12. Aquatic Biological Resources

12.1 Introduction

This chapter describes the aquatic habitat and fish resources found within the Extended, Secondary, and Primary study areas. Descriptions and maps of these three study areas are provided in Chapter 1 Introduction. Fish species of management concern include special-status species and species that have substantial tribal, commercial or recreation value. The biology and life history of these species are described in Appendix 12A Aquatic Species Life Histories.

Permits and authorizations for aquatic biological resources are presented in Chapter 4 Environmental Compliance and Permit Summary. The regulatory setting for aquatic biological resources is presented in Appendix 4A Environmental Compliance.

The descriptions and evaluation of potential impacts in this chapter are presented using a broad, generalized approach for the Secondary and Extended study areas, whereas the Primary Study Area is presented in greater detail. Potential local and regional impacts from constructing, operating, and maintaining the alternatives are described and compared to applicable significance thresholds. Mitigation measures are provided for identified significant or potentially significant impacts, where appropriate.

The descriptions of species and biological and hydrodynamic processes in this chapter frequently use the terms “Delta” and “San Francisco Estuary.” The Delta refers to the Sacramento-San Joaquin Delta, as legally defined in the Delta Protection Act. The San Francisco Estuary refers to the portion of the Sacramento-San Joaquin rivers watershed downstream of Chipps Island that is influenced by tidal action, and where fresh water and salt water mix. The estuary includes Suisun, San Pablo, and San Francisco bays.

12.2 Environmental Setting/Affected Environment

This section, which is organized by study area, describes fish and aquatic resources that would be affected by the implementation of the alternatives considered in this EIR/EIS. Effects on aquatic resources resulting from changes in Central Valley Project (CVP) and State Water Project (SWP) operations may occur in water bodies in the Extended Study Area; in the Trinity and lower Klamath rivers; and in rivers of the Central Valley, the Delta, and San Francisco Estuary (Secondary Study Area). Effects on aquatic resources resulting from construction under the Sites Reservoir alternatives may occur in Funks Creek, Stone Corral Creek, Grapevine Creek, and Antelope Creek in the proposed Sites Reservoir Inundation Area (Primary Study Area).

As described in Chapter 1 Introduction, the Extended, Secondary, and Primary study areas include the service area of the CVP and SWP through the Central Valley, San Francisco Bay Area, Central Coast, and Southern California; areas with CVP and SWP facilities; and the areas within the Project footprint and buffer. Compared to the Existing Conditions/No Project/No Action Condition, implementation of the action alternatives would result in the following changes in operations: the CVP and SWP reservoirs and surface water flows downstream of those reservoirs, flows in the Sacramento River and the Delta downstream of the Tehama-Colusa Canal Authority (TCCA) and Glenn-Colusa Irrigation District (GCID) Main Canal intakes, and flows at the Delevan Pipeline Intake/Discharge Facilities. It is anticipated that reservoir operations and related flow conditions in the San Joaquin River watershed upstream from the Delta (as defined at Vernalis) would not be affected by implementation of the action alternatives as compared to the Existing Conditions/No Project/No Action Condition. Surface water conditions in the San Francisco Bay Area, Central Coast, and Southern California regions also would not be affected by implementation of the action alternatives as compared to the Existing Conditions/No Project/No Action Condition because the surface water streams generally are not affected by availability of CVP and SWP water supplies. Therefore, aquatic resources are not further discussed in this chapter for the San Joaquin River upstream from Vernalis or streams in the San Francisco Bay Area, Central Coast, and Southern California regions.

12.2.1 Methodology

Queries of special-status fish and aquatic species databases were conducted to generate lists of species to be evaluated in this chapter. A county-level California Natural Diversity Database (CNDDB) search was conducted using the Quick View Tool (California Department of Fish and Wildlife [CDFW], 2017a; formerly known as California Department of Fish and Game [CDFG]) to determine the special-status fish species that may occur within the 33 counties included in the Extended Study Area, the 18 counties included in the Secondary Study Area, and the 2 counties in the Primary Study Area. Note that some counties are included in more than one of these study areas. The generated lists include the entire county, and therefore may contain species that would be found in the county but not in all waterways in the county. Lists of special-status fish species that may occur within the Extended, Secondary, and Primary study areas were generated using the U.S. Fish and Wildlife Service's (USFWS) Information for Planning and Conservation (IPaC) website (USFWS, 2017). Each list includes federal endangered, threatened, and candidate species (including aquatic species), as well as areas of designated critical habitat. Critical habitat is habitat that is essential to the conservation of the species and is protected pursuant to the Federal Endangered Species Act (FESA). IPaC includes only those species for which USFWS is the sole lead agency or for which USFWS and the National Marine Fisheries Service (NMFS) share the lead responsibilities.

Many fish and aquatic species use one or more of the study areas during all or some portion of their lives; however, certain fish and aquatic species were selected to be the focus of the analysis of alternatives considered in this EIR/EIS based on their sensitivity and potential to be affected by implementation of the Sites Reservoir alternatives, as summarized in Tables 12-1, 12-2, and 12-3. These species are fish and marine mammal species listed as threatened or endangered, or at risk of being listed as endangered or threatened, legally protected, or otherwise considered sensitive by the USFWS, NMFS, or CDFW, as well as fish that have tribal, commercial, or recreational importance. In addition, salmon, steelhead, sturgeon, striped bass, and American shad are managed in accordance with Section 3406 of the Central Valley Project Improvement Act (CVPIA). Details on the status, life history, and habitat requirements for each of the aquatic species analyzed in this EIR/EIS are provided in Appendix 12A Aquatic Species Life Histories. Changes in the operation of the CVP and SWP attributable to implementation of the action alternatives would not directly affect ocean conditions; however, operational changes have the potential to affect Southern Resident killer whales indirectly by influencing the number of Chinook salmon produced in the Sacramento and San Joaquin rivers (and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales. Therefore, Southern Resident killer whales are included in the list of species of management concern for the Secondary Study Area.

The analysis for special-status species in this section is focused on fish species listed pursuant to the FESA that could occur within the Sacramento/San Joaquin River and Delta region as described in USFWS's IPaC website (USFWS, 2017). For species listed pursuant to the California Endangered

Species Act (CESA) in this region, the January 2017 Special Animals List maintained by CDFW was consulted (CDFW, 2017b). Documents or data that are specific to areas and species within the Secondary Study Area were also reviewed to characterize aquatic biological resources.

12.2.2 Extended Study Area

The Extended Study Area, consisting of the SWP and CVP service areas (see Figure 1-3), is the largest and most diverse of the three study areas in terms of size, geography, land use, and habitat conditions. As such, it is described and evaluated at the lowest level of detail. The Sites Reservoir Project's (Project's) purpose of improved water supply reliability has the potential for long-term direct and indirect effects within these two service areas, primarily in the reservoirs that supply the service areas. The Extended Study Area also includes wildlife refuges that could receive Level 4[1] water supply from the Project. Those wildlife refuges are located within seven counties in the Extended Study Area (see Figure 1-4).

12.2.2.1 National Wildlife Refuges and Wildlife Areas

In addition to providing irrigation water to the Sacramento and San Joaquin valleys, and domestic water to cities and industries in Sacramento County and the east and south Bay areas, the CVP supplies water to wildlife refuges.

Numerous fish species occur in the waterways that deliver CVP Level 4 water to the wetlands within the wildlife refuges. In the Sacramento River Basin, the refuges that receive Level 4 water include the Sacramento and Delevan national wildlife refuges (NWR). Waterways within these refuges include creeks, the Colusa Basin Drain (CBD), and many smaller water supply and drainage ditches. Most resident fish in the waterways that supply the refuge system are non-native warm-water species. The fish species of management concern that are found in the Sacramento River system and CBD are discussed in more detail in Sections 12.2.2 (Sacramento) and 12.2.3 (CBD).

The waterways of the NWRs and Wildlife Areas (WAs) within the San Joaquin River Basin and Tulare Lake Basin that receive Level 4 water supply also support warm-water resident fish species. Listed fish species are not known to occur within the San Joaquin River Basin and the Tulare Lake Basin NWRs and WAs within the Extended Study Area (Bureau of Reclamation [Reclamation] et al., 2001; USFWS, 2004). Fish species commonly found in the San Joaquin River Basin NWR water conveyance ditches and canals include spotted bass (*Micropterus punctulatus*), largemouth bass (*M. salmoides*), channel catfish (*Ictalurus punctatus*), sunfish (*Lepomis* spp.), brown bullhead (*Ameiurus nebulosus*), and common carp (*Cyprinus carpio*). Sacramento splittail (*Pogonichthys macrolepidotus*) may occur within the San Joaquin River Basin NWRs during periods of spring flooding or high flows. Spawning populations of fall-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley Steelhead (*Oncorynchus mykiss*), and lamprey (*Lampetra* spp.) are known to occur in the San Joaquin River Basin north and downstream of the NWRs (Reclamation et al., 2001). Fish passage upstream of the Merced River confluence is limited during the fall by a fish barrier that CDFW maintains in the San Joaquin River to prevent passage of adult fall-run Chinook salmon.

[1] The Level 4 water deliveries that could be affected by Project operation are contracted to: The Sacramento and Delevan National Wildlife Refuges (NWR), the West Bear Creek unit of the San Luis NWR Complex and the Merced unit of the Merced NWR; the Los Banos, Volta, and Mendota Wildlife Areas, the China Island and Salt Slough units of the North Grasslands Wildlife Area, and private wetlands of the Grassland Resource Conservation District within the San Joaquin River Basin; and the Kern and Pixley NWRs within the Tulare Lake Basin.

12.2.2.2 Export Service Area Reservoirs

The CVP and SWP reservoirs (including San Luis Reservoir) that supply the service areas within the Extended Study Area support warm-water and cold-water sport fish, such as striped bass (*Morone saxatilis*), largemouth bass, and resident rainbow trout (*Oncorhynchus mykiss*). Fish species listed as sensitive, threatened, or endangered are found downstream of the major Central Valley reservoirs and in the Sacramento-San Joaquin Delta (Delta), but do not persist in the aqueduct and other constructed water conveyance and storage facilities. The fish species of management concern that are found in the Sacramento River Watershed and Delta are discussed in more detail in Section 12.2.2. Fish species of management concern that occur within and downstream of the CVP and SWP export service area reservoirs of the Extended Study Area are listed in Table 12-1.

Table 12-1
Fish Species of Management Concern in Export Service Area Reservoirs in the Extended Study Area

Species	Scientific Name	Federal Status	State Status[a]	Tribal, Commercial, or Recreational Importance	Potential Location of Occurrence Within Study Area[b]
Hardhead	*Mylopharodon conocephalus*	None	Species of Special Concern	No	Reservoirs, streams
Striped Bass	*Morone saxatilis*	None	None	Yes	Reservoirs, streams
Black Bass (Largemouth, Smallmouth, Spotted)	*Micropterus spp.*	None	None	Yes	Reservoirs, streams

[a]Includes species listed by the State of California as threatened, endangered, or Species of Special Concern.

[b]Indicates locations in the Extended Study Area where the species is potentially present or known to occur.

12.2.3 Secondary Study Area

The Secondary Study Area is smaller than the Extended Study Area, and consists of SWP and CVP facilities that could be affected by Project operations (see Figure 1-5). This study area has been described and evaluated in more detail than the Extended Study Area. Operational changes could occur as a result of the cooperative and integrated operation of the Project's facilities with those State and federal projects located on the Trinity River, Sacramento River, Clear Creek, Spring Creek, Feather River, and American River, and in the Delta. The following subsections describe the environmental setting/affected environment in the Sacramento, Feather, American, and Trinity river watersheds; in the Delta; and in the San Francisco Bay Estuary.

12.2.3.1 Sacramento River Watershed

The aquatic environments associated with the Sacramento River Watershed include Shasta Lake, Keswick Reservoir, Whiskeytown Reservoir, Spring Creek, Clear Creek, and the Sacramento River downstream of Keswick Dam. The Sacramento River Watershed drains an area of approximately 27,000 square miles and is the largest watershed in California (Figure 12-1). Its headwater streams upstream of Shasta Dam include the Fall, Upper Sacramento, Pit, and McCloud rivers. The watershed also includes the Feather River and American River watersheds.

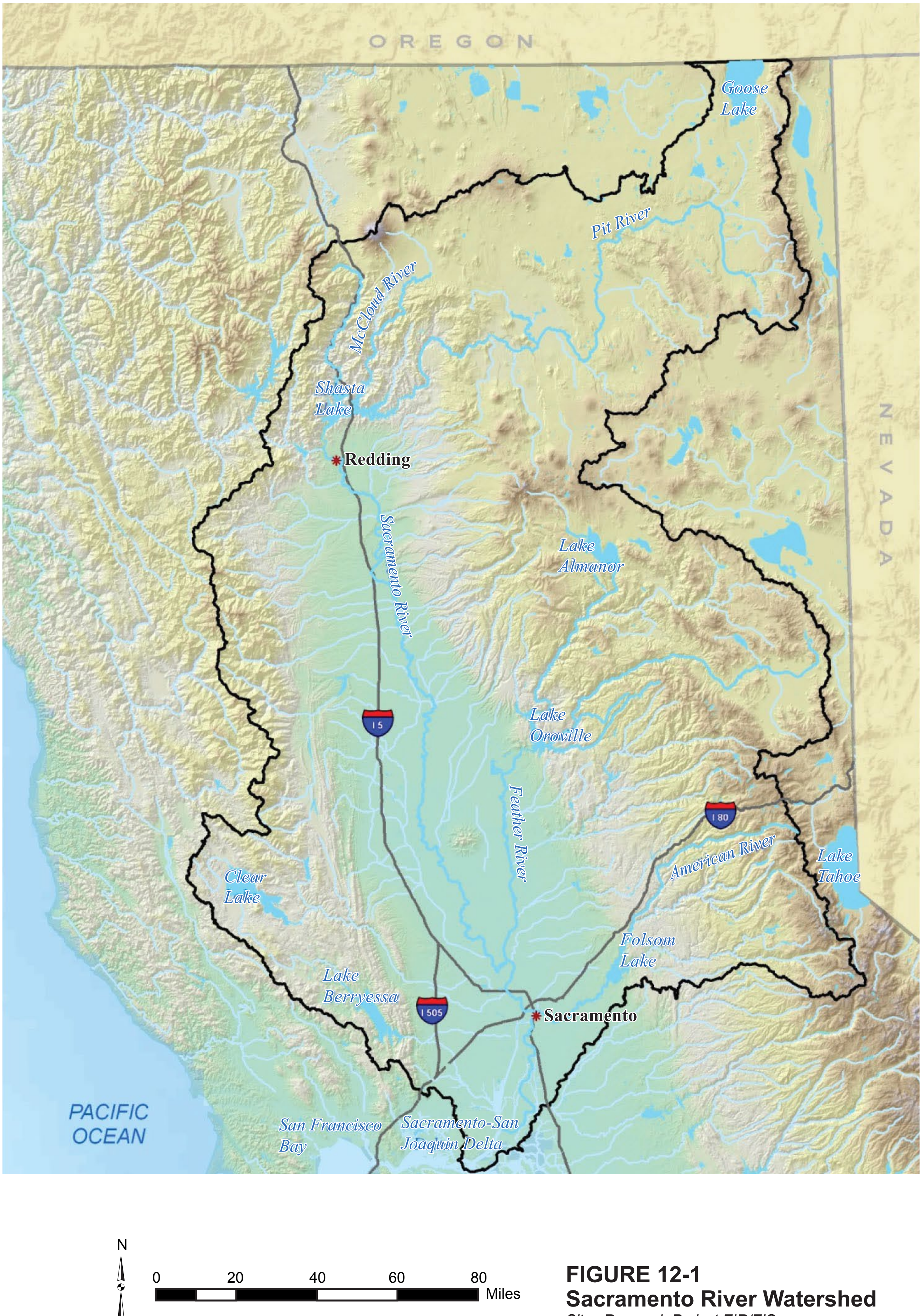


FIGURE 12-1
Sacramento River Watershed
Sites Reservoir Project EIR/EIS

The Sacramento River Watershed supports several fish species of management concern (Table 12-2), including green sturgeon (*Acipenser medirostris)*, Central Valley steelhead, and winter-, spring-, fall-, and late fall-run Chinook salmon.

Table 12-2
Species of Management Concern in the Secondary Study Area

Species or Population[a]	Scientific Name	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Potential for Occurrence Within Study Area[c]
Coho Salmon *Southern Oregon/Northern California Coast ESU*	*Oncorhynchus kisutch*	Threatened	Threatened	Yes	Trinity River, Klamath River
Eulachon *Southern DPS*	*Thaleichthys pacificus*	Threatened	None	Yes	Klamath River
Spring-run Chinook Salmon *Upper Klamath-Trinity River ESU*	*Oncorhynchus tshawytscha*	None	Species of Special Concern	Yes	Trinity River, Klamath River
Steelhead (winter- and summer-run) *Klamath Mountains Province DPS*	*Onchorynchus mykiss*	None	Species of Special Concern[e]	Yes	Trinity River, Klamath River
Winter-run Chinook Salmon[d] *Sacramento River ESU*	*Oncorhynchus tshawytscha*	Endangered	Endangered	Yes	Sacramento River, Delta, and Suisun Marsh
Spring-run Chinook Salmon[d] *Central Valley ESU*	*Oncorhynchus tshawytscha*	Threatened	Threatened	Yes	Clear Creek, Sacramento River[f], Feather River, Delta, and Suisun Marsh
Fall-/late Fall-run Chinook Salmon *Central Valley ESU*	*Oncorhynchus tshawytscha*	None	Species of Special Concern	Yes	Clear Creek, Feather River, Sacramento River, American River, Delta, and Suisun Marsh
Steelhead[d] *Central Valley DPS*	*Onchorynchus mykiss*	Threatened	None	Yes	Clear Creek, Feather River, Sacramento River; American River, Delta, and Suisun Marsh
Green Sturgeon[d] *Southern DPS*	*Acipenser medirostris*	Threatened	Species of Special Concern	Yes	Trinity River, Klamath River, Feather River, Sacramento River, Delta, and Suisun Marsh
White Sturgeon	*Acipenser transmontanus*	None	None	Yes	Trinity River, Klamath River, Feather River, Sacramento River, American River, Delta, and Suisun Marsh
Delta Smelt[d]	*Hypomesus transpacificus*	Threatened	Endangered	No	Delta and Suisun Marsh

Species or Population[a]	Scientific Name	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Potential for Occurrence Within Study Area[c]
Longfin Smelt *Bay Delta DPS*	*Spirinchus thaleichthys*	Candidate	Threatened	No	Delta and Suisun Marsh
Sacramento Splittail	*Pogonichthys macrolepidotus*	None	Species of Special Concern	No	Feather River, American River, Sacramento River, Delta, and Suisun Marsh
Hardhead	*Mylopharodon conocephalus*	None	Species of Special Concern	No	Clear Creek, Feather River, Sacramento River, American River, Delta
River Lamprey	*Lampetra ayresi*	None	None	Yes	Feather River, American River, Sacramento River, Delta, and Suisun Marsh
Pacific Lamprey	*Lampetra tridentata*	None	None	Yes	Trinity River, Klamath River, Clear Creek, Feather River, Sacramento River, American River, and Delta
Striped Bass	*Morone saxatilis*	None	None	Yes	Feather River, American River, Sacramento River, Delta, and Suisun Marsh
American Shad	*Alosa sapidissima*	None	None	Yes	Trinity River, Feather River, American River, Sacramento River, Delta, and Suisun Marsh
Black Bass (Largemouth, Smallmouth, Spotted)	*Micropterus spp.*	None	None	Yes	CVP/SWP Reservoirs, Trinity River, Feather River, American River, Sacramento River, Delta, and Suisun Marsh,

[a]The term “population” refers to the listed Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS) for that species.

[b]Includes species listed by the State of California as threatened, endangered, or Species of Special Concern.

[c]Indicates locations in the Secondary Study Area where the species is potentially present or known to occur.

[d]Critical habitat has been designated for this species.

[e]The California Species of Special Concern designation refers only to the summer-run of the Klamath Mountains Province DPS steelhead population.

[f]Also includes lower reaches of tributaries (e.g., American River) used for nonnatal rearing areas by juvenile salmon.

Shasta Lake

Shasta Lake supports cold-water and warm-water fisheries. Thermal stratification, which occurs in Shasta Lake annually between April and November, establishes a warm surface water layer (epilimnion), a middle water layer characterized by decreasing temperature with increasing depth (metalimnion or thermocline), and a bottom cold-water layer (hypolimnion). The warm epilimnion of Shasta Lake can reach a peak water temperature of 80 degrees Fahrenheit (°F) (Reclamation, 2003) and provides habitat for warm-water fishes, whereas the reservoir's cold metalimnion and hypolimnion provides habitat for cold-water fish species throughout the summer and fall. Hence, Shasta Lake supports a "two-story" fishery during the stratified portion of the year (April through November).

Cold-water species include rainbow trout, brown trout (*Salmo trutta)*, landlocked white sturgeon, landlocked coho salmon (Reclamation et al., 2003), and landlocked Chinook salmon (Reclamation, 2013). The lake's rainbow trout and Chinook salmon fishery are sustained through stocking of hatchery-raised fish. Shasta Lake warm-water species include smallmouth bass (*Micropterus dolomieu*), largemouth bass, spotted bass, black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), channel catfish, white catfish (*Ameiurus catus*), and brown bullhead (California Department of Water Resources [DWR] et al., 2013). Non-game species in Shasta Lake include golden shiner (*Notemigonus crysoleucas*), threadfin shad (*Dorosoma petenense*), common carp, Sacramento sucker (*Catostomus occidentalis*), and Sacramento pikeminnow (*Ptychocheilus grandis*) (DWR et al., 2013; Reclamation, 2013). The rainbow trout, Chinook salmon, smallmouth, largemouth, and spotted bass fisheries are important sport fisheries in the area.

Although developed primarily for irrigation, the multiple-purpose Shasta Lake also provides flood control, improves Sacramento River navigation, supplies domestic and industrial water, generates hydropower, provides fish and wildlife habitat, creates opportunities for recreation, and enhances water quality. These uses of Shasta Lake water cause water surface elevations to fluctuate by approximately 55 feet over the course of a year (Reclamation, 2003). Reservoir surface elevation fluctuations can disturb shallow, nearshore habitats that support spawning and rearing habitat for warm-water fish species.

Disruptions to littoral habitat also occur from shoreline wave action caused by wind and boating activity (Reclamation et al., 2003). Littoral habitat supports spawning and rearing habitat for warm-water fish that are important for the sport fishery. These fish include smallmouth, largemouth, and spotted bass; black crappie; bluegill; and green sunfish. These fish species spawn in the spring between March and June. Surface water fluctuations during spring can dewater nests and reduce the amount of overhanging, emergent, and submerged vegetative cover, which can reduce the abundance of these fish species (DWR, 2002). However, the shoreline of Shasta Lake is generally steep, which limits shallow, warm-water fish habitat and is not conducive to the establishment of vegetation or other shoreline cover (Reclamation, 2003).

Keswick Reservoir

Keswick Reservoir is a re-regulating reservoir for Shasta Dam. The water surface elevation is relatively constant, but can fluctuate 1 to 3 feet daily and as much as 8 to 9 feet annually. Residence time for water in Keswick Reservoir is approximately 1 day, compared with a residence time of approximately 1 year for water in Shasta Lake. Consequently, water temperatures tend to be controlled by releases from Shasta Dam Diversions, as well as diversions from Whiskeytown Lake through the Spring Creek Tunnel and Powerplant, and average less than 55°F. Despite the cool temperatures, the reservoir supports warm-water fishes such as largemouth bass, crappie, and catfish; and cold-water fishes, including rainbow trout (Reclamation, 2003). CDFW occasionally plants hatchery-reared rainbow trout in Keswick Reservoir. The reservoir is accessible from shore and by boat, but it is not heavily used for fishing. Keswick Dam is the uppermost barrier to anadromous fish migrating up the Sacramento River.

Whiskeytown Lake

Whiskeytown Lake supports cold-water and warm-water fisheries. Cold-water fish species include rainbow trout, brown trout, landlocked Chinook salmon, and kokanee (landlocked sockeye) salmon (*Oncorhynchus nerka*). The lake is well known for its kokanee salmon sport fishery. CDFW plants kokanee in Whiskeytown Lake, but kokanee also spawn in tributaries, such as Brandy and Whiskeytown creeks upstream of the reservoir. Warm-water fish species include largemouth bass, crappie, green sunfish, and various species of catfish.

From Whiskeytown Lake, water is released into the lower portion of Clear Creek via Whiskeytown Dam and into Keswick Reservoir through the Spring Creek Tunnel. The cold-water pool in Whiskeytown Lake is managed to provide cold water for release to the Sacramento River and Clear Creek. Temperature control curtains are operated on Whiskeytown Lake and on Lewiston Reservoir to improve the amount of cold-water pool available for release to the Sacramento River for winter-run Chinook salmon. The Whiskeytown Lake curtains are the Oak Bottom curtain located at the Judge Francis Carr Powerhouse outlet and at Spring Creek curtain at the Spring Creek Tunnel inlet. The Oak Bottom curtain was repaired and prevents the mixing of cold Trinity River water with warm surface water and directs it to the reservoir's deep cold-water layer. The Spring Creek Tunnel curtain was replaced in 2011 and prevents the diversion of warm surface water while allowing the diversion of cold water from the reservoir's bottom layer. Similar to Shasta Lake, fluctuations in surface water elevations disturb littoral habitat and warm-water fish species important to the sport fishery.

