specifically protect nesting colony sites and avoid injury or mortality to adults, nestlings, and eggs. Habitat management and enhancement will further benefit the species.

Overall, the BDCP will provide a net benefit to the tricolored blackbird by improving overall habitat quality for tricolored blackbirds, and by increasing the protection of breeding and nonbreeding habitat. These protected areas will be managed, enhanced, and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the tricolored blackbird.

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5.6.15 Western Burrowing Owl

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the western burrowing owl. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*, and more specific assessment methods are described below. The habitat model used to assess effects for the western burrowing owl includes vegetation and land cover types used by the species for nesting and foraging characterized as high-, moderate-, and low-value habitat depending on reported use patterns from the literature. Vegetation types were assigned to a suitability category based on the species requirements as described in Appendix 2.A, *Covered Species Accounts*. Further details regarding the habitat model, including assumptions on which the model is based, are also provided in Appendix 2.A*.* Factors considered in assessing the quality of affected habitat for the western burrowing owl, to the extent that information is available, include vegetation type and structural characteristics, topographical and other land form characteristics, potential for ground squirrels, and cultivation practices.

5.6.15.1 Adverse Effects

5.6.15.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 34,676 acres[13] of modeled habitat (8.3% of the modeled habitat in the Plan Area) for the western burrowing owl (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*), of which 3,203 acres is of high value, 4,677 acres is of moderate value, and 26,796 acres is of low value. Most of the loss will result from tidal natural communities restoration.

Most burrowing owl occurrences are associated with the moderate to high habitat value categories and thus the large number of acres of low-value habitat affected represents marginally suitable but unoccupied habitat. Western burrowing owl habitat will be permanently lost due to tidal restoration, conveyance facility construction, transmission line construction, bypass improvements, and floodplain restoration.

Conveyance Facility Construction

The construction of the conveyance facility and associated infrastructure will result in the permanent loss of 2,778 acres of modeled burrowing owl habitat in Conservation Zones 3, 4, 5, 6, and 8, the majority of which is low-value cultivated land (2,521 acres). Approximately 201 acres of high-value grassland habitat will be removed, the majority of which is be associated with the construction of the Byron Forebay. There are several CNDDB records for western burrowing owls in the vicinity of the conveyance facilities near the forebay. Removal of high value habitat in this area from construction of project facilities including the establishment of the forebay borrow and spoils area, could remove occupied habitat, displace nesting and wintering owls, and fragment occupied habitats.

[13] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Transmission Line Construction

The transmission line alternative with the greatest effect will result in the permanent removal of approximately 6 acres of modeled burrowing owl habitat, including 6 acres of low-value cultivated land and 0.7 acre of high-value grassland.

Fremont Weir/Yolo Bypass Improvements

.These activities will permanently remove approximately 857 acres of modeled burrowing owl habitat in Conservation Zone 2, the majority of which is of low to moderate value due to cultivation and existing frequency of inundation.

Tidal Natural Communities Restoration

.This activity will result in the permanent removal or conversion of approximately 25,027 acres of modeled burrowing owl habitat from Conservation Zones 1, 2, 4, 5, 6, 7, 8, 10, and 11. Of the total, 24,056 acres will result from conversion to tidal marsh, and 971 acres will result from removal due to riparian restoration (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The majority of removed or converted acres (18,300 acres) are low-value cultivated land; however, some of the loss (2,856 acres) will consist of high-value grassland habitat. Tidal restoration will directly remove and fragment remaining high-value grassland habitat just north of Rio Vista in and around French and Prospect Islands, and in an area south of Rio Vista around Threemile Slough. Tidal natural community restoration will affect one extant record of burrowing owl just northeast of Oakley along Dutch Slough and one possibly extirpated occurrence in Suisun Marsh. Because the estimates of the habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on western burrowing owl occupied habitat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 5,580 acres of modeled burrowing owl habitat in Conservation Zones 2, 4, and 7 for the western burrowing owl (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Of these, 1,589 acres will be removed as a result of levee construction activities and 3,991 acres will be removed through riparian restoration activities. Most of the acres removed (5,460 acres) are low-value cultivated lands. Only 50 acres are high-value grasslands, occurring in small patches along the San Joaquin, Old, and Middle Rivers in Conservation Zone 7.

Nontidal Marsh Restoration

This activity will result in the permanent loss of about 400 acres of low quality burrowing owl habitat in Conservation Zones 2 and 4 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

Conservation Hatcheries Facilities

This activity will result in the permanent loss of about 35 acres of high-value burrowing owl habitat in Conservation Zone 1.

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5.6.15.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), Yolo Bypass operations will result in the periodic inundation of 7,226 acres of modeled western burrowing owl habitat, a large proportion of which (6,555 acres) is low-value cultivated land and grassland habitat (valued low due to existing frequency of inundation). The increased frequency and length of inundation in Yolo Bypass will not substantially affect the western burrowing owl. Few nesting burrowing owls have been reported in the Yolo Bypass, likely due to existing periodic inundation. One possibly extirpated record of a western burrowing owl along the east side of the Yolo Bypass near the Deep Water Channel will be affected by these actions.

Floodplain Restoration

Construction of setback levees could result in periodic inundation of up to 7,226 acres of western burrowing owl habitat. The majority of this habitat (6,555 acres) is low-value cultivated land. No CNDDB records of western burrowing owls will be affected by these actions.

5.6.15.1.3 Construction-Related Effects

Construction-related effects on the western burrowing owl include short-term, temporary effects from water conveyance construction and long-term, temporary effects from establishment of borrow and spoils sites. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent to assessing the quality of affected habitat or the specific nature of the effect.

By LLT, construction activities are expected to temporarily remove a total of 3,100 acres of modeled burrowing owl habitat, including short-term, temporary (2,290 acres) and long-term, temporary (810 acres) effects (Table 5.6-1a *Maximum Allowable Habitat Loss, Wildlife*). Nearly all of the affected modeled habitat is cultivated land. Most of the affected modeled habitat (2,593 acres) is low-value cultivated land. Only 404 acres represent high-value grassland habitat.

Temporary Habitat Loss (Short-Term)

Construction-related effects will temporarily disturb 2,290 acres of habitat for the western burrowing owl (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Of this, 1934 acres (84%) is low-value cultivated habitat. Only 253 acres (11%) is high-value grassland habitat. Temporarily disturbed areas will be restored in kind as western burrowing owl habitat within 1 year following completion of construction and management activities.

Long-Term Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 810 acres of modeled habitat for this species in Conservation Zones 4, 5, and 8 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Of the total, only 151 acres are high-value grassland habitat. Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

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Construction-Related Injury or Mortality

Construction will not likely cause injury or mortality to the western burrowing owl; however, preconstruction surveys, construction monitoring, and no-disturbance buffers will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

BDCP construction activities, including conveyance construction, tidal restoration, Yolo Bypass enhancement, and floodplain restoration could cause noise and visual disturbances, which could in turn affect burrowing owl nesting and foraging behavior adjacent to activity areas. Any disturbance within 250 feet of a burrow occupied by burrowing owl during the breeding season (February 1 through August 31) and within 160 feet during the nonbreeding season (September 1 through January 31) could potentially displace winter owls or cause abandonment of active nests. A total of 13,290 acres of modeled burrowing owl habitat, 2,446 acres of which is high value grassland habitat, would temporarily be made less suitable as a result of construction noise and visual disturbances (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Potential effects of these disturbances on western burrowing owls will be minimized with implementation of the burrowing owl avoidance and minimization measures in Appendix 3.C, *Avoidance and Minimization Measures,* which require surveys to determine the presence of active sites and the establishment of no-disturbance set-backs around active sites.

5.6.15.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Activities associated with ongoing operation and maintenance of facilities could result in localized loss of western burrowing owl habitat, injury or mortality of burrowing owls, and temporary noise and disturbance effects over the term of the BDCP. These activities may include road, levee, and facilities maintenance that remove or disturb active burrows, and rodent abatement programs around conveyance facilities. These effects will be minimized to the extent possible with the implementation of the measures described in Appendix 3.C. *Avoidance and Minimization Measures,* which require surveys to determine presence or absence and the establishment of no-disturbance set-backs around active sites.

Habitat Enhancement and Management

Activities associated with habitat enhancement and management intended to maintain and improve habitat functions in protected habitats could result in localized loss of western burrowing owl habitat, injury or mortality of burrowing owls, and temporary noise and disturbance effects over the term of the BDCP. These effects will be minimized with implementation of measures described in Appendix 3.C. *Avoidance and Minimization Measures,* which require surveys to determine presence or absence and the establishment of no-disturbance set-backs around active sites. Over the term of the BDCP, enhancement and management actions on protected lands are expected to result in a net benefit because these actions are intended to improve habitat functions for western burrowing owl and other covered species.

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5.6.15.1.5 Impact of Take on Species

The breeding range of the western burrowing owl extends south from southern Canada throughout most of the western half of the United States and south to central Mexico. The winter range extends from central California southeastward through Arizona, New Mexico, and Texas and south into northern and central Mexico and coincides with southern breeding range where the species is resident year-round (Haug et al. 1993). Burrowing owls were once widespread and generally common over western North America in treeless, well-drained grasslands, steppes, deserts, prairies, and agricultural lands (Haug et al. 1993). Owl population throughout the species' North American range are reportedly declining (James and Espie 1997; Klute et al. 2003).

There are approximately 420,935 acres of modeled habitat for western burrowing owl in the Plan Area; however approximately 294,238 acres of this habitat (roughly 70%) is low-value cultivated land. Permanent loss of habitat can be described based on the proportion of low-, moderate-, and high-value habitat removed. Due to the distribution of burrowing owls in the Plan Area and the species' preference for grassland (high value) and pastureland (moderate value) land cover types, the loss of these habitat categories are more directly associated with direct impacts on the species. The removal of most modeled cultivated land (low value) is not expected to affect the distribution or abundance of the species and in most cases is unlikely to affect individual active burrow sites. Approximately 4.7% of the modeled high-value habitat and 8.0% of moderate- value habitat will be permanently removed by BDCP activities. The loss of this habitat is more likely to affect the local distribution and abundance of the species. Therefore, to more effectively address the loss of high- and moderate-value habitats, the primary conservation elements are also directed at the conservation of high- and moderate-value habitat types.

TThe species is a year-round resident in the Plan Area; however, local migratory patterns and the extent to which migrants occupy the Plan Area during the nonbreeding season are unclear. Data from CNDDB and more recent surveys conducted by DWR indicate that the species is distributed primarily along the western perimeter of the Plan Area. This area also corresponds with the distribution of moderate to high value habitat. Therefore, the removal of moderate and high value habitat also has a substantially greater likelihood of directly affecting active nesting or wintering burrows. Within this region, which includes primarily Conservation Zones 1, 8, 9, and 11, the largest proportion of the known nesting population with potential to be affected by BDCP activities is in the vicinity of Clifton Court Forebay in Conservation Zone 8. Occupied habitats in Conservation Zones 1, 9, and 11 will be less affected by BDCP activities.

Although the implementation of the BDCP will result in the permanent, temporary, and periodic effects on the western burrowing owl as discussed above, take resulting from these actions will not have an adverse population-level effect on the species. Implementation of the BDCP will result in loss of one extant and two possibly extirpated burrowing owl occurrences in the Plan Area; however, there may be others. Ten of the 128 documented burrowing owl occurrences in the Plan Area are in locations that already have some degree of protection from development or other impacts.

5.6.15.2 Beneficial Effects

The BDCP Implementation Office will protect 8,000 acres of grassland from any future threats of land conversion and reduce the effects of current levels of habitat fragmentation. This will expand the amount of suitable habitat in the Plan Area and support existing western burrowing owl

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populations that occur to the west of Conservation Zone 8 in Contra Costa County and in the areas surrounding Conservation Zones 1 and 11 in Solano County, which will especially benefit declining populations in the vicinity of Suisun Marsh and San Pablo Bay.

The BDCP will further benefit western burrowing owl by increasing the amount of burrows in protected and restored grasslands (CM11), which will open opportunities for dispersing western burrowing owls to establish new territories, and by increasing the diversity of prey options (CM11) and thus minimizing the effect that population swings of any one prey species would have on western burrowing owls.

Although cultivated lands are in the low suitability category for burrowing owl use, western burrowing owls are known to use road, canal, and levee embankments that have ground squirrel burrows or culverts, and thus the management of cultivated lands for western burrowing owl foraging habitat may further expand and support populations in the Plan Area in the long term. At least 1,000 acres of pasture lands and other moderately valued foraging habitat for the western burrowing owl will be protected in Conservation Zones 1 and 11 near or adjacent to occupied grassland habitats (CM3). Patches of habitat in cultivated lands that may support western burrowing owl prey species (insects and small mammals) will be protected (CM3). Implementation of this objective may allow western burrowing owls to establish a greater presence in the central portion of the Delta.

The western burrowing owl will be conserved in cooperation and in conjunction with neighboring and overlapping HCP/NCCPs to ensure that conservation actions occur where they most benefit the regional western burrowing owl population and where they are compatible with conservation of other species associated with grassland and cultivated land. The western burrowing owl conservation strategy is expected to sustain the existing population of western burrowing owls and provide for future increases in the species' abundance and distribution within and adjacent to the Plan Area.

5.6.15.3 Net Effects

Full implementation of the BDCP will result in at least 31,779 acres (8%) decrease of habitat for the western burrowing owl, and at least 17,277 acres increase (23%) of western burrowing owl habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

Specific BDCP actions are expected to adversely affect burrowing owls through the permanent removal of 34,670 acres of modeled burrowing owl habitat, including 3,197 acres of high-value habitat and 4,677 acres of moderate-value habitat. While this will result in a net loss of moderate- and high-value modeled habitat, the loss represents only a small percentage of the available moderate- and high-value habitat in the Plan Area and the majority of affected acres are lands that are unoccupied by burrowing owls. With the exception of the area in the vicinity of the Clifton Court Forebay, most of the loss of modeled burrowing owl habitat will not affect current breeding or wintering sites. Therefore, most of the loss of burrowing owl habitat will not affect the distribution or abundance of the species in the Plan Area. The remaining moderate- to high-value habitat is expected to sustain the current population.

The loss of high- and moderate-value western burrowing owl habitat is offset by three key conservation objectives: protection of 8,000 acres of grassland in Conservation Zones 1, 8, and 11; protection of an additional 1,000 acres of moderate-value pastureland with the grassland-pastureland matrix of Conservation Zones 1 and 11, and restoration of 2,000 acres of grassland.

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Other conservation objectives that target cultivated land protection will be sufficient to sustain and expand existing burrowing owl populations in low-value habitat areas. Therefore, aAlthough the total acreage of available high- and moderate-value habitat would decrease in the Plan Area, BDCP protection, enhancement, and management of 11,000 acres of habitat in key areas known to be occupied by burrowing owls will increase the extent of burrowing habitat under protected status with the BDCP Plan Area by at least 10% (Table 5.6-3a, *Net Effects, Wildlife*), and will provide sufficient habitat for the protection and expansion of the burrowing owl population.

Overall, the BDCP will provide a net benefit to the western burrowing owl through the protection, management, and enhancement of high- and moderate-value habitats in the Plan Area where the species is known to occur, and the increase in extent of habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the western burrowing owl.

5.6.16 Western Yellow-Billed Cuckoo

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the western yellow-billed cuckoo. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the western yellow-billed cuckoo includes two habitat types: breeding habitat and migratory habitat. The model for breeding habitat includes plant alliances from the valley/foothill riparian modeled habitat that contain a dense forest canopy for foraging with understory willow for nesting, and a minimum patch size of 25 acres. Western yellow-billed cuckoo nesting in the Plan Area has not been confirmed for approximately 100 years (California Department of Water Resources 2011). The model for migratory habitat includes the same valley/foothill riparian plant alliances as breeding habitat, but without the minimum patch size designation. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the western yellow-billed cuckoo, to the extent that information is available, include location in relation to species occurrences and existing protected lands (Categories 1 and 2 open space[14]), and habitat patch size and configuration.

5.6.16.1 Adverse Effects

5.6.16.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 859 acres[15] of habitat (7% of the habitat in the Plan Area) for the western yellow-billed cuckoo, including 488 acres of breeding habitat and 371 acres of migratory habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in permanent habitat loss for the western yellow-billed cuckoo include conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, and floodplain restoration. The covered activity resulting in most (72%) of the habitat loss is tidal natural communities restoration.

[14] See Section 5.3.5.2 *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories

[15] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Conveyance Facility Construction

Construction of all conveyance facilities, including transmission lines, will result in the permanent removal of approximately 8 acres of migratory habitat for the western yellow-billed cuckoo (less than 1% of migratory habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of low quality for the species: it consists of small patches scattered through Conservation Zones 3, 4, 5, 6, and 8, most of which are narrow strips along irrigation and drainage channels. The western yellow-billed cuckoo is likely not present in habitat along the conveyance facility alignment: the alignment was surveyed by DWR biologists in 2009 and 2010, and western yellow-billed cuckoo was not detected.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 212 acres of habitat for western yellow-billed cuckoo (2% of the habitat in the Plan Area), including approximately 205 acres of breeding habitat and 6 acres of migratory habitat. (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Most of this habitat is of low to moderate quality: although it is located in and near Category 1 open space, the modeled habitat to be affected in the vicinity of Fremont Weir includes grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation. There are no western yellow-billed cuckoo occurrences near the Fremont Weir, although the extent to which this area has been surveyed for the species is unknown.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 617 acres of western yellow-billed cuckoo habitat (5% of the habitat in the Plan Area), including 271 acres of breeding habitat and 346 acres of migratory habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat loss will take place in the Suisun, Cache Slough, Cosumnes, West Delta, and South Delta ROAs. The majority of the habitat to be lost is in Conservation Zones 2 (36%) and 5 (34%), and the remainder is scattered in Conservation Zones 1, 4, 6, 7, 8, and 11. Most of the habitat loss in Conservation Zone 2 is in Cache Slough ROA, around Liberty Island, and is of moderate to high quality as it includes some relatively large habitat patches. Most of the habitat loss in Conservation Zone 5 is located in the vicinity of Frank's Tract and Brannan Island State Recreation Areas (Category 2 open space) and is also of moderate to high quality in that it includes relatively large habitat patches. The remainder of the habitat loss potentially resulting from tidal natural communities restoration is of low to moderate quality, mostly in relatively small patches and narrow strips along drainage channels and surrounded by agricultural lands. Western yellow-billed cuckoo was detected by DWR in 2009 in Conservation Zone 4 just west of the Cosumnes ROA, but nesting was not confirmed (California Department of Water Resources 2011). There are no western yellow-billed cuckoo occurrences in the ROAs, although the extent to which these areas have been surveyed for the species is unknown. Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on western yellow-billed cuckoo habitat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of an estimated 21 acres of western yellow-billed cuckoo habitat (0.2% of the habitat in the Plan Area), including 11 acres of breeding habitat and 10 acres of migratory habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of moderate quality: although it consists primarily of

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small patches, these patches are in proximity to other habitat along the San Joaquin River, and some of the patches are adjacent to existing Categories 1 and 2 open space. Because the estimates of habitat loss resulting from floodplain restoration are based on projections of where restoration may occur, actual habitat loss is expected to be lower because of sites will be selected to minimize effects on western yellow-billed cuckoo habitat.

5.6.16.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 21 acres of habitat for the western yellow-billed cuckoo (less than 1% of the habitat in the Plan Area), including 11 acres of breeding habitat and 10 acres of migratory habitat.

Floodplain Restoration

Based on hypothetical floodplain restoration, this activity will periodically inundate 141 acres of habitat for the western yellow-billed cuckoo (1% of the habitat in the Plan Area), including 28 acres of breeding and 114 acres of migratory habitat.

Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the western yellow-billed cuckoo because flooding is unlikely to occur during the breeding season when cuckoos could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal.

5.6.16.1.3 Construction-Related Effects

Construction-related effects on this species include temporary habitat loss, potential construction-related injury or mortality, and indirect noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 125 acres of habitat for the western yellow-billed cuckoo (1% of the habitat in the Plan Area), including 97 acres of breeding habitat and 28 acres of migratory habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily removed areas will be restored as riparian habitat within one year following completion of construction activities. Although the effects are considered temporary, five years to several decades may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, most of the riparian vegetation to be temporarily removed in the Plan Area is early to mid-successional: therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first five to ten years after the initial restoration activities are complete.

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Construction-Related Injury or Mortality

Although western yellow-billed cuckoo nesting has not been confirmed in the Delta for approximately 100 years, a 2009 sighting by DWR (within unconfirmed nesting) and the presence of suitable habitat indicates that the species may nest in the Plan Area presently or in the future (California Department of Water Resources 2011). If the western yellow-billed cuckoo nests where covered activities are to occur, the operation of equipment for construction activities could result in injury or mortality of individuals. Risk would be greatest to eggs and nestlings that could be injured or killed through crushing from heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely as these individuals are expected to avoid contact with construction equipment. Injury or mortality to nesting western yellow-billed cuckoos will be avoided through preconstruction surveys and establishment of no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance within 1,300 feet of construction activities could temporarily affect the use of 1,629 acres (13%) of modeled western yellow-billed cuckoo habitat, including 866 acres of breeding and 763 acres of migratory habitat (Table 5.6-2a, *Indirect Effects, Wildlife*). As described above, there are no nesting records for this species in the Plan Area over the last approximately 100 years but recent sightings indicate that the species may become established in the Plan Area during Plan implementation. Indirect noise and visual effects to nesting cuckoos, if found, will be minimized by establishing 250-foot no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures.*

5.6.16.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing facility operation and maintenance will have little, if any, adverse effect on the western yellow-billed cuckoo. Noise and visual disturbance within 500 feet of facilities could affect the use of 5 acres (less than 0.01%) of modeled western yellow-billed cuckoo habitat (Table 5.6-2a, *Indirect Effects, Wildlife*).

Habitat Enhancement and Management

Activities associated natural communities enhancement and management within protected western yellow-billed cuckoo habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of cuckoos, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

The BDCP covered activities and conservation measures will have no other indirect effects on the western yellow-billed cuckoo.

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5.6.16.1.5 Impact of Take on Species

There are two recognized subspecies of yellow-billed cuckoo, *C. a. occidentalis*, found west of the Rocky Mountains and *C. a. americanus*, found in deciduous forests east of the Rocky Mountains. There is a continuing debate over the taxonomic separation of the two subspecies, based on genetics studies initiated by USFWS during the status review for federal listing. While the eastern subspecies' range includes all states east of the Rocky Mountains and the southern regions of Quebec and Ontario, breeding populations of the western subspecies are limited to California, Arizona, and western New Mexico (Halterman 1991). Studies conducted since the 1970s indicate that there may be fewer than 50 breeding pairs of the western yellow-billed cuckoo in California (Gaines 1974; Halterman 1991;, Laymon et al. 1997). Although sustained breeding populations occur to the north of the Plan Area at isolated sites along the Sacramento River, there are no recent breeding records of western yellow-billed cuckoos in the Plan Area. The scattered sightings over the last 50 years are presumed to be from migrating birds.

Based on modeled habitat for the western yellow-billed cuckoo, the Plan Area supports 4,735 acres of potentially suitable breeding habitat and 7,868 acres of migratory habitat. Of this, up to 488 acres of breeding habitat (10% of the breeding habitat in the Plan Area) and 371 acres of migratory habitat (5% of the migratory habitat in the Plan Area) will be permanently removed by BDCP activities. This and other adverse effects on the western yellow-billed cuckoo resulting from BDCP covered activities, as described above, are not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- Cuckoo presence in the Plan Area is currently limited to infrequent migrants passing through the area.
- The breeding and migratory habitat to be lost is small relative to the species range and the amount that will remain in the Plan Area.
- Most permanently removed habitat consists of relatively small, fragmented riparian stands that do not provide high quality habitat for the cuckoo.

5.6.16.2 Beneficial Effects

The BDCP Implementation Office will restore approximately 5,000 acres of valley/foothill riparian natural community the Plan Area. These lands will be managed as a mosaic of seral stages, age classes, and plant heights and types characteristic of the valley/foothill riparian community. The emphasis will be on developing and maintaining wide bands or large patches of interconnected valley/foothill riparian forests. Over time, this will provide large, contiguous areas of suitable habitat for the western yellow-billed cuckoo as the riparian structural diversity required by cuckoos is achieved (i.e., mature forest canopy with a well-developed shrub understory). At least 500 acres of mature riparian forest will be maintained in large blocks (which must have a minimum patch size of at least 50 acres each) in Conservation Zones 4 and/or 7, further assuring that suitable habitat characteristics for the western yellow-billed cuckoo will be conserved. These BDCP restoration actions will increase the likelihood that the western yellow-billed cuckoo will continue to migrate through and potentially reinitiate breeding in the Plan Area.

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5.6.16.3 Net Effects

Full implementation of the BDCP will result in at least 1,832 acres (15%) increase of habitat for the western yellow-billed cuckoo, and at least 2,612 acres increase (61%) of western yellow-billed cuckoo habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

The habitat that will be lost as a result of covered activities is of low to moderate quality, consisting primarily of relatively small, isolated patches and narrow strips of riparian vegetation within a cultivated landscape. The restored and protected habitat will consist of large, contiguous areas, at least 500 acres of which will be managed to sustain appropriate vegetation structural requirements for the species. Restoration, protection, and management of western yellow-billed cuckoo habitat in the Plan Area will increase opportunities for a breeding population of western yellow-billed cuckoos to become reestablished in the Plan Area after approximately 100 years with no nesting records.

Overall, the BDCP will provide a substantial net benefit to the western yellow-billed cuckoo through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the western yellow-billed cuckoo.

5.6.17 White-Tailed Kite

This section describes the adverse, beneficial, and net effects of the BDCP covered activities and conservation measures on the white-tailed kite. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*. The model maps the distribution of suitable white-tailed kite habitat in the Plan Area according to the species' two primary life requisites, nesting habitat and foraging habitat. The modeled habitat for white-tailed kite is based on selected mapping units from the valley/foothill riparian, grasslands, alkali seasonal wetlands, managed wetlands, vernal pool complexes, and cultivated lands. Breeding habitat for white-tailed kite includes all valley riparian types that support an overstory component. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Size and configuration is considered in assessing the quality of affected nesting habitat for the white-tailed kite.

5.6.17.1 Adverse Effects

5.6.17.1.1 Permanent Habitat Loss, Conversion and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up to 832 acres[16] of breeding habitat (6% of the nesting habitat in the Plan Area) and 44,196 acres of foraging habitat (9% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in permanent loss or conversion of habitat for the white-tailed kite include conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, nontidal marsh restoration, and conservation hatcheries facilities. The covered activity resulting in the majority (77%) of the loss or conversion is tidal natural communities restoration: most of this involves

[16] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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conversion from one type of habitat used by white-tailed kite to another, rather than actual habitat loss.

Conveyance Facility Construction

This activity will result in the permanent removal of approximately 13 acres of breeding habitat (less than 1% of nesting habitat in the Plan Area) and 2,397 acres of foraging habitat (0.5% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The nesting habitat to be lost consists of narrow strips of riparian vegetation adjacent to canals.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 211 acres of breeding habitat (1.5% of breeding habitat in the Plan Area) and 892 acres of foraging habitat (0.2% of the foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although the 211 acres of modeled breeding habitat is located in and near Category 1 open space, it consists of grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation.

Tidal Natural Communities Restoration

This activity will result in the permanent removal or conversion of approximately 560 acres of breeding habitat (4% of breeding habitat in the Plan Area) for the white-tailed kite. The largest patches of nesting habitat to be lost are in the Cosumnes ROA. Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on nesting habitat for white-tailed kite.

Additionally, approximately 33,273 acres of foraging habitat for the white-tailed kite (7% of foraging habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*) will be converted as a result of tidal restoration, but a portion will be converted to tidal perennial aquatic natural community and the remainder will continue to provide foraging habitat for the white-tailed kite.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 42 acres of breeding habitat (0.3% of breeding habitat in the Plan Area) and 1,697 acres of foraging habitat (0.3% of foraging habitat in the Plan Area) for the white-tailed kite.

Nontidal Marsh Restoration

This activity will result in the permanent conversion of an estimated 400 acres of cultivated lands providing foraging habitat (less than 0.1% of foraging habitat in the Plan Area) for the white-tailed kite in Conservation Zones 2 and 4 (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This will result in conversion from cultivated land to nontidal marsh but will not result in loss of white-tailed kite foraging habitat, as nontidal marsh restoration will also provide foraging habitat for the kite.

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Conservation Hatcheries Facilities

This activity will result in the permanent removal of an estimated 35 acres of foraging habitat (less than 0.1% of foraging habitat in the Plan Area) for white-tailed kite (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

5.6.17.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*),this activity will periodically inundate 42 acres of breeding habitat (0.3% of breeding habitat in the Plan Area) and 1,697 acres of foraging habitat (0.3% of foraging habitat in the Plan Area) for the white-tailed kite. Although flood frequency will increase in the Yolo Bypass area, the flooding regime is expected to be within the tolerance range for riparian vegetation in the bypass and the cultivated lands will continue to provide foraging habitat for the white-tailed kite. However, white-tailed kites generally laying their eggs in early to mid-spring, and there is potential for increased flooding and extension of flooding into spring to result in a nest site being surrounded by water during a flood event, which could cause nest abandonment. There are no known nesting occurrences for white-tailed kites in Yolo Bypass, although the extent to which this area has been surveyed for nesting kites is unknown.

Floodplain Restoration

Based on hypothetical floodplain restoration, this activity will periodically flood 229 acres of breeding habitat (2% of the breeding habitat in the Plan Area) and 7,423 acres of foraging habitat (0.2% of foraging habitat in the Plan Area) for the white-tailed kite. Periodic flooding is not expected to adversely affect nesting or foraging value for the white-tailed kite in the restored floodplain.

Habitat inundated by both Yolo Bypass improvements and floodplain restoration is expected to recover following draw-down and to provide suitable foraging conditions until the following inundation period. Thus, this is considered a periodic effect that is unlikely to affect white-tailed kite distribution and abundance, or foraging use of the Plan Area.

5.6.17.1.3 Construction-Related Effects

Construction-related effects on the white-tailed kite include temporary habitat loss (short-term and long-term), potential construction-related injury or mortality, and indirect noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-term)

Construction-related effects will temporarily disturb 150 acres of nesting habitat (1% of nesting habitat in the Plan Area) and 2,494 acres of foraging habitat (0.5% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily removed areas will be restored as riparian habitat within 1 year following completion of construction activities. Although the effects are considered temporary, 5 years to several decades

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may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, most of the riparian vegetation to be temporarily removed in the Plan Area is early to mid-successional: therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first 5 to 10 years after the initial restoration activities are complete.

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 954 acres of foraging habitat (0.2% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

If the white-tailed kite nests where covered activities are to occur, the operation of equipment for construction activities could result in injury or mortality of individuals. Risk would be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely as these individuals are expected to avoid contact with construction equipment. Injury or mortality to nesting white-tailed kites will be avoided through preconstruction surveys and establishment of no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures.*

Indirect Construction-Related Effects

Noise and visual disturbance within 1,300 feet of construction activities could affect the use of 1,661 acres of nesting habitat (11% of nesting habitat in the Plan Area) and 14,306 acres of foraging habitat (3% of foraging habitat in the Plan Area) for the white-tailed kite during construction (Table 5.6-2a, *Indirect Effects, Wildlife*). Indirect noise and visual effects on nesting white-tailed kites, if found, will be minimized by establishing 200-yard no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.17.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing facility operation and maintenance will have little if any adverse effect on the white-tailed kite. Noise and visual disturbance within 1,300 feet of facilities could affect the use of 6 acres of nesting habitat (less than 1% of nesting habitat in the Plan Area) for the white-tailed kite (Table 5.6-2a, *Indirect Effects, Wildlife*).

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected white-tailed kite habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of nesting white-tailed kites, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with the implementation of 200-yard no-

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disturbance buffers around active nest sites as described in Appendix 3.C, *Avoidance and Minimization Measures.*

Other Indirect Effects

New transmission lines will increase the risk of white-tailed kite power line strikes and/or electrocution. The existing network of power lines in the Plan Area poses this risk for white-tailed kites and any incremental increase in this effect associated with the new power lines is expected to be minor.

5.6.17.1.5 Impact of Take on Species

The distribution of the white-tailed kite includes the east coast and southeast United States, the southwest United States from Texas to California, and north to Washington State, and from Mexico to South America. California is currently considered the breeding range stronghold for the white-tailed kite in North America, with nearly all areas up to elevations at the western Sierra Nevada foothills and southeastern deserts occupied (Small 1994; Dunk 1995). The Plan Area represents a small portion of the species' range-wide distribution. The permanent loss or conversion of up to 6% of the nesting habitat and 9% of foraging habitat in the Plan Area as a result of covered activities, and other effects described above, are not expected to adversely affect the long-term survival of white-tailed kite for the following reasons.

- Approximately 77% of the foraging habitat effects involve conversion from one habitat type to another alternate form of suitable foraging habitat.
- The Plan Area represents a small portion of the species' range
- The disturbance of active nests will be avoided as described in Appendix 3.C, Avoidance and Minimization Measures.

5.6.17.2 Beneficial Effects

The BDCP Implementation Office will restore at least 5,000 acres and protect at least 750 acres of valley/foothill riparian natural community, providing nesting habitat for the white-tailed kite. Large patches of riparian habitat provide higher value nesting habitat than narrow bands of trees, where white-tailed kites are often displaced by Swainson's hawks. Achieving these objectives will improve white-tailed kite breeding habitat in the Plan Area in the long term by providing large patches of riparian habitat. Suitable foraging habitat for the white-tailed kite (i.e., low, herbaceous vegetation including marshes, grasslands, and many types of cultivated lands) will be present throughout the Plan Area, and most of the riparian restoration will be within 5 to 8 miles of suitable foraging habitat.

Protection of 8,000 acres of grasslands in Conservation Zones 1, 8, and 11 will provide suitable foraging habitat for the white-tailed kite, which is known to occur within or adjacent to each of these three conservation zones. This will benefit the white-tailed kite by increasing the abundance of voles and other small mammals upon which white-tailed kites prey. Protection of at least 20,000 acres of cultivated lands will provide additional foraging habitat for white-tailed kites in the reserve system. This will benefit the white-tailed kite by reducing any future losses of or changes to suitable foraging habitat on cultivated lands and reduce current, as well as the threat of habitat fragmentation. Restoration of at least 4,800 acres of tidal brackish emergent wetland, 13,900 acres of tidal freshwater emergent wetland, and 400 acres of nontidal marsh are also expected to provide high-

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value foraging habitat for the kite. Maintenance and protection of small patches of wildlife habitats that occur within BDCP conserved cultivated lands, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, and wetlands, will provide additional nesting and foraging habitat for the white-tailed kite.

5.6.17.3 Net Effects

Full implementation of the BDCP will result in an estimated 37,806 acres (7%) decrease of habitat for the white-tailed kite, and an estimated 23,786 acres increase (22%) of white-tailed kite habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*). The nesting habitat that will be lost as a result of covered activities consists of narrow strips and small patches of riparian vegetation, while the restored valley/foothill riparian natural community will provide large, contiguous areas of nesting habitat that are of higher quality for the species and will reduce the species' vulnerability to competition from Swainson's hawks. Most of the foraging habitat to be lost consists of cultivated lands. The restored wetlands will provide high-quality foraging habitat that is expected to provide an abundance of prey and to expose white-tailed kites to fewer human-related disturbances and pesticides than cultivated lands.

Overall, the BDCP will provide a substantial net benefit to the white-tailed kite through the increase in available habitat, habitat quality, and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the white-tailed kite.

5.6.18 Yellow-Breasted Chat

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the yellow-breasted chat. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants* and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model used to assess effects for the yellow-breasted chat identifies suitable nesting and migratory habitat as those plant alliances from the valley/foothill riparian modeled habitat that contain a shrub component of blackberry, California wild rose, dogwood, coyote bush, willow, and other shrub species, and an overstory component that includes valley oak, coast live oak, Fremont cottonwood, white alder, box elder, Oregon ash, willow, or walnut. Primary nesting and migratory habitat is qualitatively distinguished from secondary habitat in Delta areas as those plant associations that support a greater percentage of a suitable shrub cover, particularly blackberry and California wild rose, and have an open to moderately dense overstory canopy, using data from Hickson and Keeler-Wolf (2007). No distinction is made between primary and secondary habitat for Suisun Marsh/Yolo Basin habitats because supporting information is lacking: for this reason, and to facilitate the discussion of species effects, this effects analysis only provides the breakdown between primary and secondary habitat in the habitat loss totals and associated tables, and does not provide this breakdown in the text by activity or effect type. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the yellow-breasted chat, to the extent that information is available, include location in relation to species occurrences and existing protected lands (Categories 1 and 2 open space[17]), and habitat patch size and configuration.

[17] See Section 5.3.5.2 *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories.