Clear Creek

Water operations in Clear Creek, including diversions to Clear Creek from the Trinity River, are components of the integrated operations of the Trinity River Division CVP system. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Powerplant and into Keswick Reservoir (up to 2,000 cubic feet per second [cfs]). All of the water diverted from the Trinity River, plus a portion of Clear Creek flows, is diverted through the Spring Creek Power Conduit into Keswick Reservoir to assist in meeting water temperature objectives in the Sacramento River (Reclamation, 2008; Western Shasta Resource Conservation District, 1996).

Whiskeytown Dam blocks access to 25 miles of historical spring-run Chinook salmon and steelhead spawning and rearing habitat (Yoshiyama et al., 1996). Whiskeytown Dam limits the contribution of coarse sediment for transport downstream in Clear Creek, which NMFS (2009a) reported has resulted in riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition, and considerable loss of spawning gravels. Since 1995, extensive habitat and flow restoration in Clear Creek has occurred under the CVPIA and CALFED programs, and in accordance with the NMFS 2009 biological opinion that has improved spawning conditions for anadromous salmonids.

Clear Creek generally receives the same temperature water as the water released to the Sacramento River, which has generally provided suitable conditions for Clear Creek fish species (Reclamation, 2008). Since 1999, mean daily water temperatures have been maintained at 60°F or less down to the U.S. Geological Survey (USGS) gauge at Igo, which is consistent with the 2004 NMFS Opinion for steelhead over summering requirements (NMFS, 2009a). Although water temperatures may exceed 60°F downstream of the Igo Gauge, mean daily temperatures near the confluence with the Sacramento River rarely exceed 70°F (USFWS, 2007). Since 2002, Reclamation has managed releases to meet a daily average water temperature of 56°F at the Igo Gauge (4 miles downstream of Whiskeytown Dam) from September 15 through October 30, to provide for spring-run Chinook salmon spawning. In 2004, an additional daily average temperature of 60°F was implemented from June 1 to September 15 to protect over-summering juvenile steelhead and holding adult spring-run Chinook salmon.

Clear Creek supports a modest run of spring-run Chinook salmon as well as fall/late fall-run Chinook salmon, steelhead, and Pacific lamprey. Clear Creek is federally designated critical habitat for Central Valley spring-run Chinook and Central Valley steelhead. Fall/late fall-run Chinook salmon primarily use the lower reaches of Clear Creek for all life history phases. A temporary picket weir installed about 7.4 miles upstream of the confluence with the Sacramento River is used to prevent fall-run Chinook salmon from spawning in the upper reaches with spring-run. The steelhead spawning distribution has expanded from the upper 4 miles of lower Clear Creek to the entire 17 miles of lower Clear Creek, although it appears to be concentrated in areas of newly added spawning gravels. Pacific lamprey is expected to inhabit all reaches in Clear Creek upstream to Whiskeytown Dam.

Sacramento River Downstream of Keswick Dam

Shasta Lake releases and, therefore, Sacramento River flow, often are governed by water temperature requirements below Keswick Dam for April through October, and by an end-of-September minimum carryover storage for Shasta Lake of 1.9 million acre-feet (MAF) to protect Sacramento River winter-run Chinook salmon. To meet the temperature objectives, a dynamic evaluation of ambient air temperature, weather forecasts, water temperature at the release point, and release rate occurs. Determination of the appropriate release rate is often made based on the temperature of the water released, rather than the rate needed to support CVP operations. Generally, it takes higher releases to meet water temperature targets with warmer water and lower releases with colder water. The cold-water pool in the reservoir is essentially a function of the volume of water in the reservoir. More cold water is available when the reservoir is full; less is available as the reservoir is drawn down. In years when CVP facilities cannot be operated to meet required temperature and storage objectives, Reclamation re-initiates consultation with NMFS.

The Sacramento River supports a wide range of aquatic habitats, from fast-flowing gravel bedded reaches with alternating riffles and pools, to slow-moving off-channel sloughs and oxbows with fine sediments (Vogel, 2011). From Keswick Dam to Red Bluff, the river is relatively narrow and deep with some areas of broader alluvial floodplain. Most of the Chinook salmon spawning habitat in the Sacramento River is located in this reach. A few miles downstream of Keswick Dam near Redding, the river enters the valley and the floodplain broadens. Historically, this area likely had wide expanses of riparian forests, but much of the river’s riparian zone is subject to urban encroachment, particularly in the Anderson/Redding area.

Between Red Bluff and Colusa, the river meanders over a broad alluvial floodplain, and flow is potentially significantly affected by tributaries during winter storms. From Colusa to Sacramento, the river is constrained by levees. In this reach, high winter flows spill from the river into a system of weirs and bypasses, including the Sutter Bypass and Yolo Bypass.

The variability and magnitude of natural seasonal flows on the Sacramento River have been significantly altered for the purposes of irrigation and flood control. The dams and diversions operated by the CVP and local irrigation districts control much of the flow in the Sacramento River. These dams and diversions include the Shasta, Keswick, Trinity, Lewiston, Whiskeytown, and Spring Creek Debris dams and diversions to the Anderson-Cottonwood Irrigation District canal downstream of Redding. Diversions from the Sacramento River also are made into the Tehama-Colusa and Corning canals near Red Bluff (TCCA and Reclamation, 2002), into the GCID Main Canal near Hamilton City, and at approximately

431 water diversions on the Sacramento River between Keswick Dam and the City of Sacramento at the I Street Bridge, many of which are unscreened (Herren and Kawasaki, 2001). Most of the diversions occur between the City of Colusa and the City of Sacramento.

A pumping plant and fish screen were completed in 2012 upstream of Red Bluff Diversion Dam (RBDD) as part of the Red Bluff Fish Passage Improvement Project to replace the dam and improve passage for Chinook salmon, steelhead, and green sturgeon. The screen design allows diversion of up to 2,500 cfs. The pumping plant has a diversion rate of 2,000 cfs and can be expanded to a rate of 2,500 cfs (Reclamation, 2009). Fish screens have been added to other intakes along the Sacramento River, including the fish ladder and fish screen constructed in 2011 at the Anderson-Cottonwood Irrigation District near Redding. Reclamation is coordinating with USFWS to support improvements at other fish screens. In 2013, CVPIA funds were used to construct the Natomas Mutual Sankey Fish Screen on the Sacramento River that replaced two existing diversions on the Natomas Cross Canal. This Project also resulted in the removal of an anadromous fish migration barrier (seasonal diversion dam) on the Natomas Cross Canal. The fish screening program also completed construction of four fish screens on the Sacramento River and one fish screen in the Delta.

The GCID Hamilton City Pumping Plant provides water primarily for agricultural users, including water for rice straw decomposition in the fall and maintenance of waterfowl habitat. In 2000, a new intake was constructed using a flat plate screen to improve protection for larval and juvenile anadromous fish. To maintain appropriate sweeping and approach velocities at the screen, a “gradient facility” was constructed in the main channel of the Sacramento River upstream of the oxbow (Vogel, 2005).

Shasta Dam has the largest impact on Sacramento River flow. In addition to altering flows, the dam has substantially reduced the quality and availability of habitat for migratory and resident fish species by blocking passage, and reducing the delivery of coarse sediment and large wood debris. The effects of Shasta Dam on spawning habitat quality and flow are especially evident in the Redding area. Downstream of Redding, the tributaries to the Sacramento River, such as Cow Creek and Cottonwood Creek, influence flow and sediment supply and reduce the impacts of Shasta Dam on channel and floodplain habitat.

To protect holding and spawning winter-run Chinook salmon, Reclamation has implemented a temperature management plan to manage cold-water reservoir storage and releases to maintain daily average water temperatures at or below 56ºF between Keswick Dam and compliance locations between Balls Ferry and Bend Bridge from May 15 to September 30 since 1993. In drier years, when reservoir storage is low, the stretch of river in which cold-water temperatures are maintained is shortened by approximately 9 miles, ending at Jelly’s Ferry Bridge. Water temperature control was improved in 1997 with the installation of the temperature control device at Shasta Dam.

To mitigate the loss of coarse sediment, Reclamation has managed an ongoing gravel augmentation program since 1997 on the Sacramento River, pursuant to the CVPIA, to improve Chinook salmon and steelhead spawning habitat in the Redding area upstream of Turtle Bay (River Mile [RM] 299). Large in-channel gravel mining pits, which were created when gravel was mined for the construction of Shasta Dam, trap the gravel as it is transported downstream, limiting the amount of spawning habitat that is enhanced and reducing the time the gravel functions as spawning habitat. The gravel is placed upstream of these pits to enhance spawning habitat for winter-run Chinook salmon, which spawn primarily between Keswick Dam and Turtle Bay.

The Sacramento River below Keswick Dam is used by several fish species of management concern, either as habitat during one or more of their life stages, or as a migration corridor to available habitat in the upper Sacramento River and its tributaries. The upper Sacramento River is federally designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the Southern Distinct Population Segment (DPS) of green sturgeon. These species of management concern are described below and in Appendix 12A Aquatic Species Life Histories. The following discussion focuses on the fish in the Sacramento River and aquatic habitat conditions.

Winter-run Chinook Salmon

Winter-run Chinook salmon are anadromous, rearing in fresh water before outmigrating to the ocean, and growing to full size in the ocean prior to returning to their natal streams to spawn. Adult winter-run Chinook salmon return to fresh water during winter, but delay spawning until spring and summer. Adults enter fresh water in an immature reproductive state, similar to spring-run Chinook, but winter-run Chinook move upstream much more quickly and then hold in the cool waters downstream of Keswick Dam for an extended period before spawning. Juveniles spend about 5 to 9 months in the river and estuary systems before entering the ocean. This life-history pattern differentiates the winter-run Chinook from other Sacramento River Chinook runs and from all other populations within the range of Chinook salmon (CDFW 1985, 1998).

Access to approximately 58 percent of the original winter-run Chinook salmon habitat has been blocked by dam construction (Reclamation, 2008). The remaining accessible habitat occurs in the Sacramento River downstream of Keswick Dam and in Battle Creek. The number of winter-run Chinook salmon in Battle Creek is unknown, but if they do occur, they are scarce (Reclamation and State Water Resources Control Board [SWRCB], 2003).

Adult winter-run Chinook salmon migrate upstream past the location of the RBDD beginning in mid-December and continuing into early August. Most of the run passes RBDD between January and May, with the peak in mid-March (CDFW, 1985). Winter-run Chinook salmon spawn only in the Sacramento River, almost exclusively above RBDD, with the majority spawning upstream of Balls Ferry (CDFW, 1998). Aerial redd surveys have indicated that the winter-run Chinook salmon spawning distribution has shifted upstream since gravel introductions began in the upper river near Keswick Dam; a high proportion of winter run Chinook spawn on placed gravel (USFWS and Reclamation, 2008). Spawning occurs May through July, with the peak in early June. Fry emergence occurs from mid-June through mid-October and fry disperse to areas downstream for rearing. Juvenile migration past RBDD may begin in late July, generally peak in September, and can continue until mid-March in drier years (Vogel and Marine, 1991). The majority (75 percent) of winter-run Chinook salmon outmigrate past RBDD as fry (Martin et al., 2001), where they rear before outmigrating to the Delta primarily in December through April (Appendix 12A Aquatic Species Life Histories). Between 44 and 81 percent (mean 65 percent) of juvenile winter-run Chinook salmon use areas downstream of the RBDD for nursery habitat, and the relative usage of rearing habitat upstream and downstream of the RBDD appear to be influenced by river flow during fry emergence (Martin et al., 2001). Winter-run Chinook salmon usually migrate past Knight's Landing once flows at Wilkins Slough rise to about 14,000 cfs; most juvenile winter-run Chinook salmon outmigrate past Chipps Island by the end of March (del Rosario et al., 2013).

Spring-run Chinook Salmon

Spring-run Chinook salmon are anadromous, rearing in fresh water before outmigrating to the ocean, and growing to full size in the ocean prior to returning to their natal streams to spawn. Naturally spawning populations of spring-run Chinook salmon are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFW, 1998). Most of these reaches are outside the Secondary Study Area; however, all spring-run Chinook salmon migratory life stages must pass through the study area.

Chinook salmon expressing spring-run timing do spawn in the mainstem Sacramento River between RBDD and Keswick Dam (NMFS, 2009a). The Sacramento River now serves primarily as a migratory corridor for the adult and juvenile life stages of spring-run (and other runs) of Chinook salmon.

In fresh water, juvenile spring-run Chinook salmon rear in natal tributaries, the Sacramento River mainstem, and nonnatal tributaries to the Sacramento River (CDFW, 1998). Out-migration timing is highly variable, as the salmon may migrate downstream as fry, juveniles, or yearlings. The out-migration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the fry and juvenile fish outmigrating through the lower Sacramento River and Delta during this period (CDFW, 1998). Peak movement of juvenile spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December and again in March (Snider and Titus, 1998, 2000a, 2000b, 2000c; Vincik et al., 2006; Roberts, 2007). Migratory cues, such as increased flows, increasing turbidity from runoff, changes in day length, or intraspecific competition from other fish in their natal streams, may spur out-migration of juveniles from the upper Sacramento River basin when they have reached the appropriate stage of maturation (NMFS, 2009a). Spring-run juveniles that remain in the Sacramento River over summer are confined to approximately 100 miles of the upper mainstem, where cool water temperatures are maintained by dam releases.

Fall-/Late Fall-run Chinook Salmon

Fall-run Chinook salmon are anadromous, rearing in fresh water before outmigrating to the ocean, and growing to full size in the ocean prior to returning to their natal streams to spawn. The fall-run Chinook salmon is an ocean-maturing type of salmon, adapted for spawning in lowland reaches of big rivers, including the mainstem Sacramento River; the late fall-run Chinook salmon is mostly a stream-maturing type (Moyle, 2002). Similar to spring-run, adult late fall-run Chinook salmon typically hold in the river for 1 to 3 months before spawning, while fall-run Chinook salmon generally spawn shortly after entering fresh water. Fall-run Chinook salmon migrate upstream past RBDD on the Sacramento River between July and December, typically spawning in upstream reaches from October through March. Late fall-run Chinook salmon migrate upstream past RBDD from August to March and spawn from January to April (NMFS, 2009a; TCCA, 2008). The majority of fall-run Chinook salmon migrate to the ocean during the first few months following emergence, although some may remain in fresh water and migrate as yearlings. Late fall-run juveniles typically enter the ocean after 7 to 13 months of rearing in fresh water, at 150- to 170 millimeters [mm] in fork length, considerably larger and older than fall-run Chinook salmon (Moyle, 2002).

The primary spawning area used by fall- and late fall-run Chinook salmon in the Sacramento River is the area from Keswick Dam downstream to RBDD. Spawning densities for each of the runs are generally highest in this reach.

Annual fall-run and late fall-run Chinook salmon escapement to the Sacramento River and its tributaries has generally been declining in the last decade, following peaks in the late 1990s to early 2000s (Azat, 2012).

Steelhead

Steelhead are the anadromous form of rainbow trout, rearing in fresh water before outmigrating to the ocean, and growing to full size in the ocean prior to returning to their natal streams to spawn. Although steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry, only winter-run steelhead are found in Central Valley rivers and streams. Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks, and the Yuba River. Populations may exist in other tributaries, and a few naturally spawning steelhead are produced in the American and Feather rivers (McEwan and Jackson, 1996).

Adult steelhead migrate upstream past the Fremont Weir between August and March, primarily from August through October. They migrate upstream past RBDD during all months of the year, but primarily during September and October (NMFS, 2009a). The primary spawning area used by steelhead in the Sacramento River is the area from Keswick Dam downstream to RBDD. Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 2 to 4 years before outmigrating to the ocean. Both spawning areas and migratory corridors are used by juvenile steelhead for rearing prior to out-migration. The Sacramento River functions primarily as a migration channel, although some rearing habitat remains in areas with setback levees (primarily upstream of Colusa) and flood bypasses (e.g., Yolo Bypass) (NMFS, 2009a).

Green Sturgeon

The Sacramento River provides habitat for green sturgeon spawning, adult holding, foraging, and juvenile rearing. Suitable spawning temperatures and spawning substrate exist for green sturgeon in the Sacramento River upstream and downstream of RBDD (Reclamation, 2008). Although the upstream extent of historical green sturgeon spawning in the Sacramento River is unknown, the observed distribution of sturgeon eggs, larvae, and juveniles indicates that spawning occurs from Hamilton City to as far upstream as Ink's Creek confluence, and possibly up to the Cow Creek confluence (Brown, 2007; Poytress et al., 2013). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, CDFW (2002) indicated that green sturgeon spawn in late spring and early summer. Peak spawning is believed to occur between April and June.

Spawning migrations and spawning by green sturgeon in the Sacramento River mainstem have been well documented over the last 15 years (Beamesderfer et al., 2004). Anglers fishing for white sturgeon or salmon commonly report catches of green sturgeon from the Sacramento River as far upstream as Hamilton City (Beamesderfer et al., 2004). Eggs, larvae, and post-larval green sturgeon are now commonly reported in sampling directed at green sturgeon and other species (Beamesderfer et al., 2004; Brown, 2007). Young of year (YOY) green sturgeon (those that were hatched earlier in the year) have been observed annually since the late 1980s in fish sampling efforts at RBDD and the GCID Main Canal intakes (Beamesderfer et al., 2004). Acoustically tagged green sturgeon were detected upstream of RBDD from 2004 to 2006 (Heublein et al., 2009). Adult green sturgeon that migrate upstream in April, May, and June are completely blocked by the Anderson Cottonwood Irrigation District diversion dam

(NMFS, 2009b), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible.

Green sturgeon from the Sacramento River are genetically distinct from their northern counterparts, indicating a spawning fidelity to their natal rivers (Israel et al., 2004), even though individuals can range widely (Lindley et al., 2008). Larval green sturgeon have been regularly captured during their dispersal stage at about 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBDD (CDFG, 2002), and at about 3 weeks old when captured at the GCID Main Canal Intake (Van Eenennaam et al., 2001).

Young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG, 2002). Rearing habitat condition and function may be affected by variation in annual and seasonal river flow and temperature characteristics.

Empirical estimates of green sturgeon abundance are not available for the Sacramento River population or any west coast population (Reclamation, 2008), and the population status is unknown (Beamesderfer et al., 2007; Adams et al., 2007). A genetic analysis of green sturgeon larvae captured in the Sacramento River resulted in an estimate of the number of adult spawning pairs upstream of RBDD ranging from 32 to 124 between 2002 and 2006 (Israel, 2006). NMFS (2009b) noted that, similar to winter-run Chinook salmon, the restriction of spawning habitat for green sturgeon to only one reach of the Sacramento River increases the vulnerability of this spawning population to catastrophic events. This was one of the primary reasons that the Southern DPS of green sturgeon was federally listed as a threatened species in 2006.

White Sturgeon

In California, white sturgeon are most abundant within the Delta region, but the population spawns mainly in the Sacramento River; a small part of the population is also thought to spawn in the Feather River (Moyle, 2002). In addition to spawning, white sturgeon embryo development and larval rearing occur in the Sacramento River (Moyle, 2002; Israel et al., 2008). White sturgeon are found in the Sacramento River, primarily downstream of RBDD (TCCA, 2008), with most spawning between Knights Landing and Colusa (Schaffter, 1997).

Spawning-stage adults generally move into the lower reaches of the Sacramento River during winter prior to spawning, then migrate upstream in response to higher flows to spawn from February to early June (Schaffter, 1997; McCabe and Tracy, 1994). Most spawning in the Sacramento River occurs in April and May (Kohlhorst, 1976). YOY white sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower Sacramento River and Delta (McCabe and Tracy, 1994; Israel et al., 2008).

Sacramento Splittail

Historically, Sacramento splittail were widespread in the Sacramento River from Redding to the Delta (Rutter, 1908 as cited in Moyle et al., 2004). This distribution has become somewhat reduced in recent years (Sommer et al., 1997, 2007a). During drier years, there is evidence that spawning occurs farther upstream (Feyrer et al., 2005). Adult splittail migrate upstream in the lower Sacramento River to above near the mouth of the Feather River, and into the Sutter and Yolo bypasses (Sommer et al., 1997; Feyrer et al., 2005; Sommer et al., 2007a).

Nonreproductive adult splittail are most abundant in moderately shallow, brackish areas, but can also be found in freshwater areas with tidal or riverine flow (Moyle et al., 2004). Adults typically migrate upstream from brackish areas in January and February, and spawn in fresh water on inundated floodplains in March and April (Moyle et al., 2004; Sommer et al., 2007a). In the Sacramento drainage, the most important spawning areas appear to be the Yolo and Sutter bypasses; however, some spawning occurs almost every year along the river edges and backwaters created by small increases in flow. Splittail spawn in the Sacramento River from Colusa to Knights Landing in most years (Feyrer et al., 2005).

Most juvenile splittail move from upstream areas downstream into the Delta, from April through August (Meng and Moyle, 1995; Sommer et al., 2007a). The production of YOY Sacramento splittail is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Sommer et al., 1997; Moyle et al., 2004; Feyrer et al., 2006a). Other factors that may affect the Sacramento splittail adult population include flood control operations and infrastructure, entrainment by irrigation diversion, recreational fishing, altered estuarine hydraulics, pollutants, and nonnative species (Moyle et al., 2004; Sommer et al., 2007a).

Pacific Lamprey

Pacific lampreys, which are anadromous, rear in fresh water before outmigrating to the ocean, and grow to full size in the ocean prior to returning to their natal streams to spawn. Data from mid-water trawls in Suisun Bay and the lower Sacramento River indicate that adults likely migrate into the Sacramento River and tributaries from late fall (November) through early-summer (June) (Hanni et al., 2006). Adult Pacific lampreys have been detected at the GCID Main Canal diversion from December through July, and nearly all year at RBDD (Hanni et al., 2006). Hannon and Deason (2008) documented Pacific lampreys spawning in the American River between early January and late May, with peak spawning typically in early April. Spawning in the Sacramento River is expected to occur during a similar timeframe. Pacific lamprey rear in parts of the Sacramento River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping at sites on the mainstem Sacramento River indicate that out-migration of Pacific lamprey peaks from early winter through early summer, but some out-migration is observed year-round at both the RBDD and the GCID Main Canal diversion dam (Hanni et al., 2006).

Striped Bass

Striped bass are anadromous; adult striped bass are distributed mainly in the lower bays and ocean during summer, and in the Delta during fall and winter. Spawning takes place in spring from April to mid-June (Leet et al., 2001), at which time striped bass swim upstream to spawning grounds. Striped bass are not believed to spawn or rear in the Sacramento River upstream of the RBDD (TCCA, 2008). Most striped bass spawning occurs in the lower Sacramento River, between Colusa and the confluence of the Sacramento and Feather rivers (Moyle, 2002). About one-half to two-thirds of the eggs are spawned in the Sacramento River and the remainder in the Delta (Leet et al., 2001). After spawning, most adult striped bass move downstream into brackish and salt water for summer and fall.

Striped bass eggs are free-floating and negatively buoyant, hatching as they drift downstream. Larvae occur in shallow and open waters of the lower reaches of the Sacramento and San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. The Sacramento River functions primarily as a migration corridor for both striped bass adults and drifting eggs/larvae.

Yolo and Sutter Bypasses

Flow from the Sacramento River spills into the Sutter and Yolo bypasses during high flow events. The bypasses form a floodplain corridor that is an important part of the flood control system, but also provides an important floodplain function for juvenile salmon, steelhead and other native fish. Fish enter the bypasses through flood relief structures and weirs, where fish such as Sacramento splittail rear and spawn during periods when floodwater is present. Increasingly, studies have shown that inundated floodplains play a major role in the life cycle of several aquatic species of concern in the Sacramento River system. The importance of the habitat within the bypasses is heightened because nearly two-thirds of the floodplain that was historically inundated have been isolated from rivers by levees, and dams and diversions have substantially reduced the inundation of floodplain that remains connected to rivers (DWR, 2012).

Sutter Bypass

The Sutter Bypass is a leveed channel that conveys overflow to the east of the Sacramento River and downstream of the Sutter Buttes along the southwest portion of the natural Sutter Basin. The Sutter Bypass is part of the Sacramento River Flood Control Project. The 18,000-acre Sutter Bypass is an expansive land area for agriculture in Sutter County during non-flood times and conveys floodwaters from the Butte Basin overflow area (including flows from Sacramento River near Ord Ferry), Butte Creek, Wadsworth Canal, Reclamation Districts 1660 and 1500 drainage plants, State drainage plants, and Tisdale Weir to the confluence of the Sacramento and Feather rivers. Floodwater from the Sacramento River upstream of Verona flows into the Sutter Bypass through the Moulton and Colusa weirs. In times of high water, Sacramento River water also enters the Sutter Bypass through the Butte Slough outfall and the Tisdale Weir. The Sutter Bypass also receives water from natural runoff areas south of Chico, overflow and weir flow from the Sacramento River, and drainage from the east side of the bypass through Wadsworth Canal and pumping plants. The bypass meets the Feather River upstream of the confluence with the Sacramento River near the Fremont Weir where floodwaters flow into the Yolo Bypass. Agriculture and wildlife habitat are the primary land uses in the bypass during periods outside the flood season and in low-flow years.

Fish communities in the Sutter Bypass appear to be structured primarily by the habitat characteristics of the floodplain and secondarily by the flood pulse dynamics (Feyrer et al., 2006b). Although dynamic flooding appears unable to override the underlying physical habitat differences in structuring the overall fish communities, it is an important factor controlling the abundance of two prominent native species: Chinook salmon and Sacramento splittail (Moyle, 2002).

Numerous fish species of management concern, including Chinook salmon, lamprey, Sacramento splittail, and largemouth bass, are known to use the Sutter Bypass (Feyrer et al., 2006b) and could potentially be affected by changes in spills from the Sacramento River into the Sutter Bypass. Other anadromous fish species also may potentially use the bypass for rearing (i.e., steelhead and sturgeon). The Sutter Bypass has been reported to be an important nursery area for anadromous salmonids of Butte Creek and the upper Sacramento River and its tributaries, particularly during wetter water years (USFWS, 2000). Flooded lands of the Sutter Bypass are also reported to be an important spawning and nursery area for Sacramento splittail (USFWS, 2000).

Yolo Bypass

The Yolo Bypass is an approximately 59,000-acre land area that conveys Sacramento River floodwaters through the Yolo Basin, a natural overflow area to the west of the Sacramento River. The Sacramento River Flood Control Project modified the basin by confining the extent of overflow through a leveed bypass and allowing flood flows to enter the Yolo Bypass from the Sacramento River over the Fremont and Sacramento weirs. The Yolo Bypass conveys floodwaters around the Sacramento metropolitan area and reconnects them to the Sacramento River at Rio Vista (Frantzich, 2014). The nearly 40-mile-long floodplain floods seasonally in winter and spring in about 60 percent of the years and is designed to convey up to 80 percent of the system's floodwaters. Tributaries within the Yolo Bypass include the Cache Creek Detention Basin, Willow Slough, and Putah Creek. Flows also enter the Yolo Bypass from the Colusa Basin, including from the CBD through the Knights Landing Ridge Cut. Land use within the bypass is predominantly agricultural production and wildlife habitat.

Aquatic habitats in the Yolo Basin include stream and slough channels for fish migration, and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al., 2001a; CALFED, 2000a, 2000b). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al., 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel (Sommer et al., 2001a, 2005). Research on the Yolo Bypass has found that juvenile salmon grow substantially faster in the Yolo Bypass floodplain than in the adjacent Sacramento River, primarily because of greater availability of invertebrate prey in the floodplain (Sommer et al., 2001a, 2005). The Yolo Bypass also creates challenges for migrating fish, including Chinook salmon and sturgeon, that migrate upstream through the bypass during periods of high flow and become trapped when they are unable to navigate upstream past the Fremont Weir.

Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most important rearing habitats for Sacramento splittail. Because the Yolo Bypass is dry during summer and fall, nonnative species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al., 2003). In addition to providing important fish habitat, seasonal inundation of the Yolo Bypass supplies phytoplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al., 2004; Lehman et al., 2008).

More recently, the Yolo Bypass has received attention as a target for restoration efforts to improve conditions for aquatic species in the Sacramento River Basin. For example, the 2009 NMFS biological opinion requires Reclamation to evaluate approaches to increase the acreage of seasonal floodplain rearing habitat. The initial performance measure was defined as 17,000 to 20,000 acres of floodplain rearing habitat, much of which would likely be achieved in the Yolo Bypass. Reclamation also is required to develop enhancement plans for lower Putah Creek, Liberty Island/lower Cache Slough, and lower Yolo Bypass. The plans also are required to develop improvements to Fremont Weir and Lisbon Weir to eliminate migration barriers and stranding potential.

The Yolo Bypass also is the focus of efforts to assess whether winter flooding of rice fields within the Yolo Bypass during the agricultural non-growing season can provide high-quality habitat for rearing juvenile Chinook salmon. Preliminary results suggest that changes to agricultural management and infrastructure that increase the frequency and extend the inundation duration of bypass flood events could allow floodplain farm fields to serve as large-scale surrogates for floodplain wetlands, which once were important salmon-rearing habitat (Katz et al, 2017).

12.2.3.2 Feather River Watershed

The aquatic environments associated with the Feather River Watershed (Figure 12-2) within the Secondary Study Area include DWR's Oroville facilities (Lake Oroville, Thermalito Diversion Pool, Thermalito Forebay, Thermalito Afterbay, the fish barrier pool, and the Feather River). The Oroville

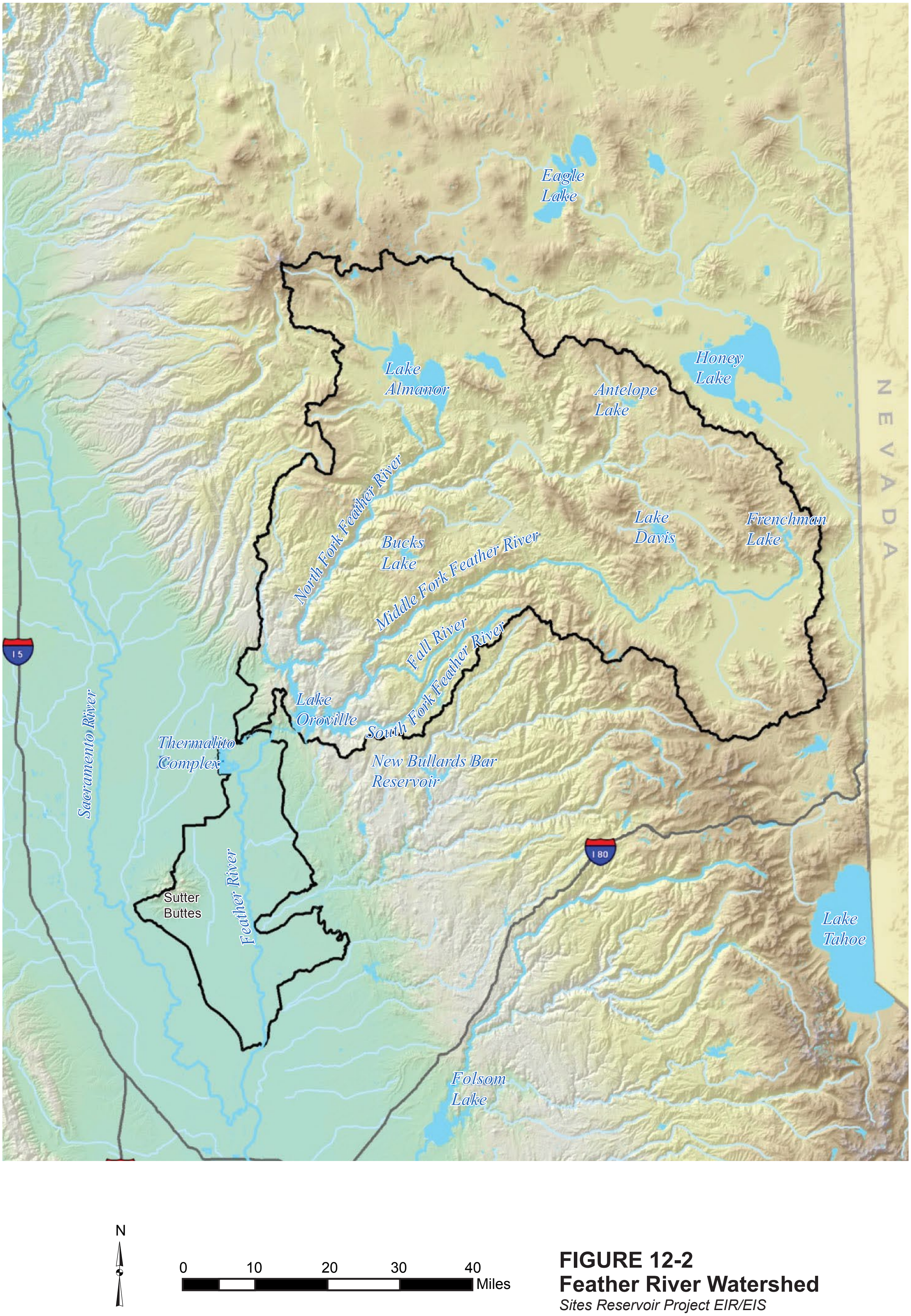


FIGURE 12-2
Feather River Watershed
Sites Reservoir Project EIR/EIS

facilities block the upstream migration of anadromous fish to historically available spawning areas in the upstream tributaries of the Feather River. Issuance of a new Federal Energy Regulatory Commission (FERC) license for the Oroville facilities is pending as of March 2017. The new license's requirements will affect aquatic habitat associated with and affected by the Oroville facilities, including the Feather River downstream of Oroville Dam.

The Feather River Watershed in the Secondary Study Area supports several fish species of management concern (Table 12-2), including sturgeon, Central Valley steelhead, and two runs of Chinook salmon. The following information provided for the SWP Oroville Facilities and the Feather River is from DWR's *May 2007 Oroville Facilities Relicensing FERC Project No. 2100 Draft Environmental Impact Report*, unless otherwise noted. Many of these species are supported in the Yuba River, a major tributary of the Feather River; however, the Yuba River is not within the Secondary Study Area for the Project; and operations of the facilities on the Yuba River (Englebright and Daguerre Point dams) would not be affected by the Project.

Lake Oroville

Lake Oroville typically thermally stratifies into three layers (epilimnion, metalimnion, and hypolimnion) beginning in the spring. FERC (2007) reports indicate that surface water temperatures of the epilimnion begin to warm in the early spring, reach maximum temperatures (approximately mid-80°F) during late July, and gradually decline to winter minimums. The transition zone (i.e., metalimnion) between the upper warm and lower cold waters typically ranges from about 30 to 50 feet below the lake surface during midsummer. The deeper water of the hypolimnion can reach a temperature of about 44°F near the reservoir bottom during periods of stratification (FERC, 2007). Because of this stratification regime, Lake Oroville supports both cold-water and warm-water fisheries. The cold-water fish use the deeper cooler well-oxygenated hypolimnion, whereas the warm-water fish are found in the warmer shallower epilimnion and near-shore littoral zone. Once Lake Oroville de-stratifies in the fall, the two fishery components mix in their habitat use.

Cold-water fish species include coho salmon, rainbow trout, brown trout, and lake trout (*Salvelinus namaycush)*. The Lake Oroville warm-water fishery is a regionally important self-sustaining recreational fishery and is the site of several annual bass fishing tournaments. Spotted bass are the most abundant bass species in Lake Oroville, followed by largemouth bass, redeye bass (*Micropterus coosae*), and smallmouth bass, respectively. Other important warm-water species include catfish, crappie, and sunfish. Common carp are also abundant in Lake Oroville.

Oroville Dam is operated for water supply, power generation, flood control, and fish and wildlife habitat. Management for these uses causes fluctuations in surface water elevation and storage throughout the year, which affects the availability of cold- and warm-water habitat within layers. Cold water is taken from Lake Oroville's hypolimnion for releases to the Feather River for Chinook salmon and steelhead. Cold-water releases to the Feather River potentially limit the amount of cold water available for salmonids in Lake Oroville.

The Lake Oroville cold-water fishery is not self-sustaining. Cold-water hatchery-raised fish are stocked in Lake Oroville as yearlings, with the intent that they will grow in the lake before being caught by anglers. Hatchery stocking is necessary to sustain the cold-water fishery. Natural recruitment to the Lake Oroville cold-water fishery is very low because of a lack of spawning and rearing habitat in the reservoir and accessible tributaries, and natural and artificial barriers to migration into tributaries with sufficient spawning and rearing habitat. From 1993 through 2000, Chinook salmon and brown trout were the only salmonid species stocked in the lake. At the recommendations of CDFW, DWR began stocking coho salmon instead of Chinook salmon and brown trout in 2002 to address an outbreak of Infectious Hematopoetic Necrosis (IHN) at the Feather River Hatchery (coho salmon are less susceptible to IHN).

The Lake Oroville warm-water fishery is self-sustaining. Black bass, a generic term used to describe bass of the genus *Micropterus*, are the most popular and important fishery, in terms of both popularity with anglers and economic effect on the area. Spotted bass are the most abundant bass species of this group in Lake Oroville, followed by largemouth bass, redeye bass, and smallmouth bass. Catfish are the next most popular warm-water sport fish sought by anglers at Lake Oroville; both channel and white catfish inhabit the lake. White and black crappie are also found in Lake Oroville; populations fluctuate widely from year to year. Bluegill and green sunfish are the most abundant sunfish species in Lake Oroville, and redear sunfish (*Lepomis microlophus*) and warmouth (*Lepomis gulosus*) exist in low numbers. Common carp, considered by many to be a nuisance species, are abundant in Lake Oroville. As described for Shasta Lake, fluctuations in surface water elevation affect littoral habitat, which can reduce the abundance of bass and sunfish (DWR, 2002).

The primary forage fish that occur in Lake Oroville are wakasagi (*Hypomesus nipponensis*) and threadfin shad. Threadfin shad were intentionally introduced in 1967 to provide forage for game fish, whereas wakasagi migrated down from an upstream reservoir in the mid-1970s. The population of threadfin shad has dwindled since the early 1990s, which may be a result of poor overwinter survival, or perhaps from competition with wakasagi for habitat and forage.

Thermalito Diversion Pool

The Feather River water temperature requirements create cold-water fishery habitat in the Thermalito Diversion Pool (Diversion Pool). The Diversion Pool is dominated by fish that have come out of Lake Oroville over the spillway or through the power plant, including rainbow trout, brown trout, and coho salmon. With the exception of excess steelhead from the Feather River Hatchery, the Diversion Pool and the Thermalito Forebay (Forebay) are not stocked with fish by CDFW.

Thermalito Forebay

The Forebay is an open, cold, shallow reservoir that remains cold throughout the year because it is supplied with water from Thermalito Diversion Pool, although pumpback operations from Thermalito Afterbay (Afterbay) can increase water temperatures in the Forebay. The Forebay provides habitat primarily for cold-water fish, although the same warm-water fish species found in Lake Oroville are believed to exist in the Forebay in low numbers (DWR, 2007). Additionally, CDFW manages a put-and-take trout fishery in the Forebay.

Thermalito Afterbay

The Afterbay provides habitat for both cold-water and warm-water fish. Changes in flow rates, pumpback operation, and water surface elevations resulting from Project operation could affect water temperatures and the quality, quantity, and distribution of fish habitat in the Afterbay.

Fish species observed in the Afterbay include largemouth bass, smallmouth bass, rainbow trout, brown trout, bluegill, redear sunfish, black crappie, channel catfish, common carp, and wakasagi. Salmonids are not regularly stocked in the Afterbay, however, some years, when the Feather River Fish Hatchery has surplus steelhead (e.g., 2005, 2011, and 2012), they are put in the Afterbay. It is unlikely that any salmonids spawn in tributaries of Thermalito Afterbay. Therefore, rainbow trout and brown trout that occur in the Afterbay likely passed through the Thermalito pumping-generating plant from the Forebay. The Afterbay likely provides good habitat for largemouth, smallmouth, and spotted bass, and large schools of wakasagi provide a good source of forage fish. There is a popular largemouth bass fishery. Bass nest dewatering from reservoir fluctuations likely limits juvenile recruitment in the Afterbay (DWR, 2004a).

Feather River Downstream of Oroville Dam

The Feather River is a major tributary to the Sacramento River, providing approximately 25 percent of the flow in the Sacramento River (FERC, 2007). The lower Feather River commences at the Low Flow Channel (LFC), which extends 8 miles from the Fish Barrier Dam to the Thermalito Afterbay Outlet. The LFC of the Feather River conveys releases from the Thermalito Diversion Dam to its confluence with the Afterbay outlet. The Fish Barrier Dam is located downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery (FERC, 2007). The fish barrier weir at the Feather River Fish Hatchery is the most upstream barrier to fish passage on the Feather River downstream of Oroville Dam. The hatchery was constructed to mitigate the loss of Chinook salmon and steelhead habitat upstream of Oroville Dam.

Minimum flows and ramping criteria in the Feather River were established in an August 1983 agreement between DWR and CDFW (DWR, 1983). The agreement specifies that DWR release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. Therefore, the LFC is operated at 600 cfs all year with variations in flow occurring rarely, only during flood control releases, or in the summer to meet downstream temperature requirements for salmonids. Water temperatures tend to be coldest in the uppermost portions of the Feather River near the fish barrier dam.

Flows in the high flow channel of the Feather River, which conveys the combined flows from the low flow channel and the Afterbay outlet, are maintained between the minimum flow and a flow no greater than 2,500 cfs from October 15 through November 30 to prevent Chinook salmon redd dewatering during the egg incubation period (DWR, 2007). The flow regime in the reach of the Feather River extending from the Thermalito Afterbay outlet (RM 59) to the confluence of the Feather and Sacramento rivers (RM 0) varies depending on runoff and month. The instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. In Critical years, however, the minimum flow can be reduced to 1,200 cfs from October to February, and to 1,000 cfs in March (DWR, 2007). Small flow contributions from Honcut Creek and the Bear River, and larger flow contributions from the Yuba River, also influence flow in this segment.

Most of the LFC flows through a single channel contained by stabilized levees. Side-channel or secondary channel habitat is limited, occurring primarily in the Steep Riffle (located 2 miles upstream of the Thermalito Afterbay Outlet) and Eye Riffle areas between RM 60-61. The channel banks and streambed consist of armored cobble as a result of periodic flood flows and the absence of gravel recruitment. However, there are nine major riffles with suitable spawning size for Chinook salmon and steelhead. Releases are made from the cold-water pool in Lake Oroville and this cold water generally provides suitable water temperatures for spawning in the LFC (DWR, 2001).

Oroville Dam, Thermalito Diversion Dam, and the fish barrier dam block gravel contribution to the Feather River. An estimated 97 percent of the sediment from the upstream watershed is trapped in Lake Oroville, such that only very fine sediment is discharged from Lake Oroville to the lower Feather River

(DWR, 2007). High flow releases from the Oroville facilities mobilize smaller substrate particle sizes. The smaller substrate sizes are not replaced by upstream gravel, resulting in a gradual coarsening of the particle size distribution of the substrate in the upper portions of the Feather River. Coarsening and armoring of the substrate size can affect the quality of spawning habitat and the distribution of spawning salmonids and other fishes. In general, the reach of river with the highest proportion of coarse substrate components is the low flow channel of the Feather River. The FERC (2007) study reported that the median gravel diameter (D50) of surface samples suggests that gravels in the low-flow channel generally are too large for successful redd construction by steelhead or salmon, and that armoring is particularly evident in this reach.

The Feather River below Oroville supports a variety of anadromous and resident fish species. The distribution of anadromous fish in the Feather River is limited to approximately 67 miles of river downstream from the Fish Barrier Dam. At least 44 species of fish have been reported to historically occur in the lower Feather River system, including numerous resident native and introduced species, and several anadromous species (FERC, 2007). Water releases from the Oroville facilities are primarily managed to benefit cold-water fisheries. There are several fish species of management concern in the Feather River downstream of Oroville Dam (Table 12-2), including spring- and fall-run Chinook salmon, Central Valley steelhead, and green sturgeon. The Feather River includes designated critical habitat for the Southern DPS of green sturgeon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. These species are described below and in Appendix 12A Aquatic Species Life Histories.

Spring-run Chinook Salmon

Approximately two-thirds of the natural spring-run and fall-run Chinook salmon spawning occur in the low-flow channel of the lower Feather River, downstream of the Fish Barrier Dam, and one-third of the spawning occurs in the high-flow channel downstream of the Thermalito Afterbay Outlet (DWR, 2007; NMFS, 2009a). NMFS (2009a) indicated that significant redd superimposition occurs in the lower Feather River because of oversaturation of the natural carrying capacity of the available spawning habitat (e.g., Sommer et al., 2001b) with an overproduction of hatchery spring-run Chinook salmon and a lack of physical separation between spring-run and fall-run Chinook salmon adults.

Adult spring-run Chinook salmon typically enter fresh water in spring, hold over summer, and spawn in fall. Juveniles typically spend a year or more in fresh water before outmigrating. Adult spring-run Chinook salmon begin their upstream migration from the ocean in late January and early February (CDFW, 1998), and migrate from the Sacramento River into spawning tributaries primarily between mid-April and mid-June (Lindley et al., 2004). Adult Chinook salmon exhibiting the typical life history of the spring-run have been found holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as April (FERC, 2007). Spring-run Chinook salmon spawning occurs during September and October, depending on water temperatures (NMFS, 2012). Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle, 2002). Most juvenile spring-run Chinook salmon outmigrate from the lower Feather River within a few days of emergence, and 95 percent of the juvenile Chinook have typically outmigrated from the Oroville facilities project area by the end of May (FERC, 2007).

An independent population of spring-run Chinook salmon historically occurred in the lower Feather River downstream of Oroville Dam, and a naturally spawning population of spring-run Chinook salmon may persist in this reach (Lindley et al., 2004). The number of naturally spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 fish in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run Chinook salmon and fall-run Chinook salmon (Good et al., 2005).

Substantial numbers of spring-run Chinook salmon, as identified by run timing, return to the Feather River Fish Hatchery. From 1986 to 2011, the median number of spring-run Chinook salmon returning to the Feather River Fish Hatchery was 3,655, compared to a median of 7,869 spring-run Chinook salmon returning to the entire Sacramento River Basin (NMFS, 2012). Abundance estimates of lower Feather River spring-run Chinook salmon may be distorted by naturally occurring genetic introgression with fall-run Chinook salmon, Feather River Fish Hatchery practices, and Federal and state escapement estimation methodology. Coded wire tags obtained from Feather River Fish Hatchery returns indicate substantial introgression has occurred between spring-run Chinook salmon and fall-run Chinook salmon populations within the lower Feather River (NMFS, 2009a).

Fall-run Chinook Salmon

Fall-run Chinook salmon generally begin upstream migration into the lower Feather River during summer months (FERC, 2007). Although timing of fall-run Chinook salmon spawning may be influenced by water temperature conditions (FERC, 2007), spawning activity in the lower Feather River occurs from late August through December and generally peaks during mid- to late November (Myers et al., 1998). Concurrent spawning with spring-run Chinook salmon, which generally occurs from September to October, has led to hybridization between the spring- and fall-run Chinook salmon in the lower Feather River (NMFS, 2012).

In the lower Feather River, fall-run Chinook salmon embryo incubation and alevin (yolk-sac fry) emergence generally occurs from mid-October through March, depending on water temperature conditions (FERC, 2007). Fall-run Chinook salmon fry emergence generally occurs in the lower Feather River downstream of the Fish Barrier Dam from late December through March, and most juvenile fall-run Chinook salmon outmigrate from the lower Feather River within a few days of emergence (FERC, 2007).

Central Valley Steelhead

Steelhead immigrate into the Feather River from July to March (McEwan, 2001). Most of the natural steelhead spawning in the lower Feather River occurs in the low-flow channel downstream of the Fish Barrier Dam; however, limited spawning also occurs downstream of the Thermalito Afterbay Outlet (FERC, 2007). Surveys indicate that redd construction generally occurs in the lower Feather River between late December and March, peaking in late January (FERC, 2007). The FERC (2007) study suggests that nearly half (48 percent) of all redds were constructed in the uppermost mile of the low-flow channel, downstream of the Fish Barrier Dam. Redd density in this 1-mile section of the low-flow channel was approximately 36 redds per mile, more than 10 times more than any other section of the lower Feather River (FERC, 2007).

A moderate percentage of the steelhead fry appear to outmigrate from the lower Feather River soon after emerging from the gravel. Juvenile steelhead that do not outmigrate may rear in the river for up to 1 year. Juvenile steelhead in the Feather River outmigrate from about February through September, with peak out-migration occurring from March through mid-April. In-river juvenile rearing is generally associated with secondary channels in the low-flow channel (e.g., Hatchery Ditch) (FERC, 2007).

Pacific Lamprey

The Pacific lamprey inhabits accessible reaches of the lower Feather River (DWR, 2003). Information on Pacific lamprey status in the lower Feather River is limited, but the loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins indicate populations are greatly decreased compared with historical levels (Moyle et al., 2010). Little information is available on factors limiting Pacific lamprey populations in the lower Feather River, but they are likely affected by many of the same factors that affect salmon and steelhead because of parallels in their life cycles.