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5.6.18.1 Adverse Effects

5.6.18.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 1,032 acres[18] of habitat (7% of the habitat in the Plan Area) for the yellow-breasted chat, including 342 acres of primary habitat, 460 acres of secondary habitat, and 230 acres of habitat in the Suisun/Upper Yolo Bypass area (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in adverse effects on yellow-breasted chat include conveyance facility construction, tidal natural communities restoration, Fremont Weir/Yolo Bypass improvements, and floodplain restoration. A majority (75%) of the permanent loss is from tidal communities restoration.

Conveyance Facility Construction

Construction of conveyance facilities, including transmission line construction, will result in the permanent removal of approximately 14 acres of habitat for the yellow-breasted chat (less than 0.1% of habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of low quality for the species: it consists of small patches scattered through Conservation Zones 3, 4, 5, 6, and 8, most of which are narrow strips along irrigation and drainage channels. The yellow-breasted chat does not likely nest in habitat along the conveyance facility alignment: the alignment was surveyed by DWR biologists in 2009, 2010, and 2011 and nesting chats were not detected.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 212 acres of yellow-breasted (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*) (1.4% of habitat in the Plan Area). Most of this habitat is of low to moderate quality: although it is located in and near Category 1 open space, the modeled habitat to be affected in the vicinity of Fremont Weir includes grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation. There are no yellow-breasted chat occurrences near the Fremont Weir, although the extent to which this area has been surveyed for the species is unknown.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 779 acres of habitat (5% of habitat in the Plan Area) in the Suisun, Cache Slough, Cosumnes, West Delta, and South Delta ROAs for the yellow-breasted chat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife).* The majority of the habitat to be lost is in Conservation Zones 2 (41%) and 5 (28%), and the remainder is scattered in Conservation Zones 1, 4, 6, 7, 8, and 11. Most of the habitat loss in Conservation Zone 2 is in Cache Slough ROA, around Liberty Island (Category 1 open space), and most of the loss in Conservation Zone 5 is located in the vicinity of Frank's Tract and Brannan Island State Recreation Areas (Category 2 open space), in the West Delta ROA: these areas are considered of moderate to high quality because they include relatively large habitat patches in or adjacent to protected lands. DWR recorded two yellow-breasted chat occurrences just east of the Cache Slough ROA and several occurrences in and around the West Delta ROA in 2009 (California Department of Water Resources

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[18] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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2011). The remainder of the habitat that will potentially be lost to tidal natural communities restoration is of low to moderate quality, mostly in relatively small patches and narrow strips along drainage channels and surrounded by cultivated lands. There are no yellow-breasted chat occurrences in these ROAs, although the extent to which these areas have been surveyed for the species is unknown. DWR recorded two occurrences in the vicinity of the South Delta ROA from their 2009 surveys (California Department of Water Resources 2011). Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on the yellow-breasted chat.

Floodplain Restoration

Based on the hypothetical floodplain restoration footprint, levee construction associated with floodplain restoration will result in the permanent removal of approximately 28 acres of habitat in Conservation Zone 6 (less than 0.1% of habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of moderate quality: although it consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River, and some of the patches are adjacent to existing Categories 1 and 2 open space. There are no yellow-breasted chat occurrences in this area, but the extent to which the area has been surveyed for the species is unknown. The estimates of habitat loss resulting from floodplain restoration are based on projections of where restoration may occur, and actual habitat loss is expected to be lower because sites will be selected to minimize effects on yellow-breasted chat habitat.

5.6.18.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 185 acres of habitat for the yellow-breasted chat (1% of the habitat in the Plan Area). Although flood frequency will increase in the Yolo Bypass area, the flooding regime is expected to be within the tolerance range for riparian vegetation in the bypass.

Floodplain Restoration

This activity will periodically inundate approximately 28 acres of yellow-breasted chat habitat (0.2% of the habitat in the Plan Area). Frequency of flooding will be on the order of once every 5 years in restored floodplain.

Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the yellow-breasted chat because flooding is unlikely to occur during the breeding season when the chat could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal.

5.6.18.1.3 Construction-Related Effects

Construction-related effects on this species include long-term, temporary habitat loss, potential construction-related injury or mortality, and indirect noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered

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activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Long-Term)

Construction-related effects will temporarily disturb 131 acres of habitat for the yellow-breasted chat (less than 1% of the habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily removed areas will be restored as riparian habitat within 1 year following completion of construction activities. Although the effects are considered temporary, 5 years to several decades may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, yellow-breasted chats occur in early- to mid-successional riparian vegetation; therefore, actively restored areas are expected to provide suitable habitat characteristics for this species within a few years. Furthermore, most of the riparian vegetation to be temporarily removed in the Plan Area is early- to mid-successional; therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first 5 to 10 years after the initial restoration activities are complete.

Construction-Related Injury or Mortality

If the yellow-breasted chat nests where covered activities are to occur, the operation of equipment for construction activities could result in injury or mortality of individuals. Risk would be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely as these individuals are expected to avoid contact with construction equipment. Injury or mortality to nesting yellow-breasted chats will be avoided through preconstruction surveys and establishment of no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures.*

Indirect Construction-Related Effects

Noise and visual disturbance within1,300 feet of construction activities could temporarily affect the use of 1,392 acres (9%) of modeled yellow-breasted chat habitat (Table 5.6-2a, *Indirect Effects, Wildlife*). Indirect noise and visual effects on nesting chats, if present, will be minimized by establishing 250-foot no-disturbance buffers around active nests as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.18.1.4 Effects of Ongoing Activities

The only ongoing activities expected to adversely affect yellow-breasted chat are habitat enhancement and management.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management within protected yellow-breasted chat habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of chats, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

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Other Indirect Effects

The BDCP covered activities and conservation measures will have no other indirect effects on the yellow-breasted chat.

5.6.18.1.5 Impact of Take on Species

The yellow-breasted chat breeds throughout much of North America and winters primarily in Mexico and Central America; a few birds also winter in California (Small 1994). According to Grinnell and Miller (1944), the species' breeding distribution includes the entire length and breadth of California exclusive of the higher mountains and coastal islands. Within the Plan Area, recent field surveys for the Delta Habitat Conservation and Conveyance Program documented 17 late-spring and summer occurrences in the Plan Area, with 12 of these located in the central Delta (California Department of Water Resources 2009). The National Audubon Society (2008) also noted pairs of yellow-breasted chats at Liberty Island, Sherman Island, and Piper Slough in the central Delta. No confirmation of breeding by yellow-breasted chats has been documented. The Plan Area represents a very small proportion of the species' range-wide distribution throughout much of North America.

The permanent loss of 1,032 acres of habitat (7% of the habitat in the Plan Area) for the yellow-breasted chat and other adverse effects described above are not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- The nesting and migratory habitat to be lost is small relative to the species' range throughout California and North America.
- Most of the permanently removed habitat consists of relatively small, fragmented riparian stands.
- Measures will be implemented to avoid injury or mortality of nesting yellow-breasted chats.

5.6.18.2 Beneficial Effects

The BDCP Implementation Office will restore at least 5,000 acres and protect at least 750 acres of valley/foothill riparian natural community, a portion of which is expected to be suitable habitat for the yellow-breasted chat. To ensure that a sufficient amount of the restored valley/foothill riparian natural community provides vegetation structure that is suitable for the yellow-breasted chat and other species with similar habitat requirements, the Implementation Office will maintain at least 1,000 acres of the valley/foothill riparian natural community as early- to mid-successional vegetation with dense, shrubby understory. Fluvial disturbance in restored floodplains is expected to help maintain this early- to mid-successional vegetation. Riparian systems subject to natural erosional and depositional processes provide conditions conducive to the establishment of dense willow stands preferred by the yellow-breasted chat for nesting. These BDCP restoration actions will improve habitat conditions and increase the likelihood of breeding by yellow-breasted chats in the Plan Area. Increasing the size and connectivity of the reserve system by acquiring lands adjacent to and between existing protected lands will benefit the yellow-breasted chat by reducing the risks of habitat fragmentation and adverse effects from adjacent lands uses. Providing an upland buffer will reduce adverse effects of adjacent land uses. This buffer, which will include transitional uplands adjacent to riparian habitat, will decrease opportunities for encroachment into riparian habitat of domestic pets that are potential predators, and human disturbances such as trampling, nest disturbance, noise and lighting. If the Implementation Office determines through population monitoring that the yellow-breasted chat population in the Plan Area is declining as a result of

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cowbird parasitism, a cowbird control program will be implemented to maintain the chat population in the Plan Area.

5.6.18.3 Net Effects

Full implementation of the BDCP will result in an estimated 3,078 acres (21%) increase of high-quality habitat for the yellow-breasted chat, and an estimated 3,977 acres increase (79%) of yellow-breasted chat habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

The habitat that will be lost as a result of covered activities is of low to moderate quality, consisting primarily of relatively small, isolated patches and narrow strips of riparian vegetation within a cultivated landscape. The restored and protected habitat will consist of large, contiguous areas, at least 1,000 acres of which will be managed to sustain appropriate vegetation structural requirements for the species. Increasing the size and connectivity of the reserve system by acquiring lands adjacent to and between existing protected lands will benefit the yellow-breasted chat by reducing the risks of habitat fragmentation and adverse effects from adjacent lands uses.

Overall, the BDCP will provide a substantial net benefit to the yellow-breasted chat through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the yellow-breasted chat.

5.6.19 Giant Garter Snake

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the giant garter snake. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants,* and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*. The habitat model used to assess effects for the giant garter snake includes aquatic habitat and upland habitat. Modeled aquatic habitat includes tidal perennial aquatic (except in Suisun Marsh), tidal freshwater emergent wetland, nontidal freshwater emergent wetland, and nontidal perennial aquatic natural communities, rice, and artificial canals and ditches. Modeled upland habitat includes all nonwetland and nonaquatic natural communities within 200 feet of modeled aquatic habitat features. The modeled upland habitat is ranked as high, moderate, or low quality based on giant garter snake associations between vegetation and cover types (U.S. Fish and Wildlife Service 2006) and historical and recent occurrence records (California Department of Fish and Game 2011; Hansen pers. comm.), and presence of features necessary to fulfill the species' life history requirements. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts*. Other factors considered in assessing the quality of affected habitat for the giant garter snake, to the extent that information is available, include proximity to conserved lands and recorded occurrences of the species, proximity to giant garter snake subpopulations identified in the draft recovery plan for this species (U.S. Fish and Wildlife Service 1999), and contribution to connectivity between giant garter snake subpopulations.

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5.6.19.1 Adverse Effects

5.6.19.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 838 acres of modeled aquatic habitat (3% of the aquatic habitat in the Plan Area), up to 5,736 acres of modeled upland habitat (6% of the upland habitat in the Plan Area), and up to 96 miles of the channels providing aquatic movement habitat (7% of movement habitat in Plan Area) for the giant garter snake (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The majority of this loss (88%) is due to tidal natural communities restoration. The majority of the effects of tidal natural communities restoration will occur in the Cache Slough ROA, which is already subject to tidal inundation, and actions in this ROA therefore will have fewer effects on giant garter snake.

Covered activities resulting in the permanent loss of giant garter snake habitat include conveyance facility construction, transmission line construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, and construction of conservation fish hatcheries, each of which is described below.

Conveyance Facility Construction

This activity will result in the permanent removal of approximately 23 acres of aquatic habitat and 340 acres of upland habitat for the giant garter snake (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Approximately 5 miles (0.3% of total miles in Plan Area) of channels providing giant garter snake movement habitat will be removed as a result of conveyance facility construction. Most of the habitat to be lost is in Conservation Zone 5, on Bouldin and Venice Islands, and in Conservation Zone 6 on Mandeville Island. The aquatic habitat in Conservation Zone 5 is consists primarily of rice and is low- to moderate-quality habitat as it is near category 1 open space to the north but is not in proximity to any recorded giant garter snake occurrences and is not located near or between subpopulations identified in the draft recovery plan. The aquatic habitat to be affected on Mandeville Island is of moderate quality in that it is Category 1 open space[19] and is approximately 1.5 miles west of a recorded CNDDB giant garter snake occurrence, but is not located near or between subpopulations identified in the draft giant garter snake recovery plan (U.S. Fish and Wildlife Service 1998). Of the 340 acres of upland habitat removed for the construction of the conveyance facility, 34 acres are high-, 206 acres are moderate-, and 190 acres are low-quality upland habitat.

Freemont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 43 acres of aquatic habitat and 174 acres of upland habitat for the giant garter snake (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The aquatic habitat to be removed is primarily of moderate to high quality based on its location in and near Category 1 open space approximately 2.5 miles from the nearest giant garter snake occurrences and approximately 5 miles north of occurrences in the Yolo Basin/Willow Slough subpopulation. The upland habitat to be removed includes 81 acres of high-quality, 82 acres of moderate-quality, and 11 acres of low-quality upland habitat.

[19] See Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories.

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Tidal Natural Communities Restoration

This activity will result in the permanent conversion of approximately 442 acres of aquatic habitat and 4,495 acres of upland habitat for the giant garter snake (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*), although not all of this conversion would adversely affect garter snake. Approximately 88 miles (6% of total miles in the Plan Area) of channels providing giant garter snake movement habitat will be removed as a result of tidal natural communities restoration. Most of the aquatic habitat to be lost is in Conservation Zones 1 and 2, in the Cache Slough ROA. This aquatic habitat is of low to moderate quality: it is in and near Category 1 open space but is not near any giant garter snake occurrences and is not near or between giant garter snake subpopulations identified in the draft recovery plan. Tidal natural communities restoration is expected to have little to no adverse effects on giant garter snake aquatic habitat in the Cache Slough ROA. There are no giant garter snake occurrences in this area, which is already tidally influenced so it has limited value for the giant garter snake (giant garter snakes may occur in tidally muted areas but are not likely to use aquatic areas with a strong tidal influence). The upland habitat affected by tidal inundation includes 814 acres of high-quality, 2,702 acres of moderate-quality, and 1,429 acres of low-quality habitat. Because the estimates of the effect of tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on giant garter snake habitat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 30 acres of aquatic habitat and 146 acres of upland habitat for giant garter snake (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Approximately 2 miles (0.1% of total miles in Plan Area) of channels providing giant garter snake movement habitat will be removed as a result of tidal natural communities restoration. The aquatic habitat to be removed is of low quality: there are no open space areas or giant garter snake occurrences in the vicinity, and the habitat to be affected is not near or between giant garter snake subpopulations identified in the draft recovery plan. The upland habitat to be removed includes 38 acres of moderate-quality and 108 acres of low-quality upland habitat.

Conservation Hatcheries Facilities

This activity will result in the permanent removal of 35 acres of moderate quality upland habitat in Conservation Zone 2 for the giant garter snake (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

5.6.19.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in the average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 30 acres of aquatic and 146 acres of upland habitat for the giant garter snake.

Giant garter snakes in the Yolo Bypass generally occur along the western edge of the bypass. These snakes are identified by USFWS (1999) as being part of the Yolo Basin/Willow Slough subpopulation of giant garter snakes, which includes occurrences on either side of the western Yolo Bypass levee

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(occurrences on the inboard side of the levee are inside the bypass, while occurrences on the outboard side are outside of the bypass). Flooding of the Yolo Bypass is currently a frequent occurrence during winter and spring along the eastern edge of Yolo Bypass, with at least one inundation event recorded in about 70% of all years. Giant garter snakes are dormant from late fall through early spring; the existing flood regime in the bypass may either prevent giant garter snakes from occupying the eastern edge of the bypass during their dormant period, or displace snakes during inundation events in this area. The entire bypass floods during extreme flood events.

Periodically inundated aquatic habitat is not expected to adversely affect the 30 acres of aquatic giant garter snake habitat because the inundation will only occur during the winter or early spring when giant garter snakes are dormant and seasonally occupy upland habitat. However, an increase in the frequency and extent (approximately 396 acres, or 5% of the upland habitat in Conservation Zone 2) of periodic inundation of upland habitat may result in drowning or displacement of dormant giant garter snakes during inundation events, which will depend in part on the extent and timing of flooding in any given year.

Floodplain Restoration

This activity will periodically inundate 44 acres of aquatic habitat and 1,659 acres of upland habitat for the giant garter snake in Conservation Zone 7. The aquatic habitat to be inundated is of low quality: it is not located in the vicinity of existing conserved lands, is not in the vicinity of any giant garter snake occurrences, and is not located near or between subpopulations identified in the recovery plan. The upland habitat to be inundated includes 672 acres of moderate-quality and 987 acres of low-quality habitat.

5.6.19.1.3 Construction-Related Effects

Construction-related effects on the giant garter snake include short- and long-term temporary habitat loss, construction-related injury and mortality, and indirect construction-related effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or the specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction will temporarily disturb 54 acres of aquatic habitat and 343 acres of upland habitat for the giant garter snake (3% of the aquatic and less than 1% of the upland habitat in the Plan Area), including 47 acres of high-quality, 136 acres of moderate-quality, and 160 acres of low-quality upland habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily disturbed areas will be restored as giant garter snake habitat within 1 year following completion of construction and management activities.

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in the long-term removal of approximately 1 acre of aquatic and 71 acres of upland habitat for the giant garter snake, including 15 acres of high-quality, 20 acres of moderate-quality, and 36 acres of low-quality upland habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although

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this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to the giant garter snake through crushing by vehicles or heavy equipment. If snakes reside where covered activities are to occur (most likely in Conservation Zones 2 and 4), the operation of equipment for land clearing, construction, operation and maintenance, restoration, enhancement, and management activities could result in injury or mortality of giant garter snakes. Increased vehicular traffic associated with BDCP actions could contribute to a higher incidence of road kill. This risk is highest from late fall through early spring, when the snakes are dormant. However, conducting construction during the active period when feasible, dewatering aquatic areas prior to construction, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance within 500 feet of construction activities could temporarily affect the use of 776 acres of modeled aquatic (3%) and 4,314 acres of modeled upland habitat (4%) for the giant garter snake (Table 5.6-2a, *Indirect Effects, Wildlife*), including 855 acres of high-quality,1,344 acres of moderate- quality, and 2,115 acres of low-quality upland habitat. These effects will be minimized by siting construction away from giant garter snake where possible, as described in *Appendix 3.C, Avoidance and Minimization Measures*.

Other Indirect Effects

The BDCP covered activities and conservation measures will have no other indirect effects on the giant garter snake.

5.6.19.1.4 Effects of Ongoing Activities

The only anticipated ongoing effects on giant garter snake will result from habitat enhancement and management activities.

Habitat Enhancement and ManagementHabitat enhancement and management activities, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury or mortality of giant garter snakes, and temporary noise and disturbance effects if individuals are present in or near work sites over the term of the BDCP. These effects cannot be quantified, but are expected to be minimal and will be avoided and minimized as described in *Appendix 3.C, Avoidance and Minimization Measures*.

5.6.19.1.5 Impact of Take on Species

The giant garter snake is endemic to the wetlands of the Central Valley. There are 268 extant CNDDB occurrences for giant garter snake range-wide, of which 25 are in the Plan Area. There are also 13 non-CNNDB extant occurrences for this species in the Plan Area. The Plan Area includes 2 of the 13 giant garter snake subpopulations identified in the draft recovery plan for this species: the two subpopulations are in the Yolo Bypass (Conservation Zone 2) and Coldani Marsh-White Slough (Conservation Zone 4) areas. The Plan Area is therefore important for the long-term survival and recovery of the giant garter snake.

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Based on modeled habitat for the giant garter snake, the Plan Area supports approximately 29,430 acres of aquatic and 95,278 acres of upland habitat for giant garter snake. Of this, up to 838 acres of aquatic habitat (3% of total in Plan Area) and 5,736 acres of upland habitat (6% of total in Plan Area) will be permanently removed. Up to 54 acres of aquatic habitat (0.2% of total in Plan Area) and 343 acres of upland habitat (0.4% of total in Plan Area) will be temporarily removed and restored to preproject conditions. Approximately 2,054 acres of giant garter snake upland habitat (2% of total in the Plan Area) may be adversely affected as a result of periodic flooding as a consequence of floodplain restoration and the operation of the Fremont Weir.

These losses of aquatic and upland habitat for giant garter snake are not expected to adversely affect the long-term survival and recovery of the species for the following reasons.

- The giant garter snake habitat to be lost is small relative to habitat availability in the Plan Area and will occur in multiple, widely separate areas (therefore not affecting one area disproportionately). Only 14% (1,125 out of 8,164 acres) of the total affected upland habitat is high quality, while the remainder is low or moderate quality.
- Most of the affected habitat is in areas where the giant garter snake is not expected to occur.
- Approximately 784 acres of aquatic habitat and 4,944 acres of upland habitat will be converted to tidal marsh, a portion of which is expected to have muted tidal influence and therefore provide suitable aquatic habitat for the species.

The BDCP's beneficial effects on the species, described below, are expected to offset the potential adverse impact of take and contribute to the long-term survival and recovery of the species in the Plan Area.

5.6.19.2 Beneficial Effects

The BDCP Implementation Office will restore at least 13,900 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7, and restore at least 400 acres of nontidal marsh in Conservation Zones 2 and 4. A portion of the restored tidal freshwater emergent wetland is expected to be suitable habitat for the giant garter snake: those areas with muted tidal influence in Conservation Zone 4 are most likely to benefit the giant garter snake. The 400 acres of nontidal marsh will be restored specifically to benefit the giant garter snake in the Yolo Basin/Willow Slough and Coldani Marsh/White Slough subpopulations. Grasslands will be protected or restored adjacent to the restored nontidal marsh to ensure sufficient adjacent upland habitat for the giant garter snake.

Protection and maintenance of cultivated lands through the BDCP will also benefit the giant garter snake. Protection of cultivated land will be prioritized in areas that provide connectivity between other protected lands. Small patches of important wildlife habitat associated with cultivated lands, such as drainages, grasslands, ponds, and wetlands, will be protected. BDCP conservation of cultivated lands will help to maintain in the landscape a matrix of suitable interconnected canals with reliable water, associated emergent vegetation, and adjacent upland habitats essential for conservation of this species. Additionally, at least 4,600 acres of rice will be maintained in Conservation Zone 2 to ensure that this valuable giant garter snake habitat persists to help sustain the Yolo Basin/Willow Slough subpopulation.

Protecting and expanding existing giant garter snake subpopulations, and providing connectivity between protected areas, is considered the most effective approach to giant garter snake

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conservation in the Plan Area. The Coldani Marsh/White Slough and Yolo Basin/Willow Slough subpopulations support the highest densities of giant garter snakes in the Plan Area and are identified as important for the recovery of the species in the draft recovery plan for the species (U.S. Fish and Wildlife Service 1998). BDCP conservation actions that target giant garter snake habitat (i.e., nontidal marsh restoration) will focus on these two important subpopulations.

5.6.19.3 Net Effects

Full implementation of the BDCP will result in an estimated 7,262 acres increase (6%) of giant garter snake habitat in the Plan Area, and an estimated 14,245 acres increase (52%) of giant garter snake habitat in protected lands (Table 5.6-3a, *Net Effects*). Most of the habitat that will be lost as a result of covered activities is located in areas with low- or moderate-quality habitat, in areas in which there are no known species occurrences, and areas that are not near or between the two giant garter snake subpopulations in the Plan Area that are identified in the draft recovery plan. Cultivated lands will be protected and marsh restored in and around these two subpopulations to protect and facilitate their expansion. Additional lands will be protected and restored to provide connectivity and facilitate genetic exchange between these two important subpopulations.

Overall, the BDCP will provide a substantial net benefit to the giant garter snake through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the giant garter snake.

5.6.20 Western Pond Turtle

This section describes the adverse, beneficial, and net effects of the BDCP covered activities and conservation measures on the western pond turtle. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The habitat suitability model is based on three habitat types: aquatic, upland nesting and overwintering habitat, and dispersal habitat. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.*

Factors considered in assessing the quality of affected aquatic habitat include natural community type and availability of adjacent nesting and dispersal habitat. The highest quality aquatic habitat types in the Plan Area consist of nontidal freshwater perennial emergent wetlands and ponds adjacent to suitable nesting and overwintering habitat (Patterson pers. comm.). Less detail is provided on effects on dispersal habitat because, although dispersal habitat is important for maintaining and increasing distribution and genetic diversity, turtles have been known to travel over many different land cover types; therefore, this habitat type is not considered limiting. The quality of dispersal habitat depends less on the habitat type itself than on the proximity of that habitat type to high-quality aquatic and nesting and overwintering habitat.

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5.6.20.1 Adverse Effects

5.6.20.1.1 Permanent Habitat Loss, Conversion and Fragmentation

BDCP covered activities will result in the permanent loss or conversion of up to 5,847 acres[20] of aquatic habitat (7% of the aquatic habitat in the Plan Area), 2,003 acres of upland nesting and overwintering habitat (4% of upland habitat in the Plan Area), and 52,112 acres of dispersal habitat (8% of dispersal habitat in the Plan Area) for the western pond turtle (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in adverse effects on the western pond turtle include conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, nontidal marsh restoration, and conservation hatcheries facilities. The covered activity accounting for most (80%) of the habitat loss or conversion is tidal natural communities restoration.

Conveyance Facility Construction

This activity will result in the permanent loss of approximately 23 acres of aquatic habitat (less than 0.01% of aquatic habitat in the Plan Area), 135 acres of upland nesting and overwintering habitat (0.3% of this habitat type in the Plan Area), and 3,945 acres of dispersal habitat (0.6% of dispersal habitat in the Plan Area) for the western pond turtle (Table 5.6-1a *Maximum Allowable Habitat Loss, Wildlife*). The majority of the permanent loss of aquatic habitat (16 of the 23 acres) and nesting and overwintering habitat (129 of the 133 acres) is in Conservation Zone 8, near Clifton Court Forebay. The aquatic habitat in the Clifton Court Forebay area is considered to be of reasonably high quality as it consists of agricultural ditches in or near known occurrences. The nesting and overwintering and dispersal habitat to be lost consists primarily of cultivated lands with some small portion of ruderal grassland habitat. Except for remnant, uncultivated patches, the agricultural lands are not suitable for nesting and overwintering unless left fallow. The remaining portions of effects from the construction of the water conveyance facility are mostly on dispersal habitat. The dispersal habitat in this region is primarily cultivated lands. While there are western pond turtle occurrences scattered throughout Conservation Zones 3, 4, 5, and 6, this effect is widely dispersed because of the long, linear nature of the pipeline footprint.

Development of theThe transmission line alternative with the greatest effect will result in the permanent removal of approximately 6 acres of natural communities that support the western pond turtle habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 45 acres of aquatic habitat (less than 0.01% of aquatic habitat in the Plan Area), 225 acres of upland nesting and overwintering habitat (0.05% of this habitat type in the Plan Area), and 958 acres of dispersal habitat (0.1% of dispersal habitat in the Plan Area) for the western pond turtle (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although there are no CNDDB occurrences in of western pond turtle in the Yolo Bypass, the species is known to be present in the Yolo Bypass Wildlife Area (California Department of Fish and Game 2008).

[20] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration footprint, this activity will result in the permanent loss or conversion of approximately 5,747 acres of aquatic habitat (7% of aquatic habitat in the Plan Area), 1,613 acres of upland nesting and overwintering habitat (3% of this habitat type in the Plan Area), and 39,604 acres of dispersal habitat (6% of dispersal habitat in the Plan Area) for the western pond turtle (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Tidal habitat restoration is expected to change existing salinity and flow conditions rather than lead to complete loss of aquatic habitat. Restoration of tidal flow where habitat consists of the calm waters of managed freshwater ponds and wetlands could have an adverse effect on the western pond turtle. Tidal restoration outside Suisun Marsh is likely to create suitable, slow-moving freshwater slough and marsh habitat.

Western pond turtles are described as common in Suisun Marsh (Patterson pers. comm.). Although the aquatic habitat model includes all tidal perennial aquatic, tidal brackish emergent wetland, and managed wetland as habitat, nearly all the pond turtle observations in Suisun Marsh have been made is in drainage ditches or near water control structures (Patterson pers. comm.). While the model does not include an aquatic class type called *drainage ditches* and therefore an effect on this habitat type cannot be calculated, it is likely that this general type of habitat accounts for a very small portion of the total modeled aquatic effects; almost certainly less than 5%, or less than 287 acres of the modeled aquatic habitat affected by tidal restoration. The quality of nesting and overwintering habitat that will be affected in the interior of Suisun Marsh is low where levees likely function as the primary nesting and overwintering habitat. The highest quality nesting and overwintering habitat to be affected is on the fringe of the marsh where the aquatic habitat is adjacent to undeveloped grassland habitat.

The habitat affected in the interior Delta (West Delta and South Delta) is of low quality, consisting of levees and intensively farmed agricultural plots, while the Cache Slough and Cosumnes-Mokelumne ROAs are less intensively farmed and have higher-value habitat for the turtle.

Floodplain Restoration

Based on the hypothetical floodplain restoration footprint, levee construction associated with floodplain restoration will result in the permanent removal of approximately 32 acres of aquatic habitat (less than 0.1% of aquatic habitat in the Plan Area), 20 acres of upland nesting and overwintering habitat (less than 0.1% of this habitat type in the Plan Area, and 1,283 acres of dispersal habitat (0.2% of dispersal habitat in the Plan Area) for the western pond turtle (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Additionally, riparian restoration will result in the conversion of 3,991 acres of cultivated lands providing dispersal habitat for the pond turtle to valley/foothill riparian natural community, but riparian areas are still expected to provide dispersal opportunities for the western pond turtle. Although there are no CNDDB occurrences for pond turtles in the areas where floodplain restoration is likely to occur, the species is known to occur along the San Joaquin River to the south in the San Joaquin River National Wildlife Refuge.

Nontidal Marsh Restoration

This activity will result in the permanent conversion of approximately 400 acres of western pond turtle dispersal habitat to aquatic habitat. This will not adversely affect the species.

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Conservation Hatcheries Facilities

This activity will result in the permanent removal of approximately 35 acres of dispersal habitat (less than 0.01% of dispersal habitat in the Plan Area) for western pond turtle in the vicinity of Rio Vista (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

5.6.20.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*),this activity will periodically inundate 32 acres of aquatic habitat (0.5% of aquatic habitat in the Plan Area), 20 acres of nesting and overwintering habitat (0.4% of this habitat type in the Plan Area), and 2,217 acres of dispersal habitat (0.4% of dispersal habitat in the Plan Area) for the western pond turtle. Increased inundation frequency and duration in the 20 acres of nesting and overwintering habitat could adversely affect overwintering adults or nestlings.

Floodplain Restoration

Seasonal flooding in restored floodplains is not expected to adversely affect aquatic and dispersal habitat, as these habitat functions are expected to remain in the seasonally inundated floodplains. Floodplains are not expected to be inundated during the nesting season, although turtle hatchlings may overwinter in the nest, and may be affected by flooding.

5.6.20.1.3 Construction-Related Effects

Construction-related effects on the western pond turtle include long-term, temporary habitat loss, construction-related mortality or injury, and indirect noise and visual effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Long-Term)

Construction-related effects will temporarily disturb 2 acres of aquatic habitat (less than 0.001% of aquatic habitat in the Plan Area), 1 acre of nesting and overwintering habitat (less than 0.001% of nesting and overwintering habitat in the Plan Area), and 119 acres of dispersal habitat (less than 0.001% of dispersal habitat in the Plan Area) for the western pond turtle (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Use of heavy equipment during construction may result in injury or mortality of western pond turtles. However, to avoid injury or mortality, preconstruction surveys will be conducted in suitable aquatic or upland nesting and overwintering habitat for the western pond turtle, and turtles found will be located outside the construction areas as described in Appendix 3.C, *Avoidance and Minimization Measures.*

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Indirect Construction-Related Effects

Noise and visual disturbance within 500 feet of construction activities could temporarily affect the use of 4,237 acres of aquatic habitat (5% of aquatic habitat in the Plan Area), 2,136 acres of upland nesting and overwintering habitat (5% of this habitat type in the Plan Area), and 17,058 acres of dispersal habitat (3% of dispersal habitat in the Plan Area) for the western pond turtle (Table 5.6-2a, *Indirect Effects, Wildlife*). These short-term effects are not expected to adversely affect the western pond turtle populations in the Plan Area.

These effects will be minimized with implementation of the western pond turtle measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.20.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing facility operation and maintenance will have little if any adverse effect on the western pond turtle. Noise and visual disturbance within 500 feet of facilities could affect the use of 1 acre (less than 0.001%) of modeled western pond turtle habitat (Table 5.6-2a, *Indirect Effects, Wildlife*).

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected western pond turtle habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury, or mortality of western pond turtles. These effects will be avoided and minimized with measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

Water operations will have an effect on salinity gradients in Suisun Marsh. This effect mechanism cannot be disaggregated from tidal natural community restoration in Suisun Marsh. It is expected that the salinity of water in Suisun Marsh will generally increase as a result of water operations, and operations of salinity control gates to mimic a more natural water flow. Results of modeling for full implementation of the BDCP show salinity to double by the late long-term compared to current conditions in late fall and winter months. Western pond turtles are primarily a freshwater species, although they are often found in brackish marsh, and they could respond negatively to increased salinity in Suisun Marsh. Changes in salinity will not be uniform across Suisun Marsh as they will likely be more pronounced in some tidal channels and sloughs than others, and most of the salinity increase will occur in the fall and winter when turtles may be overwintering in adjacent upland habitat, although it may not get cold enough to trigger overwintering and they may spend the winter in ditches (Patterson pers. comm.)

Impact of Take on Species

The Plan Area represents only a small portion of the range of the western pond turtle in California (which includes most all the Pacific drainages) and southern Oregon. Take resulting from the permanent and temporary loss or conversion habitat for the western pond turtle, and other effects described above, are not expected to result in an adverse effect on the long-term survival and recovery of western pond turtle because for the following reasons.

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- The Plan Area represents a small portion of the subspecies' entire range.
- Only 7% of the habitat in the Plan Area would be removed or converted.
- Approximately 84% of the potential habitat affected is low-value dispersal habitat.

5.6.20.2 Beneficial Effects

FThe BDCP Implementation Office will restore 27,900 to 46,800 acres of pond turtle aquatic habitat and 5,000 acres of upland nesting and overwintering habitat, and will protect and enhance 4,000 acres of dispersal habitat and at least 5,230 acres of upland nesting and overwintering habitat. The conservation strategy includes restoration of 10,000 to 20,000 acres of tidal perennial aquatic habitat, at least 13,900 acres of tidal freshwater emergent wetland, 3,600 to 4,800 acres of tidal brackish emergent wetlands, and 400 acres of nontidal freshwater emergent wetland and tidal perennial aquatic natural communities. In addition, the protection and management of existing managed wetland habitat in Suisun Marsh has potential to increase the quality of aquatic habitat. Restored emergent wetland that will most benefit the species will be freshwater emergent wetland consisting of slow-moving slough and marsh adjacent to protected, undisturbed grassland. Those aquatic features (e.g., ditches and ponds) and adjacent uplands that are preserved and managed as part of the XX acres of agricultural preserve are also expected to benefit the species. Additionally, basking platforms will be installed as needed in restored freshwater marsh to benefit the western pond turtle.

Riparian and floodplain restoration will potentially increase the quantity and quality of aquatic and nesting and overwintering habitat. Where the floodplain is widened and restored, this will allow oxbows and slow-moving side channels to form, providing suitable aquatic habitat for this species (Bury and Germano 2008; Ernst and Lovich 2009). Where riparian vegetation is restored adjacent to slower-moving channels, sloughs, and ponds, downed trees can provide important basking habitat and cover habitat for turtles. Riparian restoration in those more interior portions of Old and Middle Rivers that will be managed for riparian brush rabbit habitat have potential to benefit resident western pond turtles as riparian-adjacent grassland is an important habitat characteristic for the rabbit.

5.6.20.3 Net Effects

Full implementation of the BDCP will result in an estimated 28,987 acres (4%) decrease of habitat for the western pond turtle, and an estimated 41,073 acres increase (25%) of western pond turtle habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

BDCP implementation will increase the extent and distribution of high-value aquatic and upland nesting and overwintering habitat for the western pond turtle in the Plan Area. While the extent of dispersal habitat is expected to be reduced by approximately 7%, this habitat is extremely abundant (619,335 acres) in the Plan Area (composed primarily of cultivated lands), is not a factor limiting pond turtle distribution and abundance, and will be replaced with higher-value habitats for the western pond turtle. In Suisun Marsh, tidal restoration is likely, in the long term, to have neutral or negative effects on the western pond turtle, although the protection and management of upland grassland areas that surround Suisun Marsh have the potential to increase the quality of nesting and overwintering habitat.

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Overall, the BDCP will provide a substantial net benefit to the western pond turtle through the increase in available habitat, habitat quality, and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the western pond turtle.

5.6.21 California Red-Legged Frog

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the California red-legged frog. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*. Modeled California red-legged frog habitat in the Plan Area is restricted to freshwater aquatic, grassland, and immediately adjacent cultivated lands along the Plan Area's southwestern edge in Conservation Zones 7, 8, 9, and 11. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.*

Factors considered in assessing the quality of affected habitat for the California red-legged frog, to the extent that information is available, include presence of limiting habitat (aquatic breeding habitat), known occurrences and clusters of occurrences, proximity of the affected habitat to existing protected lands, and the overall degraded or fragmented nature of the habitat. The Plan Area represents the extreme eastern edge of the species' coastal range (Appendix 2.A, *Covered Species Accounts*) and species' occurrences are reported only from Conservation Zones 8 and 11. While covered activities and conservation measures in other Conservation Zones have potential effects on California red-legged frog, those activities near the species occurrences in Conservation Zones 8 and 11 are considered to have a disproportionately larger effect.

5.6.21.1 Adverse Effects

5.6.21.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

The only covered activity resulting in permanent loss of California red-legged habitat is conveyance facility construction.

Conveyance Facility Construction

This activity, including transmission line construction, will result in the permanent loss or conversion of up to 832 acres[21] of California red-legged frog habitat, including 1 acre of modeled aquatic habitat (0.7% of aquatic habitat in Plan Area), 168 acres of upland cover and dispersal habitat (2% of upland cover and dispersal habitat in the Plan Area), and 663 acres of dispersal habitat (3% of dispersal habitat in the Plan Area (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The aquatic habitat is not known to be used for breeding. The removed upland is of moderate quality: it is within 0.5 mile of a cluster of known occurrences to the west, although it consists of mostly of cultivated lands and small patches of grasslands, and past and current surveys have not found any evidence that this habitat is being used (California Department of Water Resources 2011).

[21] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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5.6.21.1.2 Periodic Inundation

No periodic inundation effects on the California red-legged frog will occur as a result of BDCP covered activities.

5.6.21.1.3 Construction-Related Effects

Construction-related effects on the California red-legged frog include short-term and long-term temporary habitat loss, construction-related injury or mortality, and indirect noise and visual disturbance effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction-related effects will temporarily disturb 15 acres of habitat for the California red-legged frog, including 10 acres of upland cover and dispersal habitat (0.001% of this habitat type in the Plan Area), and 5 acres of dispersal habitat (less than 0.001% of this habitat type in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Surveys have not found any evidence that this habitat is being used by the species (California Department of Water Resources 2011). Temporarily disturbed areas will be restored within 1 year following completion of construction activities.

Temporary Habitat Loss (Long-Term)

Creation and use of spoil areas during construction will temporarily disturb 631 acres of habitat for the California red-legged frog, including 151 acres of upland cover and dispersal habitat (0.02% of this habitat type in the Plan Area), and 480 acres of dispersal habitat (2% of this habitat type in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Surveys have not found any evidence that this habitat is being used by the species (California Department of Water Resources 2011). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

Construction activities associated with the water conveyance facilities, vernal pool complex restoration, and habitat and management enhancement-related activities, including operation of construction equipment, could result in injury or mortality of California red-legged frogs if present. Frogs occupying burrows could be trapped and crushed during ground-disturbing activities. Injury or mortality will be avoided and minimized through implementation of seasonal constraints and preconstruction surveys in suitable habitat, collapsing unoccupied burrows, and relocating frogs outside of the construction area, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance within 500 feet of construction activities could temporarily affect the use of 237 acres of California red-legged frog habitat, including 66 acres of upland cover and dispersal habitat (0.7% of this habitat type in the Plan Area), and 170 acres of dispersal habitat (0.9% of dispersal habitat in the Plan Area). The areas to be affected are near Clifton Court Forebay,

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and no California red-legged frogs were detected during recent surveys conducted in this area (California Department of Water Resources 2011).

Petroleum or other contaminant spills from construction equipment, drilling operations, or other activities could also affect California red-legged frogs if present. These effects will be minimized with implementation of the California red-legged frog measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.21.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing facilities operation and maintenance are expected to have little if any adverse effect on the California red-legged frog. Post-construction operation and maintenance of the above-ground water conveyance facilities could result in ongoing but periodic post-construction disturbances that could affect California red-legged frog use of the surrounding habitat. Operation of maintenance equipment, including vehicle use along transmission corridors in Conservation Zone 8, could also result in injury or mortality of California red-legged frogs if present in work sites. These effects, however, will be minimized with implementation of the California red-legged frog measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected California red-legged frog habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of California red-legged frogs. These effects will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

The BDCP covered activities and conservation measures will have no other indirect effects on the California red-legged frog.

5.6.21.1.5 Impact of Take on Species

The historical range of the California red-legged frog is generally characterized as extending south along the coast from the vicinity of Point Reyes National Seashore, Marin County, California, and inland from the vicinity of Redding, Shasta County, California, southward along the interior Coast Ranges and Sierra Nevada foothills to northwestern Baja California, Mexico (U.S. Fish and Wildlife Service 2007). While primarily absent from the valley floor, California red-legged frogs are found along the perimeter of the valley in the surrounding foothills. In the Plan Area, they are found along the very western edge of the Plan Area, in Conservation Zones 7,8, 9, and 11. There are 1,326 extant CNDDB records for California red-legged frog in the state, 12 of which (1%) are found in the Plan Area.

Take resulting from permanent and temporary habitat loss, and other adverse effects described above, are not expected to have an adverse population-level effect on California red-legged frog or an adverse effect on the species' survival and recovery for the following reasons.

- The Plan Area represents a small proportion of the species' range.

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- There are few occurrences of California red-legged frog in the Plan Area.
- The area where habitat will be lost has been surveyed for California red-legged frog and survey results were negative.

5.6.21.2 Beneficial Effects

Protection of at least 1,000 acres of grassland (CM3) in Conservation Zone 8, west of Byron Highway, will benefit the California red-legged frog by providing habitat in the portion of the Plan Area with the highest long-term conservation value for the species based on known species occurrences and large, contiguous habitat areas. Ponds and other aquatic features in the grasslands will be protected to provide aquatic habitat for this species, and surrounding grassland will provide dispersal and aestivation habitat. Protected lands in Conservation Zone 8 will connect with the East Contra Costa County HCP/NCCP reserve system and the extensive Los Vaqueros Watershed lands, including grassland areas supporting this species. This will ensure that the California red-legged frog upland and associated aquatic habitats will be preserved and enhanced in the largest possible patch sizes adjacent to occupied habitat within and adjacent to the Plan Area.

Aquatic features in the protected grasslands in Conservation Zone 8 will be maintained and enhanced to provide suitable inundation depth and duration and suitable composition of vegetative cover to support breeding California red-legged frogs (CM11). Additionally, livestock exclusion from streams and ponds and other measures will be implemented as described in CM11 to promote growth of aquatic vegetation with appropriate cover characteristics favorable to California red-legged frogs.

5.6.21.3 Net Effects

Full implementation of the BDCP will result in an estimated 421 acres (1%) decrease of habitat for the California red-legged frog, and an estimated 1,984 acres (113%) increase of California red-legged frog habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

The habitat that will be lost as a result of covered activities is of moderate quality: it is within several miles of species occurrences but consists of cultivated lands and small patches of grasslands, and the species has not been found in the areas to be affected despite recent surveys. The habitat that will be protected will consist of large, contiguous areas that will support the California red-legged frog and will be managed to sustain favorable habitat conditions for the species.

Overall, the BDCP will provide a substantial net benefit to the California red-legged frog through the increase in habitat quality and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the California red-legged frog.

5.6.22 California Tiger Salamander

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the California tiger salamander. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the California red-legged frog includes two habitat types: terrestrial cover and aestivation habitat, and aquatic breeding habitat. The model for terrestrial cover and aestivation habitat includes all grassland types and alkali seasonal wetland with a minimum patch size of

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100 acres and within a geographic area defined by species records and areas most likely to support the species (see detailed description of geographic limits in Appendix 2.A, *Covered Species Accounts*). The model for aquatic breeding habitat includes vernal pool complex and degraded vernal pool complex. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the California tiger salamander, to the extent that information is available, include habitat patch size and configuration, density of aquatic of features, and proximity to existing protected lands (Categories 1 and 2 open space[22]).

5.6.22.1 Adverse Effects

5.6.22.1.1 Permanent Habitat Loss, Conversion and Fragmentation

BDCP covered activities will result in the permanent loss of up to 519 acres[23] of California tiger salamander habitat (1% of the habitat in the Plan Area), including 42 acres of aquatic breeding habitat (3% of aquatic breeding habitat in the Plan Area) and 477 acres of aestivation and cover habitat (1% of this habitat type in the Plan Area). Covered activities resulting in permanent California tiger salamander habitat loss include conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, and conservation fisheries facilities. The covered activities resulting in the most habitat loss include tidal natural communities restoration (54% of habitat loss) and conveyance facility construction (31% of habitat loss).

Conveyance Facility Construction

This activity will result in the permanent loss of approximately 161 acres of terrestrial cover and aestivation habitat for the California tiger salamander (0.5% of this habitat type in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat loss will occur primarily in Zone 8. There is a high concentration of California tiger salamander occurrences outside the Plan Area immediately to the east of Zone 8, in the Byron Hills area. The area to be affected by conveyance facility construction is south of Clifton Court Forebay, where modeled California tiger salamander habitat is of relatively low quality in that it consists of fragmented patches of primarily terrestrial habitat surrounded by actively cultivated agricultural lands. All recorded CNDDB occurrences of California tiger salamander in Zone 8 are west of the conveyance facility alignment, and lands to the east consist primarily of actively cultivated lands that are not suitable for the species. Habitat loss in this area is not expected to contribute to habitat fragmentation or impede important California tiger salamander dispersal.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent loss of approximately 0? acres of terrestrial cover and aestivation habitat for the California tiger salamander (0.1% of this habitat type in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*).

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[22] See Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species,* for definitions of open space categories.

[23] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 42 acres of aquatic breeding habitat (0.6% of the aquatic breeding habitat in the Plan Area) and 239 acres of terrestrial cover and aestivation habitat (1% of this habitat type in the Plan Area) for the California tiger salamander (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Tidal restoration in the Cache Slough ROA will result in habitat loss along the edges of Lindsey Slough and Duck Slough, and adjacent to agricultural land along the eastern edge of a block of modeled habitat in this area. The modeled aquatic breeding habitat in this area is of relatively high quality consisting of vernal pool complex along Lindsey Slough within the Jepson Prairie area, in and near Category 1 open space. The Jepson Prairie area includes numerous California tiger salamander CNDDB recorded occurrences and overlaps with a critical habitat unit for this species, although the hypothetical tidal restoration footprint does not overlap with critical habitat or recorded occurrences in this area. The pools in the Jepson Prairie area are relatively large and undisturbed, although they are present in very low densities within the areas to be affected by tidal restoration along Lindsey Slough. The tidal restoration at Lindsey Slough will occur along the northeastern edge of the Jepson Prairie block of habitat and would not contribute to fragmentation. Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because of the ability to select sites that minimize effects on California tiger salamander.

Conservation Hatcheries Facilities

This activity will result in the permanent removal of approximately 35 acres of terrestrial cover and aestivation habitat (0.1% of this habitat type in the Plan Area) for California tiger salamanders near Rio Vista. The hatcheries facilities will be constructed on cultivated lands in low-quality habitat for the species.

5.6.22.1.2 Periodic Inundation

Yolo Bypass operations is the only covered activity expected to result in periodic inundation of California tiger salamander habitat.

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 71 acres of aquatic breeding habitat (1% of the aquatic breeding habitat in the Plan Area) and 121 acres of terrestrial cover and aestivation habitat (0.4% of this habitat type in the Plan Area) for the California tiger salamander. The modeled habitat in the Yolo Bypass is of low quality for California tiger salamander: there are no California tiger salamander records in this area and the bypass lacks vernal pool complexes with large, deep pools or large grassland areas with stock ponds and similar aquatic features that provide the highest quality habitat for this species.

5.6.22.1.3 Construction-Related Effects

Construction-related effects on this species include short-term and long-term temporary habitat loss, construction-related injury or mortality, and indirect construction-related effects. Effects on the species are described below for each effect category. Effects are described collectively for all

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covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction-related effects will temporarily disturb 10 acres of terrestrial cover and aestivation habitat for the California tiger salamander (less than .01% of this habitat type in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 151 acres of terrestrial cover and aestivation habitat for the California tiger salamander (0.5% of this habitat type in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

The operation of equipment during construction could result in injury or mortality of California tiger salamanders if present. This effect will be minimized by restricting initial ground disturbance in suitable aquatic habitat to the dry season, and through implementation of preconstruction surveys in and near suitable habitat and installation of salamander exclusion fencing as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance within 500 feet of construction activities could temporarily affect the use of 203 acres of aquatic breeding habitat (3% of aquatic habitat in the Plan Area) and 863 acres of terrestrial cover and aestivation habitat (3% of this habitat type in the Plan Area) (Table 5.6-2a, *Indirect Effects, Wildlife*). There are no known occurrences of California tiger salamanders in the areas that are expected to be affected adjacent to construction, and these indirect effects are expected to have a minimal effect on the species.

Petroleum or other contaminant spills from construction equipment, drilling operations, or other activities could affect California tiger salamander if present. This effect will be minimized with implementation of the measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.22.1.4 Effects of Ongoing Activities

The only ongoing activities expected to adversely affect California tiger salamander are habitat enhancement and management.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected California tiger salamander habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of California tiger salamander, and temporary noise and disturbance effects if individuals are present in work

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sites over the term of the BDCP. These effects will be avoided and minimized with measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.22.1.5 Impact of Take on Species

The California tiger salamander occurs from southern San Mateo County south to San Luis Obispo County, with isolated populations in Sonoma and northwestern Santa Barbara Counties. In the Central Valley and surrounding Sierra Nevada foothills, the species occurs from northern Yolo County southward to northwestern Kern County and northern Tulare and Kings Counties. There are 1,003 CNDDB California tiger salamander occurrences throughout California, 4 of which (0.4% range-wide) are in the Plan Area. The Plan Area consists of less than 10% of the species' range (Appendix 2.A, *Covered Species Accounts*).

The permanent loss of approximately 1% of the California tiger salamander modeled habitat in the Plan Area, and other effects described above that may result in take of this species, are not expected to result in an adverse impact on the species' long-term survival and recovery for the following reasons.

- The Plan Area represents a small proportion of the species' geographic range (less than 10%) and known occurrences (less than 0,4%).
- A small proportion of the modeled habitat in the Plan Area would be affected.
- The highest quality habitat that is potentially affected is in the Cache Slough ROA, where tidal restoration projects can be designed to reduce the loss of California tiger salamander habitat.

5.6.22.2 Beneficial Effects

Protection of at least 8,000 acres of grasslands and 600 acres of vernal pool complex in Conservation Zones 1, 8, and 11 will benefit the California tiger salamander by providing habitat in the portions of the Plan Area with the highest long-term conservation value for the species based on known species occurrences and large, contiguous habitat areas. Ponds and other aquatic features in the grasslands will be protected to provide aquatic habitat for this species, and surrounding grassland will provide dispersal and aestivation habitat. Protected grasslands and vernal pool complex in Conservation Zone 8 will connect with the East Contra Costa County HCP/NCCP reserve system, including grassland areas supporting this species. Protected lands in Conservation Zone 11 will connect with the future Solano County reserve system, including grassland and vernal pool complex areas supporting this species. The increased habitat extent and connectivity will increase opportunities for genetic exchange and allow for colonization of extirpated populations and restored habitats. Protecting seasonal ponds associated with grasslands will ensure that California tiger salamander aquatic habitat and associated uplands will be preserved and enhanced in the largest possible patch sizes adjacent to occupied habitat within and adjacent to the Plan Area. Grassland restoration will focus specifically on connecting fragmented patches of protected grasslands, thereby increasing dispersal opportunities for the California tiger salamander. Grasslands will be enhanced to increase burrow availability to provide refugia and cover for aestivating and dispersing California tiger salamanders.

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5.6.22.3 Net Effects

Full implementation of the BDCP will result in an estimated 252 acres (1%) increase of habitat for the California tiger salamander, and an estimated 4,042 acres (32%) increase of California tiger salamander habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

The habitat that will potentially be lost as a result of tidal natural communities restoration is of relatively high quality based on location within and adjacent to protected lands and near the Jepson Prairie, which includes a well-documented population of California tiger salamanders and designated critical habitat, although the tidal restoration would not affect designated critical habitat. However, the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, and actual habitat loss is expected to be lower because of the ability to select sites that minimize effects on California tiger salamanders. Habitat lost to other covered activities is of relatively low quality based on the fragmentation of the affected habitat and lack of protected lands or species occurrences in the vicinity. Grasslands and vernal pool complex to be protected and restored will consist of large, continuous expanses of high-quality habitat in areas that support known populations of California tiger salamander and will be managed and enhanced to sustain these populations.

Overall, the BDCP will provide a substantial net benefit to the California tiger salamander through the increase in available habitat, habitat quality, and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the California tiger salamander.

5.6.23 Western Spadefoot

This section describes the adverse, beneficial, and net effects of the BDCP covered activities and conservation measures on the western spadefoot. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the western spadefoot includes two habitat types: terrestrial cover and aestivation habitat, and aquatic breeding habitat. The model for terrestrial cover and aestivation habitat includes all grassland types and alkali seasonal wetland complex with a minimum patch size of 100 acres and within a geographic area defined in Appendix 2.A, *Covered Species Accounts*. The model for aquatic breeding habitat includes vernal pool complex and degraded vernal pool complex. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix A, *Covered Species Accounts*. Factors considered in assessing the quality of affected habitat for the western spadefoot, to the extent that information is available, include habitat patch size and configuration, and location in relation to existing protected lands (Categories 1 and 2 open space[24]). Terrestrial cover and aestivation habitat is considered of low quality if it is not connected with aquatic breeding habitat. There are no known western spadefoot occurrences in or near the Plan Area.

[24] See Section 5.3.5.2 *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories.

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5.6.23.1 Adverse Effects

5.6.23.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 598 acres[25] of western spadefoot habitat (2% of the habitat in the Plan Area), including 42 acres of aquatic breeding habitat and 556 acres of terrestrial cover and aestivation habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Covered activities resulting in permanent habitat loss include conveyance facility construction, Fremont Weir, Yolo Bypass improvement, and tidal natural communities restoration. Most of the permanent habitat loss (100% of the aquatic breeding habitat loss and 57% of the terrestrial cover and aestivation habitat loss) results from tidal natural communities restoration.

Conveyance Facility Construction

This activity will result in the permanent removal of approximately 161 acres of terrestrial cover and aestivation habitat (0.5% of this habitat type in the Plan Area) for the western spadefoot (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Most of this habitat is of low quality as it consists of small, isolated patches in Conservation Zones 6 and 8 that are surrounded by cultivated lands and are not near or connected with any aquatic breeding habitat. Some of the habitat to be lost, around Clifton Court Forebay, is near aquatic breeding habitat and Category 1 open space but within a fragmented landscape consisting of small patches of habitat surrounded by cultivated lands. Construction of facilities at Clifton Court Forebay will isolate a small patch of aquatic breeding habitat adjacent to the forebay.

Fremont Weir/Yolo Bypass Improvements

Putah Creek realignment will result in the permanent removal of an estimated 42 acres of terrestrial cover and aestivation habitat (1% of this habitat type in the Plan Area) for the western spadefoot (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This habitat is of low to moderate quality: although it is in Category 1 open space and connected with aquatic breeding habitat, the habitat that will be removed is nearly 2 miles from the aquatic breeding habitat and at the far eastern edge of the modeled habitat for this species in the bypass. This construction will not fragment habitat or isolate terrestrial cover and aestivation habitat from aquatic breeding habitat.

Tidal Natural Communities Restoration

This activity will result in the permanent loss of up to 359 acres of western spadefoot habitat (2% of the habitat in the Plan Area), including 42 acres of aquatic breeding habitat (0.5% of aquatic breeding habitat in the Plan Area) and 317 acres of terrestrial cover and aestivation habitat (1% of this habitat type in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). This loss will take place in the Cache Slough ROA. Habitat to be lost at the northern and southern ends of the ROA are of low quality as they are surrounded by lands unsuitable for the species and are not connected to aquatic breeding habitat. Habitat to be lost in the vicinity of Lindsey Slough is of higher quality: it consists of both aquatic and terrestrial cover and aestivated habitat that are interconnected, and is within and near Category 1 open space. This area is contiguous with Jepson Prairie, which consists of a large vernal pool complex that provides suitable habitat for the western

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[25] Impact acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual impacts will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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spadefoot. However, there are no known occurrences for the western spadefoot in this area. Jepson Prairie is a well-known area for vernal pools and supports a large number of rare plant and wildlife species. Many wildlife surveys have been conducted in the Jepson Prairie area, and the western spadefoot would likely have been detected if present. Therefore, the likelihood that the western spadefoot occurs in the Cache Slough ROA is low.

5.6.23.1.2 Periodic Inundation

The only covered activity potentially adversely affecting western spadefoot as a result of periodic inundation is Yolo Bypass operations.

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions*), this activity will periodically inundate 73 acres of aquatic breeding habitat (1% of the aquatic breeding habitat in the Plan Area) and 125 acres of terrestrial cover and aestivation habitat (4% of this habitat type in the Plan Area) for the western spadefoot. The habitat that would be inundated is of moderate quality: it is in and near existing Category 1 open space (including Tule Ranch) and consists of interconnected aquatic breeding and cover and aestivation habitat, but there are no known western spadefoot occurrences in the Yolo Bypass. Most of the aquatic breeding habitat is along the western edge of the bypass, which is seldom expected to flood. Periodic inundation is not expected to have adverse population effects on the western spadefoot.

5.6.23.1.3 Construction-Related Effects

Construction-related effects on the western spadefoot include short-term and long-term temporary habitat loss, potential injury or mortality, and indirect effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction-related effects will temporarily disturb 10 acres of terrestrial cover and aestivation habitat for the western spadefoot (less than 0.01% of the terrestrial cover and aestivation habitat in the Plan Area) (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 151 acres of terrestrial cover and aestivation habitat (0.5% of this habitat type in the Plan Area) for the western spadefoot (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

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Construction-Related Injury or Mortality

The operation of equipment during construction could result in injury or mortality of the western spadefoot if present. This effect will be minimized by establishing 250-foot no-disturbance buffers around vernal pools, where possible, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise, visual, and other indirect disturbance within 500 feet of construction activities could temporarily affect the use of 203 acres of aquatic breeding habitat (3% of aquatic breeding habitat in the Plan Area) and 887 acres of terrestrial cover and aestivation habitat (3% of this habitat type in the Plan Area) (Table 5.6-2a, *Indirect Effects, Wildlife*). However, this will have minimal if any effect on the western spadefoot because it is likely not present in areas adjacent to construction activities. This effect, if any, will be minimized by establishing 250-foot no-disturbance buffers around vernal pools, where possible, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.23.1.4 Effects of Ongoing Activities

The only ongoing BDCP covered activities potentially adversely affecting the western spadefoot are habitat enhancement and management.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected western spadefoot habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury ,or mortality of western spadefoot, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with implementation measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

5.6.23.1.5 Impact of Take on Species

The current range of the western spadefoot includes portions of the Central Valley and bordering foothills, the coast range south of Monterey, southern California, and Baja California, Mexico as far south as Mesa de San Carlos. There are no known occurrences of the western spadefoot in the Plan Area, and the Plan Area represents less than 5% of the species' range-wide distribution. The permanent loss of approximately 2% of the modeled western spadefoot habitat in the Plan Area and other adverse effects described above potentially resulting in take of western spadefoot will not adversely affect the long-term survival of the species for the following reasons.

- The Plan Area represents a minor proportion of the species range.
- A small proportion of the modeled habitat in the Plan Area would be lost as a result of BDCP covered activities.
- There are no known occurrences of this species in the Plan Area.
- Measures will be implemented to minimize effects on aquatic breeding habitat.

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5.6.23.2 Beneficial Effects

Protection of at least 8,000 acres of grasslands and 600 acres of vernal pool complex (CM3) in Conservation Zones 1, 8, and 11 will benefit the western spadefoot by providing habitat in the portions of the Plan Area with the highest long-term conservation value for the species based on large, contiguous habitat areas. Protected grasslands and vernal pool complex in Conservation Zone 8 will connect with the East Contra Costa County HCP/NCCP reserve system, including grassland areas with suitable habitat for this species. Protected lands in Conservation Zone 11 will connect with the future Solano County reserve system, including grassland and vernal pool complex areas supporting suitable habitat for this species. Grassland restoration will focus specifically on connecting fragmented patches of protected grasslands, thereby increasing dispersal opportunities for the western spadefoot, if present in the Plan Area. Grasslands will be enhanced to increase burrow availability to provide refugia and cover for aestivating and dispersing, if the species is present (CM11).

5.6.23.3 Net Effects

Full implementation of the BDCP will result in an estimated 178 acres (0.5%) increase of high-quality habitat for the western spadefoot, and an estimated 4,805 acres (0.5%) increase of western spadefoot habitat in protected lands) (Table 5.6-3a, *Net Effects, Wildlife*).

The habitat that will potentially be lost as a result of tidal restoration is of relatively high quality based on location within and adjacent to protected lands and near the Jepson Prairie, which consists of a large, unfragmented block of vernal pool complex supporting suitable habitat for the species, although the western spadefoot has not been documented in this location or elsewhere in the Plan Area. The estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, and actual habitat loss is expected to be lower because sites will be selected to minimize effects on vernal pool complex. Habitat lost to other covered activities is of relatively low quality based on the fragmentation of the affected habitat and lack of protected lands in the vicinity. Grasslands and vernal pool complex to be protected and restored will consist of large, continuous expanses of high quality habitat in areas most likely to support the species. These lands will be managed and enhanced to sustain the western spadefoot, if present.

Overall, the BDCP will provide a substantial net benefit to the western spadefoot through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the western spadefoot.

5.6.24 Valley Elderberry Longhorn Beetle

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the valley elderberry longhorn beetle. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the valley elderberry longhorn beetle includes plant associations in the BDCP area where elderberry shrubs are expected to be found. This is represented by selected plant alliances from the valley/foothill riparian modeled habitat, and the grassland and vernal pool modeled habitats within 200 feet of streams. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* The model grossly overestimates the actual amount of valley elderberry longhorn beetle habitat in

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the Plan Area, as only those areas supporting elderberry shrubs are suitable for valley elderberry longhorn beetle, and only a small proportion of those shrubs are expected to support the species. The distribution of elderberry shrubs within modeled habitat in the Plan Area cannot be determined at this time, but will be determined during Plan implementation and all loss of elderberry shrubs will be offset.

5.6.24.1 Adverse Effects

Because the valley elderberry longhorn beetle habitat model does not accurately predict the actual amount of actual valley elderberry longhorn beetle habitat in the Plan Area (areas with elderberry shrubs), the analysis below does not discuss acreages and locations of adverse effects in detail for each covered activity and effect type. Rather, it quantifies total modeled acreage affected for each effect type and generally describes the covered activities that will result in these effects. The analysis also describes adverse effects in relation to distribution of known occurrences. However, this assessment is incomplete because the entire Plan Area has not been surveyed for this species (elderberry shrubs were surveyed and mapped along the conveyance facility alignment, but this did not include surveys for sign of the species) and known occurrences do not likely accurately represent the species' distribution in the Plan Area. Preconstruction surveys, avoidance measures, and monitoring will be implemented to ensure loss of elderberry shrubs is minimized, and that any loss is mitigated as described in *Beneficial Effects*, below.

5.6.24.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in permanent removal of 1,654 acres of modeled valley elderberry longhorn beetle habitat (5% of habitat in the Plan Area), including 1,058 acres of modeled riparian habitat and 596 acres of nonriparian channels and grassland modeled habitat. This estimate is conservative because it almost certainly overestimates actual effects on occupied habitat because elderberry shrubs are present in only a fraction of the modeled habitat and beetles occupy only a fraction of elderberry shrubs. Covered activities that that will result in the permanent loss of modeled valley elderberry longhorn beetle habitat include conveyance facilities construction (130 acres), tidal natural communities restoration (1,209 acres), Fremont Weir/Yolo Bypass improvements (265 acres), and floodplain restoration (51 acres). The modeled habitat to be lost is dispersed widely throughout the Plan Area (261 acres in Conservation Zone 1, 601 acres in Conservation Zone 2, 26 acres in Conservation Zone 3, 52 acres in Conservation Zone 4, 365 acres in Conservation Zone 5, 127 acres in Conservation Zone 6, 69 acres in Conservation Zone 7, 80 acres in Conservation Zone 8, and 73 acres in Conservation Zone 11). In Conservation Zone 2, where most of the habitat loss will occur, 258 acres of loss are associated with Fremont Weir improvements: this habitat is less than 1mile from a valley elderberry longhorn beetle occurrence west of Yolo Bypass in Yolo County. Approximately 343 acres of loss in Conservation Zone 2 will occur as a result of tidal natural communities restoration in the Cache Slough ROA. There are no known valley elderberry longhorn beetle occurrences in this area or any of the other areas to be permanently affected except in Conservation Zone 7, where the hypothetical footprint for levee construction associated with floodplain restoration is within 1 mile of a known valley elderberry longhorn beetle occurrence.

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5.6.24.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Section 5.2, *Methods*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions* in Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*), this activity will periodically inundate 43 acres of habitat for the valley elderberry longhorn beetle (0.5% of habitat in the Plan Area), including 43 acres of riparian habitat and 8 acres of modeled nonriparian channel and grassland habitat.

Floodplain Restoration

This activity will periodically inundate approximately 552 acres of modeled valley elderberry longhorn beetle habitat (2% of habitat in Plan Area), including 265 acres of riparian habitat and 286 acres of nonriparian channels and grassland habitat.

It is unknown at this time how much of the modeled habitat that would be inundated as a result of these activities consists of elderberry shrubs. Furthermore, there is a lack of data regarding tolerance of elderberry shrubs to periodic inundation. To address these uncertainties, elderberry shrubs in flooded areas will be monitored and if they show signs of water stress as a result of increased flooding they will be mitigated by transplanting shrubs and establishing riparian vegetation with elderberry plantings, consistent with Valley Elderberry Longhorn Beetle Conservation Guidelines (U.S. Fish and Wildlife Service 1999) and described under *Beneficial Effects.*

5.6.24.1.3 Construction-Related Effects

Construction-related effects on this species include temporary habitat loss, potential injury or mortality, and indirect effects of dust and vibrations.

Temporary Habitat Loss

Construction-related effects will temporarily disturb approximately 335 acres of modeled valley elderberry longhorn beetle habitat (1% of habitat in the Plan Area), including 157 acres of riparian habitat and 198 acres of nonriparian channels and grassland. Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction potentially results in injury or mortality of valley elderberry longhorn beetle larvae occupying elderberry shrubs; however, preconstruction surveys will be conducted and 100-foot no-disturbance buffers will be established where possible to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Dust, vibrations, and other indirect disturbance within 100 feet of construction activities could temporarily affect the use of 585 acres of modeled valley elderberry longhorn beetle habitat (2% of modeled habitat in the Plan Area), including 343acres of riparian habitat and 242 acres of nonriparian channel and grassland habitat (Table 5.6-2a, *Indirect Effects, Wildlife*). These adverse

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effects will be minimized by conducting preconstruction surveys and establishing 100-foot no-disturbance buffers where possible to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.24.1.4 Effects of Ongoing Activities

The only ongoing BDCP activities with the potential to adversely affect the valley elderberry longhorn beetle are those related to habitat enhancement and management activities.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management, such as grazing practices and ground disturbance or herbicide use in the control of nonnative vegetation, intended to maintain and improve habitat functions of BDCP protected habitats for covered species in Conservation Zones 1 and 11 could result in loss of host plants and the potential for injury or mortality to beetles. These effects would be minimized by establishing 100-foot no-disturbance buffers around elderberry shrubs, to the extent possible, and through implementation of other avoidance and minimization measures consistent with U.S. Fish and Wildlife Service guidelines and described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.24.1.5 Impact of Take on Species

The valley elderberry longhorn beetle occurs throughout the Central Valley. There are 201 extant CNDDB occurrences of valley elderberry longhorn beetle in California, three of which (1.5% rangewide) are in the Plan Area.

BDCP covered activities would permanently remove 1,654 acres (4% of habitat in the Plan Area) and temporarily remove 355 acres (1% of habitat in the Plan Area) of valley elderberry longhorn beetle modeled habitat. However, the model greatly overestimates the area that is actually suitable for this species because elderberry shrubs only constitute a small portion of the modeled habitat, and the beetle is only expected to occupy a small portion of these shrubs. Although the hypothetical footprint for BDCP activities does not overlap with any CNDDB occurrences for this species, the Plan Area has not been extensively surveyed for the valley elderberry longhorn beetle, and the species likely occurs in portions of the Plan Area where surveys have not yet been conducted. Take of the valley elderberry longhorn beetle as a result of permanently removing 1,654 acres and temporarily removing 355 acres, and other effects described above, is not expected to result in an adverse impact on the long-term survival and recovery of the valley elderberry longhorn beetle for the following reasons.

- The Plan Area represents less than 10% of the species' rangewide distribution.
- The amount of modeled habitat that will be lost is a small fraction (1%) of the total modeled habitat in the Plan Area.
- Habitat loss will be widely dispersed throughout the Plan Area and will not be concentrated in any one location that might place disproportional loss on an occupied area.
- Projects will be designed to avoid and minimize effects on elderberry shrubs.

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5.6.24.2 Beneficial Effects

Floodplain restoration (CM5) is expected to benefit the valley elderberry longhorn beetle by providing suitable habitat conditions through floodplain restoration. Flood control efforts, and accompanying reduction in the width of the riparian corridor, have contributed to decreased valley elderberry longhorn beetle occupancy in riparian stretches along the Sacramento River (Lang et al. 1989). Floodplain restoration and associated riparian restoration will increase the width of the riparian corridor, and recharging of floodplain groundwater will promote and sustain riparian vegetation, including elderberry shrub host plants. Most of the floodplain restoration is planned to occur in Conservation Zone 7. There is one current CNDDB occurrence record (#158) for the valley elderberry longhorn beetle in Conservation Zone 7, which reports one adult captured and beetle exit holes observed in elderberry shrubs near Middle River or Old River in 1984. There is another CNDDB occurrence record (#45) for this species immediately south of Conservation Zone 7, outside the Plan Area at Caswell Memorial State Park. This record reports two elderberry plants containing beetle exit holes, observed in 1985. It is unknown whether these two valley elderberry longhorn beetle occurrences in and near Conservation Zone 7 are still extant, but these records indicate that the species is potentially present in Conservation Zone 7. This indicates that floodplain restoration in Conservation Zone 7 will potentially benefit the species by providing additional habitat where elderberries are present in the restored riparian areas, and conditions for population expansion in this zone.

Restoration of 5,000 acres of valley/foothill riparian (CM7) is expected to substantially benefit the valley elderberry longhorn beetle. While the entire 5,000 acres is not expected to provide suitable habitat conditions for the valley elderberry longhorn beetle, some portion of this acreage will benefit the species where restoration occurs in the vicinity of existing populations and where suitable elderberry shrubs are planted or colonize naturally. Most of the 5,000 acres of riparian restoration will take place within the restored floodplain. Elderberry plantings will be incorporated into riparian restoration plantings, which is expected to directly benefit the valley elderberry longhorn beetle by increasing the abundance and distribution of its host plant species. In turn, this will provide opportunities to expand the distribution and increase the abundance of valley elderberry longhorn beetle populations in the Plan Area.

In addition to the riparian restoration described above, the Implementation Office will mitigate for loss of elderberry shrubs by creating valley elderberry longhorn beetle habitat consistent with the U.S. Fish and Wildlife Service (1999) valley elderberry longhorn beetle conservation guidelines, and planting elderberry shrubs in high-density clusters (CM7, CM11). These guidelines require transplanting shrubs from the areas of effect to restoration sites, and planting additional elderberry seedlings at ratios ranging from 1:1 to 8:1 (seedlings planted to stems affected) for all stems over 1 inch in diameter. As specified in the 1999 guidelines, the mitigation ratio will depend on the diameter of each stem affected, presence or absence of valley elderberry longhorn beetle exit holes in each shrub, and whether or not each shrub lost is in a riparian area.

Valley elderberry longhorn beetle habitat restoration will be sited within drainages immediately adjacent to or in the vicinity of sites known to be occupied by valley elderberry longhorn beetles. This objective will focus restoration on the drainages close to sites occupied by the valley elderberry longhorn beetle. This species has distinct, relatively isolated populations in individual drainages, likely due to the beetle's limited dispersal capability (Collinge et al. 2001). The species is unlikely to colonize unoccupied drainages, even if suitable habitat is present. This necessitates siting habitat restoration within or in the vicinity of occupied drainages. Known occupied habitat in the Plan Area

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occurs in Conservation Zones 2 and 7 in three occurrences, but additional known occurrences are expected to be found as the reserve system is assembled. Some occurrences are known from agricultural ditches and railroad tracks, and these do not provide opportunities to restore dense patches of elderberry shrubs within a riparian matrix directly adjacent to occupied areas. In these cases, restoration will be located within reasonable dispersal distance for the valley elderberry longhorn beetle from known occurrences.