Ocean-stage adults likely migrate into the lower Feather River in spring and early summer, where they hold for approximately 1 year before spawning (Hanni et al., 2006). Hannon and Deason (2008) have documented Pacific lamprey spawning in the nearby American River from between early January and late May, with peak spawning typically occurring in early April. Pacific lamprey ammocoetes rear in the lower Feather River for all or part of their 5-¬ to 7-year freshwater residence. Data from rotary screw trapping suggest that out-migration of Pacific lamprey generally occurs from early winter through early summer (Hanni et al., 2006), although some out-migration likely occurs year-round as observed in the mainstem Sacramento River (Hanni et al., 2006) and in other river systems (Moyle, 2002).

Sacramento Splittail

Sacramento splittail enter the lower Feather River, primarily in wet years, with most individuals collected in the high-flow channel downstream of Thermalito Afterbay Outlet (DWR, 2004b). On the lower Feather River, February through May was assumed to encompass the period of splittail spawning, egg incubation, and initial rearing (Sommer et al., 2008; DWR, 2004b). Splittail use shallow flooded vegetation for spawning and are infrequently observed in the Feather River from the confluence with the Sacramento River up to Honcut Creek. Most spawning activity in the Feather River is thought to occur downstream of the Yuba River confluence (FERC, 2007). The primary factor that likely limits the lower Feather River splittail population is availability of spawning and rearing habitats as related to inundation of floodplains (Moyle et al., 2004; DWR, 2004b).

Green Sturgeon

Although the presence of green sturgeon in the Sacramento River has been supported by direct angler observations and rotary screw trapping of eggs, larvae, and YOY green sturgeon, only intermittent observations of green sturgeon have been reported in the lower Feather River (Beamesderfer et al., 2007). The occasional capture of larval green sturgeon in outmigrant traps suggests that green sturgeon spawn in the lower Feather River (Moyle, 2002). However, prior to 2011, only two records of adult green sturgeon in the lower Feather River were confirmed (NMFS, 2005). In 2011, videography monitoring conducted by the Anadromous Fish Restoration Program confirmed green sturgeon spawning activity in the lower Feather River and found evidence of spawning behavior in the Yuba River (Anadromous Fish Restoration Program, 2011). Seesholtz et al. (2014) provided the first documentation of green sturgeon spawning in the Feather River.

White Sturgeon

White sturgeon are known to use the lower Feather River primarily for spawning, embryo development, and early rearing. Limited quantitative information is available on the status of white sturgeon in the lower Feather River, but the spawning population was most likely much larger prior to construction of Oroville Dam in 1961 (Israel et al., 2008). Seesholtz (2003) reported no evidence of sturgeon was found in the lower Feather River after an exhaustive search for their presence in 2003. However, 16 white sturgeon were recorded from creel surveys and sightings during 2006, and more were captured by anglers in 2007 (Israel et al., 2008). Numerous factors likely limit the success of the white sturgeon population in the lower Feather River, but loss of historical habitat, alteration of temperatures and flows caused by Oroville Dam and other impoundments in the watershed, and recreational fishing and poaching are expected to be among the most important factors.

Striped Bass

Striped bass occur in the lower Feather River and have been reported to occur in the Thermalito Forebay (FERC, 2007). Striped bass are a popular sport fish in the lower Feather River during periods when they migrate upstream to spawn.

American Shad

American shad enter the Feather River annually in spring to spawn and are popular for sport fishing. American shad are present in the lower Feather River from May through mid-December during the adult immigration, spawning, and out-migration periods of their life cycle (DWR, 2003).

12.2.3.3 Trinity River Watershed

The Trinity River watershed (Figure 12-3) includes Trinity Lake, Lewiston Reservoir and the Trinity River from Lewiston Reservoir to the confluence with the Klamath River, and the portion of the lower Klamath River watershed in Humboldt and Del Norte counties from the confluence with the Trinity River to the Pacific Ocean. The CVP Trinity Lake and Lewiston Reservoir are located upstream of the confluences of several Trinity River tributaries (i.e., north fork, south fork, and New River), and flows on these tributaries are not affected by CVP facilities. The aquatic environment associated with the Trinity River Watershed within the Secondary Study Area includes Reclamation’s Trinity River Division (TRD) facilities, which include Trinity Lake, Lewiston Reservoir, Whiskeytown Lake (which is described in the Sacramento River Watershed section), and the Trinity River downstream of Lewiston Dam.

Fish species of management concern found in the Trinity River Watershed portion of the Secondary Study Area are shown in Table 12-2.

Trinity Lake and Lewiston Reservoir

Releases from Trinity Lake are re-regulated in Lewiston Reservoir prior to release downstream into the Trinity River. Lewiston Reservoir also acts as a forebay for the trans-basin export of water into Whiskeytown Lake via the Clear Creek Tunnel.

Operation of the TRD is integrated with operation of the Shasta Division of the CVP. For example, TRD exports have been made in consideration of minimum flow and temperature requirements in the Trinity and Sacramento rivers, storage levels and cold-water pool in Trinity and Shasta lakes, and other CVP operating requirements (e.g., CVP deliveries, water quality requirements). Trinity Lake is also operated to maximize power production during the summer and fall. Most TRD exports occur in the spring and summer. At the same time, temperature objectives to protect Trinity River salmon must be met. Addressing the temperature needs of the two systems is only one of the factors that influence operations.

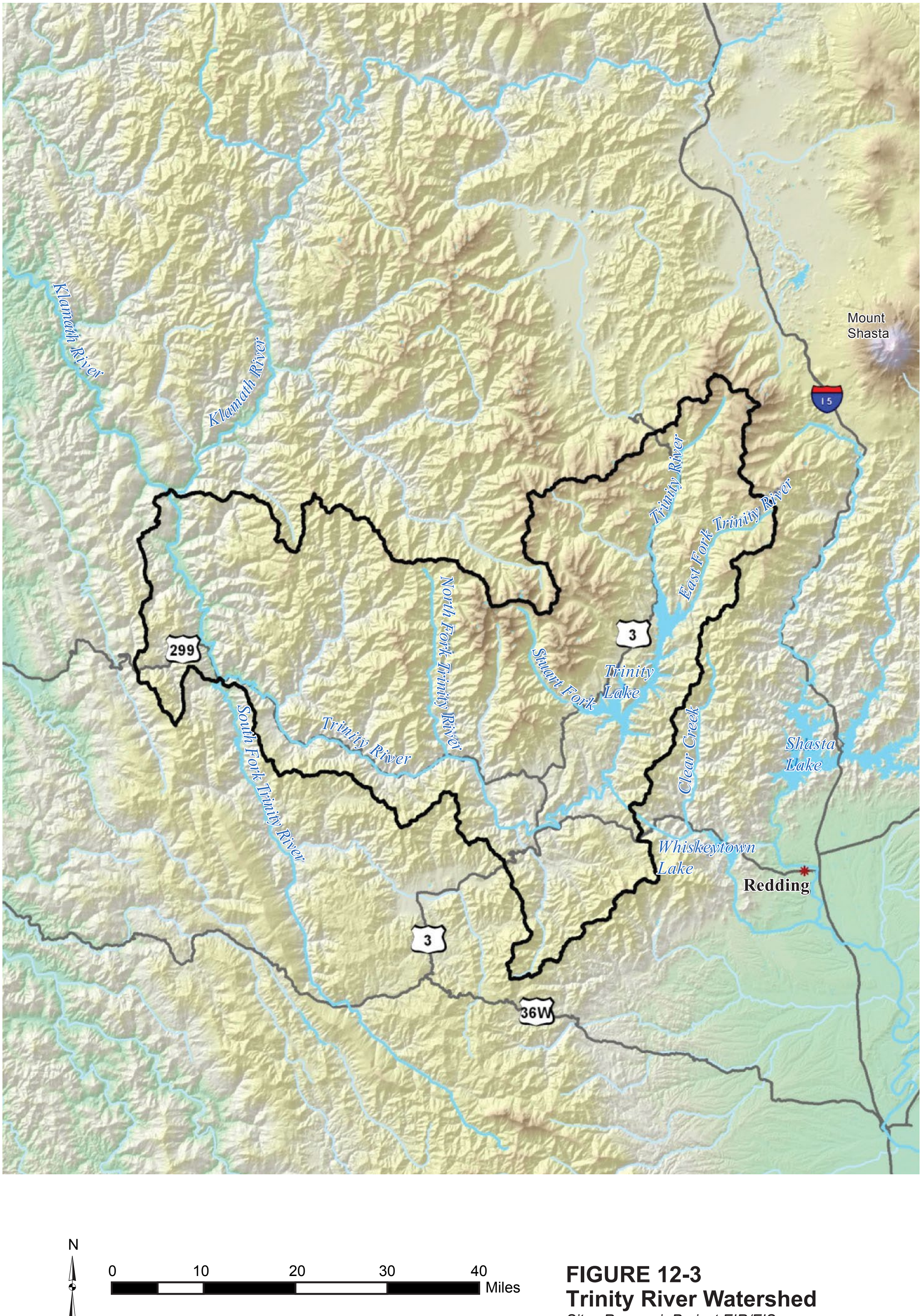


FIGURE 12-3
Trinity River Watershed
Sites Reservoir Project EIR/EIS

Based on the 2000 Trinity River Mainstem Fishery Restoration Record of Decision, flow is released from Trinity Lake to provide a range of flows from 368,600 to 815,000 AF in Trinity River downstream of Lewiston Dam. This amount is scheduled in coordination with the USFWS to best meet habitat, temperature, and sediment objectives in the Trinity River Basin (Reclamation, 2008).

Trinity Lake is created by Trinity Dam and is considered relatively unproductive, with low-standing crops of phytoplankton and zooplankton (USFWS et al., 2004). The fish in Trinity Lake include cold-water and warm-water species. Trinity Lake supports a sport fishery for smallmouth bass, largemouth bass, rainbow and brown trout, and kokanee salmon. Other fish species in Trinity Lake include speckled dace (*Rhinichthys osculus)*, Klamath smallscale sucker (*Catostomus rimiculus*), Coast Range sculpin (*Cottus aleuticus*), and the nonnative green sunfish (*Lepomis cyanellus*) and brown bullhead (*Ameiurus nebulosus)*. Lewiston Reservoir supports the same cold-water species as Trinity Lake, but does not support a warm-water fishery for bass, sunfish, or bullhead (USFWS et al., 2004)

Trinity River and Lower Klamath River

Native anadromous salmonids found in the mainstem Trinity River and its tributaries downstream of Lewiston Dam are spring- and fall-run Chinook salmon, coho salmon, and steelhead (North Coast Regional Water Quality Control Board [RWQCB] and Reclamation, 2009). Native non-salmonid anadromous species that inhabit the Trinity River Basin include green sturgeon, white sturgeon, Pacific lamprey, and eulachon. The Trinity River is the largest tributary of the Klamath River and makes a substantial contribution to the flows in the lower Klamath River.

The hydrologic and geomorphic changes following construction of the Trinity and Lewiston dams changed the character of the river channel substantially, and altered the quantity and quality of aquatic habitat. Riparian vegetation was allowed to encroach on areas that had previously been scoured by flood flows, resulting in the formation of a riparian berm that armored and anchored the river banks, and prevented meandering of the river channel (USFWS et al., 2000). The berm reduced the potential for encroachment and maturation of woody vegetation along the stabilized channel.

The ongoing Trinity River Restoration Program includes specific minimum instream flows (as described in Chapter 6 Surface Water Resources); mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (North Coast RWQCB and Reclamation, 2009; USFWS et al., 2000). These restoration actions are occurring in the 40-mile restoration reach between Lewiston Dam and the confluence with north fork of the Trinity River (Trinity River Restoration Program, 2014).

The Trinity River Hatchery is located immediately downstream of Lewiston Dam. The hatchery is operated by CDFW and funded by Reclamation to mitigate the loss of salmonid production upstream of Lewiston Dam resulting from the Trinity Dam. The hatchery produces coho salmon, fall-run Chinook salmon, spring-run Chinook salmon, and steelhead.

The lower portion of the Klamath River begins where the Trinity River flows into it near Weitchpec, which is located about 43 miles upstream from the Pacific Ocean. This section of the Klamath River serves primarily as a migration corridor for salmonids, with most spawning and rearing occurring upstream of the confluence with the Trinity River or in the larger tributaries (e.g., Blue Creek) to the mainstem Klamath River.

Fish species of management concern that occur in the lower Klamath River downstream of the Trinity River confluence include all those found in the Trinity River, as well as eulachon. Eulachon is a smelt species in the Klamath River system found upstream of the estuary. Eulachon are anadromous broadcast spawners that spawn in the lower reaches of rivers and tributaries and usually die after spawning. This species was historically important to local tribes and supported a subsistence fishery on the lower Klamath River. However, it is likely that the eulachon has been extirpated or nearly so on the lower Klamath River (NMFS, 2015).

12.2.3.4 American River Watershed

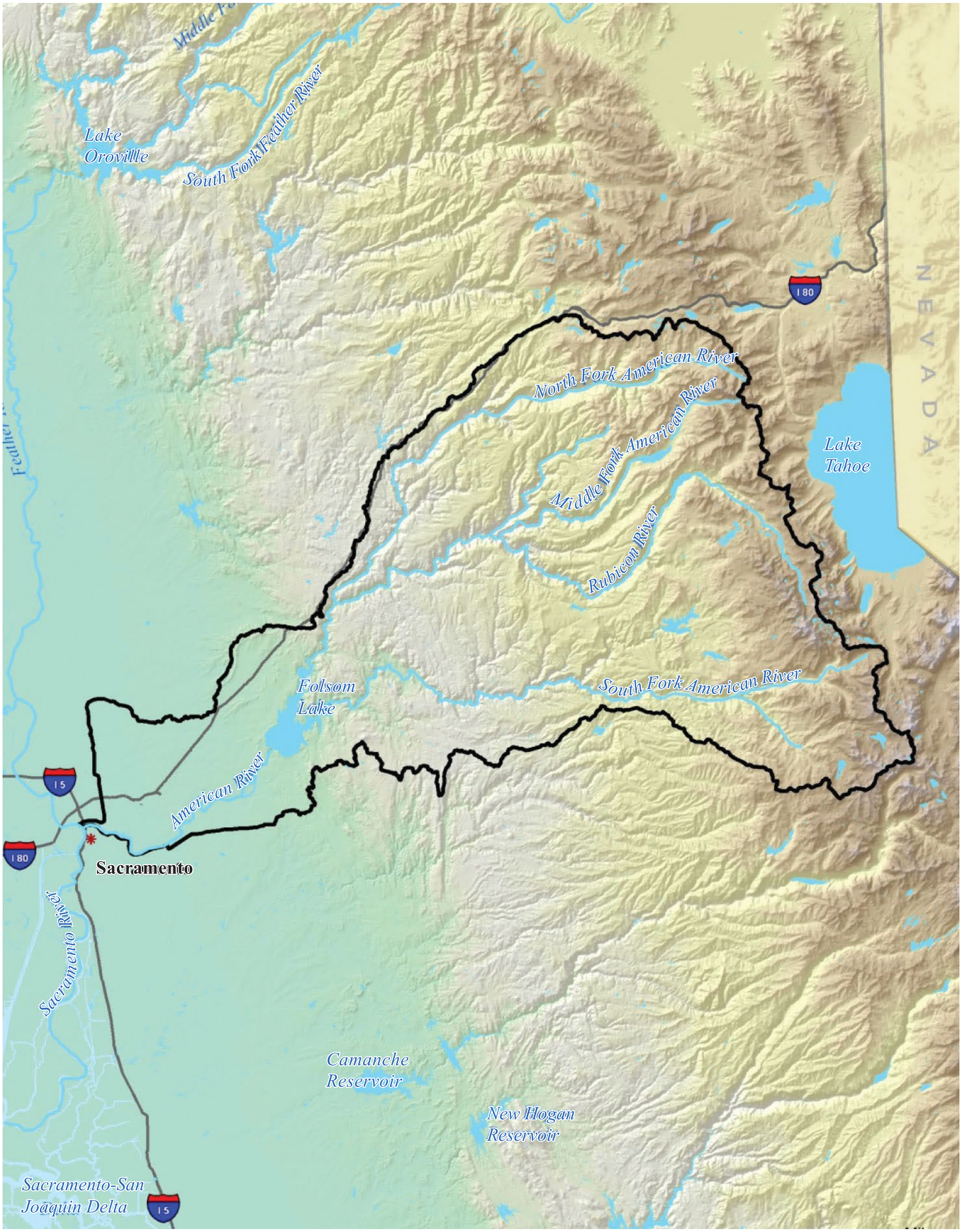
The American River watershed encompasses approximately 2,100 square miles (Reclamation et al., 2006). The three forks of the American River (north, middle, and south forks) converge upstream of Folsom Dam, with the combined flow moving through Lake Natoma and the lower American River for about 23 miles before entering the Sacramento River (Figure 12-4).

Fish species of management concern found in the American River Watershed portion of the Secondary Study Area are shown in Table 12-2.

Folsom Lake and Lake Natoma

Similar to the other large Central Valley reservoirs, strong thermal stratification occurs within Folsom Lake annually from April to November. The stratification breaks down when cooler temperatures, winter rains, and high inflows create mixing and result in “turnover” (Reclamation, 2005; U.S. Army Corps of Engineers [USACE] et al., 2012). During periods of thermal stratification, the resulting segregation of habitats allow for both cold-water and warm-water species to coexist in Folsom Lake (USACE et al., 2012). Largemouth bass, smallmouth bass, spotted bass, bluegill, crappie, and catfish constitute the primary warm-water sport fisheries of Folsom Lake. The lake’s cold-water sport species include rainbow and brown trout, kokanee salmon, and Chinook salmon, all of which are or have been stocked by CDFW. Although brown trout are no longer stocked, a population still remains in the lake. These species are stream spawners and, therefore, do not reproduce within the lake. However, some spawning by one or more of these species may occur in the American River upstream of Folsom Lake. Other species that occur in the lake include hardhead (*Ariopsis felis*), California roach (*Hesperoleucus symmetricus)*, Sacramento sucker, and Sacramento pikeminnow.

Folsom Lake’s cold-water pool is important not only to the lake’s cold-water fish species, but also to lower American River fall-run Chinook salmon and steelhead. Seasonal releases from the lake’s cold-water pool provide thermal conditions in the lower American River that support annual in-river production of these salmonid species. The cold-water pool in Folsom is primarily managed to sustain releases during October and November to maximally benefit fall-run Chinook salmon immigration, spawning, and incubation, but is not large enough to allow for cold-water releases during the warmest months (July through September) to provide maximum thermal benefits to lower American River steelhead.



N

0 10 20 30 40 Miles

FIGURE 12-4
American River Watershed
Sites Reservoir Project EIR/EIS

Nimbus Dam and Powerplant are located downstream from Folsom Dam. The dam forms Lake Natoma, which re-regulates water released from Folsom Dam, maintaining more uniform flows in the lower American River. Lake Natoma is a shallow reservoir with an average depth of about 16 feet (Reclamation, 2005). Surface water elevations in Lake Natoma may fluctuate between 4 and 7 feet daily (USACE et al., 2012). Lake Natoma has relatively low productivity as a fishery because of the effects of wide water temperature variability associated with the lake’s fluctuating elevation. Reclamation (2007) reports that fish species found in Lake Natoma are generally the same as those in Folsom Lake. Although CDFW annually stocks Lake Natoma with hatchery rainbow trout, conditions in Lake Natoma are more favorable for warm-water fish species (Reclamation, 2007).

American River Downstream of Nimbus Dam

The lower American River extends approximately 23 miles from Nimbus Dam downstream to the confluence with the Sacramento River. Access to the upper reaches of the river by anadromous fish is blocked at Nimbus Dam. Flows and water temperatures in the lower American River are controlled by operations of Folsom Lake. Seasonal releases from the reservoir’s cold-water pool provide thermal conditions in the lower American River that support annual in-river production of these salmonid species. Folsom Lake’s cold-water pool is typically not large enough to allow for cold-water releases during the warmest months (July through September) to provide maximum thermal benefits to lower American River steelhead, and cold-water releases during October and November that would maximally benefit fall-run Chinook salmon immigration and holding, spawning, and embryo incubation. Consequently, management of the reservoir’s cold-water pool on an annual basis is essential to providing thermal benefits to both fall-run Chinook salmon and steelhead, within the constraints of cold-water pool availability.

Additionally, Folsom Dam has blocked the downstream transport of sediment that contributes to the formation and maintenance of habitat for aquatic species. In 2008, Reclamation, in coordination with USFWS and the Sacramento Water Forum, began implementation of salmonid habitat improvement in the lower American River. An estimated 5,000 cubic yards of gravel and cobble were placed just upstream of Nimbus Fish Hatchery in 2008, followed by an estimated 7,000 cubic yards adjacent to the Nimbus Fish Hatchery in fall 2009. In September 2010, approximately 11,688 cubic yards (approximately 16,200 tons) of gravel and cobble were placed at Sailor Bar to enhance spawning habitat for Chinook salmon and steelhead in the lower American River (Merz et al., 2012). Additional gravel augmentation projects have been implemented. In 2008, Reclamation also began implementing floodplain and spawning habitat restoration projects in the American River to assist in meeting the requirements of the 1992 CVPIA, Section 3406 (b)(13). Spawning and rearing habitat enhancement projects occurred each year from 2008 through 2014 in the reach from Nimbus Dam down to River Bend Park. These annual projects are planned to continue.

The lower American River provides a diversity of aquatic habitats, including shallow fast-water riffles, runs, pools, and off-channel backwater habitats. At least 40 species of fish have been reported to occur in the lower American River system, including numerous resident native and introduced species, as well as several anadromous species (Surface Water Resources, Inc. [SWRI], 2004). Species of management concern found in the lower American River include fall-run Chinook salmon, steelhead, Sacramento splittail, striped bass, and American shad (Table 12-2). The American River contains designated critical habitat for Central Valley steelhead and Central Valley spring-run Chinook salmon, as well as the Southern DPS of green sturgeon. These species are described below and in Appendix 12A Aquatic Species Life Histories.

Fall-run Chinook Salmon

With more than 125 miles of available upstream salmonid spawning habitat, the American River historically served as a regionally vital component for the health of fall- and spring-run Chinook salmon populations (Water Forum, 2001). Although dam construction eliminated the spring-run fishery, the lower American River continues to function as spawning and rearing habitat for large numbers of fall-run Chinook salmon. The river supports a mixed run of hatchery and naturally produced fall-run Chinook salmon. Analysis by CDFW and USFWS (2010) indicated that approximately 84 percent of the natural fall-run Chinook salmon spawners in the American River are hatchery-origin fish. Kormos et al. (2012) reported that 79 percent of the fall-run Chinook salmon entering the Nimbus Fish Hatchery in 2010 and 32 percent of the fish spawning in the American River were of hatchery origin. During the winter, some juvenile spring-run Chinook salmon have been found rearing in the lower portions of the American River (Snider and Titus, 2000d, 2002).

Adult fall-run Chinook salmon enter the lower American River from about mid-September through January, with peak migration occurring from approximately mid-October through December (Williams, 2001). Spawning occurs from about mid-October through early February, with peak spawning occurring from mid-October through December. Chinook salmon spawning occurs within an 18-mile stretch from Paradise Beach to Nimbus Dam; however, most spawning occurs in the uppermost 3 miles (CDFW, 2012a). Chinook salmon egg and alevin incubation occurs in the lower American River from about mid-October through April. There is high variability from year to year; however, most incubation occurs from about mid-October through February. Chinook salmon fry emergence occurs from January through mid-April, and juvenile rearing extends from January to about mid-July (Williams, 2001). Most Chinook salmon outmigrate from the lower American River as fry between December and July, peaking in February to March (Snider and Titus, 2002; Pacific States Marine Fisheries Commission [PSMFC], 2014).

The primary factor potentially limiting fall-run Chinook salmon and steelhead production within the lower American River is believed to be high water temperatures during portions of their residency in the river. High water temperatures during the fall can delay the onset of spawning by Chinook salmon, and river water temperatures can become unsuitably high for juvenile salmon rearing during spring and for steelhead rearing during summer. In addition, relatively low October and November flows tend to increase the amount of fall-run Chinook salmon redd superimposition (occurs when females dig up the fertilized eggs of other females), thereby potentially reducing the number of juveniles produced per female.

Steelhead

Natural spawning by steelhead in the American River occurs (Hannon and Deason, 2008), but the population is supported primarily by the Nimbus Fish Hatchery. The total estimated steelhead return to the river (spawning naturally and in the hatchery) has ranged from 946 to 3,426 fish, averaging 2,184 fish per year from 2002 to 2010 (California Hatchery Scientific Review Group, 2012). Steelhead spawning surveys have shown approximately 300 steelhead spawning in the river each year (Hannon and Deason, 2008). Lindley et al. (2007) classifies the listed (i.e., naturally spawning) population of American River steelhead at a high risk of extinction because it is reportedly mostly composed of steelhead originating from Nimbus Fish Hatchery. NMFS views the American River population as important to the survival and recovery of the species (NMFS, 2009a).