5.6.24.3 Net Effects

Full implementation of the BDCP will result in an estimated 3,778 acres (11%) increase of modeled habitat for the valley elderberry longhorn beetle, and at least 6,848 acres (71%) increase of valley elderberry longhorn beetle habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

The habitat that will be lost as a result of covered activities is widely distributed throughout the Plan Area and is not within any area known to be occupied by the species, and only a small fraction of the modeled habitat to be lost supports elderberry shrubs. The habitat to be restored will include elderberry shrubs, which will be planted near sites known to be occupied by the species. The valley elderberry longhorn beetle has poor dispersal ability, and only by restoring suitable habitat near occupied areas can populations be expanded. Any loss of elderberry shrubs will be offset consistent with U.S. Fish and Wildlife Service guidelines, and occupied shrubs that are removed will be transplanted to restoration sites. These measures are expected to offset any population effects resulting from covered activities, and to facilitate expansion of valley elderberry longhorn beetle populations in the Plan Area.

Overall, the BDCP will provide a substantial net benefit to the valley elderberry longhorn beetle through the increase in available habitat adjacent to known occupied habitat. These restored areas will be protected areas and managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the valley elderberry longhorn beetle.

5.6.25 Vernal Pool Crustaceans

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on the vernal pool tadpole shrimp, Conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, midvalley fairy shrimp, and California linderiella, collectively referred to as the vernal pool crustaceans. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the vernal pool crustaceans consists of two layers: vernal pool complex, which consists of vernal pools and uplands that display characteristic vernal pool and swale visual signatures that have not been significantly affected by agricultural or development practices; and degraded vernal pool complex, which consists of low-quality ephemeral habitat ranging from areas with vernal pool and swale visual signatures that display clear evidence of significant disturbance due to plowing, discing, or leveling to areas with clearly artificial basins such as shallow agricultural ditches, depressions in fallow fields, and areas of compacted soils in pastures. For the purpose of the effects analysis, vernal pool complex is categorized as high quality for vernal pool crustaceans and degraded vernal pool complex is categorized as low quality for these species. Also included as low quality for vernal pool crustaceans are areas along the eastern boundary of Conservation Zone 1 that are mapped as vernal pool complex because they flood seasonally and support typical vernal pool plants, but do not include topographic depressions that are characteristic of vernal pool crustacean habitat. Further details regarding the habitat model, including assumptions on which the

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model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the vernal pool crustaceans, to the extent that information is available, include habitat patch size, density of vernal pools, and proximity to existing protected lands (Categories 1 and 2 open space[26]).

5.6.25.1 Adverse Effects

5.6.25.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

The only BDCP covered activity that will result in permanent loss of vernal pool crustacean habitat is tidal natural communities restoration.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 94 acres of vernal pool crustacean habitat (1% of habitat in the Plan Area), including 42 acres of high-quality and 52 acres of low-quality habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Wildlife*). The high-quality habitat loss will take place in the Cache Slough ROA in Conservation Zone 1, along the upper edges of Lindsey Slough and Hass Slough. Vernal pools in this area occur within a matrix of annual grasslands. Although the pools in this general area are relatively large and undisturbed, they are present in very low densities in the areas potentially affected by tidal natural communities restoration along Lindsey Slough. The habitat that would be lost in this area is part of a large, unfragmented expanse of vernal pool crustacean habitat in the Jepson Prairie Core Recovery Area; however, the tidal natural communities restoration at Lindsey Slough will occur along the northeastern edge of this large block of habitat and will not contribute to fragmentation.

The low-quality habitat to be lost includes lands in the Suisun ROA, along the eastern boundary of Conservation Zone 1, that are mapped as vernal pool complex because they flood seasonally and support typical vernal pool plants, but do not include topographic depressions that are characteristic of vernal pool crustacean habitat. This habitat is dotted along the northern and eastern boundaries of Suisun Marsh. Along the northern boundary of Suisun Marsh, the vernal pool crustacean habitat that would be lost is north of the Portrero Hills Landfill entrance, directly adjacent to existing Category 1 open space and part of the Jepson Prairie Core Recovery Area identified in the vernal pool recovery plan (U.S. Fish and Wildlife Service 1998). This area includes one Conservancy fairy shrimp occurrence (CNDDB occurrence #13) that would potentially be adversely affected by tidal inundation. On the eastern edge of Suisun Marsh the affected low-quality habitat consists of small patches within or adjacent to protected lands, but not within the core recovery area.

Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on the covered vernal pool crustaceans.

5.6.25.1.2 Periodic Inundation

Modeled vernal pool crustacean habitat will not be affected by periodic inundation.

[26] See Section 5.3.5.2 *Effects Analysis for Wildlife and Plant Species* for definitions of open space categories.

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5.6.25.1.3 Construction-Related Effects

Construction-related effects on this species include indirect dust and hydrologic effects, and construction-related mortality. Temporary habitat loss is not expected, because all work areas for tidal restoration will occur within the footprint for permanent loss or in nonhabitat areas. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or the specific nature of the effect.

Construction-Related Injury or Mortality

Construction may cause mortality to vernal pool crustaceans or their cysts if vernal pools are affected by ground-disturbing activities. Disturbance of vernal pools will be avoided where possible, as described in Appendix 3.C, *Avoidance and Minimization Measures.*

Indirect Construction-Related Effects

Dust and hydrological modification within 200 feet of construction activities could temporarily affect the use of 136 acres of modeled vernal pool crustacean habitat (Table 5.6-2a, *Indirect Effects, Wildlife*), including 90 acres of high-quality and 46 acres of low-quality habitat. As described in Appendix 3.C, *Avoidance and Minimization Measures*, restoration projects will be designed to avoid vernal pool complexes to the extent possible, with 250-foot no-disturbance buffers between construction activities and vernal pools.

5.6.25.1.4 Effects of Ongoing Activities

The only ongoing BDCP activities with potential to adversely affect vernal pool crustaceans are habitat enhancement and management activities.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected vernal pool complexes, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse habitat effects. These effects are expected to be minimal, and will be avoided and minimized with measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.25.1.5 Impact of Take on Species

Conservancy Fairy Shrimp

There are only 34 known occurrences of Conservancy fairy shrimp range-wide, four (12%) of which are in the Plan Area. The Plan Area includes a portion of Jepson Prairie, which is a core recovery area for Conservancy fairy shrimp and supports 12 (35%) of the range-wide occurrences for this species (four in the Plan Area and eight outside the Plan Area but in the vicinity).

Of the four existing CNDDB recorded occurrences in the Plan Area, three are on protected lands and one (3%, of statewide occurrences) will potentially be adversely affected as a result of tidal restoration. This occurrence, based on hypothetical restoration footprints, is CNDDB occurrence #13, north of Portrero Hills. This occurrence is inside the Jepson Prairie core recovery area but is in marginal habitat: it is described in CNDDB as occurring in drainage ditches that run along the south

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side of an existing capped landfill but are connected to large vernal pools to the east (California Department of Fish and Game 2011). Additional areas within the 42 acres of high-quality and 52 acres of low-quality habitat may be occupied by this species; however, due to the low density of pools in potentially affected areas, the amount of actual occupied habitat to be removed will likely be low. Furthermore, preconstruction surveys will confirm presence or absence of Conservancy fairy shrimp and avoidance measures will be implemented as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Take of Conservancy fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- A small proportion (1%) of habitat in the Plan Area would be removed.
- Losses will be limited by the low density or lack of pools in the vernal pool complex.
- The degraded vernal pool complex that will be lost level has a high level of disturbance and a paucity of aquatic habitat.
- The marginal habitat (drainage ditch) is where the one Conservancy fairy shrimp occurrence will potentially be lost.
- The measures described in Appendix 3.C, *Avoidance and Minimization Measures* will be implemented.

Longhorn Fairy Shrimp

The Plan Area does not include any CNDDB recorded occurrences of longhorn fairy shrimp, although there are occurrences in the vicinity of the Plan Area to the southwest, in the Byron Hills area. The portion of the Plan Area most likely to support this species is in Conservation Zone 8, the zone nearest to known occurrences. There will be no affects on modeled habitat for longhorn fairy shrimp in Conservation Zone 8. However, it is possible that longhorn fairy shrimp also occurs within modeled habitat that will be lost in Conservation Zones 1 and 11. This species is very rare, with only 11 recorded occurrences throughout the state: therefore, any loss of occupied habitat would have the potential to adversely affect the species' long-term survival and recovery. Preactivity surveys will confirm presence or absence of longhorn fairy shrimp and avoidance measures will be implemented as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Take of longhorn fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- Lack of any existing CNDDB recorded occurrences of this species in the Plan Area.
- A small proportion (1%) of habitat in the Plan Area would be removed.
- The vernal pool complex that will be lost has a low density or lack of pools.
- The degraded vernal pool complex that will be lost level has a high level of disturbance and a paucity of aquatic habitat.
- The measures described in Appendix 3.C, *Avoidance and Minimization Measures* will be implemented.

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Vernal Pool Fairy Shrimp

Vernal pool fairy shrimp is one of the more widespread covered vernal pool crustacean species, with 605 recorded occurrences throughout the state. The Plan Area includes 13 (2%) of the state-wide occurrences, 11 (84%) of which are on protected lands. Based on the hypothetical footprint for tidal natural communities restoration, one existing vernal pool fairy shrimp CNDDB recorded occurrence would be affected (CNDDB Occurrence #184). This occurrence is from a drainage ditch along the south side of a capped landfill north of Portrero Hills. Additional suitable habitat to be affected may also be occupied by this species. However, loss of occupied habitat will be minimized as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Take of vernal pool fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- A small proportion of this species' range and known occurrences are present in the Plan Area.
- A small proportion (1%) of habitat in the Plan Area would be removed.
- The vernal pool complex that will be lost has a low density or lack of pools.
- The degraded vernal pool complex that will be lost level has a high level of disturbance and a paucity of aquatic habitat.
- The measures described in Appendix 3.C, *Avoidance and Minimization Measures* will be implemented.

Midvalley Fairy Shrimp

There are 99 CNDDB occurrences of midvalley fairy shrimp rangewide, of which five (5%) occur in the Plan Area. None of these occurrences overlap with footprints for activities that could result in permanent or temporary habitat loss. Take of midvalley fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- A small proportion (5%) of known species occurs in the Plan Area.
- A small proportion (1%) of habitat in the Plan Area will be removed.
- The vernal pool complex that will be lost has a low density or lack of pools.
- The degraded vernal pool complex that will be lost level has a high level of disturbance and a paucity of aquatic habitat.
- The measures described in Appendix 3.C, *Avoidance and Minimization Measures* will be implemented.

California Linderiella

There are 320 CNDDB occurrences of California linderiella rangewide, of which 11 (3%) occur in the Plan Area. None of these occurrences overlap with footprints for activities that could result in permanent or temporary habitat loss. Take of California linderiella as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- A small proportion (3%) of known species occurs in the Plan Area.

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- A small proportion (1%) of habitat in the Plan Area will be removed.
- The vernal pool complex that will be lost has a low density or lack of pools.
- The degraded vernal pool complex that will be lost level has a high level of disturbance and a paucity of aquatic habitat.
- The measures described in Appendix 3.C, *Avoidance and Minimization Measures* will be implemented.

5.6.25.2 Beneficial Effects

With full implementation of the BDCP, at least 600 acres of vernal pool complex will be protected (CM3) and additional restoration will be implemented to achieve no net loss of vernal pool complex (CM8). The protection and restoration will take place primarily in core recovery areas for the vernal pool crustaceans as identified in the recovery plan (U.S. Fish and Wildlife Service 2005), and will increase the size and connectivity of vernal pool complex reserves in and adjacent to the Plan Area. The vernal pool reserve system will incorporate a range of inundation characteristics in order to accommodate the varying needs of all the covered vernal pool crustacean species. These core recovery areas where protection and restoration will be focused have the highest concentrations of covered vernal pool crustacean occurrences in the Plan Area, and they also coincide with the BDCP conservation zones that include relatively large, unfragmented blocks of unprotected vernal pool complex adjacent to protected lands. At least one Conservancy fairy shrimp occurrence will be preserved in the reserve system.

Additionally, the vernal pool complexes in the reserve system will be managed and enhanced (CM11) to provide the appropriate ponding characteristics for supporting and sustaining the vernal pool crustaceans, and to increase native biodiversity and reduce invasive plant species detrimental to vernal pool hydrology.

5.6.25.3 Net Effects

Full implementation of the BDCP will result in no net loss of vernal pool crustacean habitat, and at least 600 acres (13%) increase of vernal pool crustacean habitat in protected lands (Table 5.6-3a, *Net Effects, Wildlife*).

While some of the habitat that may be lost as a result of tidal restoration in Cache Slough ROA (Conservation Zone 1) is of relatively high quality in that it is in a core recovery area for vernal pool crustaceans and is part of a large, contiguous vernal pool complex with protected lands and multiple vernal pool crustacean species occurrences, the loss will occur along the edge of this complex in an area that has a relatively low pool density. Habitat that will be affected around the margins of Suisun Marsh in Suisun ROA (Conservation Zone 11) is mostly disturbed or of low quality, consisting of drainage ditches adjacent to Portrero Landfill and areas that periodically flood but do not pond. The areas that will be conserved will consist of high-quality vernal pool complex in core vernal pool recovery areas that will be interconnected and managed to sustain populations of covered vernal pool crustaceans.

Overall, the BDCP will provide a substantial net benefit to the covered vernal pool crustaceans through the increase in available habitat, habitat quality, and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the covered vernal pool crustaceans.

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5.6.26 Brittlescale and Heartscale

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation measures, on brittlescale and heartscale. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The brittlescale habitat model included hydrological features such as stream corridors and playa pools with either alluvium associated with the Montezuma Block along the western boundary of the Plan Area (Band 1998; Graymer et al. 2002), or on alluvium associated with tertiary formations located along the southwest boundary of the Plan Area (Schruben et al. 1998). The heartscale model includes alkali seasonal wetland, vernal pool, and grassland natural communities underlain by Solano, Pescadero, Willows soil series. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for brittlescale and heartscale, to the extent that information is available, include patch size and connectivity to other habitat patches, especially those that are currently protected.

5.6.26.1 Adverse Effects

5.6.26.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 363 acres of heartscale modeled habitat and 2 acres[27] of brittlescale modeled habitat (10.7% and 0.4% of modeled habitat, respectively, in the Plan Area) (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Covered activities resulting in permanent adverse effects on brittlescale and heartscale include tidal natural communities restoration.

Tidal Natural Communities Restoration

This activity will result in the removal of 363 acres of heartscale modeled habitat and 2 acres of brittlescale modeled habitat in Conservation Zones 1 and 11. Tidal restoration in Conservation Zone 1 has potential to inundate 272 acres of heartscale modeled habitat and 1 acre of brittlescale habitat. The effects on heartscale and brittlescale modeled habitat in Conservation Zone 1 and Conservation Zone 11 are described below.

Brittlescale modeled habitat around Suisun Marsh appears, for the most part, as small, linear patches that are orientated perpendicular to the marsh. Only the tip of a long, linear patch comes close to the marsh and therefore has any potential to overlap with tidal restoration activities. There are four clusters of these linear habitat patches on the northern and eastern edges of Suisun Marsh, each with several habitat patches within 2 to 3 miles of one another. These clusters of patches are separated by a distance of 2 to 5 miles.

The first habitat cluster is located near the entrance to Protrero Hills Landfill. The habitat in this area is of moderate to high quality. It is disrupted by the landfill entrance road and SR 12 and is not in proximity to other habitat patches (the nearest habitat patch is approximately 2 miles away). However, the habitat patch, as well as the land surrounding it, is undeveloped, immediately adjacent to protected lands to the west, and includes extant occurrences of heartscale and brittlescale. In

[27] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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addition, there are two other BDCP covered species occurrences in very close proximity to this habitat patch: alkali milk-vetch and San Joaquin spearscale. This habitat patch cluster is the only one of the four clusters surrounding Suisun Marsh with occurrences of brittlescale and is therefore considered to have the highest quality habitat in Conservation Zone 11. This habitat patch also has the highest potential to be affected by tidal restoration as tidal marsh parcels immediately west of the patch have elevations suitable for restoration (Essex Partnership 2009).

The second cluster of habitat patches is located between SR 12 and the Plan Area boundary, near Denverton, in the upland area adjacent to the northeast corner of Suisun Marsh. These patches are of moderate to high quality. Although SR 12 does intersect the southern portion of the habitat, the land is undeveloped and adjacent to protected lands to the north and the south. There is a brittlescale occurrence to the northwest, just outside the Plan Area boundary, as well as a Carquinez goldenbush occurrence just to the northeast of this habitat patch. Because of the location of SR 12, these habitat patches are not likely to be affected by tidal restoration.

The third clustered habitat patches are also located in the Denverton area, but south of SR 12. The habitat patches in this cluster are of moderate to high quality. The habitat is protected from development, is surrounded by land that is currently undeveloped, and overlaps with two occurrences of Carquinez goldenbush. The fourth cluster of habitat patches is located further south still along the eastern border of Suisun Marsh in the Bird's Landing area. The habitat patches in this area are also currently protected, surrounded by undeveloped lands, and include one occurrence each of brittlescale and Carquinez goldenbush. There is some potential for tidal restoration projects to occur in this area, but less so than the area immediately west of Potrero Hills.

5.6.26.1.2 Periodic Inundation

Yolo Bypass operations are the only covered activities expected to result in periodic inundation of heartscale habitat.

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Section 5.2, *Methods,* and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions* in Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*), this activity will periodically inundate 61 acres of modeled heartscale habitat. Periodic inundation will alter the seasonal wetland hydrology, creating wetter conditions that will potentially be unsuitable for heartscale. Heartscale occurs in microhabitats that seasonally have saturated soils for short periods but typically are not inundated.

5.6.26.1.3 Construction-Related Effects

No direct construction-related effects on brittlescale and heartscale are anticipated.

Indirect Construction-Related Effects

Disturbance within 250 feet of construction activities could temporarily affect the use of 193 acres and 3 acres (40.89% and 0.63%) of respective modeled heartscale and brittlescale habitat (Table 5.6-2b *Indirect Effects, Plants*). These construction activities may temporarily affect approximately 192 acres of heartscale habitat and 3 acres of brittlescale habitat due to tidal marsh restoration, and approximately 1 acre due to Fremont Weir/Yolo Bypass enhancements. Indirect

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effects on plants include the collection of dust on leaves or the contamination of soil from construction site runoff. These effects on modeled habitat are very unlikely to affect individual plants. These adverse effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.26.1.4 Effects of Ongoing Activities

Operation and maintenance of the water conveyance facilities and habitat enhancement activities will not affect heartscale and brittlescale modeled habitat. The BDCP covered activities will have no other indirect effects on the brittlescale and heartscale.

5.6.26.1.5 Impact of Take on Species

Heartscale is known from 49 confirmed, extant occurrences (64 total) in the state [28], 2 of which are in the Plan Area (Table 5.6-4, *Covered Plant Species Occurrences, Effects, and Conservation Requirements*). Brittlescale is currently known from 59 extant occurrences in the state and three in the Plan Area. Two acres of brittlescale modeled habitat and 653 acres of heartscale modeled habitat have potential to be affected by BDCP activities. Because a very low proportion of the species occurrences are in the Plan Area and because only a small area of potentially suitable habitat will be affected (Table 5.6-1b *Maximum Allowable Habitat Loss, Plants*). the BDCP will not adversely affect on the species' long-term survival and recovery.

5.6.26.2 Beneficial Effects

The BDCP Implementation Office will restore at least 113 acres and protect 649 acres of alkali seasonal wetland complex, grassland, and vernal pool complex natural communities expected to be suitable habitat for heartscale and brittlescale. Heartscale and brittlescale habitat models include vernal pool and alkali seasonal wetland habitat in Conservation Zones 1 and 11; therefore, restoration or protection of these two community types in these locations will benefit both species. While grassland is not the primary habitat for heartscale and brittlescale, it is often adjacent to, buffers, or surrounds heartscale habitat and, therefore, its protection has the potential to provide connectivity between and within protected areas that include heartscale occurrences as well as provide a buffer between habitat and development.

Restoration and protection of these three community types in Conservation Zones 1 and 11 will provide the most benefit to both species while restoration and protection in Conservation Zone 8 will only benefit brittlescale. The grassland minimum commitment of 2,500 acres each in Conservation Zones 1 and 11 insures that portions of high-quality brittlescale and heartscale habitat in and around Suisun Marsh and Jepson Prairie will be protected. The 1,000-acre minimum grassland protection commitment for Conservation Zone 8 ensures portions of brittlescale habitat will be protected in that region of the Plan Area.

The protection of vernal pool and alkali seasonal wetland acres will increase the preserve size of Jepson Prairie and Suisun Marsh, which contain habitat for and occurrences of heartscale and brittlescale. There is also potential to create connectivity between the Jepson Prairie protection lands and Suisun Marsh preservation lands in Conservation Zones 1 and 11 as well as between conservation lands in the Almont Hills Core Recovery Area in Conservation Zone 8, and the Los

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[28] Thirteen occurrences have not been observed for more than 25 years and ten occurrences are presumed to be extirpated (California Department of Fish and Game 2011).

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Vaqueros Reservoir conservation area outside the Plan Area. The protection of vernal pool and alkali seasonal wetland habitat may also capture currently known, extant, but unprotected occurrences at the edges of Suisun Marsh or in the greater Jepson Prairie preserve as well as potential yet-to-be discovered occurrences.

5.6.26.3 Net Effects

Full implementation of the BDCP will result in a 111-acre (24%) increase in brittlescale modeled habitat and a 411-acre (326%) increase in protected lands. Heartscale modeled habitat will decrease by 250 acres (-4%) and protected habitat will increase by 473 acres (17%) (Table 5.6-3b, *Net Effects, Plants*). The heartscale and brittlescale modeled habitat lost in Conservation Zone 1 and 11 as a result of the BDCP is composed of high quality alkali seasonal wetland complex, grassland, and vernal pool complex. However, vernal pool, grassland, and alkali seasonal wetland community protection will also occur in these areas, providing substantial increases in existing protected lands.

Overall, protected habitat will increase by 515% for brittlescale and 21% for heartscale, providing a substantial benefit to the species. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the species.

5.6.27 Caper-Fruited Tropidocarpum

This section describes the adverse, beneficial, and net effects of the BDCP covered activities on the caper-fruited tropidocarpum. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the caper-fruited tropidocarpum includes grassland cover types and soils with a suitable range of pH and fluvial geomorphic characteristics. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the caper-fruited tropidocarpum, to the extent that information is available, include patch size, fragmentation, presence of other covered species, and connectivity to protected lands.

5.6.27.1 Adverse Effects

5.6.27.1.1 Permanent Habitat Loss, Conversion and Fragmentation

BDCP covered activities will not result in the permanent loss of modeled caper-fruited tropidocarpum habitat (Table 5.6-1a, *Maximum Allowable Habitat Loss, Plants*). As there are no known, extant occurrences of caper-fruited tropidocarpum in the Plan Area, there are no anticipated adverse effects on occurrences.

5.6.27.1.2 Periodic Inundation

No periodic inundation effects on caper-fruited tropidocarpum modeled habitat will occur as a result of BDCP covered activities.

5.6.27.1.3 Construction-Related Effects

Construction-related effects on caper-fruited tropidocarpum modeled habitat are expected during implementation of conveyance facility construction, and include long-term, temporary habitat loss and construction-related injury or mortality. Effects on the species are described below for each

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effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Long-Term)

Establishment and use of borrow and spoil areas associated with water facility construction will result in long-term temporary removal of approximately 34 acres of caper-fruited tropidocarpum modeled habitat in Conservation Zone 8 (2.4% of total habitat in the Plan Area) (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). The majority of caper-fruited tropidocarpum modeled habitat in Conservation Zone 8 is located south of Clifton Court Forebay. The affected modeled habitat is composed of patchy areas that contain irrigated pasture or hayfields. The area of habitat is small and not contiguous with other similar patches of modeled habitat, although much habitat remains in the vicinity that is likely to be suitable habitat but was not identified by the habitat model. The native soils and hydrology of these areas have likely been altered from historic conditions to support past and ongoing agricultural practices. Therefore, the affected modeled habitat is considered to be of very low quality. No occurrences of caper-fruited tropidocarpum have been reported in the affected modeled habitat, but six historic occurrences of caper-fruited tropidocarpum have been reported in the Plan Area, and the adjacent hills support habitat of potentially higher quality than the affected modeled habitat. Temporarily disturbed areas will be restored as grassland habitat within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction will not likely cause injury or mortality to caper-fruited tropidocarpum because there are no known, extant occurrences in the Plan Area; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Indirect effects on caper-fruited tropidocarpum are not expected because there are no known, extant occurrences in the Plan Area; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.27.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

The operation and maintenance of BDCP facilities are not expected to adversely affect the caper-fruited tropidocarpum.

Habitat Enhancement and Management

Habitat management and enhancement activities in grassland habitat, such as livestock grazing or the control of nonnative vegetation, could result in the mortality of individual caper-fruited tropidocarpum if plants are present in these sites over the term of the BDCP. These potential effects will be minimized with the implementation of herbicide application BMPs and by the general and

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caper-fruited tropidocarpum avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.* The range of habitat management and enhancement related activities that could be implemented in restored caper-fruited tropidocarpum habitat is expected to maintain and improve the habitat functions for this species over the term of the BDCP.

Other Indirect Effects

The BDCP covered activities will have no other indirect effects on caper-fruited tropidocarpum.

5.6.27.1.5 Impact of Take on Species

Caper-fruited tropidocarpum was historically known from the northwestern San Joaquin Valley and the outer North Coast Range and was thought to be extinct throughout its range until rediscovery in 2000 at Fort Hunter Liggett in Monterey County. There are 13 known extant occurrences throughout its historical range. Within the Plan Area, caper-fruited tropidocarpum was observed historically at six locations between Byron and the City of Tracy (California Department of Fish and Game 2011; Consortium of California Herbaria 2011). The alkaline grasslands in the Plan Area between Byron and Tracy are the most likely areas where caper-fruited tropidocarpum might be found, if it is still extant in the Plan Area.

Full implementation of the BDCP will temporarily remove up to 34 acres out of a total of 1,410 acres of modeled caper-fruited tropidocarpum habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). There are no known extant occurrences in the Plan Area, so there are no anticipated effects on individual plants. The small area of effect on modeled habitat, which is of low quality, is not expected to adversely affect the species' long-term survival and recovery.

5.6.27.2 Beneficial Effects

The BDCP Implementation Office will result in the protection of 143 acres (10% of existing habitat) and the restoration of 36 acres (3.5% of existing habitat) of high-quality grassland habitat in moderately alkaline soils between Byron and Tracy near the western boundary of Conservation Zone 8 (Table 5.6-3b, *Net Effects, Plants*). This area is considered of high quality because it occurs within a matrix of protected lands, is undeveloped and buffered by undeveloped lands, includes historical caper-fruited tropidocarpum occurrences on adjacent lands just outside the Plan Area, and provides habitat for other BDCP covered species, including alkali milk-vetch, San Joaquin spearscale, and San Joaquin kit fox. In addition, protection of acres in this area would create a linkage of protected lands between the Altamont Hills Vernal Pool Recovery Area and the protected lands surrounding the Los Vaqueros Reservoir and Diablo State Park.

5.6.27.3 Net Effects

Full implementation of the BDCP will result in a net gain of 36 acres of modeled habitat and a net increase in 179 acres of protected lands. This will increase the proportion of habitat that is protected by 851%. (Table 5.6-3b, *Net Effects, Plants*). Implementation of the BDCP will result in the long-term loss of 34 acres of low quality habitat but will increase the amount of high-quality, habitat by 36 acres. In addition, the protected highest quality caper-fruited tropidocarpum habitat would increase by 179 acres.

Overall, the BDCP will provide a substantial net benefit to caper-fruited tropidocarpum primarily through the increase in available, protected habitat. The protected areas will be managed to support

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high quality habitat for caper-fruited tropidocarpum. Therefore, BDCP supports the recovery of caper-fruited tropidocarpum. Currently, there are no extant occurrences of caper-fruited tropidocarpum in the Plan Area; however, if the species were rediscovered in Plan-protected habitat, then the BDCP would provide a major contribution toward its recovery.

5.6.28 Carquinez Goldenbush

This section describes the adverse, beneficial, and net effects of the BDCP covered activities, including conservation, measures on the Carquinez goldenbush. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the Carquinez goldenbush includes intermittent and perennial stream corridors on alluvium soil units related to the Montezuma Block. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the Carquinez goldenbush, to the extent that information is available, include the presence of occurrences of either Carquinez goldenbush or another covered species, patch size, proximity to protected lands, and connectivity between patches.

5.6.28.1 Adverse Effects

5.6.28.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss or fragmentation of up to 2 acres of habitat (0.2% of the habitat in the Plan Area) for Carquinez goldenbush (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Covered activities resulting in adverse effects on Carquinez goldenbush include tidal natural communities restoration.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 2 acres (0.2% of modeled habitat) of Carquinez goldenbush modeled habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). These two acres occur in Conservation Zone 11 and are located between Denverton and Bird's Landing on the eastern border of Suisun Marsh. These acres are considered high-quality habitat because they are currently protected within a large, relatively intact vernal pool, alkali seasonal wetland, and grassland matrix; they contribute to connectivity between northern and southern habitat; and there are several occurrences of Carquinez goldenbush in this area. Permanent loss and fragmentation of Carquinez goldenbush modeled habitat will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

5.6.28.1.2 Periodic Inundation

There are no periodic inundation effects on Carquinez goldenbush.

5.6.28.1.3 Construction-Related Effects

Construction-related effects on this species include indirect effects associated with tidal marsh restoration. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the

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extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Indirect Construction-Related Effects

Tidal marsh restoration disturbance within 250 feet of construction activities could temporarily affect 73 acres (7.1%) of modeled Carquinez goldenbush habitat (Table 5.6-2b, *Indirect Effects, Plants).* Dust, petroleum contamination or spills, water runoff, and sedimentation associated with restoration-related ground-disturbing activities could temporarily affect habitat conditions on 8 acres of Carquinez goldenbush modeled habitat near tidal restoration sites. These adverse effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.28.1.4 Effects of Ongoing Activities

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management, such as grazing practices and ground disturbance or herbicide use in the control of nonnative vegetation, intended to maintain and improve habitat functions of BDCP protected habitats for Carquinez goldenbush and other covered species in Conservation Zones 1 and 11 could result in local adverse effects on habitat and the mortality of Carquinez goldenbush individuals if present in work sites over the term of the BDCP. These effects will be minimized with implementation of the general, vernal pool complex, and Carquinez goldenbush avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.28.1.5 Impact of Take on Species

There are 14 known, extant occurrences of Carquinez goldenbush from Solano and Contra Costa counties, seven of which are in the Plan Area (California Department of Fish and Game 2011). All but the Contra Costa occurrence are found in the greater Jepson Prairie/Montezuma Hills area, either just inside or just outside the Plan Area. Two acres of high-quality habitat could be lost as a result of tidal habitat restoration. The take of 2 acres of modeled habitat will not adversely affect the long-term survival and recovery of the species.

5.6.28.2 Beneficial Effects

Restoration and protection of grassland, vernal pool, and alkali seasonal wetland natural communities will result in the restoration of 22 acres (2% increase) and the protection of 83 acres (22% increase) of Carquinez goldenbush habitat. Vernal pool, alkali seasonal wetland, and grassland habitat in Conservation Zones 1 and 11 are considered of high quality. For the most part, this area consists of large, relatively unfragmented patches of undeveloped land. There are seven occurrences of Carquinez goldenbush scattered throughout the area, with many occurrences of vernal pool and alkali seasonal wetland species. The protected lands of Suisun Marsh and the Jepson Prairie complex buffer adjacent habitat from development and provide connectivity across the landscape. In addition, one occurrence of Carquinez goldenbush will be protected in Conservation Zone 1 or 11.

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5.6.28.3 Net Effects

Up to 2 acres (0.1%) of high-quality Carquinez goldenbush modeled habitat will be permanently lost as a result of full implementation of the BDCP (Table 5.6-3b, *Net Effects, Plants).* The restoration and protection of high-quality alkali seasonal wetland, vernal pool, and grassland natural community will result in a 22-acre (2%) increase in high-quality habitat and a 105-acre increase (28%) in protected habitat for Carquinez goldenbush. In addition, one occurrence of Carquinez goldenbush will be protected. This will increase the number of protected occurrences by 20% (Table 5.6-4, *Covered Plant Species Occurrences*).

Overall, the BDCP will provide a substantial net benefit to Carquinez goldenbush through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of Carquinez goldenbush.

5.6.29 Delta Button Celery

This section describes the adverse, beneficial, and net effects of the BDCP covered activities on the delta button celery. The methods used to assess these effects are described in Section 5.2.7, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the delta button celery includes all areas between the levees from the Mossdale Bridge to Vernalis consisting of alkali seasonal wetland complex, vernal pool complex and grassland on selected soil types in the San Joaquin Basin (i.e., south of the mainstem San Joaquin River). Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the delta button celery, to the extent that information is available, include fragmentation, presence of ground disturbance, such as disking, proximity to known or historic occurrences, hydrology, and connectivity between large patches of suitable or potential habitat.

5.6.29.1 Adverse Effects

5.6.29.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 25 acres[29] of modeled habitat (0.8% of the modeled habitat in the Plan Area) for delta button celery (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Covered activities resulting in loss of delta button celery habitat include water conveyance and floodplain restoration construction.

Conveyance Facility Construction

This activity, including transmission line construction, will result in the permanent loss of approximately 18 acres of delta button celery modeled habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*) in Conservation Zone 8, immediately south of the Clifton Court Forebay. The affected modeled habitat is composed of two small, degraded patches of grassland (California annual grasslands-herbaceous) that are considered to be of very low habitat quality. These small patches of modeled habitat are not near known or historical delta button celery occurrences and are isolated

[29] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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from other delta button celery modeled habitat by agriculture. These patches of are not adjacent to existing conservation lands or near occurrences of other rare species, nor do they provide connectivity between larger, intact patches of delta button celery modeled habitat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent loss of approximately 7 acres of delta button celery modeled habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*) in Conservation Zone 7, between Mossdale Bridge and Vernalis. Construction activity for floodplain restoration will primarily occur outside the levees, where there is no delta button celery modeled habitat. However, where levee breaches are made, the construction footprint will reach inside the levees, thus causing small, dispersed effects on delta button celery modeled habitat along this portion of the San Joaquin River.

The highest quality habitat to be affected by construction of levee breeches occurs at the very southern tip of the Plan Area, near Vernalis, and effects in this area are less than 1 acre total. This area is presumed to include the highest quality modeled delta button celery habitat in the Plan Area because it includes the visual signature of overland flood flows and is downstream of two presumed extant delta button celery occurrences that are located just outside the Plan Area. In addition, there are occurrences of other BDCP covered species present in the same location and some small patches of protected lands.

The majority of the 7 acres of potential habitat loss occurs in Conservation Zone 7, immediately south of the Mossdale Bridge, with some smaller portion of the construction footprint directly north of the bridge. The area just north of the Mossdale Bridge includes an historic occurrence that is likely extirpated (California Department of Fish and Game 2012). This portion of the San Joaquin River is considered low-quality delta button celery habitat. The river in this section is much more narrow and confined and does not possess any of the native biologic, hydrologic, or geomorphic signatures as the more southern reaches do.

5.6.29.1.2 Periodic Inundation

Floodplain restoration is the only covered activity expected to result in periodic inundation of delta button celery habitat.

Floodplain Restoration

This activity will periodically inundate approximately 18 acres of modeled habitat for the delta button celery (0.5% of the modeled habitat in the Plan Area). There are currently no known delta button celery occurrences in the Plan Area, so inundation is unlikely to affect individual plants. Floodplain restoration is expected to benefit this species, as describe below in *Beneficial Effects*, below.

5.6.29.1.3 Construction-Related Effects

Construction-related effects on delta button celery are associated with floodplain restoration. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

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Temporary Habitat Loss

Construction-related effects will temporarily disturb 8 acres of delta button celery habitat (0.2% of the modeled habitat in the Plan Area) (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). The temporary ground disturbance will occur in discrete patches between Mossdale Bridge and Vernalis, where delta button celery modeled habitat overlaps with the planned location of floodplain restoration. There are no known, extant occurrences in these areas, or elsewhere in the Plan Area.

Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities. Because delta button celery occurs in areas of exposed soil in river-adjacent wetlands that experience slow overland flow, the habitat is expected to be suitable for recolonization almost immediately upon completion of restoration.

Construction-Related Injury or Mortality

Construction will not likely cause injury or mortality to the delta button celery as there are no known, extant occurrences in the Plan Area; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Disturbance of delta button celery within 250 feet of construction activities could temporarily affect 30 acres (0.9%) of modeled delta button celery habitat (Table 5.6-2b, *Indirect Effects, Plants*). These construction activities will include water conveyance and floodplain restoration construction. Indirect effects on plants include dust collection on leaves and soil contamination from construction site runoff. Indirect effects on delta button celery are not expected because there are no known extant occurrences in the Plan Area. Adverse effects on newly discovered occurrences will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.29.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

The operation and maintenance of BDCP facilities are not expected to adversely affect the delta button celery.

Habitat Enhancement and Management

Habitat management and enhancement related activities in restored seasonally inundated floodplain and in protected alkaline habitats, such as the control of nonnative vegetation, could result in the mortality of individual delta button celery plants if it is present in these sites over the term of the BDCP. These potential effects will be minimized with the implementation of herbicide application BMPs and by the general and delta button celery avoidance and minimization measures described in Appenidx 3.C, *Avoidance and Minimization Measures*.

Other Indirect Effects

The BDCP covered activities will have no other indirect effects on the delta button celery.

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5.6.29.1.5 Impact of Take on Species

There are 26 known occurrences of delta button celery in the state, 6 of which are possibly extirpated (including the 2 in the Plan Area), and 2 that may have been incorrectly identified (Preston pers. comm.). The two presumably extirpated occurrences in the Plan Area are located in Conservation Zone 9 and Conservation Zone 7, one on the alluvial plain of Kellogg and Marsh Creeks immediately west of Discovery Bay (Conservation Zone 9) and one along the San Joaquin River northeast of Tracy (Conservation Zone 7). The species is still found throughout its historical range, with the greatest density of occurrences in Merced County.

Full implementation of the BDCP will permanently remove up to 25 acres out of a total of 3,330 acres of modeled delta button celery habitat. There are no known occurrences in the Plan Area, so there are no anticipated effects on individual plants. The small amount of effect on modeled habitat is not expected to adversely affect the species' long-term survival and recovery.

5.6.29.2 Beneficial Effects

The BDCP Implementation Office will restore an estimated 277acres and protect 243acres of delta button celery modeled habitat through the implementation of grassland, alkali seasonal wetland, vernal pool, and riparian natural community objectives. To ensure that a sufficient amount of the restored and protected grassland, alkali seasonal wetland, vernal pool, and riparian natural communities specifically benefits the delta button celery, the Implementation Office will preserve and restore areas with suitable soils and hydrology, as delta button celery requires specific alkaline soil types and vernally mesic conditions.

In addition to the restoration and protection of delta button celery habitat, the Implementation Office will create two new occurrences of delta button celery in Conservation Zone 7, between the Mossdale Bridge and Vernalis. This portion of the Plan Area is likely the highest quality delta button celery habitat: it is just downstream of two extant delta button celery occurrences, is adjacent to existing conservation lands, and has geomorphic signatures more consistent with the historical condition. Occurrences will be created in those areas with suitable soils and hydrology.

5.6.29.3 Net Effects

Full implementation of the BDCP will result in an estimated 252-acre net increase in delta button celery habitat (8% of 3,330 acres of habitat in the Plan Area) and a 520-acre increase in protected lands (including restoration acres protected) (a 192% increase in existing protected lands in the Plan Area) (Table 5.6-3b, *Net Effects, Plants*).

The habitat that will be lost as a result of water conveyance and floodplain restoration varies from low to high quality, but occurs in small, isolated patches. The habitat that will be protected and restored in Conservation Zone 7 is expected to be of very high quality in that it will restore the necessary vernally mesic habitat in the floodplain of the San Joaquin River, where appropriate soils are known to occur. In addition, the Implementation Office will create two new occurrences along this stretch of high-quality habitat.

Overall, the BDCP will provide a substantial net benefit to delta button celery primarily through the increase in available protected habitat and the creation of two occurrences. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the delta button celery.

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5.6.30 Delta Mudwort and Mason's Lilaeopsis

This section describes the adverse, beneficial, and net effects of the BDCP covered activities on the delta mudwort and Mason's lilaeopsis. The methods used to assess these effects are described in Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the delta mudwort and Mason's lilaeopsis includes areas within 10 feet on either side of the landward boundary of tidal perennial aquatic land cover type. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Because these species are so widely distributed throughout the Plan Area, the primary factor considered in assessing the quality of affected habitat for the delta mudwort and Mason's lilaeopsis is the presence of occurrences.

5.6.30.1 Adverse Effects

5.6.30.1.1 Permanent Habitat Loss, Conversion and Fragmentation

BDCP covered activities will result in the permanent loss of up to 130 acres[30] (2% of the habitat in the Plan Area) and the conversion of up to 10 acres (less than 0.1% of habitat in the Plan Area) of delta mudwort and Mason's lilaeopsis habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Covered activities resulting in permanent loss or conversion of delta mudwort and Mason's lilaeopsis habitat include water conveyance facility construction and operation (11% of all habitat loss) and tidal natural communities restoration (60% of all habitat loss) in Conservation Zones 1, 2, 3, 6, 8, and 11.

Conveyance Facility Construction

This activity will result in the permanent removal of up to 14 acres of delta mudwort and Mason's lilaeopsis habitat (Table 5.6-1b *Maximum Allowable Habitat Loss, Plants*) in Conservation Zones 3, 6, and 8. Six acres of modeled habitat will be removed in Conservation Zone 3 associated with the construction of the intake pumps along the Sacramento River. There are no occurrences of either species in this northern region of the Plan Area. In Conservation Zones 6 and 8, 4 and 6 acres of modeled habitat will be removed, respectively, where tunnel/pipeline construction passes over river sections. There are occurrences near the tunnel alignment in Conservation Zone 6, but none close enough to likely be affected by tunnel construction. In Conservation Zone 8, occurrences of both delta mudwort and Mason's lilaeopsis occur along the conveyance facility alignment. However, like most occurrences of both of these species, the overlap is with a portion of a much longer, linear occurrence that extends to the east; therefore, only a portion of the occurrence (and suitable habitat) is expected to be lost as a result of this covered activity.

Tidal Natural Communities Restoration

This activity will result in the permanent removal and conversion of approximately 72 acres and 6 acres, respectively, of delta mudwort and Mason's lilaeopsis habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). The majority of the delta mudwort habitat loss caused by tidal restoration, 72 acres, will occur in Conservation Zone 11 as a result of tidal inundation or flooding. The greatest portion of habitat conversion, 6 acres, will occur in Conservation Zone 11. Desiccation

[30] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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effects are attributed to tidal muting, a localized effect of tidal restoration. Tidal muting is described further under *Other Indirect Effects.*

5.6.30.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Section 5.2, *Methods*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions* in Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*), this activity will periodically inundate 55 acres of habitat for delta mudwort and Mason's lilaeopsis (1% of habitat in the Plan Area). Although this species is intertidal and tolerates inundation, the duration and frequency of increased inundation will determine the severity of the effect. Because this species is an annual and has a life history well suited for the intertidal environment, occurrences will likely be able to recolonize after a prolonged inundation event.

Floodplain Restoration

This activity will periodically inundate 12 acres of habitat for delta mudwort and Mason's lilaeopsis (0.1% of the modeled habitat in the Plan Area). This effect is expected to be within the natural range of inundation for these species and therefore is expected to have either no effect or possibly beneficial effects on Delta mudwort and Mason's lilaeopsis.

5.6.30.1.3 Construction-Related Effects

Construction-related effects on these species include short-term, temporary habitat loss and construction-related injury or mortality. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Short-Term)

Construction-related effects will temporarily disturb 13 acres of habitat for the delta mudwort and Mason's lilaeopsis (1% of the modeled habitat in the Plan Area) (Table 5.6-1, *Maximum Allowable Habitat Loss, Plants*). Temporary disturbance of delta mudwort and Mason's lilaeopsis habitat may remove individuals and partially disturb an occurrence. Temporarily disturbed areas will be restored as delta mudwort and Mason's lilaeopsis habitat within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to the delta mudwort and Mason's lilaeopsis plants by crushing individuals or disturbing the soil near occurrences; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

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Indirect Construction-Related Effects

Disturbance within 250 feet of construction activities could temporarily affect the use of 306acres (5%) of modeled habitat (Table 5.6-2b *Indirect Effects, Plants*). These construction activities will include those associated with tidal marsh restoration, tunnel/pipeline construction, Fremont Weir and Yolo Bypass improvements, and floodplain restoration levee construction. Indirect effects on plants primarily include dust collection on leaves and contamination by construction runoff. These effects are temporary and are not expected to last more than 1 year. These adverse effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.30.1.4 Effects of Ongoing Activities

The only ongoing adverse effects on delta mudwort and Mason's lilaeopsis are indirect effects of restoration or ongoing operations.

Other Indirect Effects

Water operations (CM1), tidal natural communities restoration (CM4), and sea-level rise are all expected to affect salinity throughout the Delta, most significantly in Suisun Marsh and the west Delta, less significantly in the central Delta, and with little to no anticipated effect in the north and south Deltas (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*) . In the LLT period, salinity is expected to increase by 10 to 50% in Suisun Bay and the west Delta in addition to what would have been expected without the BDCP. Conditions are expected to be only slightly more saline (10 to 20%) in the winter and spring, moderately more saline in the summer (20 to 30%) and significantly more saline (50%) between July and September. Resulting salinities are expected to be within the normal range of tolerance for these species, so no adverse effects are expected. The BDCP covered activities will have no other indirect effects on delta mudwort or Mason's lilaeopsis.

Tidal muting or damping is a reduction in tidal amplitude or tidal elevation range. Tidal range is the distance between the highest and lowest tidal elevation. A decrease in tidal range (i.e., the reduction in the distance between high and low tide elevation) means the average elevation of the low tide increases and the average elevation of the high tide decreases. The RMA and the DSM2 models predicted tidal muting to occur throughout the Delta as a result of tidal natural communities restoration and the related increase in wetted surface area caused by reintroducing tidal action into previously leveed areas. The effect is localized and therefore greatest in those areas nearest tidal restoration sites. For a more detailed description of the RMA and DSM2 modeling results, see Section C.A.5.2 in Attachment C.A of Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*.

Tidal muting is likely to result in a contraction of currently available delta mudwort and Mason's lilaeopsis habitat in those stretches of habitat nearest tidal restoration sites. In these areas, the average elevation of high tide will decrease, resulting in the desiccation and conversion of the habitat that exists at the higher elevations. The mean elevation of low tide will increase such that habitat at the lower elevations in the species' elevation range is likely to be flooded. The result is a potential loss of habitat in both the upper and lower elevation ranges of the species.

While the tidal muting effect will occur throughout the range of delta mudwort and Mason's lilaeopsis in the Plan Area, the timing of the effect will be widely dispersed both spatially and temporally. Tidal natural communities restoration will occur in Conservation Zones 1, 2, 4, 5, 6, 7, and 11 and will be constructed gradually, in phases, between years 1 and 40 of the permit term (see

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Table 6-1 in Chapter 6, *Plan Implementation*, for the implementation schedule). In addition to the widely dispersed nature of the effect, occurrences of delta mudwort and Mason's lilaeopsis are configured in long, linear stretches with patches of individuals scattered throughout; only a portion of any given occurrence will be exposed to the most severe, localized effect of habitat flooding or conversion. It is for these reasons that only a partial loss of occurrences is expected as a result of tidal natural communities restoration.

5.6.30.1.5 Impact of Take on Species

Delta mudwort and Mason's lilaeopsis are nearly endemic to the Plan Area. Thus, BDCP actions have the potential to affect the range-wide status of both species, as described below.

Delta Mudwort

According to the CNDDB, there are 62 occurrence records for delta mudwort in California, all of which are in the Plan Area. Twenty-two (35%) of the occurrences are located partly or entirely in Category 1, 2, and 3 existing open space (See Section 5.2, *Methods* for category definitions). Two occurrences are located in the tunnel/pipeline alignment for water conveyance facilities, and five occurrences are at locations that will be subject to the tidal damping effect of tidal habitat restoration. However, as mentioned above, these covered activities are expected to result in the permanent loss of only portions of known occurrences of delta mudwort. A small percentage of modeled habitat in the Plan Area will be lost (6%, or 360 of 6,074 acres) and a high proportion (32%) of occurrences in the Plan Area are currently protected, therefore take as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of delta mudwort.

Mason's Lilaeopsis

Currently, the CNDDB has 227 occurrence records for Mason's lilaeopsis in California. Of these occurrences, 200 (88%) are located in the Plan Area. Eighty-eight occurrences in the Plan Area (42%) are located partly or entirely in existing conservation or preservation areas. Eleven occurrences are located in the tunnel/pipeline alignment for water conveyance facilities, and 20 occurrences are at locations that will be subject to the tidal damping effect of tidal restoration. However, as mentioned in the sections above, these covered activities are expected to only partially remove these occurrences. A small percentage of modeled habitat in the Plan Area will be affected (6%, or 360/6,074 acres) and a high proportion (42%) of occurrences in the Plan Area are currently protected; therefore, take as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of Mason's lilaeopsis.

5.6.30.2 Beneficial Effects

The BDCP Implementation Office will protect and restore at least 2,018 acres and protect at least 75 additional acres of suitable delta mudwort and Mason's lilaeopsis habitat. The breaching of levees and the restoration of sinuous, high density, dendritic networks of tidal channels will provide most of the 2,018 restored acres. Restored sites are expected to significantly increase the amount of available, high-quality habitat. Restored habitat is expected to be of very high quality primarily because of the topographic improvements that will be made in restored areas and the proximity of restored habitat to existing occurrences that will be necessary to provide propagules and seed for colonization. All habitat for delta mudwort and Mason's lilaeopsis that is restored and protected is expected to provide for the expansion of existing occurrences as well as the colonization of new

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ones (see Chapter 3, *Conservation Strategy*, Section 3.3.5.40, *Delta Mudwort and Mason's Lilaeopsis* for a more complete description of the landscape and natural community objectives that will benefit these species).

5.6.30.3 Net Effects

Full implementation of the BDCP will result in at least a 2,018-acre (33%) increase in high-quality habitat for delta mudwort and Mason's lilaeopsis. In addition, implementation of the BDCP will result in the additional protection of 2,093 acres of delta mudwort and Mason's lilaeopsis habitat. With full implementation of the BDCP, protected land will increase from 1,507 acres to 3,517 acres, a 134 % percent increase in acres of protected land (Table 5.6-3b, *Net Effects, Plants*). The habitat that will be lost as a result of water conveyance facilities construction, tidal restoration, Fremont Weir and Yolo Bypass improvements, and floodplain restoration is either occupied or in proximity to an occurrence. For this reason, habitat to be removed is considered to be high quality. However, habitat removal is expected to be scattered throughout the Delta in small patches, and will only result in the partial loss of occurrences rather than permanent loss. The habitat that will be protected and restored is expected to be of equal or higher value than that which is expected to be lost. This is primarily because small patches of occupied and unoccupied habitat will be lost, but large patches of habitat will be protected and restored. The improvement in habitat quality is primarily due to the more natural tidal channel form that restored areas will have. In addition, all conserved habitat will be protected and managed to ensure species-specific biological goals and objectives are achieved in perpetuity.

Overall, the BDCP will provide a substantial net benefit to delta mudwort and Mason's lilaeopsis through the increase in available and protected habitat. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the delta mudwort and Mason's lilaeopsis.

5.6.31 Delta Tule Pea and Suisun Marsh Aster

This section describes the adverse, beneficial, and net effects of the BDCP covered activities on the Delta tule pea and Suisun Marsh aster. The methods used to assess these effects are described in Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the Delta tule pea and Suisun Marsh aster includes freshwater emergent wetland within the legal Delta and and tidal brackish emergent marsh with an elevation range of 7 to 10 feet in Suisun Marsh. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Because these species are so widely distributed throughout the Plan Area, the primary factor considered in assessing the quality of Delta tule pea and Suisun Marsh aster is the presence of occurrences.

5.6.31.1 Adverse Effects

5.6.31.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 1,132 acres[31] of habitat (19.5% of the habitat in the Plan Area) for Delta tule pea and Suisun Marsh aster (Table 5.6-1b, *Maximum*

[31] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance

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Allowable Habitat Loss, Plants). Covered activities resulting in adverse effects on Delta tule pea and Suisun Marsh aster include tidal natural communities restoration.

Tidal Natural Communities Restoration

This activity will result in the permanent removal or fragmentation of approximately 1,599 acres of modeled habitat (27% of modeled habitat) for the Delta tule pea and Suisun Marsh aster (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Habitat loss will occur in Conservation Zones 1, 4, 5, 6, and 11, with 98% (1,107 acres) of the affected acres occurring in Suisun Marsh in Conservation Zone 11.

The 1,599 acres of habitat loss is caused primarily by effect of tidal damping, a localized effect associated with tidal restoration. Tidal damping or tidal muting is a reduction in tidal range; the range of stage or elevation that the tide fluctuates between. This damping effect, as discussed for delta mudwort and Mason's lilaeopsis, will result in a contraction of available habitat. The mean elevation of high tide decreases while the mean elevation of low tide increases. The result is more frequent flooding at the lower elevation range of the species habitat and the possible desiccation of that habitat located at the upper elevations of the species' range.

The tidal damping effect will be dispersed spatially and temporally. Geographically, the location of restoration ares is dispersed among four ROAs and restoration will be ongoing throughout the first 40 years of the permit term. The result is many, small, localized tidal range effects. The widely distributed nature of Delta tule pea and Suisun Marsh aster occurrences in Suisun Marsh should provide great resiliency to this type of effect. It is for these reasons that the loss of Delta tule pea and Suisun Marsh aster occurrences are not expected.

Channel margin enhancement-related activities (CM6) could result in the direct mortality of any Delta tule pea and Suisun Marsh aster individual or patch of individuals present along affected channel margins. Enhancement of channel margins is expected to restore substrate supporting these species' habitats along the affected reach of channel margin. Construction effects such as dust production may disturb occupied Delta tule pea and Suisun Marsh aster habitats if present near enhancement sites. These effects will be minimized with implementation of delta tule pea and Suisun Marsh aster avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*. No permanent or temporary indirect effects are expected from channel margin enhancement.

5.6.31.1.2 Periodic Inundation

Floodplain restoration and flooding of Yolo Bypass are the only covered activities expected to result in periodic inundation of Delta tule pea and Suisun Marsh aster habitat.

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Section 5.2, *Methods*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions* in Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*), this activity will periodically inundate 3 acres of habitat for both Delta tule pea and Suisun Marsh aster. Operation of the Fremont Weir under *CM2 Yolo Bypass Fisheries Enhancement* is expected to increase the frequency and duration of inundation of tidal wetland habitats in the Yolo Bypass area.

monitoring to ensure that they do not exceed estimates.

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Three acres of Delta tule pea and Suisun Marsh aster modeled habitat overlap with the flooded Yolo Bypass areas in Conservation Zone 1 (there are currently no known occurrences of Delta tule pea or Suisun Marsh aster in the Yolo Bypass area). These habitat areas are currently inundated when flood flows overtop the Fremont Weir and the BDCP will increase the frequency and duration of the existing inundation pattern. All effects of Fremont Weir operations on Delta tule pea and Suisun Marsh aster modeled habitat will be incurred starting in the near-term evaluation period. These effects of increased periodic inundation are expected to be in the natural range of inundation for these species and, therefore, are expected to have either no effect or possible beneficial effects on Delta tule pea and Suisun Marsh aster.

Floodplain Restoration

Implementation of CM5 *Seasonally Inundated Floodplain*, by setting back levees and encouraging an expansion of flooded habitat, is expected to increase the frequency and duration of flooding in Conservation Zone 7. One acre of Delta tule pea and Suisun Marsh aster modeled habitat overlaps with floodplain areas in Conservation Zone 7 likely to be restored and therefore periodically inundated during the implementation of the BDCP. There are no known occurrences of the Delta tule pea or Suisun Marsh aster known in Conservation Zone 7. Increased inundation and floodplain scour associated with a more natural flood regime is expected to be well within the normal range of flood tolerance and disturbance for these two plant species.

5.6.31.1.3 Construction-Related Effects

Construction-related effects on this species include temporary habitat loss and indirect construction-related activities. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 33 acres (0.6%) of habitat respectively for Delta tule pea and Suisun Marsh aster (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Temporary disturbance of Delta tule pea and Suisun Marsh aster has potential to remove individuals and partially disturb occurrences. Temporarily disturbed areas will be restored as tidal freshwater emergent wetland and valley/foothill riparian habitat within one year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction will not likely cause injury or mortality to the Delta tule pea and Suisun Marsh aster; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of these species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Disturbance within 250 feet of construction activities could temporarily affect the use of 422 acres (7%) of modeled habitat (Table 5.6-2b, *Indirect Effects, Plants*). These construction activities will include tidal marsh restoration, water conveyance construction, and floodplain restoration levee

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construction. Indirect effects on plants primarily include dust collection on leaves and contamination by construction runoff. These effects are temporary and are not expected to last more than one year. These adverse effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.31.1.4 Effects of Ongoing Activities

The only ongoing adverse effects on Delta tule pea and Suisun Marsh aster are habitat enhancement and management, and indirect effects of restoration and sea-level rise. Ultimately, management actions are expected to result in net benefits for both species.

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for Delta tule pea and Suisun Marsh aster. Conducting these activities in tidal aquatic habitats, such as the control of nonnative vegetation, to maintain and improve habitat functions of restored tidal aquatic habitats could result in mortality of Delta tule pea and Suisun Marsh aster if they are present in work sites over the term of the BDCP. These potential effects will be minimized with the implementation of herbicide application BMPs and the implementation of the general and Delta tule pea and Suisun Marsh aster avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*. The range of habitat enhancement and management activities that will be implemented in restored Delta tule pea and Suisun Marsh aster habitat is expected to maintain and improve the functions of the habitat for these species over the term of the BDCP. No permanent direct effects or permanent or temporary indirect effects are expected for Delta tule pea and Suisun Marsh aster modeled habitat associated with habitat enhancement and management activities.

Other Indirect Effects

Water operations (CM1), tidal natural community restoration (CM4), and sea-level rise are all expected to affect salinity throughout the Delta, most significantly in the Suisun Bay and west Delta, less significantly in the central Delta, and with little to no anticipated effect in the north and south Deltas . In the LLT, salinity is expected to increase by 10 to 50% in Suisun Bay and west Delta in addition to what would have been expected without the BDCP. Conditions are expected to be only slightly more saline (10 to 20%) in the winter and spring, moderately more saline in the summer (20 to 30%) and significantly more saline (50%) between July and September. For more detail regarding the increase in salinity see Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*.

The change in salinity associated with BDCP implementation is expected to be within the range of salinity tolerance for Delta tule pea and Suisun Marsh aster. This is supported by the current range and distribution of the species. There are occurrences found as far west as the Carquinez Strait area between the cities of Rodeo and Martinez. Geographically speaking, these occurrences are much closer to the ocean and thus experience increased concentrations of salinity. It is for this reason that no further attempt was made to quantify the effect of salinity change on these species. While some change in spatial distribution is expected, changes to salinity overall are not expected to have a measurable effect on Delta tule pea and Suisun Marsh aster.

5.6.31.1.5 Impact of Take on Species

There are 129 known, extant CNDDB occurrences of Delta tule pea, of which 110 are within the Plan Area. There are 168 known, extant occurrences of Suisun Marsh aster, 155 of which are in the Plan

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Area. These two species are limited to the North Bay region of the San Francisco Bay, so the remained of occurrences are found in Napa and Petaluma marshes or along the edge of the bay. Of the 110 Delta tule pea Plan Area occurrences, 34 occur on protected lands, 40 of the 155 Suisun Marsh aster occurrences are protected (Table 5.6.4, *Covered Plant Species, Occurrences, Effects, and Conservation Requirements*).

The 1,599 acres of potential permanent loss will occur throughout the Plan Area in small, localized patches. The long, linear configuration of occurrences is ideal protection against a small, localized effect. While it is expected that some portion of the occurrence will be effected tidal range contraction, it is not expected that any one entire occurrence will be lost. However, because of the uncertainty surrounding the effect, it is possible that the implementation of the BDCP could adversely affect the species. Implementation of BDCP's beneficial effects, described below, are expected to offset potential adverse effects of habitat loss and contribute to the long-term survival and recovery of the species in the Plan Area.

5.6.31.2 Beneficial Effects

The BDCP Implementation Office will restore at least 3,092 acres (26%) of Delta tule pea and Suisun Marsh habitat and protect 38 additional acres of additional habitat (Table 5.6.3b, *Net Effects, Plants*). The breaching of levees and the restoration of sinuous, high density, dendritic networks of tidal channels provides the bulk of the 3,092 restored acres. Restored sites are expected to significantly increase the amount of available, high quality habitat. Restored habitat is expected to be of very high quality primarily because of the topographic improvements that will be made in restored areas and the proximity of restored habitat to existing occurrences that will be necessary to provide propagules and seed for colonization. All habitat for Delta tule pea and Suisun Marsh aster that is restored and protected is expected to provide for the expansion of existing occurrences as well as the colonization of new ones (see Chapter 3 *Conservation Strategy*, Section 3.3.5.40, *Delta Tule Pea and Suisun Marsh Aster* for a more complete description of the landscape and natural community objectives that will benefit these species). Tidal restoration and floodplain restoration are expected to produce a minimum of 16,970 acres of tidal brackish and freshwater emergent wetland, tidal mudflat, and valley/foothill riparian natural communities. Some small portion of this (likely a portion similar to that which currently exists) will provide suitable habitat for Delta tule pea and Suisun Marsh aster in Conservation Zones 1, 2, 5, 6, 7, and 11.

5.6.31.3 Net Effects

Full implementation of the BDCP will result in a net increase of 1,493 acres of high quality habitat (26%) and 2,058 acres (56%) of additional protected lands (Table 5.6-3b, *Net Effects, Plants*). The habitat that will be lost as a result of covered activities is either occupied or in proximity to an occurrence and is therefore considered high quality. However, habitat that will be removed is expected to be scattered throughout the Delta in small patches, and will only result in the partial loss of occurrences rather than permanent loss of entire occurrences. The habitat that will be protected and restored is expected to be of equal or higher value than that which is expected to be lost. This is primarily because small patches of occupied and unoccupied habitat will be lost, but large patches of habitat will be protected and restored. The improvement in habitat quality is primarily due to the more natural tidal channel form that restored areas will have. In addition, all conserved habitat will be protected and managed to ensure species-specific biological goals and objectives are achieved in perpetuity.

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Overall, the BDCP will provide a substantial net benefit to the Delta tule pea and Suisun Marsh aster through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of Delta tule pea and Suisun Marsh aster.

5.6.32 Side-Flowering Skullcap

This section describes the adverse, beneficial, and net effects of the BDCP covered activities on the side-flowering skullcap. The methods used to assess these effects are described in Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the side-flowering skullcap includes a subset of nine vegetation types in the valley/foothill riparian natural community. These vegetation types were mapped by Hickson and Keeler Wolf (2007) and could generally be described as cottonwood, alder, willow, and oak riparian forest. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the side-flowering skullcap, to the extent that information is available, include the size and density of riparian patches, connectivity between patches as well as with other natural communities, proximity to existing conservation lands, and the presence of recorded occurrences of side-flowering skullcap as well as other rare species.

5.6.32.1 Adverse Effects

5.6.32.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss and/or fragmentation of up to 34 acres[32] of habitat (1.4% of the habitat in the Plan Area) for the side-flowering skullcap (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Covered activities resulting in adverse effects on side-flowering skullcap include water conveyance facility construction, tidal habitat restoration, and floodplain restoration.

Conveyance Facility Construction

This activity will result in the permanent removal and/or fragmentation of approximately 1 acre (less than 0.1%) of side-flowering skullcap modeled habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Water conveyance construction in Conservation Zone 3 occurs in five distinct, but proximate locations along the Sacramento River west and south of Elk Grove. The acres of side-flowering skullcap modeled habitat that overlap with the effect footprint are composed of long, linear patches of riparian habitat along the Sacramento River. Due to the small patch size and fragmented nature, these acres of riparian habitat are considered to be of low to moderate value.

Tidal Natural Communities Restoration

This activity will result in the permanent removal and/or fragmentation of approximately 31 acres (1.2%) of side-flowering skullcap modeled habitat (Table 5.6-1b *Maximum Allowable Habitat Loss, Plants*). The tidal habitat restoration hypothetical footprint overlaps with 18 acres of side-flowering skullcap modeled habitat in the tidal restoration areas in the greater Cache Slough area, which spans

[32] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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both Conservation Zones 1 and 2. Side-flowering skullcap habitat in Conservation Zones 1 and 2 are considered to be of low to moderate quality as there is very little riparian habitat and no known occurrences of side-flowering skullcap. In Conservation Zones 4 and 5, there are 13 acres of effects on side-flowering skullcap modeled habitat. Habitat is considered to be of higher quality in this area, especially in Conservation Zone 4, as this is where the highest concentration of occurrences is found.

Floodplain Restoration

Based on the hypothetical floodplain restoration footprint, levee construction associated with floodplain restoration will result in the permanent removal of approximately1 acre of side-flowering skullcap modeled habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). These acres are located just south of the Interstate 205 bridge at Mossdale Landing and just west of Weatherbee Lake. The acres are characterized to be of low or moderate habitat quality due to the small and fragmented nature of the patch, the adjacent land use, which is often cultivated lands, and the lack of rare species occurrences (including that of the side-flowering skullcap) or adjacent protected land.

5.6.32.1.2 Periodic Inundation

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Section 5.2, *Methods*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions* in Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*), this activity will periodically inundate 9 acres (0.4%) of habitat for side-flowering skullcap. While these habitat areas are currently inundated during periods when flood flows overtop the Fremont Weir, Fremont Weir operations under the BDCP will increase the frequency and duration of inundation. Effects of increased periodic inundation are expected to be within the natural range of inundation for this species and operations of the Fremont Weir/Yolo Bypass are expected to have little to no effect on side-flowering skullcap.

Floodplain Restoration

This activity will periodically inundate 5 acres (0.2%) of side-flowering skullcap habitat. The inundation effect is expected to be within the natural range of inundation tolerance of this species and therefore is expected to have either no or possibly beneficial effects on side-flowering skullcap. Increasing the extent of floodplain area subject to overbank flows also will reestablish riparian woody vegetation and lead to the creation of additional side-flowering skullcap habitat.

5.6.32.1.3 Construction-Related Effects

Construction-related effects on this species include long-term, temporary habitat loss associated with the conveyance option and floodplain restoration, and temporary disturbance associated with indirect construction-related effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

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Temporary Habitat Loss (Long-Term)

Construction-related effects will temporarily disturb 29 acres (1.2%) of habitat for the side-flowering skullcap (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Dust, petroleum contamination or discharges, water runoff, and sedimentation associated with restoration-related ground-disturbing activities could temporarily affect habitat conditions on side-flowering skullcap modeled habitat near restoration sites. These effects will be minimized with the implementation of construction BMPs and the general and side-flowering skullcap avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.* Temporarily disturbed areas will be restored as valley/foothill riparian habitat within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction will not likely cause injury or mortality to the side-flowering skullcap; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Disturbance within 250 feet of construction activities could indirectly affect 176 acres (7.1%) of modeled valley/foothill riparian habitat (Table 5.6-2b, *Indirect Effects, Plants*). Indirect, construction-site effects such as dust, petroleum contamination or spills, water runoff, and sedimentation could temporarily affect habitat conditions. In addition, construction could introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for side-flowering skullcap. These adverse effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.32.1.4 Effects of Ongoing Activities

The only ongoing activities that will affect the species are habitat enhancement and management activities.

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for side-flowering skullcap. Habitat management and enhancement related activities in tidal aquatic habitats, such as the control of nonnative vegetation, to maintain and improve habitat functions of restored tidal aquatic habitats could result in the mortality of side-flowering skullcap individuals if present in work sites over the term of the BDCP. These potential effects will be minimized with the implementation of herbicide application BMPs and by the general and side-flowering skullcap avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*. The range of habitat management and enhancement activities that could be implemented in restored side-flowering skullcap habitat is expected to maintain and improve the functions of the habitat for side-flowering skullcap over the term of the BDCP.

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5.6.32.1.5 Impact of Take on Species

All 12 of the known, extant occurrences of side-flowering skullcap that occur in the state are found within the Plan Area (Table 5.6-4, *Covered Plant Species Occurrences, Effects, and Conservation Requirements*). In summer 2009, during botanical surveys of the Plan Area, side-flowering skullcap was found growing on rotting pilings and stumps in and along the channels of Snodgrass Slough, Lost Slough, and the Mokelumne River. The habitat is this area is considered of high quality for this species, as evidenced by the high density of occurrence concentrations. While occurrences in California are rare (California Native Plant Society 2011) and localized to the Plan Area, side-flowering skullcap is widely distributed throughout the United States and is known to be relatively common in the Midwest and on the East Coast.

The permanent loss of 34 acres (1.4%) and the periodic loss of 29 acres (1.2%) of modeled habitat is not expected to adversely affect the long-term survival and recovery of side-flowering skullcap for the following reasons.

- The majority of these effects do not occur in the area known to provide habitat for current, extant occurrences.
- Direct effects on individual plants can be avoided by relocation.
- The activities that are likely to affect the species also have some potential to provide a net benefit.

5.6.32.2 Beneficial Effects

Implementation of the BDCP will result in the protection of 104 acres (4% increase of protected lands) and the restoration of 696 acres (94% increase in total habitat) of side-flowering skullcap habitat (Table 5.6-3b, *Net Effects, Plants*). The restoration of 696 acres of the valley/foothill riparian community (CM7) is expected to provide conditions favorable for maintaining and increasing the distribution and abundance of side-flowering skullcap and its habitat in the Plan Area. Riparian restoration will be performed at the same time and in the same locations as the following conservation measures: floodplain restoration (CM5), tidal marsh restoration (CM4), and channel margin enhancement (CM6). Each type of restoration will contribute a number of riparian acres toward the 696-acre total. The restored habitat is expected to be of moderate to high quality for side-flowering skullcap in that it is likely to contain larger, better-connected patches where woody debris can collect and provide new habitat.

5.6.32.3 Net Effects

Full implementation of the BDCP will result in the permanent loss of 34 acres (1.4%) of low- to moderate-quality habitat. Tidal and riparian restoration will result in a 662-acre (27%) increase in available habitat and a 564-acre (112%) increase in protected lands (Table 5.6-3b, *Net Effects, Plants*). Restored and protected habitat is expected to be of moderate to high quality for the side-flowering skullcap. Tidal and riparian restoration in Conservation Zone 4 is expected to produce the highest quality side-flowering habitat because the greatest density of occurrences is found in the Cosumnes-Mokelumne ROA. Restoration in this area has the greatest potential to expand the range and distribution of the side-flowering skullcap in the Plan Area.

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Overall, the BDCP will provide a substantial net benefit to the side-flowering skullcap through the increase in available and protected habitat. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of side-flowered skullcap.

5.6.33 Slough Thistle

This section describes the adverse, beneficial, and net effects of the BDCP covered activities on the slough thistle. The methods used to assess these effects are described in Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the slough thistle includes all areas between the levees from the Interstate 205 Bridge near Mossdale Landing to the southern border of the Plan Area in Vernalis. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the slough thistle, to the extent that information is available, include patch size, level of fragmentation, adjacency to existing conservation lands, proximity to extant slough thistle occurrences, known ability to support a robust slough thistle population, hydrology, geomorphology, and patch connectivity.

5.6.33.1 Adverse Effects

5.6.33.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss and/or fragmentation of up to five acres[33] of habitat (0.3% of the habitat in the Plan Area) for the slough thistle (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Covered activities resulting in adverse effects on slough thistle include floodplain restoration.

Floodplain Restoration

Based on the hypothetical floodplain restoration footprint, levee construction associated with floodplain restoration will result in the permanent removal of approximately six acres of modeled slough thistle habitat (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). The six acres represents many small-acreage overlaps between the hypothetical floodplain restoration footprint, which occurs almost exclusively outside the levees of the San Joaquin, Old and Middle Rivers, and slough thistle modeled habitat, which occurs exclusively inside the levees of the San Joaquin River. The permanent effects associated with floodplain restoration will occur almost exclusively outside the levees, on cultivated lands. The effects on slough thistle habitat acreage occur in the location of large levee breaches, where flood flows will access newly restored floodplain.

All six of the affected acres in the levees are considered high-quality habitat. These acres occur in modeled habitat that is proximate to an existing occurrence of slough thistle as well as those of several other covered species, including riparian brush rabbit and riparian woodrat. The San Joaquin River has some of the highest quality river and floodplain habitat in the Plan Area in that it has some remnant geomorphological traits such as river meanders, riffles, and gravel bars. Conservation lands are interspersed throughout this reach of the San Joaquin River and just outside the Plan Area, to the south and east, is the San Joaquin River National Wildlife Refuge, which

[33] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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represents some of the largest, most intact riparian scrub and forest habitat in the greater Delta area.

5.6.33.1.2 Periodic Inundation

Floodplain restoration is the only covered activity expected to result in periodic inundation of slough thistle habitat.