Nielsen et al. (2005) found steelhead in the American River to be genetically different from other Central Valley stocks. Eel River steelhead were used to found the Nimbus Hatchery stock, and steelhead from the American River (collected from both the Nimbus Fish Hatchery and the American River) are genetically more similar to Eel River steelhead than other Central Valley Steelhead stocks. Based on studies by Hallock et al. (1961), Staley (1976), and Nielsen et al. (2005), Lee and Chilton (2007) reported that American River winter-run steelhead are genetically and phenotypically different, and demonstrate a later upstream migration period than Central Valley Steelhead. Zimmerman et al. (2008) also noted that there remains a strong resident component (i.e., fish that do not migrate to the ocean) of the *O. mykiss* population that interacts with and produces anadromous individuals. Steelhead and Rainbow Trout are the same species and when juveniles of the species are found in fresh water, it is unclear if they will exhibit an anadromous (steelhead) or resident (Rainbow Trout) life history strategy. Thus, they are often collectively referred to as *O. mykiss* at this stage to indicate this uncertainty.

Adult steelhead enter the American River from November through April with a peak occurring from December through March (SWRI, 2001). Steelhead have been trapped at Nimbus Fish Hatchery as early as the first week of October. Survey indicates that steelhead spawning occurs in the lower American River from late December through early April, with the peak occurring in late February to early March (Hannon and Deason, 2008). Spawning density is highest in the upper 7 miles of the river, but spawning occurs as far downstream as Paradise Beach. About 90 percent of spawning occurs upstream of the Watt Avenue Bridge (Hannon and Deason, 2008).

Embryo incubation begins with the onset of spawning in late December and generally extends through May, although incubation can occur into June in some years (SWRI, 2001). Steelhead embryo and alevin mortality associated with high flows in the American River has not been documented, but flows high enough to mobilize spawning gravels do occur during the spawning and embryo incubation periods (i.e., late December through early April) (NMFS, 2009a).

Juvenile *O. mykiss* have been documented year-round throughout the lower American River, with rearing generally upstream of spawning areas. Juveniles reportedly can rear in the lower American River for a year or more before outmigrating as smolts from January through June (Snider and Titus, 2000d; SWRI, 2001). However, Snider and Titus (2002) reported only 1 yearling steelhead capture, and PSMFC (2014) reported capturing primarily YOY fry and parr. Peak out-migration occurs from March through May (McEwan and Jackson, 1996; SWRI, 2001; PSMFC, 2014).

Rearing habitat for juvenile steelhead in the lower American River occurs throughout the upper reaches downstream to Paradise Beach. In summer, juveniles occur in most major riffle areas, with the highest concentrations near the higher density spawning areas (Reclamation, 2008). The number of juveniles in the American River decreases throughout summer (Reclamation, 2008). Warm water temperatures stress juvenile steelhead rearing in the American River, particularly during summer and early fall (Lower American River Task Force, 2002; Water Forum, 2005; NMFS, 2014). However, laboratory studies suggest that American River steelhead may be more tolerant of high temperatures than steelhead from regions farther north (Myrick and Cech, 2004).

Pacific Lamprey

The Pacific lamprey inhabits accessible reaches of the American River. Information on the status of Pacific lamprey in the American River is limited, but the loss of historical habitat and apparent population declines throughout California indicate populations are greatly decreased compared to historical levels (Moyle et al., 2010).

Hannon and Deason (2008) documented Pacific lamprey spawning in the American River between early January and late May, with peak spawning typically in early April. Pacific lamprey ammocoetes rear in the American River for all or part of their 5 to 7-year freshwater residence. Data from rotary screw trapping in the nearby Feather River suggest that out-migration of Pacific lamprey generally occurs from early winter through early summer (Hanni et al., 2006), although some out-migration likely occurs year-round, as observed at sites on the mainstem Sacramento River (Hanni et al., 2006) and in other river systems (Moyle, 2002).

Because of the parallels in their life cycles, particularly spawning, lampreys may be affected by many of the same factors that affect salmon and steelhead. Little information is available on factors influencing Pacific lamprey populations in the American River, but the dams likely play an important role. Moyle et al. (2010) suggested that in addition to blocking upstream migration, dams may disrupt upstream sediment inputs required to maintain habitat for ammocoetes and subject ammocoetes to rapid decreases in stream flow. Moyle et al. (2010) also indicated that ramping rates sufficient to protect salmonids may not be adequate to prevent the stranding of ammocoetes and metamorphosing individuals, which are vulnerable to desiccation and avian predation. Additionally, commercial harvest of lampreys on the American River (presumably for bait) may reduce spawning success in some years (Hannon and Deason, 2008).

Sacramento Splittail

Splittail likely spawn in the lower reaches of the American River (Sommer et al., 1997, 2008; Moyle et al., 2004). During wet years, upstream migration is more directed and fish tend to swim farther upstream (Moyle, 2002), thus more individuals are expected to use the American River in wet years. Although juvenile splittail are known to rear in upstream areas for a year or more (Baxter, 1999), most move to the Delta after only a few weeks of rearing on floodplain habitat (Reclamation, 2008). Most juveniles move downstream into the Delta from April to August (Meng and Moyle, 1995). The primary factor potentially limiting the American River population of Sacramento splittail is availability of inundated floodplains for spawning and rearing habitats (Moyle et al., 2004).

White Sturgeon

Limited quantitative information is available on the distribution and status of white sturgeon in the American River; however, small numbers of adults apparently use the American River, as evidenced by sturgeon report cards submitted to CDFW by anglers (e.g., CDFG, 2012b).

Striped Bass

Striped bass are found in the American River throughout the year, with the greatest abundance in summer (SWRI, 2001). Although the occurrence of spawning in the American River is uncertain, the river is believed to serve as a nursery area for YOY and subadult striped bass (SWRI, 2001). Striped bass are distributed from the confluence with the Sacramento River to Nimbus Dam (Moyle, 2002), and they provide a locally important sportfishing resource.

American Shad

Adult American shad ascend the lower American River to spawn during the late spring. During this period, they provide an important sport fishery. The shortage of adequate attraction flows in major tributaries such as the American River may be contributing to declines in the population (Moyle, 2002).

12.2.3.5 Sacramento-San Joaquin Delta

Historical modification of ecosystem processes and functions in the Delta and throughout the Sacramento and San Joaquin river watersheds has influenced aquatic habitat conditions, which directly affect special-status species and other species of management concern. The Delta was once a vast marsh and floodplain intersected by meandering channels and sloughs that provided habitat for a rich diversity of fish, wildlife, and plants. The existing Delta is a system composed of artificially channeled, dredged, and leveed waterways, initially constructed by local farmers to support farming, but now used to protect urban development against flooding and to convey water supplies to cities and farms in the Bay Area, San Joaquin Valley, and southern California.

Aquatic habitat conditions are the result of a combination of unaltered discharges from surface water and groundwater flowing into the Delta, and managed releases from reservoirs. Flows in the Delta vary seasonally and annually with rainfall, run-off, and water supply management. The volume and distribution of water in the watershed influence water quality, aquatic habitat, fish communities, and important ecological processes and functions.

Fish communities in the Delta include a mix of native species, some with low abundance, and a variety of introduced fish, some with high abundance (Matern et al., 2002; Feyrer and Healey, 2003; Nobriga et al., 2005; Brown and May, 2006; Moyle and Bennett, 2008; Grimaldo et al., 2012). Although there is limited knowledge of the ecology of native fishes in the past, the historical assemblages of fish upstream of and in the Delta were different from the current assemblages (Moyle, 2002). For example, the Sacramento perch, once abundant in sloughs off main channels, was extirpated from the Delta (Rutter, 1908). Conversely, a large number of nonnative species of fish have been either intentionally (e.g., striped bass, channel catfish, American shad, threadfin shad, and largemouth bass) or unintentionally (e.g., goldfish) introduced into the system.

Fish species of management concern found in the Delta portion of the Secondary Study Area are shown in Table 12-2. The listing status, life history, and factors affecting population abundance for these species that inhabit the Delta and may be affected by construction or operation of the Project are discussed in Appendix 12A Aquatic Species Life Histories. The Delta has been identified as Essential Fish Habitat for the commercially managed species (northern anchovy (*Engraulis mordax)*, Pacific sardine (*Sardinops sagax)*, starry flounder (*Platichthys stellatus*), and Chinook salmon). USFWS and NMFS have designated all or part of the Delta within the Secondary Study Area as critical habitat or Essential Fish Habitat for delta smelt, Central Valley steelhead, winter- and spring-run Chinook salmon, and green sturgeon.

Use of the various aquatic habitats within the Delta by individual species is often determined by multiple physical factors (e.g., flow, salinity, wind, tide, and temperature), many of which vary at multiple temporal scales (Kimmerer, 2004). Resident and migratory fish use Delta aquatic habitats for spawning, rearing, foraging, and escape cover. Striped bass, delta smelt, Sacramento splittail, and many resident Delta fish use this habitat for rearing and as adults (CALFED, 2000c). Young steelhead and Chinook salmon forage in these productive waters as fry and juveniles to gain weight and improve condition before entering the ocean.

Flow management in the Delta has created stress on aquatic resources by (1) changing aspects of the historical flow regime (timing, magnitude, duration) that affect water quality parameters such as water temperature, turbidity and salinity that support life history traits of native species; (2) limiting access to or quality of habitat; (3) contributing to conditions better suited to invasive, nonnative species (reduced spring flows, increased summer inflows and exports, and low- and less-variable interior Delta salinity [Moyle and Bennett, 2008]); and (4) causing reverse flows in channels leading to project export facilities that can entrain fish (Mount et al., 2012). Native species of the Delta are adapted to and depend on variable flow conditions at multiple scales as influenced by the region's dramatic seasonal and inter-annual climatic variation. In particular, most native fishes evolved reproductive or out-migration timing associated with historical peak flows during spring (Moyle, 2002).

The Interagency Ecological Program (IEP) has been monitoring fish populations in the Delta and San Francisco Estuary for decades. Survey methods have included beach seining, midwater trawls, Kodiak trawls, otter trawls, and other methods (Honey et al., 2004) to sample the pelagic fish assemblage throughout the estuary. Three of the most prominent resident pelagic fishes captured in the surveys (delta smelt, longfin smelt, and striped bass) have shown substantial long-term population declines (Kimmerer et al., 2000; Bennett, 2005; Rosenfield and Baxter, 2007). Reductions in pelagic fish abundance since 2002 have been recognized as a serious water and fish management issue and have become known as the Pelagic Organism Decline (POD) (Sommer et al., 2007b).

Stressors contributing to the POD, fish species of management concern, and other aquatic resources within the Delta are discussed below.

Stressors Affecting Delta Fish Species

Changes in Aquatic Habitats

Landscape-scale changes resulting from flood management infrastructure dating back to 1855, along with flow modification, have eliminated most of the historical hydrologic connectivity of floodplains and aquatic ecosystems in the Delta and its tributaries, thereby degrading and diminishing Delta habitat for native plant and animal communities (Mount et al., 2012). The large reduction of hydrologic variability and landscape complexity, coupled with degradation of water quality, has supported invasive aquatic species that have further degraded conditions for native species. Due to the combination of these factors, the Delta appears to have undergone an ecological regime shift unfavorable to many native species (Moyle and Bennett, 2008; Baxter et al., 2010). Factors that affect habitat quantity and quality such as temperature, turbidity, salinity, and contaminants are summarized below.

Water Temperature

Long-term temperature records from selected sites in the Delta show substantial seasonal and daily fluctuations in water temperature (Kimmerer, 2004). While daily variations are evident and likely important to organisms, seasonal variations are much greater (Wagner et al., 2011). Water temperatures in the Delta follow a seasonal pattern of winter cold-water conditions and summer warm-water conditions, largely because of the region's Mediterranean climate, with alternating cool-wet and hot-dry seasons. There are also clear regional variations in water temperature. In the Delta, the most significant changes in water temperatures have been in the form of increased summer water temperatures over large areas of the Delta as a result of high summer ambient air temperatures, the increased temperature of river inflows, and to a lesser extent, reduced quantities of freshwater inflow and modified tidal and groundwater hydraulics (Kimmerer, 2004; Mount et al., 2012; National Research Council, 2012; Wagner et al., 2011). Water temperatures in summer now approach or exceed the generally accepted upper thermal tolerances (e.g., 20 to 25 degrees Celsius [°C]) for cold-water fish species such as salmonids, and Delta-dependent species such as delta smelt. This is especially true in parts of the south Delta and San Joaquin River, potentially restricting the distribution of these species and precluding previously important rearing areas (National Research Council, 2012). Further increases are expected over the course of the century with climate change (Cloern et al., 2011; Wagner et al., 2011; Brown, 2013).

Turbidity

Turbidity is an important water quality component in the Delta that affects physical habitat through sedimentation, and food web dynamics through attenuation of light in the water column. Light attenuation, in turn, affects the extent of the photic zone, where primary production can occur, and the ability of predators to locate prey and for prey to escape predation. Turbidity has been declining in the Delta, as indicated by sediment data collected by the USGS since the 1950s (Wright and Schoellhamer 2004), with important implications for food web dynamics and predation. Higher water clarity is at least partially caused by increased water filtration and plankton grazing by introduced species such as the highly abundant overbite clams (*Corbula amurensis*) and other benthic organisms (Kimmerer, 2004; Greene et al., 2011). High nutrient loads, coupled with reduced sediment loads and higher water clarity, could contribute to plankton and algal blooms and overall increased eutrophic conditions in some areas (Kimmerer, 2004). Studies have shown that distribution of delta smelt is correlated with turbidity (e.g., Feyrer et al., 2007; Nobriga et al., 2008; Grimaldo et al., 2009; Sommer and Mejia, 2013).

Salinity

Salinity is a critical factor influencing plant and animal communities in the Delta. Although estuarine fish species are generally tolerant of a range of salinity, this varies by species and life stage. Some species can be highly sensitive to excessively low or high salinity during physiologically vulnerable periods, such as reproductive and early life history stages. Although the Delta is tidally influenced, most of the Delta is fresh water year-round, because of inflows from rivers. The south Delta can have low salinity because of agricultural return water. The tidally influenced low salinity zone can move upstream into the central Delta. Significant increases and decreases in salinity detected for various stations and months have been linked to changing flow patterns (Jassby et al., 1995; Enright and Culberson, 2009; Shellenbarger and Schoellhamer, 2011; Cloern and Jassby, 2012).

The brackish low salinity zone (LSZ) is an important region for retention of organisms and particles and for nutrient cycling. The size and location of the LSZ are considered key factors determining the quantity and quality of low salinity rearing habitat available to delta smelt and other estuarine species. LSZ size and location are determined by the interaction of dynamic tidal and river flows with the topography of the region (Reclamation, 2011, 2012; Kimmerer et al., 2013). In the Delta, the position of the LSZ is commonly expressed in terms of X2, which is the distance from the Golden Gate Bridge (in kilometers [km]) along the axis of the estuary to the 2 parts per thousand (ppt) salinity isopleth measured near the bottom of the water column (Jassby et al., 1995). X2 represents the approximate center of the LSZ (Kimmerer et al., 2013). X2 is an index of the physical response of the estuary to freshwater outflow from the Delta because it decreases with increasing outflow as increasing freshwater outflow prevents seawater from moving landward.

Annual abundance indices of several estuarine fish and invertebrate species have a negative relationship with spring X2; abundance indices increase when X2 and the LSZ are more westward, and Delta outflow is higher in the late winter and spring months (Jassby et al., 1995; Kimmerer, 2002a, 2002b; Kimmerer et al., 2009). Delta smelt summer abundance indices have a significant relationship with prior fall X2 and fall abundance (USFWS, 2008; Mount et al., 2012). Changes in spring and fall X2 have also been linked to long-term fish declines in the Delta and San Francisco Estuary (Thomson et al., 2010; Mac Nally et al., 2010). However, much uncertainty remains regarding the causal mechanisms for the observed biological responses of biota to X2.

In a recent study, Kimmerer et al. (2013) used the three-dimensional hydrodynamic "UnTRIM" model to produce detailed maps of the distribution of salinity in the San Francisco Estuary under different outflow conditions. Kimmerer et al. (2013) also examined the relationships between X2 and the area, average depth, and volume of the LSZ. They found that these relationships were bimodal, with the largest volumes and areas and shallowest depths at X2 values below 50 km (LSZ centered on San Pablo Bay), and secondary peaks at X2 values between 60 and 75 km (LSZ in the smaller Suisun Bay). Area and volume were smallest and depth greatest at X2 values between 50 and 60 km when the LSZ was constricted in Carquinez Strait, and between 80 and 85 km when the LSZ is in the confluence region of the Sacramento and San Joaquin rivers.

Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways, yet trends in contaminant loadings and their ecosystem effects are not well understood. Efforts are underway to evaluate direct and indirect toxic effects of man-made contaminants and natural toxins on the POD fishes.

There are longstanding concerns related to mercury and selenium in the Sacramento and San Joaquin watersheds, the Delta, and San Francisco Bay (see Chapter 7 Surface Water Quality for additional detail on these constituents). These elements are often associated with sediment and may be particularly important because sediment is transported with significant rain events. Methylmercury has not been shown to be a direct problem for fish in the Delta, but studies of other fish summarized by Alpers et al. (2008) indicate that mercury in fish has been linked to hormonal and reproductive effects, liver necrosis, and altered behavior in fish. With regard to selenium, benthic foragers like sturgeon and Sacramento splittail have the greatest risk of selenium toxicity.

Herbicides and fungicides were among the most commonly detected classes of pesticides observed in water and sediment in the Delta and are also found in fish tissue (Orlando et al., 2013; Smalling et al., 2013). Herbicides are known to affect primary producers, while insecticides are known to affect predator-prey relationships for fish, as well as lead to endocrine disruptions (Scholz et al., 2012; Junges et al., 2010; Relyea and Edwards, 2010; Riar et al., 2013; Forsgren et al., 2013). Fungicides have been found to cause endocrine disruption in fish, including reduced fecundity (Ankley et al., 2005). Although little evidence exists for acute effects of pesticides on fish or invertebrates, several studies have documented sublethal effects on fish health (Werner et al., 2008, 2010a, 2010b).

Pyrethroid pesticides have received special attention in POD studies because of their increased use in recent years and their high toxicity to aquatic organisms. Although pyrethroids are readily absorbed into sediment, they can be mobilized during high flow events and are highly toxic to zooplankton and fish (Werner and Moran, 2008). Although it has been shown that these pesticides have the capacity to affect pelagic fish populations, a direct link to the POD has yet to be demonstrated (Armor et al., 2005).

Natural toxins associated with blooms of *Microcystis aeruginosa*, a colonial cyanobacteria that produces hepatotoxins that can affect both fish and humans, have become more prevalent and widespread during the summer. Reduced stream flow in the Delta seems to promote the growth of *Microcystis*, which is more abundant in dry years (Baxter et al., 2010). Although this harmful algal bloom typically occurs in the San Joaquin River away from the core summer distribution of delta smelt, some overlap is apparent during blooms and as cells and toxins are dispersed downstream after blooms (Baxter et al., 2010). Histopathological studies of fish liver tissue suggest that fish exposed to elevated concentrations of microcystins have developed liver damage and tumors (Lehman et al., 2005, 2010). Indirect effects are also likely as *Microcystis* blooms are toxic to copepods that serve as the primary food resources of delta smelt (Ger et al., 2009, 2010a, 2010b). However, *Microcystis* blooms have not yet been identified as a primary cause of the POD (Baxter et al., 2010).

Nutrients and Food Web Support

Nutrients are essential components of terrestrial and aquatic environments because they provide a resource base for primary producers. Typically, in freshwater aquatic environments, phosphorous is the primary limiting macronutrient, whereas in marine aquatic environments, nitrogen tends to be limiting. A balanced range of abundant nutrients provides optimal conditions for maximum primary production, a robust food web, and productive fish populations. However, changes in nutrient loadings and forms, excessive amounts of nutrients, and altered nutrient ratios can lead to eutrophication and a suite of problems in aquatic ecosystems, such as low dissolved oxygen concentrations, un-ionized ammonia, excessive growth of toxic forms of cyanobacteria, and changes in components of the food web. Nutrient concentrations in the Delta have been well studied (Jassby et al., 2002; Kimmerer, 2004; Van Nieuwenhuyse, 2007; Glibert, 2010; Glibert et al., 2011, 2014).

In addition to changes in the nutrient balance in the Delta, the introduction of nonnative species can influence the aquatic food web. For example, the introductions of two clams from Asia have led to major alterations in the food web in the Delta. *Potamocorbula* is most abundant in the brackish and saline water of Suisun Bay and the western Delta, and Corbicula is most abundant in the fresh water of the central Delta. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes such as delta smelt and young Chinook salmon (Feyrer et al., 2007; Kimmerer, 2002b).

Additionally, the introduction of the clams has led to the decline of higher-food-quality native copepods and the establishment of poorer quality nonnative copepods. The cyclopoid copepod, *Limnoithona*, has rapidly become the most abundant copepod in the Delta since its introduction in 1993 (Hennessy and Enderlein, 2013). This species is hypothesized to be a low-quality food source and intraguild predator of native and nonnative calanoid copepods (California Resources Agency, 2005). The clam *Potamocorbula* also has been implicated in the reduction of the native opossum shrimp (*Mysida)*, a preferred food of Delta native fishes such as Sacramento splittail and longfin smelt (Feyrer et al., 2003). Reductions in food availability and food quality have led to lower fish foraging efficiency and reduced growth rates (Moyle, 2002).

Fish Passage and Entrainment

The Delta presents a challenge for anadromous and resident fish during upstream and downstream migration, with its complex network of channels, low eastern and southern tributary inflows, and reverse currents created by pumping for water exports. These complex conditions can lead to straying, extended exposure to predators, and entrainment during out-migration.

North Delta Fish Passage and Entrainment

In the north Delta, migrating fish encounter multiple potential pathways as they move upstream into the Sacramento or Mokelumne river systems, which can lead to fish straying into different watersheds. For example, the opening of the Delta Cross Canal (DCC) when salmon are returning to spawn to the Mokelumne and Cosumnes rivers is believed to lead to increased straying of these fish into the American and Sacramento rivers because of confusion over olfactory cues. Conversely, closures of the DCC have corresponded to reduced recoveries of Mokelumne River hatchery fish in the American River system and increased returns to the Mokelumne River Hatchery (East Bay Municipal Utility District, 2012).

Outmigrating juvenile fish moving down the mainstem Sacramento River also can enter the DCC when the gates are open and travel through the Delta via the Mokelumne and San Joaquin river channels. In the case of juvenile salmonids, this shifted route from the north Delta to the central Delta increases their mortality rate (Kjelson and Brandes, 1989; Brandes and McLain, 2001; Newman and Brandes, 2010; Perry et al., 2010, 2012). Salmon migration studies show losses of approximately 65 percent for groups of outmigrating fish that are diverted from the mainstem Sacramento River into the waterways of the central and southern Delta (Brandes and McLain, 2001; Vogel, 2004, 2008; Perry and Skalski, 2008). Perry and Skalski (2008) found that, by closing the DCC gates, total through-Delta survival of marked fish to Chipps Island increased by nearly 50 percent for fish moving downstream in the Sacramento River system. Closing the DCC gates appears to redirect the migratory path of outmigrating fish into Sutter and Steamboat sloughs and away from Georgiana Slough, resulting in higher survival rates. Species that may be affected include juvenile green sturgeon, steelhead, and winter and spring-run Chinook salmon (NMFS, 2009a).

Fish passage in the north Delta also can be affected by water quality. Water quality in the mainstem Sacramento River and its distributary sloughs can be poor at times during summer, creating conditions that may stress migrating fish or even impede migration. These stressful conditions may be related to dissolved oxygen concentrations, water temperatures, and, for some species (e.g., delta smelt), salinity.

Central and South Delta Fish Passage and Entrainment

The south Delta intake facilities include the CVP and SWP export facilities, local agency intakes, and agricultural intakes. Water flow patterns in the south Delta are influenced by the water diversion actions and operations of the south Delta seasonal temporary barriers and tides, and river inflows to the Delta (Kimmerer and Nobriga, 2008). Delta diversions can create reverse flows, drawing fish toward project facilities (Arthur et al., 1996; Kimmerer, 2008; Grimaldo et al., 2009). In addition, fish swimming through southern Delta channels can be subjected to stress from poor water quality (seasonally high temperatures, low dissolved oxygen, high water transparency, and *Microcystis* blooms) and slow water velocities in lake-like habitats. Any of these factors can cause elevated mortality rates by weakening or disorienting the fish and increasing their vulnerability to predators (Vogel, 2011).

A portion of fish that enter the CVP Jones Pumping Plant approach channel and the SWP Clifton Court Forebay are salvaged at screening and fish salvage facilities, transported downstream by trucks, and released. NMFS (2009a) estimates that the direct loss of fish from the screening and salvage process is in the range of 65 to 83.5 percent for fish from the point they enter Clifton Court Forebay or encounter the trash racks at the CVP facilities. Aquatic organisms (e.g., phytoplankton and zooplankton) that serve as food for fish also are entrained and removed from the Delta (Jassby et al., 2002; Kimmerer et al., 2008; Brown et al., 1996). Fish entrainment and salvage are particular concerns during dry years when the distributions of young striped bass, delta smelt, longfin smelt, and other migratory fish species shift closer to the project facilities (Stevens et al., 1985; Sommer et al., 1997).