Floodplain Restoration

This activity will periodically inundate six acres of habitat for the slough thistle (0.3% of the modeled habitat in the Plan Area). This periodic effect, however, is within the tolerance range of the slough thistle and is expected to increase the quality of the existing habitat by reestablishing scour processes that create and maintain this species' habitat.

5.6.33.1.3 Construction-Related Effects

Construction-related effects on this species include long-term, temporary habitat loss. Effects on the slough thistle are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Temporary Habitat Loss (Long-Term)

Construction-related effects will temporarily disturb 6 acres of habitat for the slough thistle (0.3% of the modeled habitat in the Plan Area) (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Temporarily affected areas will be restored as riparian habitat within 1 year following the completion of construction activities, but are not expected to mature to pre-BDCP conditions for several years or more, depending on the successional stage of the affected area. Because slough thistle depends on early successional riparian habitat, the habitat is expected to meet requirements for this species within the first few years after restoration construction in the temporarily disturbed area is completed.

Dust, petroleum contamination or spills, water runoff, and sedimentation associated with restoration-related ground-disturbing activities could temporarily affect habitat conditions on 25 acres of slough thistle habitat located near restoration sites in Conservation Zone 7. These potential effects will be minimized with the implementation of construction BMPs and the general and slough thistle avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.33.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

The operation and maintenance of BDCP facilities are not expected to adversely affect the slough thistle.

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for the slough thistle in restored floodplains in Conservation Zone 7. Activities such as the control of nonnative vegetation to

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maintain and improve habitat functions of existing floodplains or channel margin habitat, could result in mortality of slough thistle if plants are present in work sites or treated habitat over the term of the BDCP. This effect will be addressed with the implementation of herbicide application BMPs and the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*. The range of habitat management and enhancement activities that could be implemented in restored slough thistle habitat is expected to maintain and improve the functions of the habitat for slough thistle over the term of the BDCP.

Other Indirect Effects

The BDCP covered activities, including conservation measures, will have no other indirect effects on the slough thistle.

5.6.33.1.5 Impact of Take on Species

Slough thistle is endemic to the San Joaquin Valley and is known from 19 occurrences, two of which are in the Plan Area (Table 5.6.4, *Covered Plant Species Occurrences, Effects, and Conservation Requirements*). The remaining occurrences are from San Joaquin County in the north and in Kings and Kern Counties in the south (California Department of Fish and Game 2011). One of the Plan Area occurrences is located just north of the Interstate 205 bridge near Mossdale Landing and is considered possibly extirpated (California Department of Fish and Game 2011). The other occurrence is from a 1974 account and is described as being 1 mile north of the San Joaquin River Club on the San Joaquin River. If the occurrence north of the San Joaquin River Club is indeed extant, it is likely the northernmost occurrence with a considerably large gap separating it from those in the south.

The permanent loss of six acres of slough thistle habitat is not expected to adversely affect the long-term survival and recovery of this species. While those five acres are considered of high quality, they exist in small, fragmented patches along the linear extent of the riparian community between the levees of the San Joaquin River. Direct effects on slough thistle individuals will be avoided by the application of avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

Temporary and periodic effects on slough thistle habitat are not expected to have an adverse effect on modeled habitat. These effects, like those that are permanent, are in small, scattered patches, and will not be incurred upon individual plants or on the population. Preconstruction surveys will identify and avoid any and all individual plants. Because the remaining occurrence is within the levees, the levees will not be graded for the purposes of restoration. However, grading and levee setbacks in and around the remaining occurrence could have potential adverse effects on the occurrence by creating small- or moderate-scale hydrologic or geomorphologic changes to areas that supports the occurrence. Careful restoration siting and planning will be necessary to avoid any and all effects on the remaining slough thistle occurrence in the Plan Area. The small area of permanent and temporary effects on modeled habitat is not expected to adversely affect the species' long-term survival and recovery.

5.6.33.2 Beneficial Effects

The BDCP Implementation Office will restore at least 245 acres and protect 103 acres of seasonally inundated floodplain habitat, a portion of which is expected to be suitable habitat for the slough thistle. These acres will be adjacent to functioning floodplains rather than to agriculture. The

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restored acres will be part of the reserve system and will therefore be managed and enhanced to benefit the species. These protected acres will expand upon existing conservation lands outside the Plan Area, as is the case with the San Joaquin National Wildlife Refuge, as well as those within. In addition, the Implementing Office will protect or create two occurrences of slough thistle within the newly created floodplain on the San Joaquin River between Mossdale and Vernalis.

5.6.33.3 Net Effects

Full implementation of the BDCP will result in a 239-acre (13%) net increase in high-quality habitat for slough thistle and a 787-acre (185%) net increase in protected slough thistle habitat (Table 5.6-3b, *Net Effects, Plants*). While the effect on slough thistle habitat is relatively small, it does occur within high quality habitat. Newly restored and protected acres are expected to be of equal or greater value than those lost. In addition, two occurrences of Slough thistle will be protected or created. The creation of occurrences in the Plan Area will help maintain the northern-most border of the species range. Overall, the BDCP will provide a substantial net benefit to the slough thistle through the increase in both the availability and the protected status of habitat. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the slough thistle.

5.6.34 Soft Bird's Beak and Suisun Thistle

[***Note to Reviewers:*** *this section is in final development.*]

5.6.35 Vernal Pool Plants

This section describes the adverse, beneficial, and net effects of the BDCP covered activities on the vernal pool plant species, including the alkali milk-vetch, Boggs Lake hedge-hyssop, dwarf downingia, Heckard's peppergrass, legenere, and San Joaquin spearscale. The methods used to assess these effects are described in Section 5.3.5.2, *Effects Analysis for Wildlife and Plant Species*. The habitat model used to assess effects for the vernal pool plants consists of two GIS layers: vernal pool complex, which consists of vernal pools and uplands that display characteristic vernal pool and swale visual signatures that have not been significantly affected by agricultural or development practices; and degraded vernal pool complex, which consists of low-quality ephemeral habitat ranging from areas with vernal pool and swale visual signatures that display clear evidence of significant disturbance due to plowing, discing, or leveling to areas with clearly artificial basins such as shallow agricultural ditches, depressions in fallow fields, and areas of compacted soils in pastures. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the quality of affected habitat for the vernal pool plants, to the extent that information is available, include fragmentation, patch size, presence of other rare or covered species, disturbance, proximity to protected lands, and connectivity with adjacent patches.

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5.6.35.1 Adverse Effects

5.6.35.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

BDCP covered activities will result in the permanent loss of up to 88 acres[34] of vernal pool and 5 acres of degraded vernal pool habitat (1.1% and 0.2%, respectively, of the habitat in the Plan Area) for the vernal pool plants (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Covered activities resulting in adverse effects on vernal pool plants include transmission line construction and tidal natural communities restoration.

Transmission Line Construction

The transmission line alternative with the greatest effect will result in the permanent removal of approximately 0.8 acre, due to the loss of the grassland natural community, which includes suitable habitat for the vernal pool plants. Although the exact transmission line location is unknown, because the transmission line alignment will follow the tunnel/pipeline, the only potential location for overlap with vernal pool plants is in Conservation Zone 8. Vernal pool habitat in Conservation Zone 8 occurs in smaller, more fragmented patches; however, because these patches host occurrences of covered vernal pool plants, are intact, and occur in a mosaic of alkali seasonal wetland, the habitat is still considered or reasonably high quality.

Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration footprint, this activity will result in the permanent removal of all 88 acres of modeled vernal pool and 5 acres of degraded vernal pool (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*) in Conservation Zones 1 and 11. In Conservation Zone 1, the RMA2 modeled tidal restoration footprint overlaps with 41 acres of vernal pool complex and 5 acres of degraded vernal pool complex, all in upper reaches of Lindsey Slough in the Cache Slough ROA. In Conservation Zone 11, the RMA2 modeled tidal restoration footprint overlaps with 47 acres of vernal pool complex along the northern and northeastern border of Suisun Marsh, just to the west of entrance of Potrero Hills Landfill and then bordering the landfill along the northern and eastern border of the landfill, following the upland edge around Nurse and Montezuma Sloughs and Rack Creek.

In Conservation Zone 1, the modeled tidal restoration footprint overlaps with the edge of vernal pool complex on the eastern edge of what is known as the Jepson Prairie area and is in the Jepson Prairie Core Recovery Area. The Jepson Prairie area is a large expanse of reasonably intact vernal pool complex that spans the acres of vernal pool complex that are outside the Plan Area, between the eastern edge of Conservation Zone 1 and the northeastern edge of Conservation Zone 11. Although this area is crisscrossed with roads and the occasional home that disrupt hydrology, the vernal pool complex in this region is considered to be of very high quality due to the lack of development, large patch size, proximity to existing protected lands, and a high concentration of covered vernal pool plant and invertebrate occurrences.

In Conservation Zone 11, the vernal pool patches that overlap with the modeled tidal restoration footprint are also considered to be of very high quality. While the patches of vernal pool complex

[34] Affected acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual effects will be tracked through compliance monitoring to ensure that they do not exceed estimates.

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that border the northern and eastern edge of Suisun Marsh occur in smaller patches than those in Conservation Zone 1, they are connected to the Jepson Prairie area to the east, in the Jepson Prairie Core Recovery Area, overlap with covered vernal pool plant and invertebrate occurrences, and proximate to Suisun Marsh, a Category 1 open space (defined in Chapter 3, *Conservation Strategy*). Permanent loss and fragmentation of modeled vernal pool complex will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

The tidal restoration footprint in Conservation Zone 1 overlaps with one occurrence of Heckard's peppergrass in the Hass slough area. While presumed extant, this occurrence is from an 1891 Jepson Collection and has since not been verified (California Department of Fish and Game 2011). The area where the tidal restoration overlaps with the extent of the historical Heckard's peppergrass occurrence is in an area previously farmed for rice that never supported vernal pools (Gerlach pers.comm.). It is believed that dispersed Heckard's peppergrass seed was able to take hold here after the rice fields were abandoned and the area became emergent wetland (Gerlach pers. comm.). In Conservation Zone 11, the RMA2 modeled tidal restoration footprint partially overlaps with an extant San Joaquin spearscale occurrence near the entrance to Potrero Hill Landfill.

Although there is overlap of the hypothetical tidal restoration footprint with occurrences, it is very unlikely that restoration will affect either species because of the required surveys and avoidance protocols that will be implemented during the project-level planning phase of each tidal restoration project and then implemented during construction. However, due to uncertainty, take of one occurrence each of Heckard's peppergrass and San Joaquin spearscale is assumed (Table 5.6-1b, *Maximum Allowable Habitat Loss, Plants*). Because occurrence loss is based on hypothetical footprints and models rather than detailed project-level design, actual effects will be tracked through compliance monitoring to ensure that they do not exceed maximum allowable take. See the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures* for more detail.

5.6.35.1.2 Periodic Inundation

Yolo Bypass operations are the only covered activities expected to result in periodic inundation of vernal pool plant habitat.

Yolo Bypass Operations

Based on the estimated difference in average annual maximum inundation footprint between current and future conditions (Section 5.2, *Methods*, and Table 5.K-1, *Quantitative Effects Analysis Methods and Assumptions* in Appendix 5.K, *Effects on Natural Communities, Wildlife, and Plants*), this activity will periodically inundate 243 acres of vernal pool complex and 85 acres of degraded vernal pool complex modeled habitat for the vernal pool plants. Alkali milk-vetch, Heckard's peppergrass, and San Joaquin spearscale all have occurrences in Yolo Bypass. Vernal pool plants are adapted to inundation and are known to vary in abundance and density depending upon various factors, inundation depths being just one. The increased depth, duration, and frequency of inundation in Yolo will almost assuredly affect germination timing and will, in some years, prohibit germination altogether. While increased depth, duration, and frequency of inundation will have some effect on year-to-year abundance and distribution, it is unlikely to cause permanent loss of any existing vernal pool plants.

5.6.35.1.3 Construction-Related Effects

Construction-related effects on vernal pool plants include indirect, construction-related effects. Indirect effects are described below. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the quality of affected habitat or specific nature of the effect.

Construction-Related Injury or Mortality

Construction will not likely cause injury or mortality to the vernal pool plants; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Modeled habitat disturbance within 250 feet of construction activities could temporarily affect the habitat quality of 117acres of modeled vernal pool habitat (1.5% of total habitat in the Plan Area) and 18 acres of modeled degraded vernal pool habitat (0.2% of total habitat in the Plan Area) (Table 5.6-2b, *Indirect Effects, Plants*). These construction activities will include the collection of construction-related dust on plant leaves and the contamination of soil from construction site runoff. These adverse effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.35.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing operation and maintenance, and habitat enhancement and management activities are not expected to adversely affect the vernal pool plants. The BDCP covered activities will have no other indirect effects on the vernal pool plants.

5.6.35.1.5 Impact of Take on Species

Alkali Milk-Vetch

There are 55 known, extant occurrences of alkali milk-vetch range-wide, 27% (13 of 55) of which are in the Plan Area. The Plan Area includes portions of the Jepson Prairie and Altamont Hills core recovery areas for this species.

Of the 13 existing CNDDB recorded occurrences in the Plan Area, 54% (7 of 13) are on protected lands. Although none of the recorded occurrences overlap with areas anticipated for effect, areas in the 88 acres of vernal pool complex that could be affected by tidal natural communities restoration have potential to support this species. Take of alkali milk-vetch as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- The lack of known occurrences in areas expected to be affected.
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (1%, or 89 of 6,958 acres).
- The high percentage (54%) of occurrences in the Plan Area that are currently protected.

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- Implementation of avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

Legenere

There are 71 known, extant CNDDB occurrences of legenere range-wide, 8% (6 of 71) of which are in the Plan Area. The Plan Area includes portions of the Jepson Prairie core recovery area for this species.

All six existing CNDDB recorded occurrences in the Plan Area are on protected lands. No CNDDB recorded occurrences will be affected by BDCP covered activities. Take of legenere as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons:

- The low proportion of known occurrences in the Plan Area (6%)
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (1%, or 89 of 6,958 acres).
- The lack of known occurrences in areas that will be affected.
- The high percentage (100%) of occurrences in the Plan Area that are currently protected
- Implementation of avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

Heckard's Peppergrass

The Plan Area includes 29% (4 of 14) of the state-wide extant CNDDB occurrences, 3 of which (75%; 3 of 4) are on protected lands. One known Heckard's peppergrass occurrence has potential to be affected. This occurrence is from an 1891 Jepson collection, has not been field verified, and has the potential to occur in the vicinity of Lindsey Slough. While the loss of an occurrence is unlikely given the historical, unverified nature of the occurrence and the application of avoidance and minimization measures, it is assumed that implementation of the BDCP will result in the take of one occurrence of Heckard's peppergrass. As such, the conservation strategy requires protection of at least two currently unprotected occurrences of this species.

Take of Heckard's peppergrass as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- The high percentage (75%) of known occurrences in the Plan Area that are currently protected.
- The low percentage (29%) of occurrences in the Plan Area.
- The low percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (1%, or 89 of 6,958 acres).
- Implementation of avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

Furthermore, as described under *Beneficial Effects,* two additional occurrences will be protected with Plan implementation, resulting in 83% protection of occurrences in the Plan Area for this species.

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San Joaquin Spearscale

The Plan Area includes 14% (15 of 107) of the state-wide known, extant San Joaquin spearscale occurrences, two of which (13%; 2 of 15) are on protected lands. Based on the hypothetical footprint for tidal restoration, one known San Joaquin spearscale occurrence will be affected (CNDDB Occurrence #49). This occurrence is from alkaline grassland north of Potrero Hills, and consisted of approximately 900 plants in 2004 (California Department of Fish and Game 2011). While avoidance and minimization measures are likely to avoid effects on occupied habitat, the take of one occurrence is assumed. For this reason, two occurrences of unprotected San Joaquin spearscale will be protected.

Take of San Joaquin spearscale as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- The relatively small proportion of this species' range and the low percentage (14%) of occurrences in the Plan Area.
- The low percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (1%, or 89 of 6,958 acres).
- Implementation of avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures.*

Furthermore, as described under *Beneficial Effects,* two additional occurrences will be protected with Plan implementation, resulting in 26% protection of occurrences in the Plan Area for this species.

Boggs Lake Hedge-Hyssop

The Plan Area includes 1% (1 of 89) of the known state-wide Boggs Lake hedge-hyssop occurrences, and the one known occurrence in the Plan Area is on protected lands. Based on the hypothetical footprint for tidal restoration, no known Boggs Lake hedge-hyssop occurrences will be affected, although portions of the 89 acres of vernal pool complex to be affected may be occupied by this species.

Take of Boggs Lake hedge-hyssop as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.

- The small proportion of this species' range and known occurrences present in the Plan Area.
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (1%, or 89/6,958 acres)
- Implementation of avoidance and minimization measures described in Appendix 3.C, Avoidance and Minimization Measures.

Dwarf Downingia

The Plan Area includes 8% (10 of 122) of the known state-wide dwarf downingia occurrences, and the nine of the ten known occurrences in the Plan Area are on protected lands. Based on the hypothetical footprint for tidal restoration, no known dwarf downingia occurrences will be affected, although portions of the 89 acres of vernal pool complex to be affected may be occupied by this species.

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- Take of dwarf downingia as a result of BDCP implementation is not expected to adversely affect the long-term survival and recovery of this species for the following reasons.
- The small proportion of this species' range and known occurrences present in the Plan Area.
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (1%, or 89/6,958 acres).
- The 90% protection of the occurrences in the Plan Area.
- Implementation of avoidance and minimization measures described in Appendix 3.C, Avoidance and Minimization Measures.

5.6.35.2 Beneficial Effects

The BDCP Implementation Office will restore up to 89 acres of degraded vernal pool complex and protect 600 acres of vernal pool complex. In addition to restoration and protection of vernal pool habitat, the Implementation Office will protect two occurrences of alkali milk-vetch and San Joaquin spearscale and protect and/or create two occurrences of Heckard's peppergrass.

The covered vernal pool plant species will benefit from the vernal pool complex conservation strategy, which will involve protection and/or restoration of at least 600 acres of vernal pool complex, and additional restoration to achieve no net loss of vernal pool complex. The protection and restoration will be focused in core recovery areas for the vernal pool crustaceans as identified in the recovery plan (U.S. Fish and Wildlife Service 2005), and will increase the size and connectivity of vernal pool complex reserves in and adjacent to the Plan Area. The vernal pool reserve system will incorporate a range of inundation characteristics in order to accommodate the varying needs of all the covered vernal pool crustacean species. These core recovery areas where protection and restoration will be focused have the highest concentrations of covered vernal pool species occurrences in the Plan Area, and they also coincide with the BDCP conservation zones that include relatively large, unfragmented blocks of unprotected vernal pool complex adjacent to protected lands.

Additionally, the vernal pool complexes in the reserve system will be managed and enhanced to provide the appropriate ponding characteristics for supporting and sustaining the vernal pool plants, and to increase native biodiversity and reduce invasive plant species detrimental to vernal pool hydrology.

5.6.35.3 Net Effects

Full implementation of the BDCP will result in up to 153 acres (2%) of increase in high-quality habitat for vernal pool plants, and at least 1,009 acres of increase in protected vernal pool plant habitat (Table 5.6-3b, *Net Effects, Plants*). The habitat that will be permanently lost as a result of covered activities occurs primarily at the edges of the vernal pool complex in Conservation Zone 1 and 11 where tidal sloughs meet the surrounding upland. Protected vernal pool complex will include large patches of high quality, intact vernal pool complex in the Jepson Prairie, Collinsville or Altamont Core Recovery Areas. Newly preserved lands will expand upon, and create connectivity between, existing conservation lands. In addition, newly protected lands have potential to include undiscovered occurrences of vernal pool plants.

The Heckard's peppergrass occurrence that has potential to be affected by tidal restoration is an historical occurrence from 1891 that has not been field verified. The San Joaquin spearscale

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occurrence that has potential to be affected by tidal restoration is near the entrance to the Potrero Hills landfill. While there is some certainty that effects on these occurrences can be avoided, two occurrences of Heckard's peppergrass and San Joaquin spearscale will be protected (or created in the case of Heckard's peppergrass). In addition, two occurrences of alkali milk-vetch will be protected.

As described above, the proposed take for each of the covered vernal pool plants will not adversely affect the long-term survival or recovery of any of these species. The preservation of 600 acres of high-quality vernal pool plant habitat, and restoration of up to an additional 89 acres, that builds on the existing reserve system to create large, interconnected expanses of vernal pool complex focused in core vernal pool recovery areas, will contribute to the long-term survival and recovery vernal pool crustaceans consistent with the vernal pool recovery plan. The conservation strategy will focus on conserving known occurrences of vernal pool plants.

Overall, the BDCP will provide a substantial net benefit to the vernal pool plants primarily through habitat and occurrence protection. Protected areas will be managed and monitored to support the species. Therefore, the BDCP will contribute to the recovery of the vernal pool plants.

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5.6.36 Covered Species Tables

Table 5.6-1a. Maximum Allowable Habitat Loss, Wildlife

		Tidal Restoration (CM4)			Conveyance Option (CM1)			Fremont Weir/Yolo Bypass Improvements (CM2)			Floodplain Restoration (CM5)					
		Tidal Habitat[1] Restoration Effects (Inundation)	Tidal Habitat[2] Restoration Effects (Dessication)	Tidal Habitat Restoration Effects (Riparian)	Tunnel/Pipeline Effects6			Yolo Bypass Fisheries Enhancement [7, 10]	Yolo Bypass Fisheries Enhancement [10]	Yolo Bypass Operations	Floodplain Restoration Effects (Riparian)[10]	Floodplain Restoration Effects (Inundation) [11]	Floodplain Restoration Levee Construction Effects[11]	Floodplain Restoration Levee Construction Effects[11]	Nontidal Marsh Restoration [10]	Conservation Hatcheries Facilities[10]
Resource	Total Existing Habitat in Plan Area	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)[8]	Acres of Removed Modeled Habitat (Temporary)[9]	Acres of Removed Modeled Habitat (Long-Term Temporary)[14]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Modeled Habitat Affected (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Modeled Habitat Effects (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)
Mammals																
Riparian brush rabbit																
Riparian habitat	2,894	15	0	0	5	0	0	0	0	0	0	264	43	35	0	0
Grassland habitat	3,103	18	0	0	131	13	3	0	0	0	0	423	26	20	0	0
Riparian bush rabbit Total	5,997	33	0	0	137	142	3	0	0	0	0	686	69	54	0	0
Riparian woodrat Total	2,156	5	0	0	0	25	0	0	0	0	0	202	41	33	0	0
Salt marsh harvest mouse:																
Wetland habitat	14,265	3,479	82	0	0	0	0	0	0	0	0	0	0	0	0	0
Upland habitat	3,733	808	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt marsh harvest mouse Total	17,998	4,287	82	0	1	109	0	0	0	0	0	0	0	0	0	0
San Joaquin kit fox																
Breeding, foraging, and dispersal	5,217	0	0	0	163	10	151	0	0	0	0	0	0	0	0	0
San Joaquin kit fox Total	5,217	0	0	0	164	115	151	0	0	0	0	0	0	0	0	0
Suisun shrew																
Primary habitat	2,987	865	318	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary habitat	518	96	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suisun shrew Total	3,505	961	318	0	0	4	0	0	0	0	0	0	0	0	0	0
Townsend's big-eared bat[12]					0											
Primary foraging habitat	10,880	0[13]	0	0	18	15	0	145	58	74	0	99	9	7	0	0
Roosting and primary foraging habitat	7,493	0[13]	0	0	6	8	0	80	53	31	0	169	34	28	0	0
Secondary foraging habitat	768,626	0[13]	0	0[13]	4,096	1,520	1,600	1,028	600	2,878	3,991	9,698	2,227	1,287	0[13]	35
Townsend's big-eared bat Total	787,000	0	0	0	4,121	2,099	1,600	1,253	712	2,983	3,991	9,965	2,269	1,323	400	35
Birds																
California black rail					0											
Primary habitat	3,880	1,278	379	0	0	0	0	0	0	1	0	0	0	0	0	0
Secondary habitat	22,559	4,538	0	0	0	0	0	0	0	51	0	0	0	0	0	0
California black rail Total	26,439	5,816	379	0	0	10	0	0	0	51	0	0	0	0	0	0

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Resource	Total Existing Habitat in Plan Area	Tidal Restoration (CM4)			Conveyance Option (CM1)			Fremont Weir/Yolo Bypass Improvements (CM2)			Floodplain Restoration (CM5)				Nontidal Marsh Restoration[10]	Conservation Hatcheries Facilities[10]
		Tidal Habitat[1] Restoration Effects (Inundation)	Tidal Habitat[2] Restoration Effects (Dessication)	Tidal Habitat Restoration Effects (Riparian)	Tunnel/Pipeline Effects6			Yolo Bypass Fisheries Enhancement[7, 10]	Yolo Bypass Fisheries Enhancement[10]	Yolo Bypass Operations	Floodplain Restoration Effects (Riparian)[10]	Floodplain Restoration Effects (Inundation)[11]	Floodplain Restoration Levee Construction Effects[11]	Floodplain Restoration Levee Construction Effects[11]		
		Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)[8]	Acres of Removed Modeled Habitat (Temporary)[9]	Acres of Removed Modeled Habitat (Long-Term Temporary)[14]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Modeled Habitat Affected (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Modeled Habitat Effects (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)
California clapper rail																
Primary habitat	154	59	11	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary habitat	6,443	889	0	0	0	0	0	0	0	0	0	0	0	0	0	0
California clapper rail Total	6,597	948	11	0	0	0	0	0	0	0	0	0	0	0	0	0
California least tern Total	86,231	0	27	0	28	120	0	7	0	290	0	39	2	5	0	0
Greater sandhill crane																
Primary use area	4,556	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Secondary use area	191,531	4,794	0	0	1,714	937	727	0	0	6	0	0	0	0	0	0
Greater sandhill crane Total	196,087	4,794	0	0	1,720	1,466	727	0	0	6	0	0	0	0	0	0
Least Bell's vireo Total	14,731	778	0	0	14	35	0	212	100	97	0	147	28	21	0	0
Suisun song sparrow																
Primary habitat	3,431	977	324	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary habitat	22,248	5,010	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suisun song sparrow Total	25,678	5,987	324	0	0	10	0	0	0	0	0	0	0	0	0	0
Swainson's hawk																
Foraging habitat	435,087	26,432	0	971	2,928	1,042	954	877	480	1,688	3,991	7,332	1,688	955	400	35
Nesting habitat	10,149	407	0	0	12	13	0	210	100	38	0	188	38	31	0	0
Swainson's hawk Total	445,235	26,839	0	971	2,946	1,606	954	1,087	579	1,726	3,991	7,521	1,726	986	400	35
Tricolored blackbird:																
Breeding habitat-ag foraging	68,830	3,141	0	7	460	44	47	448	296	390	3,991	1,427	390	213	0	0
Breeding habitat-foraging	59,660	2,276	0	11	181	17	151	154	203	47	0	355	47	30	200	35
Breeding habitat-nesting	1,472	53	0	0	7	0	0	11	28	4	0	30	4	2	0	0
Nonbreeding hab-foraging ag	293,846	17,934	0	953	2,711	817	987	66	0	1,387	0	6,008	1,387	794	200	0
Nonbreeding hab-roosting	29,911	4,588	0	0	6	6	0	8	0	1	0	30	1	1	0	0
Nonbreeding habitat-foraging	37,719	2,025	0	0	20	56	0	169	0	3	0	158	3	3	0	0
Tricolored blackbird Total	491,438	30,017	0	971	3,391	1,497	1,186	856	527	1,833	3,991	8,009	1,833	1,043	400	35
Western burrowing owl																
High-value habitat	67,906	2,856	0	0	201	73	151	55	148	50	0	513	50	32	0	35
Moderate-value habitat	58,790	3,859	0	11	50	68	0	687	2	70	0	159	70	33	0	0
Low-value habitat	294,238	17,340	0	960	2,521	756	659	115	329	1,469	3,991	6,555	1,469	848	400	0
Western burrowing owl Total	420,935	24,056	0	971	2,778	1,423	810	857	479	1,589	3,991	7,226	1,589	914	400	35

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		Tidal Habitat[1] Restoration Effects (Inundation)	Tidal Habitat[2] Restoration Effects (Dessication)	Tidal Habitat Restoration Effects (Riparian)	Tunnel/Pipeline Effects6			Yolo Bypass Fisheries Enhancement [7, 10]	Yolo Bypass Fisheries Enhancement [10]	Yolo Bypass Operations	Floodplain Restoration Effects (Riparian)[10]	Floodplain Restoration Effects (Inundation) [11]	Floodplain Restoration Levee Construction Effects[11]	Floodplain Restoration Levee Construction Effects[11]	Nontidal Marsh Restoration [10]	Conservation Hatcheries Facilities[10]
Resource	**Total Existing Habitat in Plan Area**	**Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]**	**Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]**	**Acres of Removed Modeled Habitat (Permanent)**	**Acres of Removed Modeled Habitat (Permanent)[8]**	**Acres of Removed Modeled Habitat (Temporary)[9]**	**Acres of Removed Modeled Habitat (Long-Term Temporary)[14]**	**Acres of Removed Modeled Habitat (Permanent)**	**Acres of Removed Modeled Habitat (Temporary)**	**Acres of Modeled Habitat Affected (Periodic)**	**Acres of Removed Modeled Habitat (Permanent)**	**Acres of Modeled Habitat Effects (Periodic)**	**Acres of Removed Modeled Habitat (Permanent)**	**Acres of Removed Modeled Habitat (Temporary)**	**Acres of Removed Modeled Habitat (Permanent)**	**Acres of Removed Modeled Habitat (Permanent)**
Western Yellow-billed Cuckoo																
Breeding habitat	4,735	271	0	0	0	0	0	205	88	11	0	28	11	9	0	0
Migratory habitat	7,868	346	0	0	8	9	0	6	12	10	0	114	10	7	0	0
Western yellow-billed cuckoo Total	12,603	617	0	0	8	33	0	212	100	21	0	141	21	17	0	0
White-tailed kite																
Breeding habitat	14,315	560	0	0	13	17	0	211	100	42	0	229	42	33	0	0
Foraging habitat	494,710	33,273	0	971	2,937	1,042	954	892	492	1,697	3,991	7,423	1,697	960	400	35
White-tailed kite Total	509,026	33,833	0	971	2,956	1,585	954	1,103	591	1,739	3,991	7,653	1,739	993	400	35
Yellow-breasted chat																
Primary nesting and migratory habitat	7,384	306	0	0	8	3	0	5	4	23	0	91	23	15	0	0
Secondary nesting and migratory habitat	5,530	447	0	0	5	7	0	3	0	5	0	56	5	6	0	0
Suisun Marsh/Upper Yolo Bypass nest and migratory habitat	1,849	26	0	0	0	0	0	205	95	0	0	0	0	0	0	0
Yellow-breasted chat Total	14,764	779	0	0	14	35	0	212	100	28	0	147	28	21	0	0
Reptiles																
Giant garter snake																
Aquatic breeding, foraging and movement	29,430	742	0	0	23	19	0	43	17	30	0	44	30	18	0	0
Upland-high	18,377	814	0	0	34	45	1	81	3	0	0	0	0	0	0	0
Upland-moderate	40,192	2,702	0	0	206	86	15	82	20	38	0	672	38	31	0	35
Upland-low	36,709	1,429	0	0	190	98	20	11	0	108	0	987	108	62	0	0
Giant garter snake Total	124,708	5,687	0	0	459	780	36	218	39	176	0	1,703	176	111	0	35
Western pond turtle																
Aquatic habitat[10]	81,509	5,747	0	0	23	70	0	45	2	32	0	75	32	21	0	0
Dispersal habitat	619,335	39,604	0	961	3,945	1,367	1,514	958	123	2,217	3,991	9,481	2,217	1,283	400	35
Upland nesting and overwintering	46,089	1,613	0	10	135	49	86	225	3	20	0	410	20	19	0	0
Western pond turtle Total	746,934	46,965	0	971	4,110	2,043	1,600	1,228	128	2,269	3,991	9,965	2,269	1,323	400	35
Amphibians																
California red-legged frog																
Aquatic habitat (miles) California red-legged frog	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Admin Draft

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		Tidal Habitat[1] Restoration Effects (Inundation)	Tidal Habitat[2] Restoration Effects (Dessication)	Tidal Habitat Restoration Effects (Riparian)	Tunnel/Pipeline Effects6			Yolo Bypass Fisheries Enhancement [7, 10]	Yolo Bypass Fisheries Enhancement [10]	Yolo Bypass Operations	Floodplain Restoration Effects (Riparian)[10]	Floodplain Restoration Effects (Inundation) [11]	Floodplain Restoration Levee Construction Effects[11]	Floodplain Restoration Levee Construction Effects[11]	Nontidal Marsh Restoration [10]	Conservation Hatcheries Facilities[10]
Resource	Total Existing Habitat in Plan Area	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)[8]	Acres of Removed Modeled Habitat (Temporary)[9]	Acres of Removed Modeled Habitat (Long-Term Temporary)[14]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Modeled Habitat Affected (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Modeled Habitat Effects (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)
Aquatic habitat	149	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Upland cover and dispersal habitat	9,055	0	0	0	168	10	151	0	0	0	0	0	0	0	0	0
Dispersal habitat	19,644	0	0	0	663	5	480	0	0	0	0	0	0	0	0	0
California red-legged frog Total	28,848	0	0	0	838	572	631	0	0	0	0	0	0	0	0	0
California tiger salamander																
Aquatic breeding habitat	7,332	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terrestrial cover and aestivation habitat	28,895	239	0	0	161	10	151	42	0	0	0	0	0	0	0	35
California tiger salamander Total	36,226	280	0	0	162	115	151	42	0	0	0	0	0	0	0	35
Western spadefoot																
Aquatic breeding habitat (miles) western spadefoot	78	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aquatic breeding habitat	7,335	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terrestrial cover and aestivation habitat	29,546	317	0	0	161	10	151	42	0	0	0	0	0	0	0	35
Western spadefoot Total	36,881	359	0	0	162	115	151	42	0	0	0	0	0	0	0	35
Invertebrates																
Valley elderberry longhorn beetle																
Riparian vegetation	17,796	778	0	0	24	22	0	213	100	43	0	265	43	35	0	0
Non-riparian channels and grasslands	16,485	431	0	0	105	38	0	52	147	8	0	286	8	13	0	0
Valley elderberry longhorn beetle Total	34,281	1,209	0	0	130	190	0	265	246	51	0	552	51	48	0	0
California linderiella																
High quality habitat	7,770	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low quality habitat	2,631	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
California linderiella Total					0	0	0				0	0	0	0	0	0
Conservancy fairy shrimp																
High quality habitat	7,770	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low quality habitat	2,631	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conservancy fairy shrimp Total					0	0	0				0	0	0	0	0	0
Longhorn fairy shrimp																
High quality habitat	7,770	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low quality habitat	2,631	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Resource	Total Existing Habitat in Plan Area	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[1]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)[8]	Acres of Removed Modeled Habitat (Temporary)[9]	Acres of Removed Modeled Habitat (Long-Term Temporary)[14]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Modeled Habitat Affected (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Modeled Habitat Effects (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)
Longhorn fairy shrimp Total					0	0	0				0	0	0	0	0	0
Mid valley fairy shrimp																
High quality habitat	7,770	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low quality habitat	2,631	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mid valley fairy shrimp Total					0	0	0				0	0	0	0	0	0
Vernal pool fairy shrimp																
High quality habitat	7,770	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low quality habitat	2,631	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vernal pool fairy shrimp Total					0	0	0				0	0	0	0	0	0
Vernal pool tadpole shrimp																
High quality habitat	7,770	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low quality habitat	2,631	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vernal pool tadpole shrimp Total					0	0	0				0	0	0	0	0	0

[1] Inundation: Tidal flooding of existing wetland habitat as a result of tidal restoration actions. See Table 5.K-3 for a description of relevant assumptions.

[2] Desiccation: The drying out of wetland habitat as a result of tidal dampening (the downward shift in tidal range), the result of which is a conversion from a tidal brackish or freshwater emergent wetland community to the grassland community. See Table 5.K-3 for a description of relevant assumptions.

[3] Removed/Converted: Removed: habitat is no longer usable for any life stage of the species. Converted: change from one habitat type (e.g., primary) to another habitat type (e.g., secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g.., primary or secondary) to another, lesser function. See Table 5.K-2 for a description of relevant assumptions.

[4] Borrow/Spoil Area: Borrow: a location from where construction material, such as sand or clay, will be taken. Spoil:area where construction by-prodcuts, such as removed earth, will be placed and stored. Borrow/spoil: an area that will originally be used for borrow and then later be used for spoil.

[5] Calculation of effects based on hypothetical restoration designs include only areas modeled by RMA that were classified as either 'Below MLLW' or 'MLLW to MHHW' except where noted.

[6] The impact numbers do not incorporate the impacts associated with temporary Transmission Line corridors used during construction as alignments were not available at the time of the analysis.

[7] Disturbance effect acreages reflect those associated with Fremont Weir improvements, Putah Creek realignment activities, Lisbon Weir and fish crossing improvements, and Sacramento Weir improvements.

[8] Features in this category include the following conveyance-related facilities: Forebay, Intake Facilities, Permanent Access Roads, and Shaft Locations. Totals under Conveyance Option (CM1) include Transmission Line impacts.

[9] Features in this category include the following conveyance covered activities: Barge Unloading Facility, Control Structure Work Area, Intake Road Work Area, Intake Work Area, Pipeline, Pipeline Work Area, Road Work Area, Safe Haven Work Area, Temporary Access Road Work Area, Tunnel Work Area. Totals under Conveyance Option (CM1) include Transmission Line impacts.

[10] Based on restoration design assumptions described in Appendix E Habitat Restoration and effects analysis assumptoins detailed in Table 5.K-2.

[11] Calculation of effects based on hypothetical floodplain restoration designs.

[12] Foraging habitat will remain suitable for Townsend's big-eared bat with tidal inundation or desiccation.

[13] Effect is conversion from one habitat type to another of equal or better habitat value, so no loss of habitat is incurred.

[14] Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Appendix K Table 5.K.7. Wildlife Modeled Habitat Loss and Conversion by Covered Activity.

Note: The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use—Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

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Table 5.6-1a. Maximum Allowable Habitat Loss, Wildlife (Continued)—Total Effects

Resource	Total Existing Habitat in Plan Area	Total Effects			
		Total Acres of Modeled Habitat Removed (Permanent)	Total Acres of Modeled Habitat Removed (Temporary)	Total Habitat Modeled Removed (Long-Term Temporary)	Total Acres of Modeled Habitat Affected (Periodically)
Mammals					
Riparian brush rabbit					
Riparian habitat	2,894	63	165	0	264
Grassland habitat	3,103	175	32	3	423
Riparian bush rabbit Total	5,997	238	197	3	686
Riparian woodrat Total	2,156	46	33	0	202
Salt marsh harvest mouse:					
Wetland habitat	14,265	3,562	109	0	0
Upland habitat	3,733	808	0	0	0
Salt marsh harvest mouse Total	17,998	4,287	109	0	0
San Joaquin kit fox					
Breeding, foraging, and dispersal	5,217	163	120	151	0
San Joaquin kit fox Total	5,217	163	120	151	0
Suisun shrew					
Primary habitat	2,987	1,183	0	0	0
Secondary habitat	518	96	0	0	0
Suisun shrew Total	3,505	1,279	0	0	0
Townsend's big-eared bat[12]					
Primary foraging habitat	10,880	172	637	0	173
Roosting and primary foraging habitat	7,493	237	90	0	200
Secondary foraging habitat	768,626	12,747	3,407	1,600	12,575
Townsend's big-eared bat Total	787,000	13,156	4,134	1,600	12,948
Birds					**0**
California black rail					
Primary habitat	3,880	1,657	0	0	1
Secondary habitat	22,559	4,538	0	0	51
California black rail Total	26,439	6,195	0	0	51
California clapper rail					
Primary habitat	154	70	0	0	0
Secondary habitat	6,443	889	0	0	0
California clapper rail Total	6,597	959	0	0	0
California least tern Total	86,231	65	125	0	330
Greater sandhill crane					
Primary use area	4,556	0	4	0	0
Secondary use area	191,531	6,507	937	727	6

Resource	Total Existing Habitat in Plan Area	Total Effects			
		Total Acres of Modeled Habitat Removed (Permanent)	Total Acres of Modeled Habitat Removed (Temporary)	Total Habitat Modeled Removed (Long-Term Temporary)	Total Acres of Modeled Habitat Affected (Periodically)
Greater sandhill crane Total	196,087	6,507	940	727	6
Least Bell's vireo Total	14,731	1,032	131	0	244
Suisun song sparrow					
Primary habitat	3,431	1,301	0	0	0
Secondary habitat	22,248	5,010	0	0	0
Suisun song sparrow Total	25,678	6,311	0	0	0
Swainson’s hawk					
Foraging habitat	435,087	37,323	2,476	954	9,021
Nesting habitat	10,149	666	144	0	226
Swainson’s hawk Total	445,235	37,988	2,621	954	9,247
Tricolored blackbird:					
Breeding habitat-ag foraging	68,830	8,436	552	47	1,817
Breeding habitat-foraging	59,660	2,904	250	151	402
Breeding habitat-nesting	1,472	76	30	0	35
Nonbreeding hab-foraging ag	293,846	23,256	1,611	987	7,395
Nonbreeding hab-roosting	29,911	4,604	7	0	31
Nonbreeding habitat-foraging	37,719	2,217	59	0	162
Tricolored blackbird Total	491,438	41,487	2,510	1,186	9,841
Western burrowing owl					
High-value habitat	67,906	3,203	253	151	564
Moderate-value habitat	58,790	4,677	103	0	228
Low-value habitat	294,238	26,796	1,934	659	8,024
Western burrowing owl Total	420,935	34,676	2,290	810	8,816
Western Yellow-billed Cuckoo					
Breeding habitat	4,735	488	97	0	39
Migratory habitat	7,868	371	28	0	124
Western yellow-billed cuckoo Total	12,603	859	125	0	163
White-tailed kite					
Breeding habitat	14,315	832	676	0	271
Foraging habitat	494,710	44,196	2,494	954	9,120
White-tailed kite Total	509,026	45,028	3,170	954	9,391
Yellow-breasted chat					
Primary nesting and migratory habitat	7,384	342	23	0	115
Secondary nesting and migratory habitat	5,530	460	13	0	60
Suisun Marsh/Upper Yolo Bypass nest and migratory habitat	1,849	230	95	0	0
Yellow-breasted chat Total	14,764	1,032	131	0	175

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Resource	Total Existing Habitat in Plan Area	Total Effects: Total Acres of Modeled Habitat Removed (Permanent)	Total Acres of Modeled Habitat Removed (Temporary)	Total Habitat Modeled Removed (Long-Term Temporary)	Total Acres of Modeled Habitat Affected (Periodically)
Reptiles					
Giant garter snake					
Aquatic breeding, foraging and movement	29,430	838	54	0	74
Upland-high	18,377	935	47	1	0
Upland-moderate	40,192	3,063	136	15	710
Upland-low	36,709	1,738	160	20	1,095
Giant garter snake Total	124,708	6,574	398	36	1,879
Western pond turtle					
Aquatic habitat[10]	81,509	5,847	94	0	107
Dispersal habitat	619,335	52,112	2,773	1,514	11,698
Upland nesting and overwintering	46,089	2,003	627	86	430
Western pond turtle Total	746,934	59,968	3,494	1,600	12,235
Amphibians					
California red-legged frog					
Aquatic habitat (miles) California red-legged frog	29	0	0	0	0
Aquatic habitat	149	1	0	0	0
Upland cover and dispersal habitat	9,055	168	10	151	0
Dispersal habitat	19,644	663	5	480	0
California red-legged frog Total	28,848	832	15	631	0
California tiger salamander					
Aquatic breeding habitat	7,332	42	0	0	0
Terrestrial cover and aestivation habitat	28,895	477	10	151	0
California tiger salamander Total	36,226	519	10	151	0
Western spadefoot					
Aquatic breeding habitat (miles) western spadefoot	78	2	0	0	0
Aquatic breeding habitat	7,335	42	0	0	0
Terrestrial cover and aestivation habitat	29,546	556	10	151	0
Western spadefoot Total	36,881	598	10	151	0
Invertebrates					
Valley elderberry longhorn beetle					
Riparian vegetation	17,796	1,058	157	0	308
Non-riparian channels and grasslands	16,485	596	198	0	295
Valley elderberry longhorn beetle Total	34,281	1,654	355	0	603
California linderiella					
High quality habitat	7,770	42	0	0	0
Low quality habitat	2,631	52	0	0	0

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Note to Reader: This is a revised working draft prepared by the BDCP consultants. This document is currently undergoing review by the Department of Water Resources with input from the Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and U.S. Bureau of Reclamation and does not necessarily reflect the position of the state or federal agencies. It is expected to go through several more revisions prior to being released for formal public review and comment in 2012. All members of the public will have an opportunity to provide comments on the public draft of a revised version of this document during the formal public review and comment period. Responses will be prepared only on comments submitted in the formal public review and comment period.

Resource	Total Existing Habitat in Plan Area	Total Effects			
		Total Acres of Modeled Habitat Removed (Permanent)	**Total Acres of Modeled Habitat Removed (Temporary)**	**Total Habitat Modeled Removed (Long-Term Temporary)**	**Total Acres of Modeled Habitat Affected (Periodically)**
California linderiella Total		94	0	0	0
Conservancy fairy shrimp					
High quality habitat	7,770	42	0	0	0
Low quality habitat	2,631	52	0	0	0
Conservancy fairy shrimp Total		94	0	0	0
Longhorn fairy shrimp					
High quality habitat	7,770	42	0	0	0
Low quality habitat	2,631	52	0	0	0
Longhorn fairy shrimp Total		94	0	0	0
Mid valley fairy shrimp					
High quality habitat	7,770	42	0	0	0
Low quality habitat	2,631	52	0	0	0
Mid valley fairy shrimp Total		94	0	0	0
Vernal pool fairy shrimp					
High quality habitat	7,770	42	0	0	0
Low quality habitat	2,631	52	0	0	0
Vernal pool fairy shrimp Total		94	0	0	0
Vernal pool tadpole shrimp					
High quality habitat	7,770	42	0	0	0
Low quality habitat	2,631	52	0	0	0
Vernal pool tadpole shrimp Total		94	0	0	0

[1] Inundation: Tidal flooding of existing wetland habitat as a result of tidal restoration actions. See Table 5.K-3 for a description of relevant assumptions.

[2] Desiccation: The drying out of wetland habitat as a result of tidal dampening (the downward shift in tidal range), the result of which is a conversion from a tidal brackish or freshwater emergent wetland community to the grassland community. See Table 5.K-3 for a description of relevant assumptions.

[3] Removed/Converted: Removed: habitat is no longer usable for any life stage of the species. Converted: change from one habitat type (e.g., primary) to another habitat type (e.g., secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g.., primary or secondary) to another, lesser function. See Table 5.K-2 for a description of relevant assumptions.

[4] Borrow/Spoil Area: Borrow: a location from where construction material, such as sand or clay, will be taken. Spoil:area where construction by-prodcuts, such as removed earth, will be placed and stored. Borrow/spoil: an area that will originally be used for borrow and then later be used for spoil.

[5] Calculation of effects based on hypothetical restoration designs include only areas modeled by RMA that were classified as either 'Below MLLW' or 'MLLW to MHHW' except where noted.

[6] The impact numbers do not incorporate the impacts associated with temporary Transmission Line corridors used during construction as alignments were not available at the time of the analysis.

[7] Disturbance effect acreages reflect those associated with Fremont Weir improvements, Putah Creek realignment activities, Lisbon Weir and fish crossing improvements, and Sacramento Weir improvements.

[8] Features in this category include the following conveyance-related facilities: Forebay, Intake Facilities, Permanent Access Roads, and Shaft Locations. Totals under Conveyance Option (CM1) include Transmission Line impacts.

[9] Features in this category include the following conveyance covered activities: Barge Unloading Facility, Control Structure Work Area, Intake Road Work Area, Intake Work Area, Pipeline, Pipeline Work Area, Road Work Area, Safe Haven Work Area, Temporary Access Road Work Area, Tunnel Work Area. Totals under Conveyance Option (CM1) include Transmission Line impacts.

[10] Based on restoration design assumptions described in Appendix E Habitat Restoration and effects analysis assumptoins detailed in Table 5.K-2.

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Resource	Total Existing Habitat in Plan Area	Total Effects			
		Total Acres of Modeled Habitat Removed (Permanent)	**Total Acres of Modeled Habitat Removed (Temporary)**	**Total Habitat Modeled Removed (Long-Term Temporary)**	**Total Acres of Modeled Habitat Affected (Periodically)**

[11] Calculation of effects based on hypothetical floodplain restoration designs.

[12] Foraging habitat will remain suitable for Townsend's big-eared bat with tidal inundation or desiccation.

[13] Effect is conversion from one habitat type to another of equal or better habitat value, so no loss of habitat is incurred.

[14] Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Appendix K Table 5.K.7. Wildlife Modeled Habitat Loss and Conversion by Covered Activity.

Note: The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use—Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

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Table 5.6.1-b. Maximum Allowable Habitat Loss, Plants

		Tidal Restoration (CM4)			Conveyance Option (CM1)			Fremont Weir/Yolo Bypass Improvements (CM2)			Floodplain Restoration (CM5)					
		Tidal Habitat[1] Restoration Effects (Inundation)	Tidal Habitat[2] Restoration Effects (Desiccation)	Tidal Habitat Restoration Effects (Riparian)	Tunnel/Pipeline Effects6			Yolo Bypass Fisheries Enhancement[7, 10]	Yolo Bypass Fisheries Enhancement[7, 10]	Yolo Bypass Operations	Floodplain Restoration Effects (Riparian)[10]	Floodplain Restoration Effects (Inundation)[11]	Floodplain Restoration Levee Construction Effects[11]	Floodplain Restoration Levee Construction Effects[11]	Nontidal Marsh Restoration[10]	Conservation Hatcheries Facilities[10]
Resource	Total Existing Habitat in Plan Area	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[5]	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[6]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)[8]	Acres of Removed Modeled Habitat (Temporary)[9]	Acres of Removed Modeled Habitat[4] (Long-Term Temporary)[12]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Modeled Habitat Affected (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Modeled Habitat Effects (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)
Alkali milk-vetch																
Vernal pool Complex	7,907	88	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Degraded Vernal Pool Complex	2,494	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alkali milk-vetch Total	10,401	93	0	0	1	0	0	0	0	76	0	0	0	0	0	0
Brittlescale Total	472	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Boggs Lake hedge-hyssop																
Vernal pool Complex	7,907	88	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Degraded Vernal Pool Complex	2,494	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boggs Lake hedge-hyssop Total	10,401	94	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Caper-fruited tropidocarpum Total	1,410	0	0	0	1	0	34	0	0	0	0	0	0	0	0	0
Carquinez goldenbush Total	1,019	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Delta button celery Total	3,330	26	0	0	19	0	0	0	0	0	0	18	7	8	0	0
Delta mudwort Total	6,074	140	10	0	14	42	0	3	0	21	0	12	1	2	0	0
Delta tule pea Total	5,817	1,132	467	0	0	33	0	0	0	3	0	1	0	0	0	0
Dwarf downingia							0									
Vernal pool Complex	7,907	88	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Degraded Vernal Pool Complex	2,494	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dwarf downingia Total	10,401	93	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Heartscale Total	6,071	363	0	0	1	0	0	0	0	61	0	0	0	0	0	0
Heckard’s peppergrass							0									
Vernal pool Complex	7,907	88	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Degraded Vernal Pool Complex	2,494	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heckard’s peppergrass Total	10,401	94	0	0	1	0	0	0	0	76	0	0	0	0	0	0
Legenere							0									
Vernal pool Complex	7,907	88	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Degraded Vernal Pool Complex	2,494	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Legenere Total	10,401	93	0	0	0	0	0	0	0	76	0	0	0	0	0	0
Mason’s lilaeopsis Total	6,074	140	10	0	14	42	0	3	0	21	0	12	1	2	0	0
San Joaquin spearscale							0									
Vernal pool Complex	7,907	88	0	0	0	0	0	0	0	76	0	0	0	0	0	0

		Tidal Restoration (CM4)			Conveyance Option (CM1)			Fremont Weir/Yolo Bypass Improvements (CM2)			Floodplain Restoration (CM5)					
		Tidal Habitat[1] Restoration Effects (Inundation)	Tidal Habitat[2] Restoration Effects (Desiccation)	Tidal Habitat Restoration Effects (Riparian)	Tunnel/Pipeline Effects6			Yolo Bypass Fisheries Enhancement [7, 10]	Yolo Bypass Fisheries Enhancement [7, 10]	Yolo Bypass Operations	Floodplain Restoration Effects (Riparian)[10]	Floodplain Restoration Effects (Inundation)[11]	Floodplain Restoration Levee Construction Effects[11]	Floodplain Restoration Levee Construction Effects[11]	Nontidal Marsh Restoration[10]	Conservation Hatcheries Facilities[10]
Resource	Total Existing Habitat in Plan Area	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[5]	Acres of Removed/ Converted[3] Modeled Habitat (Permanent)[6]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)[8]	Acres of Removed Modeled Habitat (Temporary)[9]	Acres of Removed Modeled Habitat[4] (Long-Term Temporary)[12]	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Modeled Habitat Affected (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Modeled Habitat Effects (Periodic)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Permanent)	Acres of Removed Modeled Habitat (Permanent)
Degraded Vernal Pool Complex	2,494	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Joaquin spearscale Total	10,401	93	0	0	1	0	0	0	0	76	0	0	0	0	0	0
Side-flowering skullcap Total	2,495	31	0	0	2	28	0	0	0	9	0	5	1	1	0	0
Slough thistle Total	1,834	0	0	0	0	25	0	0	0	0	0	6	5	6	0	0
Soft bird's-beak Total	1,225	86	86	0	0	0	0	0	0	0	0	0	0	0	0	0
Suisun Marsh aster Total	5,817	1,132	467	0	0	33	0	0	0	3	0	1	0	0	0	0
Suisun thistle Total	1,129	86	86	0	0	0	0	0	0	0	0	0	0	0	0	0

1 Inundation: Tidal flooding of existing wetland habitat as a result of tidal restoration actions. See Table 5.K-3 for a description of relevant assumptions.

2 Desiccation: The drying out of wetland habitat as a result of tidal dampening (the downward shift in tidal range), the result of which is a conversion from a tidal brackish or freshwater emergent wetland community to the grassland community. See Table 5.K-3 for a description of relevant assumptions.

3 Removed/Converted: Removed: habitat is no longer usable for any life stage of the species. Converted: change from one habitat type (e.g., primary) to another habitat type (e.g., secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g.., primary or secondary) to another, lesser function. See Table 5.K-2 for a description of relevant assumptions.

4 Borrow/Spoil Area: Borrow: a location from where construction material, such as sand or clay, will be taken. Spoil:area where construction by-prodcuts, such as removed earth, will be placed and stored. Borrow/spoil: an area that will originally be used for borrow and then later be used for spoil.

5 Calculation of impacts based on hypothetical restoration designs include only areas modeled by RMA that were classified as either 'Below MLLW' or 'MLLW to MHHW' except where noted.

6 The impact numbers do not incorporate the impacts associated with temporary Transmission Line corridors used during construction as alignments were not available at the time of the analysis.

7 Disturbance effect acreages reflect those associated with Fremont Weir improvements, Putal Creek realignment activities Lisbon Weir and fish crossing improvements, and Sacramento Weir improvments.

8 Features in this category include the following conveyance-related facilities: Forebay, Intake Facilities, Permanent Access Roads, and Shaft Locations. Totals under Conveyance Option (CM1) include Transmission Line impacts.

9 Features in this category include the following conveyance features: Barge Unloading Facility, Control Structure Work Area, Intake Road Work Area, Intake Work Area, Pipeline, Pipeline Work Area, Road Work Area, Safe Haven Work Area, Temporary Access Road, Tunnel Work Area. Totals under Conveyance Option (CM1) include Transmission Line impacts.

10 Based on restoration design assumptions described in Appendix E Habitat Restoration and effects analysis assumptoins detailed in Table 5.K-2.

11 Calculation of effects based on hypothetical floodplain restoration designs.

12 Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Table 5.K-8, *Plant Modeled Habitat Loss and Conversion by Covered Activity*.

Note: The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use—Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

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1 **Table 5.6.1-b. Maximum Allowable Habitat Loss, Plants (Continued)—Total Effects**

Resource	Total Existing Habitat in Plan Area	Total Effects			
		Total Acres of Modeled Habitat Removed (Permanent & Muck)	Total Acres of Modeled Habitat Removed (Temporary)	Total Acres of Modeled Habitat Removed (Borrow & Spoil)	Total Acres of Modeled Habitat Affected (Periodically)
Alkali milk-vetch					
Vernal pool Complex	7,907	88	0	0	76
Degraded Vernal Pool Complex	2,494	5	0	0	0
Alkali milk-vetch Total	10,401	94	0	0	76
Brittlescale Total	472	2	0	0	0
Boggs Lake hedge-hyssop					
Vernal pool Complex	7,907	88	0	0	76
Degraded Vernal Pool Complex	2,494	5	0	0	0
Boggs Lake hedge-hyssop Total	10,401	94	0	0	76
Caper-fruited tropidocarpum Total	1,410	0	0	34	0
Carquinez goldenbush Total	1,019	2	0	0	0
Delta button celery Total	3,330	26	8	0	18
Delta mudwort Total	6,074	140	44	0	33
Delta tule pea Total	5,817	1,599	33	0	4
Dwarf downingia					
Vernal pool Complex	7,907	88	0	0	76
Degraded Vernal Pool Complex	2,494	5	0	0	0
Dwarf downingia Total	10,401	94	0	0	76
Heartscale Total	6,071	363	0	0	61
Heckard’s peppergrass					
Vernal pool Complex	7,907	88	0	0	76
Degraded Vernal Pool Complex	2,494	5	0	0	0
Heckard’s peppergrass Total	10,401	94	0	0	76
Legenere					
Vernal pool Complex	7,907	88	0	0	76
Degraded Vernal Pool Complex	2,494	5	0	0	0
Legenere Total	10,401	94	0	0	76
Mason’s lilaeopsis Total	6,074	140	44	0	33
San Joaquin spearscale					
Vernal pool Complex	7,907	89	0	0	76
Degraded Vernal Pool Complex	2,494	5	0	0	0
San Joaquin spearscale Total	10,401	94	0	0	76
Side-flowering skullcap Total	2,495	34	29	0	14
Slough thistle Total	1,834	5	31	0	6
Soft bird’s-beak Total	1,225	658	0	0	0
Suisun Marsh aster Total	5,817	1,599	33	0	4
Suisun thistle Total	1,129	572	0	0	0

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Resource	Total Existing Habitat in Plan Area	Total Effects			
		Total Acres of Modeled Habitat Removed (Permanent & Muck)	Total Acres of Modeled Habitat Removed (Temporary)	Total Acres of Modeled Habitat Removed (Borrow & Spoil)	Total Acres of Modeled Habitat Affected (Periodically)

[1] Inundation: Tidal flooding of existing wetland habitat as a result of tidal restoration actions. See Table 5.K-3 for a description of relevant assumptions.

[2] Desiccation: The drying out of wetland habitat as a result of tidal dampening (the downward shift in tidal range), the result of which is a conversion from a tidal brackish or freshwater emergent wetland community to the grassland community. See Table 5.K-3 for a description of relevant assumptions.

[3] Removed/Converted: Removed: habitat is no longer usable for any life stage of the species. Converted: change from one habitat type (e.g., primary) to another habitat type (e.g., secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g.., primary or secondary) to another, lesser function. See Table 5.K-2 for a description of relevant assumptions.

[4] Borrow/Spoil Area: Borrow: a location from where construction material, such as sand or clay, will be taken. Spoil:area where construction by-prodcuts, such as removed earth, will be placed and stored. Borrow/spoil: an area that will originally be used for borrow and then later be used for spoil.

[5] Calculation of impacts based on hypothetical restoration designs include only areas modeled by RMA that were classified as either 'Below MLLW' or 'MLLW to MHHW' except where noted.

[6] The impact numbers do not incorporate the impacts associated with temporary Transmission Line corridors used during construction as alignments were not available at the time of the analysis.

[7] Disturbance effect acreages reflect those associated with Fremont Weir improvements, Putal Creek realignment activities Lisbon Weir and fish crossing improvements, and Sacramento Weir improvments.

[8] Features in this category include the following conveyance-related facilities: Forebay, Intake Facilities, Permanent Access Roads, and Shaft Locations. Totals under Conveyance Option (CM1) include Transmission Line impacts.

[9] Features in this category include the following conveyance features: Barge Unloading Facility, Control Structure Work Area, Intake Road Work Area, Intake Work Area, Pipeline, Pipeline Work Area, Road Work Area, Safe Haven Work Area, Temporary Access Road, Tunnel Work Area. Totals under Conveyance Option (CM1) include Transmission Line impacts.

[10] Based on restoration design assumptions described in Appendix E Habitat Restoration and effects analysis assumptoins detailed in Table 5.K-2.

[11] Calculation of effects based on hypothetical floodplain restoration designs.

[12] Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Table 5.K-8, *Plant Modeled Habitat Loss and Conversion by Covered Activity*.

Note: The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use—Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

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Table 5.6-2a. Indirect Effects, Wildlife

		Tidal Marsh Restoration Indirect Effects	Tunnel/Pipeline Indirect Effects[2]		Fremont Weir/ Yolo Bypass Enhancements		Floodplain Restoration Levee Construction	Total Indirect Effects	
Resource	**Total Existing Habitat in Plan Area**	**Construction (Temporary Indirect Effects[1]**	**Tunnel/Pipeline Construction (Temporary Indirect Effects)[3]**	**Tunnel/ Pipeline O&M (Permanent Indirect Effects)**	**Construction Indirect Effects**	**O&M Indirect Effects**	**Construction Indirect Effects**	**Temporary Indirect Effects**	**Permanent Indirect Effects**
Mammals									
Riparian brush rabbit									
Riparian habitat	2,894	51	112	0	0	0	45	208	0
Grassland habitat	3,103	50	4	0	0	0	74	129	0
Riparian brush rabbit Total	5,997	102	116	0	0	0	119	336	0
Riparian woodrat	2,156	NA	NA	NA	NA	NA	NA	0	0
San Joaquin kit fox									
Breeding, foraging, and disper	5,217	0	113	0	0	0	0	113	0
Riparian woodrat Total	5,217	0	113	0	0	0	0	113	0
Salt marsh harvest mouse									
Wetland habitat	14,265	93	0	0	0	0	0	93	0
Upland habitat	3,733	61	0	0	0	0	0	61	0
Salt marsh harvest mouse Total	17,998	154	0	0	0	0	0	154	0
Suisun shrew									
Primary Habitat	2,987	82	0	0	0	0	0	82	0
Secondary Habitat	518	23	0	0	0	0	0	23	0
Suisun shrew Total	3,505	105	0	0	0	0	0	105	0
Townsend’s western big-eared bat									
Primary foraging habitat	10,880	NA	NA	NA	NA	NA	NA	0	0
Roosting and primary foraging habitat	7,493	224	33	0	150	0	86	492	0
Secondary foraging habitat	768,626	NA	NA	NA	NA	NA	NA	0	0
Townsend’s western big-eared bat Total	787,000	224	33	0	150	0	86	492	0
Birds									
California black rail									
Primary habitat	3,880	320	0	0	0	0	0	320	0
Secondary habitat	22,559	194	10	0	0	0	0	204	0
California black rail Total	26,439	514	10	0	0	0	0	524	0
California clapper rail									
Primary habitat	154	9	0	0	0	0	0	9	0
Secondary habitat	6,443	520	0	0	0	0	0	520	0
California clapper rail Total	6,597	529	0	0	0	0	0	529	0
California Least Tern Total	86,231	2,793	662	0	40	0	105	3,600	0
Greater sandhill crane									
Primary Use Area	4,556	2,020	6,594	523	91	0	0	9,229	523
Secondary Use Area	191,531	0	357	0	0	0	0	357	0

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		Tidal Marsh Restoration Indirect Effects	Tunnel/Pipeline Indirect Effects[2]		Fremont Weir/ Yolo Bypass Enhancements		Floodplain Restoration Levee Construction	Total Indirect Effects	
Resource	Total Existing Habitat in Plan Area	Construction (Temporary Indirect Effects[1]	Tunnel/Pipeline Construction (Temporary Indirect Effects)[3]	Tunnel/ Pipeline O&M (Permanent Indirect Effects)	Construction Indirect Effects	O&M Indirect Effects	Construction Indirect Effects	Temporary Indirect Effects	Permanent Indirect Effects
Greater sandhill crane Total	196,087	2,020	6,952	523	91	0	0	9,586	523
Least Bell's Vireo Total	14,731	624	76	1	282	0	88	1,071	1
Suisun song sparrow									
Primary Habitat	3,431	278	0	0	0	0	0	278	0
Secondary Habitat	22,248	582	0	0	0	0	0	582	0
Suisun song sparrow Total	25,678	860	0	0	0	0	0	860	0
Swainson's hawk									
Foraging habitat	435,087	4,660	3,228	0	1,371	0	4,138	13,398	0
Nesting habitat	10,149	466	99	4	505	0	178	1,251	4
Swainson's hawk Total	445,235	5,126	3,327	4	1,876	0	4,316	14,650	4
Tricolored blackbird									
Breeding Habitat-Ag Foraging	68,830	498	85	0	439	0	832	1,854	0
Breeding Habitat-Foraging	59,660	1,106	183	0	546	0	94	1,928	0
Breeding Habitat-Nesting	1,472	623	19	0	46	0	57	744	0
Nonbreeding Hab-Foraging Ag	293,846	2,181	2,920	0	150	0	3,589	8,839	0
Nonbreeding Hab-Roosting	29,911	465	44	1	10	0	8	528	1
NonBreeding Habitat-Foraging	37,719	966	199	0	93	0	22	1,280	0
Tricolored blackbird Total	491,438	5,838	3,449	1	1,283	0	4,601	15,174	1
Western burrowing owl									
High-value habitat	67,906	1,711	373	0	247	0	115	2,446	0
Moderate-value habitat	58,790	2,332	2,775	0	289	0	3,710	9,107	0
Low-value habitat	294,238	979	48	0	629	0	82	1,738	0
Western burrowing owl Total	420,935	5,022	3,196	0	1,165	0	3,907	13,290	0
Western Yellow-billed Cuckoo									
Breeding habitat	4,735	277	45	0	438	0	106	866	0
Migratory habitat	7,868	470	119	5	86	0	83	763	5
Western Yellow-billed Cuckoo Total	12,603	748	163	5	524	0	188	1,629	5
White-tailed kite									
Breeding habitat	14,315	758	151	6	523	0	224	1,661	6
Foraging habitat	494,710	5,502	3,250	0	1,405	0	4,149	14,306	0
White-tailed kite Total	509,026	6,260	3,401	6	1,928	0	4,372	15,967	6
Yellow-breasted chat									
Primary Nesting and Migratory Habitat	7,384	566	60	3	90	0	159	879	3
Secondary Nesting and Migratory Habitat	5,530	265	127	2	25	0	49	467	2
Suisun Marsh/Upper Yolo Bypass Nest and Migratory Habitat	1,849	45	0	0	0	0	0	45	0
Yellow-breasted chat Total	14,764	876	188	5	115	0	207	1,392	5

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Resource	Total Existing Habitat in Plan Area	Tidal Marsh Restoration Indirect Effects	Tunnel/Pipeline Indirect Effects[2]		Fremont Weir/ Yolo Bypass Enhancements		Floodplain Restoration Levee Construction	Total Indirect Effects	
		Construction (Temporary Indirect Effects[1]	Tunnel/Pipeline Construction (Temporary Indirect Effects)[3]	Tunnel/ Pipeline O&M (Permanent Indirect Effects)	Construction Indirect Effects	O&M Indirect Effects	Construction Indirect Effects	Temporary Indirect Effects	Permanent Indirect Effects
Reptiles									
Giant Garter Snake									
Aquatic Breeding, Foraging and Movement	29,430	500	157	0	77	0	42	776	0
Upland-High	18,377	529	153	0	173	0	0	855	0
Upland-Moderate	40,192	528	506	0	25	0	285	1,344	0
Upland-Low	36,709	1,462	336	1	175	0	141	2,115	1
Giant Garter Snake Total	124,708	3,018	1,153	1	450	0	468	5,090	1
Western pond turtle									
Aquatic Breeding, Foraging and Movement (miles)	1,298	34	14	0	3	0	4	55	0
Aquatic habitat	81,509	3,521	491	0	98	0	126	4,237	0
Dispersal habitat	619,335	5,901	4,028	1	1,659	0	5,469	17,058	1
Upland nesting and overwintering	46,089	1,462	323	0	280	0	72	2,136	0
Western pond turtle Total	746,934	10,883	4,841	2	2,037	0	5,667	23,431	2
Amphibians									
California red-legged frog									
Aquatic habitat	149	0	0	0	0	0	0	0	0
Upland cover and dispersal habitat	9,055	0	66	0	0	0	0	66	0
Dispersal habitat	19,644	0	170	0	0	0	0	170	0
California red-legged frog Total	28,848	0	237	0	0	0	0	237	0
Aquatic habitat (miles)	29	0	0	0	0	0	0	0	0
California tiger salamander									
Aquatic Breeding Habitat	7,332	195	9	0	0	0	0	203	0
Terrestrial Cover and Aestivation Habitat	28,895	660	173	0	30	0	0	863	0
California tiger salamander Total	36,226	854	182	0	30	0	0	1,066	0
Western spadefoot toad									
Aquatic Breeding Habitat	7,335	195	9	0	0	0	0	203	0
Terrestrial Cover and Aestivation Habitat	29,546	684	173	0	30	0	0	887	0
Western spadefoot toad Total	36,881	879	182	0	30	0	0	1,091	0
Aquatic Breeding Habitat (miles)	78	4	0	0	0	0	0	4	0
Invertebrates									
Valley elderberry longhorn beetle									
Riparian vegetation	17,796	262	60	0	11	0	10	343	0
Non-riparian channels and grasslands	16,485	126	17	0	66	0	32	242	0
Valley elderberry longhorn beetle Total	34,281	388	77	0	78	0	43	585	0
California linderiella									
High Quality Habitat	7,770	89	1	0	0	0	0	90	0
Low Quality Habitat	2,631	45	0	0	0	0	0	46	0

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		Tidal Marsh Restoration Indirect Effects	Tunnel/Pipeline Indirect Effects[2]		Fremont Weir/ Yolo Bypass Enhancements		Floodplain Restoration Levee Construction	Total Indirect Effects	
Resource	**Total Existing Habitat in Plan Area**	**Construction (Temporary Indirect Effects[1]**	**Tunnel/Pipeline Construction (Temporary Indirect Effects)[3]**	**Tunnel/ Pipeline O&M (Permanent Indirect Effects)**	**Construction Indirect Effects**	**O&M Indirect Effects**	**Construction Indirect Effects**	**Temporary Indirect Effects**	**Permanent Indirect Effects**
Conservancy fairy shrimp									
High Quality Habitat	7,770	89	1	0	0	0	0	90	0
Low Quality Habitat	2,631	45	0	0	0	0	0	46	0
Longhorn fairy shrimp									
High Quality Habitat	7,770	89	1	0	0	0	0	90	0
Low Quality Habitat	2,631	45	0	0	0	0	0	46	0
Mid Valley fairy shrimp									
High Quality Habitat	7,770	89	1	0	0	0	0	90	0
Low Quality Habitat	2,631	45	0	0	0	0	0	46	0
Vernal pool fairy shrimp									
High Quality Habitat	7,770	116	1	0	0	0	0	117	0
Low Quality Habitat	2,631	18	0	0	0	0	0	18	0
Vernal pool tadpole shrimp									
High Quality Habitat	7,770	116	1	0	0	0	0	117	0
Low Quality Habitat	2,631	18	0	0	0	0	0	18	0

[1] Calculation of disturbance effect was based on hypothetical restoration designs include only areas modeled by RMA and estimated from above the MHHW.

[2] The disturbance effect numbers do not incorporate the effects associated with Transmission Line corridors because additional information is required on specific footprint assumptions.

[3] Features in this category include the following convenance features: Forebay, Intake Facilties, Permanent Access Roads, and Shaft Locations, Barge Unloading Facility, Control Structure Work Area, Intake Road Work Area, Intake Work Area, Pipeline, Pipeline Work Area, Road Work Area, Safe Haven Work Area, Temporary Access Road Work Area, Tunnel Work Area.

[4] Riparian planting associated with floodplain restoration and tidal marsh restoration and periodic inundation associated with Yolo Bypass operations are assumed to not have any substantive disturbance effects.

[5] Activities associated with nontidal marsh, grassland and vernal pool restoration, and the development of Conservation Fish Hatchery do not have specific locations and are thereby unable to calculate disburbance effects on modeled covered species' habitat. Temporary disturbance effects from construction and permanent indirect effects of operations are discussed within Chapter 5.

NA = Not Applicable. Species currently is not present in the Plan Area.

Note: The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4) are assumed not to have significant disturbance effects on species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use—Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

O&M = operations and maintenance.