Salvage estimates reflect the number of fish entrained by CVP and SWP exports, but these numbers alone do not account for other sources of mortality related to the export facilities. These numbers do not include prescreen losses that occur in the waterways leading to the diversion facilities, which may in some cases reduce the number of salvageable fish (Gingras, 1997; Clark et al., 2009; Castillo et al., 2012). For delta smelt, prescreen losses appear to be where most mortality occurs (Castillo et al., 2012). In addition, actual salvage numbers do not include the entrainment of fish larvae, which cannot be collected by the fish screens. The number of fish salvaged also does not include losses of fish that pass through the louvers intended to guide fish into the fish collection facilities, or the losses during collection, handling, transport, and release back into the Delta.

Delta Agricultural Diversions

There are more than 2,200 diversions in the Delta (Herren and Kawasaki, 2001). These irrigation diversion pipes are shore-based, typically small (30- to 60-centimeter pipe diameter), and operated via pumps or gravity flow; most lack fish screens. These diversions increase total fish entrainment and losses, and alter local fish movement patterns (Kimmerer and Nobriga, 2008). Delta smelt have been found in samples of Delta irrigation diversions, as well as larger wetland management diversions downstream. However, Nobriga et al. (2004) found that the low and inconsistent entrainment of delta smelt measured in the study reflected habitat use by delta smelt and relatively small hydrodynamic influence of the diversion.

Reverse Flows

The CVP and SWP both divert water from Old River, a tidal slough that intersects the lower San Joaquin River. CVP and SWP diversions can cause the tidally averaged flow in the Old River, Middle River, and other adjacent channels in the southern Delta to reverse toward the diversions. These reverse flows contribute to the entrainment of numerous fish species, including migrating and spawning delta smelt. Patterns of entrainment vary with life history and season, as well as food availability and water quality (Grimaldo et al., 2009).

Reverse flows also affect downstream migrating juvenile Chinook salmon and steelhead. Pilot studies of the effect of DCC operations on the movement of juvenile Chinook salmon in the Delta indicate that yearlings will move into the DCC during flood tides, and can be drawn into the channel after initially migrating past the channel gates (CALFED, 2000c).

Non-Native Species

The Delta is one of the most biologically invaded estuaries in the world, with non-native species having been introduced both intentionally and unintentionally (Cohen and Carlton, 1995). Non-native fishes were introduced into the Delta for sport fishing (game fish such as striped bass, largemouth bass, smallmouth bass, bluegill, and other sunfish), as forage for game fish (threadfin shad, golden shiner, and fathead minnow), for vector control (inland silverside, western mosquitofish), for human food use (common carp, brown bullhead, and white catfish), and from accidental releases (yellowfin goby, shimofuri goby, and shokihaze goby) (Moyle, 2002). Introduced fish may compete with native fish for resources and, in some cases, prey on native species.

In addition to the introduction of non-native fishes, introduced invertebrate species have profoundly affected the Delta ecosystem. Since the introduction of the overbite clam (*Corbula amurensis*), there has been a reduction of the phytoplankton, thereby affecting the productivity of the estuary with a corresponding reduction in zooplankton and pelagic fish production. Historical relationships between Delta outflow and the populations of longfin smelt and striped bass have shifted since the introduction of this clam (Baxter et al., 2010). The Delta also has experienced successive invasions of copepod species. Copepods are zooplankton that form the food base for many pelagic fishes. An introduced copepod, *Limnoithona tetraspina*, displaced the previously dominant copepod species (*Psuedodiaptomus forbesi*) in the early 1990s. The abundance of other copepods has decreased continuously since its introduction. Limnoithona is a less suitable food item than the previous species (Baxter et al., 2010).

In addition, the introduction of two non-native invasive aquatic plants, water hyacinth and Brazilian waterweed, has reduced habitat quantity and value for many native fishes. Water hyacinth forms floating mats that greatly reduce light penetration into the water column, which can significantly reduce primary productivity and available food for fish in the underlying water column. Brazilian waterweed grows along the margins of channels in dense stands that prohibit native juvenile fish from access to shallow water habitat. Additionally, the thick cover of these two invasive plants provides excellent habitat for nonnative ambush predators such as bass, which prey on native fish species. Studies indicate low abundance of native fish such as delta smelt, Chinook salmon, and Sacramento splittail in areas of the Delta where submerged aquatic vegetation infestations are thick (Grimaldo et al., 2004, 2012; Nobriga et al., 2005).

Because of invasive species and other environmental stressors, native fishes have declined in abundance throughout the region during the period of monitoring (Matern et al., 2002; Brown and Michniuk, 2007; Sommer et al., 2007; Mount et al., 2012). Habitat degradation, changes in hydrology and water quality, and stabilization of natural environmental variability are all factors that generally favor nonnative, invasive species (Mount et al., 2012; Moyle et al., 2012).

Predation

Predation is an important factor that influences to varying degrees the behavior, distribution, and abundance of prey species in aquatic communities. Predation can have differing effects on a population of fish depending on the size or age selectivity, mode of capture, mortality rates, and other factors. Predation is a part of every food web, and native Delta fishes were part of the historical Delta food web. Because of the magnitude of change in the Delta from historical times and the introduction of nonnative predators, it is logical to conclude that predation may have increased in importance as a mortality factor for Delta fishes, with some observers suggesting that it is likely the primary source of mortality for juvenile salmonids in the Delta (Vogel, 2011).

In 2013, a panel of experts was convened to review data on predation in the Delta and draw preliminary conclusions on the effects of predation on salmonids. The panel acknowledged that the system supports large populations of fish predators that consume juvenile salmonids (Grossman et al., 2013). However, the panel concluded that because of extensive flow modification, altered habitat conditions, native and nonnative fish and avian predators, temperature and dissolved oxygen limitations, and the overall reduction in salmon population size, it was unclear what proportion of the juvenile salmonid mortality could be attributed to predation. The panel further indicated that predation, while the proximate cause of mortality, may be influenced by a combination of other stressors that make fish more vulnerable to predation.

12.2.3.6 San Francisco Estuary (including San Pablo Bay and Suisun Bay)

Suisun Bay is a shallow embayment between Chipps Island at the western boundary of the Delta and the Benicia-Martinez Bridge at the eastern end of Carquinez Strait. Adjacent to Suisun Bay is Suisun Marsh, the largest brackish marsh in the United States. The narrow, 12-mile-long Suisun Bay is a large area of open water that is transitional between the fresh waters of the Delta and the salt waters of San Francisco Bay; it is a shallow region of wind-stirred, brackish water, lined with tidal marshes (Moyle, 2008). Suisun Marsh is an approximately 74,130-acre marsh that is largely managed as freshwater wetlands to support waterfowl hunting (Moyle, 2008). Suisun Marsh maintains its freshwater character because of inflow from the Sacramento River via Montezuma Slough (Moyle, 2008). Large tidal gates on the upper end of Montezuma Slough control salinity in the marsh by allowing fresh water to flow in but preventing the tides from pushing it back out again (Moyle, 2008).

The estuary's aquatic and wetland habitats range from the brackish water of the lower Delta and Suisun Bay to the dilute salt water of San Pablo Bay, and the highly saline waters of South San Francisco Bay. Delta outflow interacts with tides to determine how far salt water intrudes from the ocean into the estuary. Delta outflow varies with hydrology, reservoir releases, and diversions upstream (DWR, 2009).

Fish species that are found in the San Francisco Estuary are virtually the same as those in the Delta, although the estuary is more likely to contain euryhaline[2] marine species and early life history stages of estuarine-dependent species such as striped bass, delta smelt, and longfin smelt (Moyle, 2002). Fish species abundance and distribution in the estuary are influenced by seasonal and annual variability in hydrologic conditions, including the magnitude of flows into the Delta from the Sacramento and San Joaquin rivers and other tributaries, outflow from the Delta into San Francisco Bay, and the salinity gradient which varies by region and fluctuates with outflow and tidal actions from the Pacific Ocean (Moyle, 2008). Fish species of management concern found in the San Francisco Estuary portion of the Secondary Study Area are shown in Table 12-2.

The San Francisco Estuary supports a spectrum of diverse habitats that are important to the species that inhabit them. Tidal perennial aquatic habitat is one natural community that occurs within greater San Francisco Bay ecological zones that many fish species of management concern are highly dependent on. Tidal perennial habitat includes deep water aquatic (greater than 10 feet deep from mean lower low tide [the lowest of the low tides in a day]), shallow aquatic (less than or equal to 10 feet deep from mean lower low tide), and unvegetated intertidal (i.e., tideflats) zones of estuarine bays, river channels, and sloughs (Moyle, 2008).

Many fish spend their entire lives in the tidal perennial aquatic community and use it for foraging, spawning, rearing, resting, and migration. Resident and migratory fish use tidal perennial aquatic habitat for spawning, rearing, foraging, and escape cover. Striped bass, delta smelt, Sacramento splittail, and many resident Bay-Delta fish use this habitat for rearing and as adults (CALFED, 2000c). Young steelhead and Chinook salmon forage in these productive waters as fry and juveniles to put on weight before entering the ocean. Changes in physical attributes of the water column, such as flow, salinity and water temperature, provide environmental cues for some species to trigger the timing of biological events, such as migration and spawning.

Fish species of management concern that depend on these tidal marshes and adjoining sloughs, mudflats, and embayments include delta smelt, longfin smelt, Chinook salmon, green sturgeon, white sturgeon,

[2] Capable of tolerating a wide range of saltwater concentrations.

Pacific herring (*Clupea pallasii)*, and starry flounder. However, many new species of plants and animals have been introduced. These exotic and invasive species, such as the Chinese mitten crab (*Eriocheir sinensis*) and Asian clam (*Corbicula fluminea)*, threaten to undermine the estuary's food web and alter its ecosystem (DWR, 2009).

12.2.3.7 Pacific Ocean Habitat of the Southern Resident Killer Whale

The Pacific Ocean along the coast of California is included in this description of the affected environment because it provides habitat for the Southern Resident killer whale population. The effect of the action, however, is limited to changes in the number of Chinook salmon produced in the Central Valley entering the Pacific Ocean, which are an important component of the killer whale diet.

Southern Resident killer whales are found primarily in the coastal waters off the shore of British Columbia, Washington, and Oregon in summer and fall (NMFS, 2008). During winter, killer whales are sometimes found off the coast of central California and more frequently off the Washington coast (Hilborn et al., 2012).

The 2005 NMFS endangerment listing (*Federal Register*, 2005) for the Southern Resident killer whale distinct population segment lists several factors that may be limiting the recovery of killer whales, including the quantity and quality of prey, accumulation of toxic contaminants, and sound and vessel disturbance. In the Recovery Plan for Southern Resident killer whales (*Orcinus orca*), NMFS (2008) posits that reduced prey availability forces whales to spend more time foraging, which may lead to reduced reproductive rates and higher mortality rates. Reduced food availability may lead to mobilization of fat stores, which can release stored contaminants and adversely affect reproduction or immune function (NMFS, 2008).

The Independent Science Panel reported that Southern Resident killer whales depend on Chinook salmon as a critical food resource (Hilborn et al., 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook salmon were the most frequent prey item for killer whales in two regions of the whale's summer range off the coast of British Columbia and Washington state, representing more than 90 percent of the diet in July and August. Samples indicated that when Southern Resident killer whales are in inland waters from May to September, they consume Chinook salmon stocks that originate from regions including the Fraser River, Puget Sound, the Central British Columbia Coast, West and East Vancouver Island, and Central Valley California (Hanson et al., 2010).

Significant changes in food availability for killer whales have occurred over the past 150 years, largely because of human impacts on prey species. Salmon abundance has been reduced over the entire range of the Southern Resident killer whales, from British Columbia to California. The Recovery Plan for Southern Resident killer whales (*Orcinus orca*) (NMFS, 2008) indicates that wild salmon have declined primarily because of degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. The recovery plan supports restoration efforts to rebuild depleted salmon populations and other prey to ensure an adequate food base for Southern Resident killer whales.

Central Valley streams produce Chinook salmon that contribute to the diet of Southern Resident killer whales. The number of Central Valley salmon that annually enter the ocean and survive to a size susceptible to predation by killer whales is not known. However, estimates of total Chinook salmon production produced by the Comprehensive Assessment and Monitoring Program, administered by USFWS and Reclamation, provide an approximation of the size of the ocean population of Central Valley Chinook salmon potentially available to killer whales. Since 1992, total production of fall-run Chinook salmon ranged from 53,129 in 2009 to 1,436,928 in 2002 (U.S. Department of the Interior, 2012). The term “total production” here represents the number of fish that returned from the ocean plus those that were taken as part of the commercial and sport fishery. It does not include natural mortality in the ocean, including salmon taken by killer whales.

12.2.4 Primary Study Area

12.2.4.1 Methodology

For fish species listed pursuant to FESA that could occur within the Primary Study Area, the Fish and Wildlife Services IPaC website (USFWS, 2017) was consulted. For species listed pursuant to CESA in this region, the January 2017 Special Animals List maintained by CDFW was consulted (CDFW, 2017b). Documents or data specific to areas and species within the Primary Study Area were also reviewed to characterize aquatic biological resources. Additionally, CDFW conducted fisheries surveys and monitoring within the Primary Study Area (CDFG, 2003, 2011).

12.2.4.2 Waterways that Could be Affected by Project Facilities

The Primary Study Area includes the following waterways that could be affected by construction, operation, and maintenance of Project facilities: Grapevine Creek, Antelope Creek, Funks Creek, Stone Corral Creek, Hunters Creek, CBD, Tehama-Colusa Canal, GCID Main Canal, and Funks Reservoir. Grapevine Creek, Antelope Creek, Funks Creek, Stone Corral Creek, and Hunters Creek are all ephemeral streams, which limit the diversity of fish species that inhabit these streams and the seasonality of their use. Fish species of management concern found in the Primary Study Area are shown in Table 12-3.

Table 12-3
Fish Species of Management Concern in the Primary Study Area

Species or *Population*[a]	**Scientific Name**	**Federal Status**	**State Status[b]**	**Tribal, Commercial, or Recreational Importance**	**Potential Location of Occurrence Within Study Area[c]**
Spring-run Chinook Salmon[d] *Central Valley ESU*	*Oncorhynchus tshawytscha*	Threatened	Threatened	Yes	Colusa Basin Drain
Steelhead[d] *Central Valley DPS*	*Onchorynchus mykiss*	Threatened	None	Yes	Colusa Basin Drain
Fall-/late Fall-run Chinook Salmon *Central Valley ESU*	*Oncorhynchus tshawytscha*	None	Species of Special Concern	Yes	Colusa Basin Drain
River Lamprey	*Lampetra ayresi*	None	None	Yes	Colusa Basin Drain
Pacific Lamprey	*Lampetra tridentata*	None	None	Yes	Colusa Basin Drain
Sacramento Splittail	*Pogonichthys macrolepidotus*	None	Species of Special Concern	No	Colusa Basin Drain

Species or *Population*[a]	Scientific Name	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Potential Location of Occurrence Within Study Area[c]
Hardhead	*Mylopharodon conocephalus*	None	Species of Special Concern	No	Grapevine Creek, Funks Creek, Stone Corral Creek, Antelope Creek, Hunter's Creek, Colusa Basin Drain, Tehama-Colusa Canal, GCID Main Canal
Striped Bass	*Morone saxatilis*	None	None	Yes	Tehama-Colusa Canal, GCID Main Canal
Black Bass (Largemouth, Smallmouth, Spotted)	*Micropterus spp.*	None	None	Yes	Grapevine Creek, Funks Creek, Stone Corral Creek, Antelope Creek, Hunter's Creek, Colusa Basin Drain, Tehama-Colusa Canal, GCID Main Canal

a. The term "population" refers to the listed Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS) for that species.

b. Includes species listed by the State of California as threatened, endangered, or Species of Special Concern.

c Indicates locations in the Primary Study Area where the species is potentially present or known to occur.

d Critical habitat has been designated for this species.

Project facilities within the Primary Study Area, and the waterways that those facilities could affect, are shown in Table 12-4 and in Figure 12-5.

Table 12-4
Project Facilities in the Primary Study Area and the Potentially Affected Waterways

Project Facilities	Affected Waterway
Sites Reservoir Inundation Area	Grapevine Creek, Funks Creek, Stone Corral Creek, Antelope Creek
Golden Gate Dam, Sites Dam, and Saddle Dams	Stone Corral Creek, Funks Creek
Sites Reservoir Inlet/Outlet Structure	Funks Creek
Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure, Sites Pumping/Generating Plant, Sites Electrical Switchyard, and Field Office Maintenance Yard	None
South Bridge and Roads	Antelope Creek, Grapevine Creek, Stone Corral Creek, Funks Creek
Recreation Areas	None
Holthouse Dam and Reservoir (including Sites Pumping/Generating Plant Approach Channel, Funks Reservoir Dredging)	Funks Creek
Holthouse Spillway and Stilling Basin and Spillway Bridge	Funks Creek
WAPA Transmission Line Relocation	None
Tehama-Colusa Canal Construction Bypass Pipeline and Existing Connections	None

Project Facilities	Affected Waterway
Additional Pumps at the Red Bluff Pumping Plant	Sacramento River
TRR (including the TRR to Funks Creek Pipeline)	Funks Creek
TRR Pipeline, TRR Pipeline Road, TRR Pumping/Generating Plant, TRR Electrical Switchyard, GCID Main Canal Connection to the TRR	None
GCID Main Canal Facilities Modifications	Sacramento River
Delevan Pipeline Intake/Discharge Facilities	Sacramento River
Delevan Pipeline	Hunters Creek, Colusa Basin Drain
Delevan Power Line	None
Transmission Lines, Substations, and Distribution Lines	None
Project Buffer	Grapevine Creek, Funks Creek, Stone Corral Creek, Antelope Creek

Funks Creek, Stone Corral Creek, Grapevine Creek, and Antelope Creek

The portions of Funks, Stone Corral, Grapevine, and Antelope creeks within the Sites Reservoir footprint are characterized by deeply incised channels that are largely devoid of riparian cover as a result of heavy cattle use (Brown, 2000). On the valley floor, Funks Creek and Stone Corral Creek flow through irrigated pasture, rice fields, and row crop agriculture until they flow into the CBD. They are incised and revetted in some areas, and have been straightened and altered by changes in land use. During summer, much of the streambed of the Primary Study Area creeks is dry, except for occasional pools or when receiving agricultural drainage or runoff. In addition, water quality is reported to be poor and high in dissolved minerals (Brown, 2000)

Studies of fish in streams that flow through the proposed Sites and Colusa Reservoir areas were conducted in 1998 and 1999 (CDFW, 2003). Within the footprint of the potential inundation areas, 36 sample stations were seined, Stone Corral, Funks, Hunters, Minton, Logan, and Antelope creeks as well as 7 farm impoundment ponds in the area, were also seined. In the potential inundation areas, 12 fish species were caught in 1998 and 1999; 5 species were game fishes and 7 species were non-game fishes. Fish species of management concern captured consisted of Chinook salmon, Pacific lamprey, hardhead, Sacramento splittail, and largemouth bass (CDFW, 2003).

Table 12-5 identifies fish species found in Funks, Stone Corral reek, Grapevine, and Antelope Creeks in the proposed Sites Reservoir Inundation Area. These species were observed during sampling conducted between January 1998 and July 1999 (CDFW, 2003). Most of the fish sampled were less than 6 inches long, suggesting that juveniles rear in these creeks and move downstream to larger bodies of water as adults. Many of the native minnow species found in these creeks typically ascend seasonal creeks in winter and spawn there in early spring (Moyle, 2002). Most adults migrate downstream after spawning. One spring-run Chinook salmon carcass was observed in Antelope Creek during sampling (CDFW, 2003). Live Chinook salmon and Chinook salmon carcasses were also observed in Funks Creek downstream of Funks Reservoir. These fish likely strayed from the Sacramento River during high flows or migrated up the Yolo Bypass and through the Knights Landing Ridge Cut. In 2016 and 2017, improvements were made at the Knights Landing Outfall Gates and the Wallace Weir to prevent fish from straying in the CBD. Suitable Chinook salmon spawning habitat does not exist downstream of Funks Reservoir, and spawning habitat is not known to exist on Antelope Creek as water quality and hydraulic conditions are not suitable to support a population.

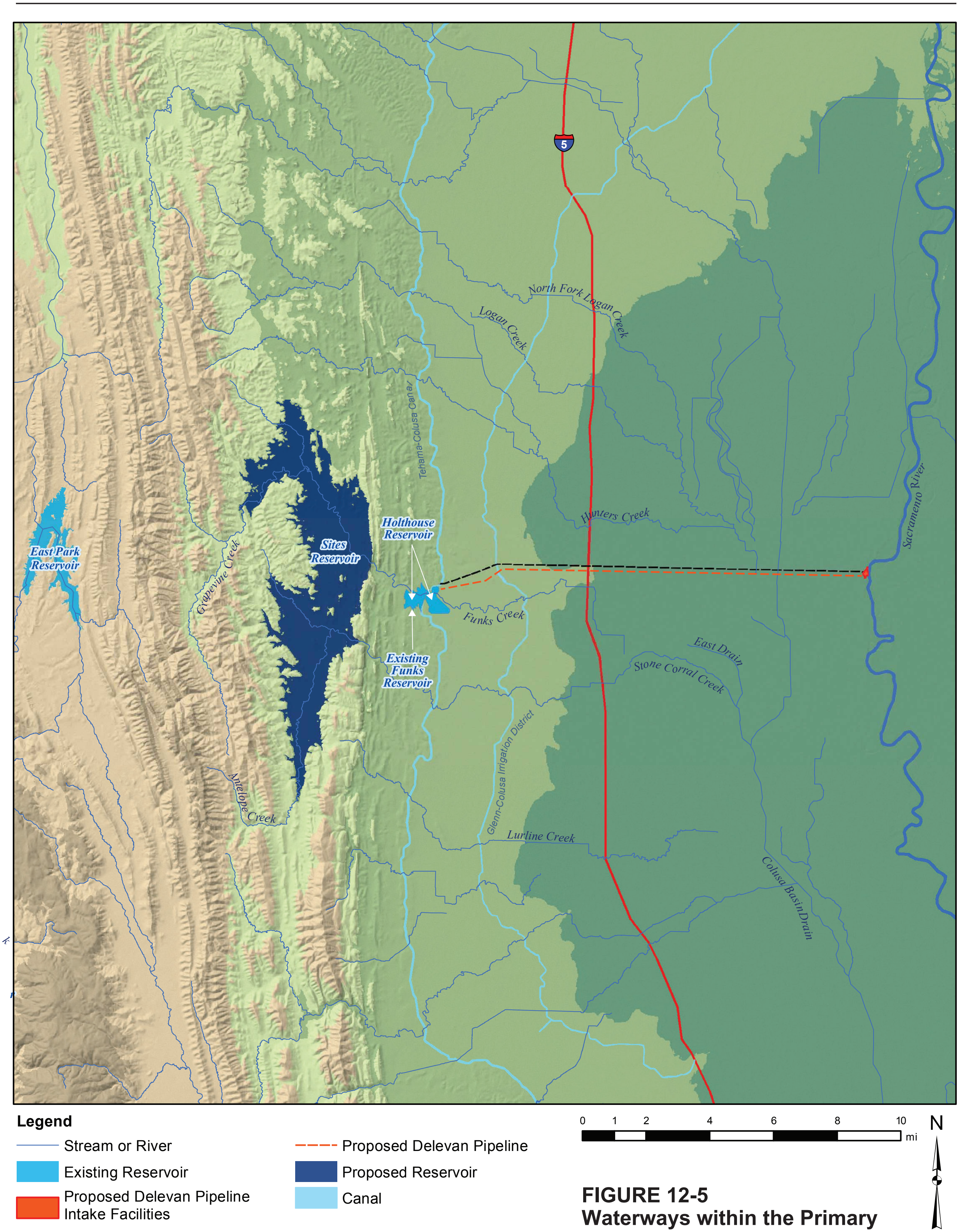


FIGURE 12-5
Waterways within the Primary Study Area
Sites Reservoir Project EIR/EIS

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Table 12-5
Fish Species Observed by CDFW during Sampling Efforts in the Proposed Sites Reservoir Inundation Area

Common Name	Scientific Name
Chinook Salmon	*Oncorhynchus tshawytscha*
Bluegill	*Lepomis macrochirus*
Green Sunfish	*Lepomis cyanellus*
Largemouth Bass	*Micropterus salmoides*
California Roach	*Hesperoleucus symmetricus*
Hitch	*Lavinia exilicauda*
Sacramento Pikeminnow	*Ptychocheilus grandis*
Sacramento Blackfish	*Orthodon microlepidotus*
Sacramento Sucker	*Catostomus occidentalis*
Mosquitofish	*Gambusia affinis*
Sculpin sp.	*Cottus sp.*
Red-eared Sunfish	*Lepomis microlophus*

Hunters Creek and the Colusa Basin Drain

The Delevan Pipeline would cross Hunters Creek near its confluence with the CBD. This stream has not been sampled to determine which fish species are found there. Due to the similar hydrology, channel form, and riparian habitat, Hunters Creek likely has a species composition similar to the streams found in the Sites Reservoir footprint.

The Delevan Pipeline would also cross under the CBD using an inverted siphon. Historically, the CBD was a natural channel that transported water from westside tributaries, such as Willow, Funks, Stone Corral, and Freshwater creeks, to the Sacramento River. It also carried floodwater from the Sacramento River. When agricultural operations began in the Sacramento Valley, the CBD was channelized and dredged to carry agricultural runoff in addition to natural flows. The banks are scoured by periodic high flows and provide little cover for fish; however, some instream cover is provided by large and small woody debris (CDFW, 2003). The bottom of the drain is largely mud. Water in the CBD is turbid and warm during the summer, and turbid and cool during the winter.

Table 12-6 identifies the fish species observed during sampling efforts in the drain conducted between January and July 1999 (CDFW, 2003). Fall-, late fall-, and spring-run Chinook salmon have also been observed in the CBD. Steelhead may also be present, with potential spawning habitat existing upstream of the Primary Study Area in Willow Creek and Freshwater Creek, but none were captured during sampling efforts (CDFW, 2003).

Table 12-6
Fish Species Observed by CDFW during Sampling Efforts in the Colusa Basin Drain

Common Name	Scientific Name
Central Valley Chinook Salmon	*Oncorhynchus tshawytscha*
White Catfish	*Ictalurus catus*
Brown Bullhead	*Ameiurus nebulosus*
Black Bullhead	*Ameiurus melas*
Channel Catfish	*Ictalurus punctatus*
Bluegill	*Lepomis macrochirus*
Green Sunfish	*Lepomis cyanellus*
Largemouth Bass	*Micropterus salmoides*
Black Crappie	*Pomoxis nigromaculatus*
White Crappie	*Pomoxis annularis*
Pacific Lamprey	*Lampetra ayresi*
Threadfin Shad	*Dorosoma petenense*
California Roach	*Hesperoleucus symmetricus*
Hitch	*Lavinia exilicauda*
Fathead Minnow	*Pimephales promelas*
Common Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Sacramento Pikeminnow	*Ptychocheilus grandis*
Sacramento Blackfish	*Orthodon microlepidotus*
Sacramento Splittail	*Pogonichthys macrolepidotus*
Hardhead	*Mylopharodon conocephalus*
Sacramento Sucker	*Catostomus occidentalis*
Inland Silverside	*Menidia beryllina*
Mosquitofish	*Gambusia affinis*
Sculpin sp.	*Cottus sp.*
Tule Perch	*Hysterocarpus traski*
Big Scale Logperch	*Percina macrolepida*

Tehama-Colusa Canal and GCID Main Canal

The Tehama-Colusa Canal and the GCID Main Canal provide habitat for native and non-native fish species. Native fish that are common in the canals are Sacramento sucker, Sacramento pikeminnow, hardhead, and hitch (*Lavinia exilicauda*). Non-native fish species include striped bass, black bass, sunfish, and common carp. Many of the native fish that occur in the canals likely enter through the intakes as larvae (Reclamation, 2001). Existing screens at the pumping plants are designed to prevent entrainment of Chinook salmon and steelhead into the canals.

Sacramento River at the Potential Intake Facilities

The reach of the Sacramento River at the proposed Delevan Pipeline Intake/Discharge Facilities and the existing intakes for the Tehama-Colusa and GCID Main canals provide habitat for migrating adult and juvenile Central Valley steelhead, and winter-, spring-, late fall-, and fall-run Chinook salmon. The majority of spawning for all runs generally occurs upstream of the Red Bluff Pumping Plant. A limited number of fall- and late fall-run Chinook salmon also spawn in the river near Red Bluff and the diversion into the Tehama-Colusa Canal, and have spawned as far down as the intake to the GCID Main Canal.

Adult, larval, and juvenile white and green sturgeon also migrate and can hold in the vicinity of the proposed Delevan Pipeline Intake/Discharge Facilities site and the existing diversions into the Tehama-Colusa and GCID Main canals. White sturgeon likely spawn in the vicinity of the GCID Main Canal diversion and proposed Delevan Pipeline Intake/Discharge Facilities. Green sturgeon are known to spawn in the vicinity of the Tehama-Colusa and GCID Main Canal intakes (Poytress et al., 2011). It is not known if green sturgeon spawn farther downstream at the proposed Delevan Pipeline Intake/Discharge Facilities site, but tracking data indicate that green sturgeon do not hold in this area during the spawning period. Sturgeon egg and larva surveys have been conducted on the Sacramento River downstream of Jelly's Ferry Bridge (RM 266.5) to upstream of the GCID Main Canal diversion (RM 206.5). Spawning has been confirmed (eggs have been collected) as far upstream as RM 264.5 (near Inks Creek) and as far downstream as RM 206.5 upstream of GCID Main Canal diversion) (Poytress et al., 2009, 2011, 2013). CDFW conducted juvenile salmonid monitoring at the location of the proposed Delevan Pipeline Intake/Discharge Facilities site and approximately 1 mile upstream of the Tisdale Weir (CDFW, 2011). Sampling showed that juvenile Chinook salmon do migrate past the site in the summer (August), but are most abundant during the winter months (December to February). Chinook salmon juveniles were most abundant during periods of high flow. Abundance decreased as flows receded. The abundance of fish passing the site also appeared to increase during periods of high turbidity (associated with relatively small increases in flow).

12.3 Environmental Impacts/Environmental Consequences

12.3.1 Evaluation Criteria and Significance Thresholds

Significance criteria represent the thresholds that were used to identify whether an impact would be potentially significant. Appendix G of the *CEQA Guidelines* suggests the following evaluation criteria for biological resources:

Would the Project:

- Have a substantial adverse effect, either directly or indirectly through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFW, NMFS, or USFWS?
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

The evaluation criteria used for this impact analysis represent a combination of the Appendix G criteria and professional judgment that considers current regulations, standards, and/or consultation with agencies, knowledge of the area, currently available and peer-reviewed scientific literature, and the context and intensity of the environmental effects. For the aquatic biological resources impact assessment, indicators (e.g., water temperatures, flows) were used to evaluate whether the Project would have an impact on a species' habitat. The impact indicators and evaluation guidelines were developed based on an extensive review of fisheries literature, with special emphasis on research conducted in the Central Valley. Impact determinations were based on consideration of all evaluated impact indicators for all life stages for a particular species in a particular river or geographic region (e.g., the Delta, the Export Service Area).

For the purposes of this analysis, an alternative would result in a potentially significant impact if it would result in the following:

- A substantial adverse effect (either directly, through habitat modifications, by interfering with the movement of native fish species, or by impeding the use of native fish nursery/rearing sites) on any fish species of management concern, including species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by CDFW, NMFS, or USFWS.

12.3.2 Impact Assessment Assumptions, Methodology, and Approach

Combinations of Project facilities were used to create Alternatives A, B, C, C_1, and D. In all resource chapters, the Sites Project Authority (Authority) and Reclamation described the potential impacts associated with the construction, operation, and maintenance of each of the Project facilities for each of the five action alternatives. Some Project features/facilities and operations (e.g., reservoir size, overhead power line alignments, provision of water for local uses) differ by alternative, and are evaluated in detail within each of the resource areas chapters. As such, the Authority has evaluated all potential impacts with each feature individually, and may choose to select or combine individual features as determined necessary.

Impacts associated with the construction, operation, and maintenance for Alternative C_1 would be the same as Alternative C and are, therefore, not discussed separately below.

12.3.2.1 Assumptions

The following assumptions were made regarding Project-related construction, operation, and maintenance impacts on aquatic biological resources:

- Direct Project-related construction, operation, and maintenance activities would occur in the Primary Study Area.
- Direct Project-related operational effects would occur in the Secondary Study Area.
- The only direct Project-related construction activity that would occur in the Secondary Study Area is the installation of two additional pumps into existing bays at the Red Bluff Pumping Plant.
- The only direct Project-related operations and maintenance activity that would occur in the Secondary Study Area is the sediment removal and disposal at the two intake locations (i.e., GCID Main Canal Intake and Red Bluff Pumping Plant).
- No direct Project-related construction or maintenance activities would occur in the Extended Study Area.
- Direct Project-related operational effects would occur in both the Primary Study Area and the Secondary Study Area.
- Direct Project-related operational effects that would occur in the Extended Study Area are related to San Luis Reservoir and/or other SWP or local reservoir operation, increased reliability of water

supply to agricultural, municipal, and industrial water users, and the provision of an alternate Level 4 wildlife refuge water supply.

- The existing bank protection located upstream of the proposed Delevan Pipeline Intake/Discharge Facilities would continue to be maintained and remain functional.
- No additional channel stabilization, grade control measures, or dredging in the Sacramento River at or upstream of the Delevan Pipeline Intake/Discharge Facilities would be required.
- Ecosystem enhancement actions and operations are included as part of the proposed Project as described below.

Pulse Flow Protection Diversion Assumptions

In anticipation of the use of the analyses in this EIR/EIS by cooperating and trustee agencies to support their decision making and the future permit acquisition process with NMFS, CDFW, and other resource agencies, the hydrology and operations modeling of the proposed Project included restrictions on diversions to limit impacts on out-migrating juvenile fish as a "surrogate" for likely permit conditions. Based on recent literature and the proposed permit conditions for other diversion projects, operations modeling for the proposed Project diversions were assumed to be restricted to promote fish passage associated with pulse flow events that stimulate the observed spike in juvenile salmon out-migration. Actual operations are anticipated to be informed by real-time monitoring of fish movement.

An assumed pulse protection period was developed that would extend from October through May to address out-migration of juvenile winter-, spring-, fall- and late-fall-run Chinook salmon, as well as steelhead. Pulse flows during this period would provide flow continuity between the upper and lower Sacramento River to support fish migration. It is recognized that research regarding the benefits of pulse flows is ongoing, and further research and adaptive management would be required to develop and refine a pulse flow protection strategy for fish migration, and as such, this assumption was used for modeling and informational purposes only. Further detail on the diversion limitation assumptions is included in Chapter 5 Guide to the Resource Analysis. The diversion limitation is included as a proposed mitigation measure to address potential diversion-related impacts. It is anticipated that discussions with federal and state resource agencies would likely result in refinements to the proposed operational approach to best minimize potential impacts to aquatic resources.

Ecosystem Enhancement Storage Account Actions/Operation Included as Part of the Project

Sites Reservoir would be operated in a cooperative manner with other State and federally owned reservoirs in the Sacramento Valley to support ecosystem benefits and enhancements, including actions to increase survival of anadromous and endemic fish populations. Operational actions would include improving conditions related to water temperatures, river flows, and releases to improve Delta water quality.

The operation of Sites Reservoir to provide a variety of ecosystem benefits would allow for the potential development and administration of an ecosystem enhancement storage account, which could be managed by either the Authority or the State to provide water for ecosystem and water quality purposes. Such an account could provide a pool of dedicated storage to manage in cooperation with existing operations to improve cold-water conservation storage, stabilize river flows during critical fisheries periods, increase flows through certain watercourses and facilities (e.g., Yolo Bypass), improve water quality, and enhance habitat restoration. Operational strategies would include cooperation with the Authority, Reclamation, and DWR for the Project to divert, store, and release water to meet obligations that would otherwise be met through the operations of Shasta Lake, Trinity Lake, Folsom Lake, or Lake Oroville. Coordinated operational strategies could improve ecosystem conditions in the following manner:

- Improving the reliability of cold-water pool storage in Shasta Lake in May to increase operational flexibility to provide flows in late summer and fall to maintain suitable water temperatures in the Sacramento River, with particular emphasis on Below Normal, Dry, and Critical water year types.
- Increasing available water in Shasta Lake to increase operational flexibility to release flows from Keswick Reservoir to maintain appropriate mean daily water temperatures year-round at levels suitable for all species, races, runs, and life stages of anadromous salmonids in the Sacramento River between Keswick Dam and Red Bluff, with particular emphasis on the months of highest potential water temperature-related impacts (i.e., July through November) during Below Normal, Dry, and Critical water year types.
- Increasing available water in Shasta Lake to increase operational flexibility to release flows from Keswick Reservoir in a manner that stabilizes flows in the Sacramento River between Keswick Dam and Red Bluff to minimize dewatering of fall-run Chinook salmon redds, especially during spawning and embryo incubation life stage periods from October through March.
- Improving the reliability of cold-water pool storage in Folsom Lake in May to increase operational flexibility to provide appropriate flows with suitable water temperatures in the lower American River for juvenile steelhead over-summer rearing and fall-run Chinook salmon spawning from May through November during all water year types.
- Increasing available water in Folsom Lake to improve operational flexibility to release flows from Lake Natoma in a manner that stabilizes flows in the lower American River to accomplish the following: (1) minimize dewatering of fall-run Chinook salmon redds from October through March, (2) minimize dewatering of steelhead redds from January through May, and (3) reduce the occurrence of stranding of juvenile anadromous salmonids because of isolation events that occur when flows of 4,000 cfs or greater are reduced to less than 4,000 cfs, particularly from October through June.
- Improving the reliability of cold-water pool storage in Lake Oroville in the spring to increase operational flexibility to provide appropriate flows with suitable water temperatures in the lower Feather River for juvenile steelhead and spring-run Chinook salmon over-summer rearing and fall-run Chinook Salmon spawning from May through November during all water year types.
- Increasing available water in Lake Oroville and Thermalito Reservoir to increase operational flexibility to release flows in a manner that stabilizes flows in the lower Feather River to accomplish the following: (1) minimize redd dewatering, (2) minimize juvenile stranding, and (3) reduce the occurrence of isolation or stranding of anadromous salmonids.
- Noting that upstream actions could provide supplemental Delta outflow during summer and fall months (i.e., May through December) to help maintain X2 west of Collinsville and improve flood availability for estuarine species.
- Intending that storage and associated releases could be adaptively managed to support the operational actions found to produce the greatest benefits over time.

- Operating Sites Reservoir diversions and releases to increase the reliability of floodplain inundation in the Sutter and Yolo bypasses. In coordination with the operation of proposed bypass water control devices (e.g., the proposed Fremont Weir Adult Fish Passage Modification Project), this action would make water available to facilitate better management of the frequency, duration, and timing of inundation within the floodplain of the Sacramento River and the Sutter and Yolo bypasses.

- Increasing water availability in the CBD to support elements of the State's Delta Smelt Resiliency Strategy. This action would close the Knights Landing Outfall Gates and route flows in the CBD into the Yolo Bypass to promote the production and export of food into areas where delta smelt are known to occur.

12.3.2.2 Methodology

Existing conditions and the future No Project/No Action alternatives were assumed to be similar in the Primary Study Area, given the generally rural nature of the area and limited potential for growth and development in Glenn and Colusa counties within the 2030 study period used for this EIR/EIS; this is further described in Chapter 2 Alternatives Analysis. As a result, within the Primary Study Area, it is anticipated that the No Project/No Action Alternative would not entail material changes in conditions, compared to the existing conditions baseline.

With respect to the Secondary and Extended study areas, the effects of the proposed action alternatives would be primarily related to changes to available water supplies in the Secondary and Extended study areas and the Project's cooperative operations with other existing large reservoirs in the Sacramento watershed, and the resultant potential impacts and benefits to biological resources, land use, recreation, socioeconomic conditions, and other resource areas. DWR has projected future water demands through 2030 conditions that assume the vast majority of CVP and SWP water contractors would use their total contract amounts, and that most senior water rights users also would fully use most of their water rights. This increased demand, in addition to the projects currently under construction and those that have received approvals and permits at the time of preparation of the EIR/EIS, would constitute the No Project/No Action Condition. As described in Chapter 2 Alternative Analysis, the primary difference in these projected water demands would be in the Sacramento Valley; and as of the time of preparation of this EIR/EIS, the water demands have expanded to the levels projected to be achieved on or before 2030.

Accordingly, existing conditions and the No Project/No Action alternatives are assumed to be the same for this EIR/EIS and as such are referred to as the Existing Conditions/No Project/No Action Condition, which is further discussed in Chapter 2 Alternatives Analysis. Applicable reasonably foreseeable plans, projects, programs, and policies that may be implemented in the future, but that have not yet been approved, are included as part of the analysis of cumulative impacts in Chapter 35 Cumulative Impacts.

For each of the study areas (i.e., Extended, Secondary, and Primary), the impact assessment evaluates potential impacts on fish and marine mammal species of management concern (see Appendix 12A Aquatic Species Life Histories).

The impact assessment for aquatic biological resources consisted of three primary elements: (1) temporary and localized impacts associated with construction of the Project infrastructure and facility components; (2) ongoing impacts associated with operation and maintenance of the Project facilities; and

(3) impacts associated with changes in SWP and CVP Operations due to operation of the Project facilities.

The assessment of potential impacts on fish species of management concern in the Primary Study Area consisted primarily of a qualitative evaluation of construction, operation, and maintenance effects at each of the facilities that would be constructed, operated, and maintained with implementation of the Project. Because there would be no construction of Project facilities in the Secondary and Extended study areas (with the exception of installation of two additional pumps at the Red Bluff Pumping Plant), the impact assessment in these study areas relied primarily on modeled hydrologic changes in SWP and CVP operations that would occur as a result of Project operations. The analytical approach used to assess impacts in each of the study areas is described in the following subsections. A more detailed description of the rationale and indicators used to assess the potential impacts of ongoing hydrologic changes associated with SWP and CVP Operations is provided in Appendix 12B Fisheries Impact Assessment Methodology.

Extended Study Area

The Extended Study Area consists of the SWP/CVP water service areas, San Luis Reservoir, and the Level 4 wildlife refuges located throughout the water distribution system. Because no Project facilities would be constructed or maintained within the Extended Study Area, only operational impacts associated with Alternatives A, B, C and D are discussed in the impacts analysis for the Extended Study Area. The impact assessment relied primarily on modeled hydrologic changes in SWP and CVP operations that would occur as a result of Project operations. For fisheries impact evaluation purposes, the focus of the analyses in the Extended Study Area was on changes that could occur at San Luis Reservoir.

Changes in SWP/CVP operations resulting from implementation of the alternatives could potentially alter seasonal water storage, surface elevation, and drawdown in San Luis Reservoir. These changes in operation at San Luis Reservoir have the potential to alter habitat conditions for the cold-water and warm-water fisheries present in the reservoir. Impacts on cold-water and warm-water fisheries in San Luis Reservoir were evaluated using the same methodology that was used for the reservoirs included in the Secondary Study Area, as described below.

Changes to Level 4 water supply reliability could potentially affect fisheries resources in the wildlife refuges or in the water distribution systems within the refuges. Potential changes in water deliveries to individual refuges are not provided as part of the CALSIM II model output used to assess changes in SWP and CVP operations. Therefore, impacts on aquatic resources related to changes in Level 4 water supply to these refuges were evaluated qualitatively under the alternatives, relative to the Existing Conditions/No Project/No Action Condition.

Secondary Study Area

The Secondary Study Area consists of the SWP and CVP water bodies and the waterways within the Sacramento River, Feather River, Trinity River, and American River watersheds that lie outside of the Primary Study Area where Project facilities would be constructed. For fisheries impact evaluation purposes, the Secondary Study Area includes Trinity Lake, the Trinity River, Clear Creek, Shasta Lake, the Sacramento River downstream of Keswick Dam, Lake Oroville, the Feather River, Folsom Lake, Sutter Bypass, the American River, the Yolo Bypass, the Sacramento-San Joaquin Delta and San Francisco Estuary.

Several re-regulating reservoirs are located within the Secondary Study Area, including Lewiston Reservoir downstream of Trinity Dam, Whiskeytown Lake downstream of Lewiston Dam, Keswick Reservoir downstream of Shasta Dam, the Thermalito Complex downstream of Oroville Dam, and Lake Natoma downstream of Folsom Dam. As regulating afterbays, the re-regulating reservoirs are operated to receive highly variable flows and, as a result, monthly storage and elevation fluctuate significantly daily and hourly. Therefore, changes in releases from upstream reservoirs under the Project alternatives would not affect monthly mean storage or elevation, relative to the Existing Conditions/No Project/No Action Condition. No storage- or elevation-related impacts on fishery resources in these reservoirs are expected to occur with implementation of the Project alternatives, relative to the Existing Conditions/No Project/No Action Condition. Consequently, no assessment of potential storage- or elevation-related impacts on fishery resources in Lewiston Reservoir, Keswick Reservoir, Lake Natoma, and the Thermalito Complex was conducted.

Whiskeytown Lake also occurs in the Secondary Study Area, but because there would be no substantial differences in flows released from Whiskeytown Lake under any of the Project alternatives, storage and water surface elevations would not be expected to substantially change with implementation of the Project alternatives. Consequently, no assessment of potential impacts on fishery resources in Whiskeytown Lake or Spring Creek was conducted. In addition, only operational impacts associated with the Project alternatives are discussed in the impacts analysis for the Secondary Study Area because no construction or maintenance activities would occur within the Secondary Study Area (with the exception of installation of two additional pumps at the Red Bluff Pumping Plant).

The analysis of the effects of changes on aquatic resources with operation of the CVP and SWP is influenced by numerous factors related to the complexity of the ecosystem, changes within the system (e.g., climate change and species population trends), and the imprecision of operational controls and resolution in modeling tools. These factors are further complicated by the scientific uncertainty about fundamental aspects of aquatic species life stages and the species responses to changes in the system, and by competing points of view on the interpretation of biological and physical data within the scientific community. In light of these factors, the analysis takes an approach that presents available information and model outputs, synthesizes the results, and draws informed logical conclusions regarding the likely effects of the various alternatives. These conclusions, which are summarized by species, reflect a synthesis of the impacts and benefits that would be experienced by a given species across its life stage and in the water body it inhabits.

Many modeling tools have been developed to evaluate changes in CVP and SWP water management; as a result, multiple sources of information are available to characterize conditions (e.g., water temperature, flows, reservoir storage). Most of these modeling tools provide insight on one or two of the factors affecting the species, while some tools are more integrative (e.g., SALMOD, SacEFT, and IOS) and capture multiple relationships among physical conditions and biological responses. Available integrative models were relied upon more than evaluation of the individual components. When these integrative tools were not available, available information was used to draw conclusions based on trends indicated by the majority of the information. This approach allowed for the assembling of the full range of available information and model outputs, and determined the direction (neutral, positive, or negative) of effect supported by the information.

The impact assessment relies primarily on modeled hydrologic changes in SWP and CVP operations that would occur as a result of Project operations. The monthly flow output of the CALSIM II model was used to assess changes in reservoir water surface elevation, storage, and instream flows associated with implementation of the alternatives. The CALSIM II monthly flow output also served as input to many of the other models used to analyze potential impacts to aquatic resources. Given that the CALSIM II model uses a monthly time step, incremental flow and storage changes of 5 percent or less are generally considered within the standard range of uncertainty associated with model processing; therefore, flow changes of 5 percent or less were considered to be similar to the Existing Conditions/No Project/No Action Condition flow levels in the comparative analyses using CALSIM II conducted in this EIR/EIS. Changes in flow exceeding 10 percent were considered to represent a potentially meaningful difference.

While changes in flows in and of themselves do not necessarily constitute an effect on aquatic resources, they can affect the quantity and quality of aquatic habitats (including temperature) in rivers and their floodplains and bypasses (e.g., Sutter and Yolo bypasses), in addition to affecting fish through stranding or dewatering events that occur when flows are reduced. Potential impacts with respect to key habitat conditions such as water temperature are influenced by river flows and local conditions (e.g., river depth and velocity) and other factors, including ambient air temperatures and tributary inputs. Changes in flows also can affect ecologically important geomorphic processes such as gravel movement, sedimentation, and seed dispersal. Therefore, conclusions regarding whether a change in flow (including reduced bypass flows immediately downstream of Project diversions) would result in an impact on aquatic resources and whether that impact would be significant were determined through evaluation of the change in consideration of other available model outputs (e.g., water temperature, weighted usable area [WUA]), the context in which the change occurs (e.g., time of year and location), and professional judgment.

Impact determinations related to water temperature (which is generally considered one of the primary factors influencing anadromous fish habitat in the Sacramento River and other Sacramento Valley streams) were based on an evaluation of the magnitude of changes in the probabilities of exceeding species and life stage-specific water temperature impact indicator values (Appendix 12D). For this monthly analysis that uses two cascading models, it was determined that incremental changes of one percent or less in the frequency of exceedance were related to the uncertainties in the model processing. Therefore, changes in the exceedance probability of one percent or less were considered to be not substantially different, or “similar” in this comparative analysis. A change in the probability of exceedance greater than one percent was considered potentially important and could be indicative of a biological effect on the species/life stage for which the index was established. While likely effects from temperature on early life stages occur at a shorter temporal scale than can be captured in these models, these comparative analyses are useful for looking at long term impacts over numerous water years and types.