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Table 5.6-2b. Indirect Effects, Plants

		Tidal Marsh Restoration Indirect Effects	Tunnel/Pipeline Indirect Effects[2]		Fremont Weir/ Yolo Bypass Enhancements		Floodplain Restoration Levee Construction	Total Indirect Effects	
Resource	Total Existing Habitat in Plan Area	Construction (Temporary Indirect Effects)[1]	Tunnel/Pipeline Construction (Temporary Indirect Effects)[3]	Tunnel/Pipeline O&M (Permanent Indirect Effects)	Construction Indirect Effects	O&M Indirect Effects	Construction Indirect Effects	Temporary Indirect Effects	Permanent Indirect Effects
Alkali milk-vetch var.									
Vernal pool Complex	7,907	116	1	0	0	0	0	117	0
Degraded Vernal Pool Complex	2,494	18	0	0	0	0	0	18	0
Antioch Dunes evening primrose	19	0	0	0	0	0	0	0	0
Boggs Lake hedge-hyssop									
Vernal pool Complex	7,907	116	1	0	0	0	0	117	0
Degraded Vernal Pool Complex	2,494	18	0	0	0	0	0	18	0
Brittlescale	472	3	0	0	0	0	0	3	0
Caper-fruited tropidocarpum	1,410	0	0	0	0	0	0	0	0
Carquinez goldenbush	1,019	73	0	0	0	0	0	73	0
Contra Costa wallflower	19	0	0	0	0	0	0	0	0
Delta button celery	3,330	0	6	0	0	0	26	32	0
Delta mudwort	6,074	263	23	0	9	0	11	306	0
Delta tule pea var.	5,817	419	1	0	0	0	1	422	0
Dwarf Downingia									
Vernal pool Complex	7,907	116	1	0	0	0	0	117	0
Degraded Vernal Pool Complex	2,494	18	0	0	0	0	0	18	0
Heartscale	6,071	192	0	0	1	0	0	193	0
Heckard's peppergrass var.									
Vernal pool Complex	7,907	116	1	0	0	0	0	117	0
Degraded Vernal Pool Complex	2,494	18	0	0	0	0	0	18	0
Legenere									
Vernal pool Complex	7,907	116	1	0	0	0	0	117	0
Degraded Vernal Pool Complex	2,494	18	0	0	0	0	0	18	0
Mason's lilaeopsis	6,074	263	23	0	9	0	11	306	0
San Joaquin spearscale									
Vernal pool Complex	7,907	116	1	0	0	0	0	117	0
Degraded Vernal Pool Complex	2,494	18	0	0	0	0	0	18	0
Side-flowering skullcap	2,495	81	5	0	1	0	1	88	0
Slough thistle	1,834	0	0	0	0	0	25	25	0
Soft bird's-beak ssp.	1,225	64	0	0	0	0	0	64	0
Suisun Marsh aster	5,817	419	1	0	0	0	1	422	0
Suisun thistle var.	1,129	64	0	0	0	0	0	64	0

[1] Calculation of disturbance effect was based on hypothetical restoration designs include only areas modeled by RMA and estimated from above the MHHW.

[2] The disturbance effect numbers do not incorporate the effects associated with Transmission Line corridors because additional information is required on specific footprint assumptions.

[3] Disturbance areas areas are associated with features from the following conveyance features: Forebay, Intake Facilties, Permanent Access Roads, and Shaft Locations, Barge Unloading Facility, Control

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		Tidal Marsh Restoration Indirect Effects	Tunnel/Pipeline Indirect Effects[2]		Fremont Weir/ Yolo Bypass Enhancements		Floodplain Restoration Levee Construction	Total Indirect Effects	
Resource	Total Existing Habitat in Plan Area	Construction (Temporary Indirect Effects)[1]	Tunnel/Pipeline Construction (Temporary Indirect Effects)[3]	Tunnel/Pipeline O&M (Permanent Indirect Effects)	Construction Indirect Effects	O&M Indirect Effects	Construction Indirect Effects	Temporary Indirect Effects	Permanent Indirect Effects

Structure Work Area, Intake Road Work Area, Intake Work Area, Pipeline, Pipeline Work Area, Road Work Area, Safe Haven Work Area, Temporary Access Road Work Area, Tunnel Work Area.

[4] Riparian planting associated with floodplain restoration and tidal marsh restoration and periodic inundation associated with Yolo Bypass operations are assumed to not have any substantive disturbance effects.

[5] Activities associated with nontidal marsh, grassland and vernal pool restoration, and the development of Conservation Fish Hatchery do not have specific locations and are thereby unable to calculate disburbance effects on modeled covered species' habitat. Temporary disturbance effects from construction and permanent indirect effects of operations are discussed within Chapter 5.

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Table 5.6-3a. Net Effects, Wildlife

	Baseline		Adverse Effects				Benefits							
Resource	Acres of Total Existing Modeled Habitat in Plan Area	Acres of Existing Protected[1] Modeled Habitat	Acres of Modeled Habitat Removed/ Converted[2] (Permanent)[3]	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Long-Term Temporary)[7]	Acres of Removed Modeled Habitat (Periodic)	Acres of Modeled Habitat Protected under BDCP	Acres of Modeled Habitat Restored under BDCP[6]	Net Acres of Modeled Habitat Increased	Net Percent Increase in Acres of Modeled Habitat with Full BDCP Implementation	Total Acres of Modeled Habitat Conserved with Full BDCP Implementation	Total Acres Modeled Habitat in Protected Status with Full BDCP Implementation	Net Acres Increase in Protected Habitat with Full BDCP Implementation	Percent Change in Protected Modeled Habitat
Mammals														
Riparian brush rabbit														
Riparian Habitat	2,894	138	63	165	0	264	300	808	745	26%	1,108	1,243	1,105	800%
Grassland Habitat	3,103	314	175	32	3	423	322	81	-94	-3%	403	633	319	102%
Riparian brush rabbit Total	5,997	452	238	197	3	686	622	889	651	11%	1,511	1,876	1,424	315%
Riparian woodrat Total	2,156	101	46	33	0	202	90	602	556	26%	692	790	689	682%
Salt marsh harvest mouse:														
Wetland habitat	14,265	12,390	3,562	109	0	0	1,500	4,800	1,238	9%	6,300	15,378	2,988	24%
Upland habitat	3,733	3,149	808	0	0	0	30	0	-808	-22%	30	2,436	-713	-23%
Salt marsh harvest mouse Total	17,998	15,539	4,287	109	0	0	1,530	4,800	513	3%	6,330	17,814	2,275	15%
San Joaquin kit fox														
Breeding, Foraging, and Dispersal Habitat	5,217	638	163	120	151	0	1,000	0	-163	-3%	1,000	1,544	906	142%
San Joaquin kit fox Total	5,217	638	163	120	151	0	1,000	0	-163	-3%	1,000	1,544	906	142%
Suisun shrew														
Primary Habitat	2,987	17,114	1,183	0	0	0	1,500	4,800	3,617	121%	6,300	22,588	5,474	32%
Secondary Habitat	518	3,152	96	0	0	0	22	0	-96	-19%	23	3,095	-57	-2%
Suisun shrew Total	3,505	20,266	1,279	0	0	0	1,522	4,800	3,521	100%	6,323	25,683	5,417	27%
Townsend’s big-eared bat														
Primary foraging habitat	10,880	3,640	172	637	0	173	455	3,034	2,862	26%	3,489	6,545	2,905	80%
Roosting and primary foraging habitat	7,493	1,959	237	90	0	200	750	5000	4,763	64%	5,750	7,551	5,592	285%
Secondary foraging habitat	768,626	165,495	12,747	3,407	1,600	12,575	30,273	31,512	18,765	2%	61,785	206,833	41,338	25%
Townsend's big-eared bat Total	786,999	171,094	13,156	4,134	1,600	12,948	31,478	39,546	26,390	3%	71,024	220,929	49,835	29%
Birds														
California black rail														
Primary Habitat	3,880	15,951	1,657	0	0	1	-	2,245	588	15%	2,245	17,827	1,876	12%
Secondary Habitat	22,559	5,170	4,538	0	0	51	410	7,548	3,010	13%	7,958	8,959	3,789	73%
California black rail Total	26,439	21,121	6,195	0	0	51	410	9,793	3,598	14%	10,203	26,785	5,664	27%
California clapper rail														
Primary Habitat	154	9,363	70	0	0	0	-	56	-14	-9%	56	9,353	-10	0%
Secondary Habitat	6,443	10,232	889	0	0	0	15	4,250	3,361	52%	4,265	13,320	3,088	30%
California clapper rail Total	6,597	19,595	959	0	0	0	15	4,306	3,347	51%	4,321	22,673	3,078	16%
California least tern Total	86,231	18,077	65	125	0	330	-	10,000	9,935	12%	10,000	27,935	9,858	55%
Greater sandhill crane														
Roosting/Foraging habitat	4,555	1,710	0	4	0	0	167	550	550	12%	717	2,427	717	42%
Foraging habitat[4]	191,530	38,285	6,507	937	727	6	5,220	0	-6,507	-3%	5,220	39,772	1,487	4%

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	Baseline		Adverse Effects				Benefits							
Resource	Acres of Total Existing Modeled Habitat in Plan Area	Acres of Existing Protected[1] Modeled Habitat	Acres of Modeled Habitat Removed/ Converted[2] (Permanent)[3]	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Long-Term Temporary)[7]	Acres of Removed Modeled Habitat (Periodic)	Acres of Modeled Habitat Protected under BDCP	Acres of Modeled Habitat Restored under BDCP[6]	Net Acres of Modeled Habitat Increased	Net Percent Increase in Acres of Modeled Habitat with Full BDCP Implementation	Total Acres of Modeled Habitat Conserved with Full BDCP Implementation	Total Acres Modeled Habitat in Protected Status with Full BDCP Implementation	Net Acres Increase in Protected Habitat with Full BDCP Implementation	Percent Change in Protected Modeled Habitat
Greater sandhill crane Total	196,085	39,995	6,507	940	727	6	5,387	550	-5,957	-3%	5,937	42,199	2,204	6%
Least Bell's vireo Total	14,731	5,090	1,032	131	0	244	607	4,102	3,070	21%	4,709	9,058	3,968	78%
Suisun song sparrow														
Primary Habitat	3,431	2,218	1,301	0	0	0	4	2,083	782	23%	2,087	3,988	1,770	80%
Secondary Habitat	22,248	17,765	5,010	0	0	0	440	3,026	-1,984	-9%	3,466	16,824	-941	-5%
Suisun song sparrow Total	25,679	19,983	6,311	0	0	0	444	5,109	-1,202	-5%	5,554	20,812	829	4%
Swainson's hawk														
Foraging habitat	435,087	75,695	37,323	2,476	954	9,021	26,807	1,943	-35,380	-8%	28,750	97,570	21,875	29%
Nesting habitat5	10,149	3,254	666	144	0	226	419	2,734	2,068	20%	3,153	5,935	2,681	82%
Swainson's hawk Total	445,236	78,949	37,988	2,621	954	9,247	27,226	4,677	-33,311	-7%	31,903	103,506	24,557	31%
Tricolored blackbird														
Breeding Habitat-Ag Foraging	68,830	7,053	8,436	552	47	1,817	5,100	0	-8,436	-12%	5,100	11,692	4,639	66%
Breeding Habitat-Foraging	59,660	23,952	2,904	250	151	402	5,029	1604	-1,300	-2%	4,758	26,856	2,904	12%
Breeding Habitat-Nesting	13,157	272	75	30	0	35	53	346	271	2%	399	656	384	141%
Nonbreeding Hab-Foraging Ag	293,846	34,127	23,256	1,611	987	7,395	11,400	0	-23,256	-8%	11,400	42,585	8,458	25%
Nonbreeding Hab-Roosting	18,226	19,481	4,604	7	0	31	245	17,436	12,832	70%	17,681	33,352	13,871	71%
NonBreeding Habitat-Foraging	37,719	9,096	2,217	59	0	162	3,737	1,021	-1,196	-3%	4,758	12,546	3,450	38%
Tri-colored blackbird Total	491,438	93,981	41,492	2,510	1,186	9,841	25,564	20,407	-21,086	-4%	45,971	129,562	35,581	38%
Western burrowing owl														
High-value habitat	67,906	20,008	3,203	253	151	564	6,255	1,706	-1,497	-2%	7,961	26,141	6,133	31%
Moderate-value habitat	58,790	21,365	4,677	629	0	228	2,758	203	-4,474	-8%	2,961	22,218	853	4%
Low-value habitat	294,238	33,754	26,796	1,934	659	8,024	11,519	988	-25,808	-9%	12,507	44,044	10,290	30%
Western burrowing owl Total	420,934	75,127	34,676	3,342	810	8,816	20,532	2,897	-31,779	-8%	23,429	92,404	17,277	23%
Western Yellow-billed Cuckoo														
Breeding Habitat	4,735	2,172	488	97	0	39	198	500	12	0%	698	2,512	340	16%
Migratory Habitat	7,868	2,136	371	28	0	124	328	2,191	1,820	23%	2,519	4,408	2,272	106%
Western yellow-billed Cuckoo Total	12,603	4,308	859	125	0	163	526	2,691	1,832	15%	3,217	6,920	2,612	61%
White-tailed kite														
Breeding habitat	14,315	4,600	832	676	0	271	594	3,892	3,060	21%	4,486	8,517	3,917	85%
Foraging habitat	494,710	104,688	44,196	2,494	954	9,120	29,426	3,330	-40,866	-8%	32,756	124,557	19,869	19%
White-tailed kite Total	509,025	109,288	45,028	3,170	954	9,391	30,020	7,222	-37,806	-7%	37,242	133,074	23,786	22%
Yellow-breasted chat														
Primary Nesting and Migratory Habitat	7,384	2,191	342	23	0	115	309	2,060	1,718	23%	2,060	4,050	1,859	85%
Secondary Nesting and Migratory Habitat	5,530	1,894	460	13	0	60	231	1,543	1,083	20%	1,774	3,333	1,439	76%
Suisun Marsh/Upper Yolo Bypass Nest and Migratory Habitat	1,849	933	230	95	0	0	68	507	277	15%	575	1,304	371	40%
Yellow-breasted chat Total	14,763	5,018	1,032	131	0	175	608	4,110	3,078	21%	4,718	8,995	3,977	79%

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	Baseline		Adverse Effects				Benefits							
Resource	Acres of Total Existing Modeled Habitat in Plan Area	Acres of Existing Protected[1] Modeled Habitat	Acres of Modeled Habitat Removed/ Converted[2] (Permanent)[3]	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Long-Term Temporary)[7]	Acres of Removed Modeled Habitat (Periodic)	Acres of Modeled Habitat Protected under BDCP	Acres of Modeled Habitat Restored under BDCP[6]	Net Acres of Modeled Habitat Increased	Net Percent Increase in Acres of Modeled Habitat with Full BDCP Implementation	Total Acres of Modeled Habitat Conserved with Full BDCP Implementation	Total Acres Modeled Habitat in Protected Status with Full BDCP Implementation	Net Acres Increase in Protected Habitat with Full BDCP Implementation	Percent Change in Protected Modeled Habitat
Reptiles														
Giant Garter Snake														
Aquatic Breeding, Foraging and Movement	29,430	7,384	838	54	0	74	502	9,888	9,050	31%	10,390	17,394	10,010	136%
Upland-High	18,377	6,479	935	47	1	0	172	343	-592	-3%	515	6,414	-65	-1%
Upland-Moderate	40,192	10,012	3,063	136	15	710	806	2,093	-970	-2%	2,899	11,906	1,894	19%
Upland-Low	36,709	3,509	1,738	160	20	1,095	1,221	1,512	-226	-1%	2,733	5,915	2,406	69%
Giant garter snake Total	124,708	27,384	6,574	398	36	1,879	2,701	13,836	7,262	6%	16,537	41,629	14,245	52%
Western pond turtle														
Aquatic habitat	81,509	32,820	5,847	94	0	107	253	23,445	17,598	22%	23,698	51,935	19,115	58%
Dispersal habitat	619,335	117,131	52,112	2,773	1,514	11,698	26,310	6,280	-45,832	-7%	32,590	134,388	17,257	15%
Upland nesting and overwintering	46,089	14,859	2,003	627	86	430	4,438	1,256	-747	-2%	5,694	19,560	4,701	32%
Western pond turtle Total	746,933	164,810	59,968	3,494	1,600	12,235	31,001	30,981	-28,987	-4%	61,982	205,883	41,073	25%
Amphibians														
California red-legged frog														
Aquatic habitat	149	20	1	0	0	0	-	16	15	10%	16	36	16	79%
Upland cover and dispersal habitat	9,055	1,590	168	10	151	0	888	395	227	3%	1,283	2,792	1,202	76%
Dispersal habitat	19,644	151	663	5	480	0	780	0	-663	-3%	780	918	767	508%
California red-legged frog Total	28,848	1,761	832	15	631	0	1,668	411	-421	-1%	2,079	3,745	1,984	113%
California tiger salamander														
Aquatic breeding habitat	7,332	4,166	42	0	0	0	600	81	39	1%	681	4,838	672	16%
Terrestrial Cover and Aestivation Habitat	28,895	8,388	477	10	151	0	2,834.00	690	213	1%	3,524	11,758	3,370	40%
California tiger salamander Total	36,227	12,554	519	10	151	0	3,434	771	252	1%	4,205	16,596	4,042	32%
Western spadefoot														
Aquatic Breeding Habitat	7,335	4,167	42	0	0	0	600	81	39	1%	681	4,839	672	16%
Terrestrial Cover and Aestivation Habitat	29,546	8,436	556	10	151	0	2,873	695	139	0%	3,568	11,849	3,413	40%
Western spadefoot Total	36,881	12,603	598	10	151	0	3,473	776	178	0%	4,249	16,688	4,085	32%
Invertebrates														
Valley elderberry longhorn beetle:														
Riparian vegetation	17,796	5,397	1,058	157	0	308	744	4,962	3,904	22%	5,706	10,369	4,972	92%
Non-riparian channels and grasslands	16,485	4,283	596	198	0	295	1,657	470	-126	-1%	2,127	6,159	1,876	44%
Valley elderberry longhorn beetle Total	34,281	9,680	1,654	355	0	603	2,401	5,432	3,778	11%	7,833	16,528	6,848	71%
California linderiella														
Vernal Pool Complex	7,770	4,475	42	0	0	0	600	89	47	1%	689	5,155	680	15%
Degraded Vernal Pool Complex	2,631	745	52	0	0	1	-	0	-52	-2%	0	724	-21	-3%
California linderiella Total	10,401	5,220	94	0	0	0	600	89	-5	0%	689	5,879	659	13%
Conservancy fairy shrimp														
Vernal Pool Complex	7,770	4,475	42	0	0	0	600	89	47	1%	689	5,155	680	15%

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	Baseline		Adverse Effects				Benefits							
Resource	**Acres of Total Existing Modeled Habitat in Plan Area**	**Acres of Existing Protected[1] Modeled Habitat**	**Acres of Modeled Habitat Removed/ Converted[2] (Permanent)[3]**	**Acres of Removed Modeled Habitat (Temporary)**	**Acres of Removed Modeled Habitat (Long-Term Temporary)[7]**	**Acres of Removed Modeled Habitat (Periodic)**	**Acres of Modeled Habitat Protected under BDCP**	**Acres of Modeled Habitat Restored under BDCP[6]**	**Net Acres of Modeled Habitat Increased**	**Net Percent Increase in Acres of Modeled Habitat with Full BDCP Implementation**	**Total Acres of Modeled Habitat Conserved with Full BDCP Implementation**	**Total Acres Modeled Habitat in Protected Status with Full BDCP Implementation**	**Net Acres Increase in Protected Habitat with Full BDCP Implementation**	**Percent Change in Protected Modeled Habitat**
Degraded Vernal Pool Complex	2,631	745	52	0	0	0	-	0	-52	-2%	0	724	-21	-3%
Conservancy fairy shrimpTotal	10,401	5,220	94	0	0	0	600	89	-5	0%	689	5,879	659	13%
Longhorn fairy shrimp														
Vernal Pool Complex	7,770	4,475	42	0	0	0	600	89	47	1%	689	5,155	680	15%
Degraded Vernal Pool Complex	2,631	745	52	0	0	0	-	0	-52	-2%	0	724	-21	-3%
Longhorn fairy shrimpTotal	10,401	5,220	94	0	0	0	600	89	-5	0%	689	5,879	659	13%
Midvalley fairy shrimp														
Vernal Pool Complex	7,770	4,475	42	0	0	0	600	89	47	1%	689	5,155	680	15%
Degraded Vernal Pool Complex	2,631	745	52	0	0	0	-	0	-52	-2%	0	724	-21	-3%
Midvalley fairy shrimpTotal	10,401	5,220	94	0	0	0	600	89	-5	0%	689	5,879	659	13%
Vernal pool fairy shrimp														
Vernal Pool Complex	7,770	4,475	42	0	0	0	600	89	47	1%	689	5,155	680	15%
Degraded Vernal Pool Complex	2,631	745	52	0	0	0	-	0	-52	-2%	0	724	-21	-3%
Vernal pool fairy shrimpTotal	10,401	5,220	94	0	0	0	600	89	-5	0%	689	5,879	659	13%
Vernal pool tadpole shrimp														
Vernal Pool Complex	7,770	4,475	42	0	0	0	600	89	47	1%	689	5,155	680	15%
Degraded Vernal Pool Complex	2,631	745	52	0	0	0	-	0	-52	-2%	0	724	-21	-3%
Vernal pool tadpole shrimpTotal	10,401	5,220	94	0	0	0	600	89	-5	0%	689	5,879	659	13%

[1] Known, protected lands were categorized by three protection categories: Category 1 = Protected in perpetuity and managed for ecological protection; Caterfory 2 = Protected in perpuituity and use that maintains ecological value; and Categroy 3 = Protected in perpetuity but not managed to maintain ecological value.

[2] Removed/Converted: Removed=habitat is no longer usable for any life stage of the species. Converted = change from one habitat type (e.g., primary) to another habitat type (e.g., secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g., primary or secondary) to another, lesser function. See Table 5.K-2 for relevant assumptions.

[3] Calculation of impacts based on hypothetical restoratin designs include only areas modeled by RMA that were classified as either "Below MLLW" or "MLLW to MHHW".

[4] Grey-shaded cells indicate: Because the greater sandhill crane has a limited range within the Plan Area, the minimum greater sandhill crane BGO commitment was used here to determine acres of protection. It is likely that a greater number of cultivated land acres will benefit the crane.

[5] Grey-shaded cell indicates: Swainson's hawk nesting habitat will be restored as per Objecitve SWHK2.1: Increase distribution and abundance of potential Swainson's hawk nest trees in the Plan Area by planting and maintaining native trees along roadsides and field borders within protected cultivated lands at a rate of 1 tree per 10 acres.

[6] Grey-shaded cells indicate: This 89 acres are a maximum and are dependent upon the on the ground impact at the time of implementation.

[7] Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Table 5.K.7. Wildlife Modeled Habitat Loss and Conversion by Covered Activity.

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1 **Table 5.6-3b. Net Effects, Plants**

	Baseline		Adverse Effects					Benefits			Total Conservation				
Resource	Acres of Total Existing Modeled Habitat in Plan Area	Acres of Existing Protected [1] Modeled Habitat	Acres of Modeled Habitat Removed/ Converted[2] (Permanent)[3]	Acres of Protected Modeled Habitat Removed/ Converted[2] (Permanent)[3]	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Long-Term Temporary)[4]	Acres of Removed Modeled Habitat (Periodic)	Acres of Modeled Habitat Protected under BDCP	Acres of Modeled Habitat Restored under BDCP	Net Acres of Modeled Habitat Increased	Net Percent Change in Modeled Habitat with Full BDCP Implementation	Total Acres of Modeled Habitat Conserved with Full BDCP Implementation	Total Acres Modeled Habitat in Protected Status with Full BDCP Implementation	Net Acres Increase in Protected Habitat with Full BDCP Implementation	Percent Change in Protected Modeled Habitat
Alkali milk-vetch															
Vernal pool Complex	7,907	4,536	88	30	0	0	76	600	89	1	0%	689	5,195	659	15%
Degraded Vernal Pool Complex	2,494	684	5	0	0	0	0	256	64	59	2%	320	1,004	320	47%
Alkali milk-vetch Total	10,401	5,220	93	30	0	0	76	856	153	60	1%	1,009	6,199	979	19%
Brittlescale Total	472	126	2	1	0	0	0	536	113	111	24%	649	774	648	515%
Boggs Lake hedge-hyssop							0								
Vernal pool Complex	7,907	4,536	88	30	0	0	76	600	89	1	0%	689	5,195	659	15%
Degraded Vernal Pool Complex	2,494	684	5	0	0	0	0	256	64	59	2%	320	1,004	320	47%
Boggs Lake hedge-hyssop Total	10,401	5,220	94	30	0	0	76	856	153	59	1%	1,009	6,199	979	19%
Caper-fruited tropidocarpum Total	1,410	21	0	0	0	34	0	143	36	36	3%	179	200	179	851%
Carquinez goldenbush Total	1,019	380	2	1	0	0	0	83	22	21	2%	105	485	105	28%
Delta button celery Total	3,330	270	26	1	8	0	18	243	277	251	8%	520	788	518	192%
Delta tule pea Total	5,817	3,669	1,599	1,073	33	0	33	38	3,092	1493	26%	3,130	5,727	2,058	56%
Delta mudwort Total	6,074	1,501	140	77	44	0	4	75	2,018	1878	31%	2,093	3,517	2,016	134%
Dwarf downingia							0								
Vernal pool Complex	7,907	4,536	88	30	0	0	76	600	89	1	0%	689	5,195	659	15%
Degraded Vernal Pool Complex	2,494	684	5	0	0	0	0	256	64	59	2%	320	1,004	320	47%
Dwarf downingia Total	10,401	5,220	93	30	0	0	76	856	153	60	1%	1,009	6,199	979	19%
Heckard's peppergrass							61			0					
Vernal pool Complex	7,907	4,536	88	30	0	0	0	600	89	1	0%	689	5,195	320	15%
Degraded Vernal Pool Complex	2,494	684	5	0	0	0	76	256	64	59	2%	320	1,004	979	47%
Heckard's peppergrass Total	10,401	5,220	93	30	0	0	0	856	153	60	1%	1,009	6,199	586	19%
Heartscale Total	6,071	2,759	363	63	0	0	61	536	113	-250	-4%	649	3,345	0	21%
Legenere							0								
Vernal pool Complex	7,907	4,536	88	30	0	0	76	600	89	1	0%	689	5,195	320	15%
Degraded Vernal Pool Complex	2,494	684	5	0	0	0	0	256	64	59	2%	320	1,004	979	47%
Legenere Total	10,401	5,220	93	30	0	0	76	856	153	60	1%	1,009	6,199	2,016	19%
Mason's lilaeopsis Total	6,074	1,501	140	77	44	0	33	75	2,018	1878	31%	2,093	3,517	0	134%
San Joaquin spearscale							0								
Vernal pool Complex	7,907	4,536	88	30	0	0	76	600	89	1	0%	689	5,195	320	15%
Degraded Vernal Pool Complex	2,494	684	5	0	0	0	0	256	64	59	2%	320	1,004	979	47%
San Joaquin spearscale Total	10,401	5,220	93	30	0	0	76	856	153	60	1%	1,009	6,199	348	19%
Slough thistle Total	1,834	188	6	0	31	0	6	103	245	239	13%	348	536	787	185%
Side-flowering skullcap Total	2,495	701	34	13	29	0	14	104	696	662	27%	800	1,488	564	112%
Soft bird's-beak Total	1,225	869	86	86	0	0	0	0	650	564	46%	650	1,433	2,058	65%
Suisun Marsh aster Total	5,817	3,669	1,599	1,072.6	33	0	4	38	3,092	1493	26%	3,130	5,727	564	56%
Suisun thistle Total	1,129	830	86	86	0	0	0	0	650	564	50%	650	1,394	0	68%

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	Baseline		Adverse Effects					Benefits			Total Conservation				
Resource	Acres of Total Existing Modeled Habitat in Plan Area	Acres of Existing Protected [1] Modeled Habitat	Acres of Modeled Habitat Removed/ Converted[2] (Permanent)[3]	Acres of Protected Modeled Habitat Removed/ Converted[2] (Permanent)[3]	Acres of Removed Modeled Habitat (Temporary)	Acres of Removed Modeled Habitat (Long-Term Temporary)[4]	Acres of Removed Modeled Habitat (Periodic)	Acres of Modeled Habitat Protected under BDCP	Acres of Modeled Habitat Restored under BDCP	Net Acres of Modeled Habitat Increased	Net Percent Change in Modeled Habitat with Full BDCP Implementation	Total Acres of Modeled Habitat Conserved with Full BDCP Implementation	Total Acres Modeled Habitat in Protected Status with Full BDCP Implementation	Net Acres Increase in Protected Habitat with Full BDCP Implementation	Percent Change in Protected Modeled Habitat

[1] Known, protected lands were categorized by three protection categories: Category 1 = Protected in perpetuity and managed for ecological protection; Catergory 2 = Protected in perpuituity and use that maintains ecological value; and Category 3 = Protected in perpetuity but not managed to maintain ecological value.

[2] Removed/Converted: Removed = habitat is no longer usable for any life stage of the species. Converted = change from one habitat type (e.g., primary) to another habitat type (e.g., secondary). Conversion is considered an adverse effect only if habitat is converted from one function (e.g. primary or secondary) to another, lesser function. See Table 5.K-2 for relevant assumptions.

[3] Calculation of impacts based on hypothetical restoration designs include only areas modeled by RMA that were classified as either "Below MLLW" or "MLLW to MHHW".

[4] Long-term temporary: Includes spoil and borrow/spoil effects. Natural communities and covered species habitat will be restored; however, restoration will take longer than one year upon completion of construction. See Table 5.K-8, *Plant Modeled Habitat Loss and Conversion by Covered Activity*.

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Table 5.6-4. Covered Plant Species Occurrences, Effects, and Conservation Requirements

	Existing Condition			Adverse Effect	Outcome with Full Implementation of the BDCP			
Plant	CNDDB Occurrences in California[2]	Presumed Extant in Study Area	In Category 1, 2 or 3 Open Space[3]	Maximum Allowable Impact[4]	Protected by BDCP	Allowable Creation in lieu of New Occurrence Protected[5]	Total In Category 1, 2, or 3 Open Space with Full Implementation of the BDCP	Percent Increase in Protected Occurrences with Full Implementation of the BDCP
Alkali milk-vetch	55	14	7	–	2	–	9	22%
Boggs Lake hedge-hyssop	87	1	1	–	–	–	1	–
Brittlescale	59	3	2	–	–	–	2	–
Caper-fruited tropidocarpum	13	6 [6]	–	–	–	–	–	–
Carquinez goldenbush	14	7	4	–	1	0	5	20%
Delta button celery	26	2	0	–	2	2		200%
Delta mudwort	56	57[7]	8	– [7,8]	2	–	8	–
Delta tule pea	129	110	34	– [7,8]	2	–	34	–
Dwarf downingia	116	10	9	–	–	–	9	–
Heartscale	49 [9]	3	1	–	–	–	1	–
Heckard’s peppergrass	14	4	3	1 [10]	2	2	5	40%
Legenere	71	6	6	–	–	–	–	–
Mason’s lilaeopsis	195	190	30	– [7,8]	30	–	30	–
San Joaquin spearscale	106	14	2	1	1	–	3	33%
Slough thistle	19	2	–	–	–	2	2	200%
Side-flowering skullcap	12	12	2	–	–	–	2	–
Soft bird’s-beak[1]	24	11	7	–	–	–	7	–
Suisun Marsh aster[4]	168	155	40	– [7,8]	–	–	40	–
Suisun thistle[1]	3	3	3	–	–	–	3	–

[1] In the BDCP, an occurrence is defined as it is by the CNDDB. The Implementing Office will use the CNDDB definition to track occurrence take, protection, and creation compliance.

[2] Categories of open space are defined in Chapter 3 Conservation Strategy.

[3] Maximum number of occurrence allowed to be taken by BDCP implementation.

[4] If newly discovered occurrences are not found or are unable to be protected, the Implementing Office can create occurrences within the species known range and habitat using native seed stock. Newly created occurrences must persist, at a sustainable population for 10 years to be considered successful.

[5] CNDDB currently lists five of the six occurrences as presumed extant and one as possibly extirpated; however, it is unknown if these occurrences still persist.

[6] In addition to CNDDB occurrences, includes occurrences found in 2010 and 2011 field surveys conducted by the Delta Habitat Conveyance and Conservation Program. Occurrence numbers presented here are consistent with CNDDBs definition of occurrence.

[7] Partial occurrences may be lost due to construction or tidal damping, however, the complete loss of an occurrence is not expected as these ephemeral, annual species are expected to quickly recover from minor environmental perterbation. Pre- and post-construction and restoration monitoring will monitor occurrence persistence to insure no take occurs.

[8] CNDDB has 64 occurrences listed for the state, thirteen of which have not been observed for more than 25 years and ten of which are presumed to be extirpated (CNDDB 2011).

[9] CNDDB Occurrence number seven is a 1891 Jepson collection observation and has not been field verified; however, CNDDB (2011) lists it as “presumed extant”.

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Personal Communications

John Gerlach pers. comm.

R. Preston pers. comm.

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Chapter 5

Effects Analysis

5.7 Other Federal Regulatory Analyses Conclusions

[***Note to Reader:*** *A preliminary evaluation of the effects of the BDCP on critical habitat, essential fish habitat (EFH), and Southern Resident killer whales was released to the fish and wildlife agencies in February 2011. These evaluations provide information for the federal decision-making process that will begin after release of the public draft. These analyses will be revised and updated to reflect the proposed project and included in the public draft for use by the U.S. Fish and Wildlife Service (USFWS) and the National marine Fisheries Service (NMFS). This section will describe the conclusions of the other federal regulatory analyses required, including EFH, critical habitat, and effects on resident killer whales and will reference Appendix 5.I,* Other Federal Regulatory Analyses*. A preliminary outline is provided below for your review.*]

5.7.1 Essential Fish Habitat

[***Note to Reader****: The conclusions of the analysis of EFH will be provided in accordance with amendments to the regulations implementing the Magnuson-Stevens Act in this section. These amendments set forth new mandates for NMFS, eight regional fishery management councils (Councils), and other federal agencies to identify and protect important marine and anadromous fish habitat. The Councils (with assistance from NMFS) are required to delineate EFH for all managed species. The analysis and assessment will be in Appendix 5.I,* Other Federal Regulatory Analyses *and will cover designated EFH for Pacific Coast groundfish, coastal pelagic species, and Pacific salmon, based on their respective fishery management plans that cover the entire study area. This section will present the conclusions of the analysis.*]

5.7.1.1 Managed Species and Effects Summary

[Text forthcoming.]

5.7.1.2 Conclusions

[Text forthcoming.]

5.7.2 Endangered Species Act Section 7 Analysis

[Text forthcoming.]

5.7.2.1 Potential Effects on Southern Resident Killer Whale

[***Note to Reader****: The conclusions of the effects on Southern Resident killer whales will be presented in this section. The BDCP will affect Central Valley salmon and steelhead runs, which account for part of the prey base for Southern Resident killer whales. Therefore, the effects analysis for Southern Resident killer whales, which will be presented in Appendix 5.I, will focus on the expected outcome of the BDCP for these fish species and the indirect effect on Southern Resident killer whale of that outcome. In*

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addition to effects on prey availability, the conclusions will present the BDCP effects on contaminants and their potential indirect effects on Southern Resident killer whales.]

5.7.2.1.1 Presence and Effects Summary

[Text forthcoming.]

5.7.2.1.2 Conclusions

[Text forthcoming.]

5.7.2.2 Potential Effects on Designated Critical Habitat

[***Note to Reader:*** *Critical habitat is designated for many BDCP covered species. The conclusions of the critical habitat analysis will describe the effects of the BDCP on primary constituent elements for each species by life stage based on the results of the analysis described in Appendix 5.I.*]

5.7.2.2.1 Delta Smelt

[Summary determination of effects on critical habitat.]

5.7.2.2.2 Winter-Run Chinook Salmon

[Summary determination of effects on critical habitat.]

5.7.2.2.3 Spring-Run Chinook Salmon

[Summary determination of effects on critical habitat.]

5.7.2.2.4 Steelhead

[Summary determination of effects on critical habitat.]

5.7.2.2.5 Green Sturgeon

[Summary determination of effects on critical habitat.]

5.7.2.2.6 California Red-Legged Frog

[Summary of effects analysis relative to U.S. Fish and Wildlife Service (USFWS) description of critical habitat.]

[Summary Determination of Effects on critical habitat.]

5.7.2.2.7 California Tiger Salamander

[Summary of effects analysis relative to USFWS description of critical habitat.]

[Summary determination of effects on critical habitat.]

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5.7.2.2.8 Vernal Pool Shrimp Species (Vernal Pool Tadpole Shrimp, Conservancy Fairy Shrimp, Vernal Pool Fairy Shrimp)

[Summary of effects analysis relative to USFWS description of critical habitat.]

[Summary determination of effects on critical habitat.]

5.7.2.2.9 Suisun Thistle and Soft Bird's-Beak

[Summary of effects analysis relative to USFWS description of critical habitat.]

[Summary determination of effects on critical habitat.]

5.7.2.2.10 Inland Dune Scrub Plant Species (Contra Costa Wallflower, Antioch Dunes Primrose)

[Summary of effects analysis relative to USFWS description of critical habitat.]

[Summary determination of effects on critical habitat.]