Hydrologic simulation results of monthly river flows and end-of-month reservoir storage and elevations provided a quantitative basis to assess the potential impacts of operations on fish species, relative to the bases of comparison, for the period of simulation extending from water year 1922 through 2003 (82-year simulation period). These simulated results were used as inputs to the Upper Sacramento River Water Quality Model, Reclamation’s Water Temperature and the Folsom Reservoir CE-QUAL-W2 Models (Appendix 7E River Temperature Modeling), which simulate monthly water temperatures of the main river systems (Trinity, Sacramento, Feather, and American rivers) for the same simulation period. The water temperature results were used as inputs to Reclamation’s Early Lifestage Chinook Salmon Mortality Model (Appendix 12H Early Life-Stage Salmon Mortality Modeling) to estimate annual mortality rates for the early life stages of Chinook salmon. Flows and water temperatures were also used as inputs to other analytical tools, including IOS (Appendix 12J), SALMOD (Appendix 12I), and the

SacEFT (Appendix 8B) to estimate potential population-level impacts on various life stages and habitat for some Sacramento River fishes.

A detailed discussion of the specific methodologies and indicators used to evaluate potential impacts due to changes in SWP and CVP operations as a result of Project implementation is provided in Appendix 12B Fisheries Impact Assessment Methodology; potential effects on habitat conditions for each species and life stage are presented in Appendix 12C Fisheries Impact Summary.

Trinity, Shasta, Oroville, and Folsom Reservoirs

Implementation of the alternatives could potentially result in alterations to storage volumes and water surface elevations in Trinity, Shasta, Oroville, and Folsom reservoirs, which could potentially affect reservoir fish species. Model output parameters derived from CALSIM II used to determine potential impacts included:

- End-of-month (average annual monthly) reservoir storage volume
- End-of-month (average annual monthly) water surface elevations

During the period when these reservoirs are thermally stratified (generally April through November), cold-water fish within the reservoir reside primarily within the deeper layers of the reservoir where water temperatures remain suitable. Implementation of the cooperative operations agreements with Reclamation and DWR could increase reservoir storage during this period; implementation could also increase the reservoir’s cold-water pool volume, thereby increasing the quantity of habitat available to cold-water fish species during these months. Reservoir cold-water pool size generally increases as reservoir storage increases, although not always in direct proportion because of the influence of reservoir basin shape. Therefore, to assess potential storage-related impacts on cold-water fish habitat availability in Trinity, Shasta, Oroville, and Folsom reservoirs, end-of-month storage simulated for the alternatives were compared to end-of-month storage simulated for the Existing Conditions/No Project/No Action Condition for each month of the April through November period.

Because reservoir warm-water fish species[3] use the warm upper layer of the reservoir and nearshore littoral habitats, seasonal changes in reservoir storage, as it affects reservoir water surface elevation, and the rates at which water surface elevation change during specific periods of the year, can directly affect warm-water fish nesting and spawning success. To assess the impacts of potential reservoir water surface elevation changes on warm-water fish, the following approach was used. The magnitude of change, as measured in feet with reference to mean sea level (feet mean sea level), in reservoir water surface elevation occurring each month of the primary spawning period for nest-building fish (March through June) simulated for the alternatives was determined and compared to the Existing Conditions/No Project/No Action Condition. Specifically, the number of times that reservoir reductions of 6 feet or more per month could occur with implementation of the alternatives was compared to the number of occurrences of the same modeled for the Existing Conditions/No Project/No Action Condition (Appendix 12F).

A detailed description of the specific methods utilized to evaluate potential impacts on cold-water and warm-water fish species in each of the existing reservoirs potentially affected by implementation of the alternatives is provided in Appendix 12B Fisheries Impact Assessment Methodology.

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[3] Largemouth bass are evaluated as an indicator species in this EIR/EIS analysis to reflect potential impacts on warm-water game fishes.

Trinity River

Project operations are not expected to substantially alter instream flows, water temperatures, or habitat conditions for fish inhabiting the Trinity River. However, as part of the impact assessment, modeling results were reviewed and an analysis conducted on seasonal flows, water temperatures, and resulting habitat conditions in the Trinity River.

Implementation of the alternatives could potentially alter instream flow and seasonal water temperatures in the Trinity River below Lewiston Lake and adversely affect Trinity River fish species. CALSIM II was used to evaluate potential impacts associated with changes in flow, and Reclamation's Water Temperature Model was used to assess water temperatures in the Trinity River. Additionally, Reclamation's early life stage mortality model was used to evaluate water temperature-related mortality on fall-run Chinook salmon in the Trinity River.

A detailed description of the specific methods, including life stage periodicity and model output node locations utilized to evaluate potential impacts on species of management concern in the Trinity River, is provided in Appendix 12B Fisheries Impact Assessment Methodology.

Clear Creek

Water operations in Clear Creek, including diversions to Clear Creek from the Trinity River, are components of the integrated operations of the Trinity River Division CVP system. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Powerplant and into Keswick Reservoir (up to 2,000 cfs). As part of the CVP system, implementation of one of the alternatives has the potential to affect Clear Creek flows and water temperatures, thereby potentially affecting habitat for species of management concern.

Implementation of the alternatives could potentially alter instream flow and seasonal water temperatures in the Clear Creek below Whiskeytown Dam. Therefore, CALSIM II was used to evaluate potential impacts associated with changes in flow, and Reclamation's Water Temperature Model was used to assess water temperatures. Spawning and rearing habitat availability for Chinook salmon and steelhead was also assessed using a WUA approach (see Appendix 12L Weighted Usable Area Analysis). A detailed description of the specific methods, including life stage periodicity and model output node locations utilized to evaluate potential impacts on species of management concern in Clear Creek, is provided in Appendix 12B Fisheries Impact Assessment Methodology.

Sacramento River

Shasta Lake releases, and therefore, Sacramento River flow, often are governed by water temperature requirements below Keswick Dam for April through October specified in SWRCB Water Rights Order 90-5, and an end-of-September minimum carryover storage for Shasta Lake of 1.9 MAF to protect Sacramento River winter-run Chinook salmon described in NMFS's 2009 Reasonable and Prudent Alternative with 2011 amendments. To meet the temperature objectives, Reclamation conducts a daily dynamic evaluation of ambient air temperature, weather forecasts, water temperature at the release point, and necessary release rates. Determination of the appropriate release rate is often made based on the temperature of the water released rather than on the rate needed to support CVP operations.

While water temperature and carryover storage targets for winter-run Chinook salmon generally govern Shasta Lake releases, implementation of the alternatives would alter seasonal flows and potentially water temperatures in the Sacramento River, both with respect to proposed diversions and anticipated Shasta

Reservoir releases, which in turn could affect the relative habitat availability for fish species that are present in the Sacramento River.

Releases from Sites Reservoir into the Sacramento River at the Delevan Pipeline Intake/Discharge Facilities would alter flows and potentially water temperatures in the Sacramento River below this diversion/release point. The potential effects on Sacramento River temperature conditions downstream of the Delevan Pipeline with Sites Reservoir releases were evaluated in Appendix 7F Sites Reservoir Discharge Temperature Modeling. The results of the analysis of Alternatives C and D were compared with the temperature modeling results for the Existing Conditions/No Project/No Action Condition presented in Appendix 7E River Temperature Modeling. Only Alternatives C and D were evaluated because these alternatives would result in the worst-case impact to the Sacramento River temperature conditions downstream of the Delevan Pipeline Intake/Discharge Facilities. Of the four alternatives, Alternatives C and D include the largest configuration of the Sites Reservoir, and the largest intake and discharge facilities. The potential for stratification and cold-water availability is the largest under Alternatives C and D, and similarly, the amount of water discharged to the river is the largest under Alternatives C and D. It is assumed that Alternatives A and B would result in temperature differences smaller than those estimated under Alternatives C and D.

The potential for changes in flows and water temperatures resulting from implementation of any of the alternatives to alter habitat conditions and impact fish resources of the Sacramento River is dependent on the species-specific habitat and physiological requirements. The following tools were utilized for analyses of specific habitat variables:

- CALSIM II – Flow (Appendix 6B)
- Reclamation Water Temperature Model – Water Temperature (Appendix 7E)
- Reclamation Early Life Stage Mortality Model – Chinook salmon early life stage mortality (Appendix 12H)
- Flow-Habitat Relationships – Chinook salmon WUA analyses (Appendix 12L)
- SALMOD – Chinook salmon population mortality and production potential (Appendix 12I)
- IOS/DPM – Winter-run Chinook salmon population survival and female spawner abundance (Appendix 12J)
- SacEFT – Steelhead spawning habitat availability, egg-to-fry survival, nest (redd) dewatering, redd scour, juvenile stranding, and juvenile rearing habitat; green sturgeon water temperature-related egg mortality (Appendix 8B)

A detailed description of the specific methods, including life stage periodicity and model output node locations utilized to evaluate potential impacts on species of management concern in the Sacramento River, is provided in Appendix 12B Fisheries Impact Assessment Methodology.

Feather River

Because implementation of the alternatives may result in changes to Feather River flows and water temperatures, the impact assessment focuses on these and other habitat-based elements. Taking into account species-specific habitat requirements, operational components of the alternatives were assessed to evaluate potential impacts on identified fish species of management concern and associated aquatic habitat.

The potential for changes in flows and water temperatures resulting from implementation of the alternatives to impact fish resources of the Feather River is dependent on the species-specific habitat and physiological requirements. The following tools were utilized for analyses of specific habitat variables:

- CALSIM II – Flow
- Reclamation Water Temperature Model – Water Temperature
- Reclamation Early Life Stage Mortality Model – Chinook salmon early life stage mortality
- Flow-Habitat Relationships – Chinook salmon and steelhead spawning WUA

A detailed description of the specific methods, including life stage periodicity and model output node locations utilized to evaluate potential impacts on species of management concern in the Feather River, is provided in Appendix 12B Fisheries Impact Assessment Methodology.

Sutter Bypass

To evaluate potential changes in habitat in the Sutter Bypass, flows into and out of the bypass were used as an indicator of floodplain inundation. In the Sutter Bypass, the floodplain is well inundated at flows exceeding 4,000 cfs, and increased flow does not inundate substantially more area, except in the northern portion where inundated areas may increase by around 50 percent as flows exceed 50,000 cfs (DWR, unpublished).

The potential for modified spills into the Sutter Bypass was evaluated using CALSIM II flows for those species potentially using the Sutter Bypass for spawning and rearing. Because of the importance of the Sutter Bypass as rearing habitat and a migration corridor when inundated during the spring, a more detailed analysis using daily model output was used to determine the frequency and duration of inundation flows in the Sutter Bypass. The following tools were used for analyses of floodplain inundation in the Yolo Bypass:

- CALSIM II – Monthly spill (flows) into the Sutter Bypass at Ord Ferry and at the Moulton, Colusa, and Tisdale weirs

- Upper Sacramento River Daily Operations Model (USRDOM) – Total spill (flow) from the Sacramento River into the Sutter Bypass at the Moulton, Colusa, and Tisdale weirs and exiting the bypass
  - Flows of 0, 2,000, 4,000, 6,000, 8,000, and 10,000 cfs
  - Inundation duration of 0-10, 11-20, 21-30, 31-45, and 45+ days

The number of years with at least one event when spills into the Sutter Bypass exceeded these flows for frequency and duration was examined for the entire 82-year simulation period (Appendix 12N Yolo and Sutter Bypass Flow and Weir Spill Analysis). These comparisons were made only for the months in which juvenile salmonids and spawning splittail are anticipated to be present in the Sutter Bypass (October through April). The frequency of events during which flows into the Sutter Bypass of greater than 4,000 cfs were maintained for at least 21 days was used as an index of floodplain habitat availability. In addition, flow and inundation duration data were presented over a range of increments to provide a broad indication of how these factors would behave under the various alternatives. This presentation includes flow values less than and greater than 4,000 cfs. A detailed description of the specific methods used to evaluate species of management concern in the Sutter Bypass is provided in Appendix 12B Fisheries Impact Assessment Methodology.

Yolo Bypass

To evaluate potential changes in habitat in the Yolo Bypass, flows into and out of the bypass were used as an indicator of floodplain inundation. NMFS's 2009 draft recovery plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead recommends that the Yolo Bypass be inundated during the spring with at least 8,000 cfs to fully activate the floodplain. Flows through the Yolo Bypass of about 10,000 cfs reportedly could provide the greatest area of shallow habitat in the Yolo Bypass (Fleenor et al., 2010). Recent work for the Central Valley Flood Management Planning Program (California Resources Agency and DWR, 2016) confirms that as flows increase in the Yolo Bypass, there is a rapid increase in the inundated area up to around 40,000 cfs and then the inundated area increases only marginally as flows increase up to modeled flows of 200,000 cfs.

The potential for modified Yolo Bypass flows, including increases to provide beneficial habitat conditions, was evaluated using CALSIM II flows for those species potentially using the Yolo Bypass for spawning and rearing. Because of the importance of the Yolo Bypass as rearing habitat when inundated during the spring, a more detailed analysis using daily model output was used to determine the frequency and duration of inundation flows in the Yolo Bypass. The following tools were used for analyses of floodplain inundation in the Yolo Bypass:

- CALSIM II – Monthly Flow at the Fremont Weir and exiting the Bypass
- USRDOM – Daily Flow at the Fremont Weir and exiting the Bypass
  - Flows of 0, 2000, 4000, 6000, 8000, and 10000 cfs
  - Inundation duration of 0-10, 11-20, 21-30, 31-45, and 45+ days

The number of years with at least one event where flows into and through the Yolo Bypass exceeded these flows for frequency and duration was examined for the entire 82-year simulation period (Appendix 12N Yolo and Sutter Bypass Flow and Weir Spill Analysis). These comparisons were made only for the months in which juvenile salmonids and spawning splittail are anticipated to be present in the Yolo Bypass (October through April). Of particular importance is the frequency of events during which the floodplain is fully activated for a duration that provides rearing opportunities. Therefore, the frequency of events during which flows into (and through) the Yolo Bypass of greater than 8,000 cfs are maintained for at least 21 days was used as an index of floodplain habitat availability. The flow and inundation duration data were presented over a range of increments to provide a broad indication of how these factors would behave under the various alternatives. This presentation includes flow values less than and greater than 8,000 cfs. A detailed description of the specific methods used to evaluate species of management concern in the Yolo Bypass, is provided in Appendix 12B Fisheries Impact Assessment Methodology.

American River

Because implementation of the alternatives may result in changes to American River flows and water temperatures, the impact assessment focused on the hydrologic changes associated with implementation of the alternatives.

The potential for changes in flows and water temperatures resulting from implementation of one of the alternatives to impact fish resources of the American River is dependent on the species-specific habitat and physiological requirements. The following tools were utilized for analyses of specific habitat variables:

- CALSIM II – Flow
- Folsom Reservoir CE-QUAL-W2 Temperature Model – Water Temperature
- Reclamation Early Life Stage Mortality Model – Fall-run Chinook salmon early life stage mortality
- Flow-Habitat Relationships – Fall-run Chinook salmon and steelhead spawning WUA

A detailed description of the specific methods, including life stage periodicity and model output node locations utilized to evaluate species of management concern in the American River, is provided in Appendix 12B Fisheries Impact Assessment Methodology.

Sacramento-San Joaquin Delta

The alternatives have the potential to beneficially influence aquatic habitat conditions by releasing water for the benefit of conservation efforts in the Yolo Bypass and potentially altering Delta inflow and water export operations. Aquatic habitat conditions and export operations (e.g., fish salvage operations) were evaluated to identify potential impacts on Delta species of management concern.

Because the alternatives have the potential to influence aquatic habitat conditions by potentially altering Delta inflow and water export operations, the following were evaluated:

- Water temperature derived from Reclamation's Water Temperature Model in the lower reaches of the Sacramento River
- Delta outflow
- X2 location
- Old and Middle River reverse flows
- Fish salvage and entrainment loss

Detailed description of the specific methods, including life stage periodicity and model output node locations utilized to evaluate species of management concern in the Sacramento-San Joaquin Delta, is provided in Appendix 12B Fisheries Impact Assessment Methodology. A detailed description of the methods and results of the smelt analyses are provided in Appendix 12G Smelt Analysis; the analyses for sturgeon are in Appendix 12M Sturgeon Analysis.

In addition to the variables described above, the Delta Passage Model (DPM) was utilized to evaluate survival of Chinook salmon through the Delta. Additional detail regarding the DPM is provided in Appendix 12K Delta Passage Modeling.

Pacific Ocean Habitat of the Southern Resident Killer Whale

Operation of the Sites Project in coordination with the CVP and SWP would not directly affect ocean conditions; however, operations have the potential to affect Southern Resident Killer Whales indirectly by influencing the number of Chinook salmon (produced in the Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales. This potential impact was evaluated qualitatively based on the potential impacts to Chinook salmon, particularly any changes in production.

Primary Study Area

The impact assessment methodology for the Primary Study Area addressed the construction, operations and maintenance of facilities within the proposed Sites Reservoir Complex, Holthouse Reservoir Complex, Terminal Regulating Reservoir Complex, Delevan Pipeline Complex, and Project Buffer.

The following Project facilities were not evaluated in detail because they would not be located within, adjacent, or have a hydrologic connection to a waterway; therefore, construction, operation, or maintenance of these facilities would not affect aquatic biological resources:

- Recreation Areas
- Sites Electrical Switchyard and Field Office Maintenance Yard
- Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure
- WAPA Transmission Line Relocation
- Sites Pumping/Generating Plant Approach Channel
- Existing Tehama-Colusa Canal Connections
- TRR Pumping/Generating Plant and Electrical Switchyard
- GCID Main Canal Connection to the TRR
- GCID Main Canal Facilities Modifications
- TRR Pipeline and Road
- Delevan Power Line
- Transmission Lines, Substations, and Distribution Lines

Construction and Operations Impacts

Within the Primary Study Area, construction-related impacts would occur as a result of direct contact of construction personnel, equipment, and/or debris, and generally would be limited to the area in the immediate vicinity of the construction disturbance area, and short distances downstream. Operational impacts could occur as part of the diversion of water and maintenance of facilities.

Potential construction-related impacts to fish species and aquatic habitat that could occur would depend on the proximity of construction access routes, staging areas, and storage and disposal areas to waterways, timing of construction activities, the specific techniques used, and the specific minimization and avoidance measures implemented before, during, and after construction. Excavation, including grading and vegetation removal, would occur in the construction disturbance areas.

The impact assessment considered the potential for general effects on fish to occur, as well as the potential for activities to affect a particular fish species that may be present in or adjacent to a disturbance area or facility. Depending on the specific activity evaluated, the impact assessment considered either all, or a combination of, the elements listed below, as appropriate:

- Visual inspection of conditions within the immediate construction disturbance area and surrounding areas to determine habitat availability, use, and the potential for specific disturbance-related effects on listed fish species or aquatic habitat.

- Review of available maps and aerial photography to determine the proximity of the construction disturbance area to adjacent receiving waters.

- Evaluation of the sequencing, timing, extent (e.g., long-term or short-term duration), intensity, and severity of disturbance activities that would result from operations or construction-related activities and the use of construction equipment.
- Determination of the potential for construction or operational activities to adversely modify habitat, or appreciably diminish the value of designated or proposed critical habitat.
- Identification of avoidance measures and/or conservation measures to minimize potential construction or operational impacts on sensitive life stages of fish species that may be present during construction or operation.

For each Project facility, the assessment was based on several considerations, including the duration and extent of diversions, as well as construction-related activities and the proximity of construction-related activities to waterways. Construction and operational impacts evaluated included the potential for the following: direct harm; erosion, sedimentation, and turbidity; hydrostatic pressure waves, noise, and vibration; stranding and entrainment; aquatic habitat modification; predation risk; and fish passage issues. A discussion of the potential impact mechanisms associated with construction and operations activities that could occur under the Project alternatives that were evaluated qualitatively as part of this impact assessment is provided below. Indicators of potential impacts considered for each of these mechanisms are identified in Table 12-7.

Table 12-7
Construction- and Operation-related Impact Indicators

Impact Indicators	Indicator Value
Erosion, Sedimentation, and Turbidity	Increase in erosion, sedimentation, and turbidity from in-stream construction, resulting in habitat modification or degradation in the form of a reduction in physical habitat availability or habitat constituent element suitability for a species to substantially affect this species, relative to the basis of comparison.
Shaded Riverine Aquatic Habitat Quantity and Quality	Loss of existing shaded riverine aquatic habitat value, acreage, and riverside length, resulting in habitat modification or degradation in the form of a reduction in physical habitat availability or habitat constituent element suitability for a species to substantially affect this species, relative to the basis of comparison.
Hydrostatic Pressure Waves, Noise, and Vibration	Hydrostatic pressure waves, noise, and vibration, resulting in habitat modification or degradation in the form of a reduction in physical habitat availability or habitat constituent element suitability for a species to substantially affect this species, relative to the basis of comparison.
Stranding Potential	Stranding of a species during construction activities to substantially affect this species, relative to the basis of comparison.
Predation Risk	Increase in predation of a species to substantially affect this species, relative to the basis of comparison.
Fish Passage	Impedance with the movement of a species, resulting in habitat modification or degradation to substantially affect this species, relative to the basis of comparison.
Impingement and Entrainment	Increase in impingement and entrainment of a species to substantially affect this species, relative to the basis of comparison.

Direct Harm

Construction, operation, and maintenance activities, including grading and excavation activities, as well as clearing and grubbing vegetation, have some limited potential to “harm” juvenile and adult fishes by direct physical contact, including physical injury or mortality. Other activities associated with construction such as hydrostatic pressure (i.e., pile driving) and dewatering (behind cofferdams) also have the potential for injury or mortality of fish. Many of the streams that cross construction sites in the Primary Study Area would be re-routed around the site and most equipment to be used during construction and maintenance activities would not be operated in the streams. Together with implementation of the environmental commitments included as part of the Project (e.g., Instream Construction Work Windows) where appropriate, these actions would minimize the potential for direct harm on aquatic species as a result of equipment operation during construction activities. Therefore, the potential impacts of construction related to direct harm are not discussed further except where direct harm may occur through hydrostatic pressure (i.e., pile driving) and dewatering (behind cofferdams). Operational activities potentially resulting in direct harm are discussed in the section on stranding, impingement, and entrainment.

Erosion, Sedimentation, and Turbidity

The potential for erosion and turbidity to occur from grading and excavation activities, as well as indirectly due to a loss of vegetation associated with construction was evaluated. Environmental commitments including development and implementation of a SWPPP were assumed to limit impacts but not address in-stream (including the Sacramento River) excavation and turbidity. The magnitude of potential impacts on fish would be dependent upon the timing and extent of sediment loading, as well as flow in the stream before, during, and immediately following construction. Therefore, the impact assessment considered each of the factors to qualitatively evaluate whether the Project would change conditions in the Sacramento River and other local creeks as a result of increased erosion, sedimentation, and turbidity, relative to the Existing Conditions/No Project/No Action Condition.

Hydrostatic Pressure Waves, Noise, and Vibration

Hydrostatic pressure waves and vibration generated by disturbance activities reportedly adversely affect all life stages of fish (Washington et al., 1992). Other studies (Fitch and Young, 1948; Teleki and Chamberlain, 1978; Yelverton et al., 1975) suggest that adverse effects to fish resulting from hydrostatic pressure waves and vibration primarily are a function of species morphology and species physiology. Hydrostatic pressure waves could potentially rupture the swim bladders and other internal organs of all life stages of fish in the immediate construction disturbance area (Bonneville Power Administration, 2002; Jones & Stokes Associates, 2001; Washington et al., 1992). Additionally, noise and vibration generated by pile driving activities could potentially have sublethal effects on individual fish by causing movement into lower quality habitats (Bonneville Power Administration, 2002). Although understanding effects from pile driving activities on fish is evolving, it remains problematic. There is evidence that lethal effects can occur from pile driving, but accurately analyzing and addressing these impacts, as well as sublethal impacts (e.g., injury, temporary hearing threshold shifts, stress, and behavioral disturbance) is complicated by several factors. Sound levels and particle motion produced from pile driving can vary depending on pile type, pile size, substrate composition, and type of equipment used.

Stranding and Entrainment Potential

In-river dewatering associated with construction activities (e.g., cofferdams) may cause harm, injury, and mortality to fisheries resources by confining them to areas of increased water temperature, decreased dissolved oxygen concentration, and predation (Cushman, 1985). Fish could become trapped, or entrained[4] behind a cofferdam prior to its closure, and the removal of water associated with dewatering activities in the closed cofferdam potentially could result in stranding. The effects of stranding could include increased stress and direct mortality of stranded individuals. Therefore, the impact assessment qualitatively evaluated the potential for Project construction (i.e., cofferdam placement and removal) and operation to strand and entrain fish in the Sacramento River, relative to the Existing Conditions/No Project/No Action Condition.

Aquatic Habitat Modification

Activities such as river channel alteration, riparian vegetation and in-stream woody material (IWM) removal, and other in-stream work could potentially reduce biodiversity, macroinvertebrate production, and recolonization of disturbed substrate, as well as limit the exchange of nutrients between surface and subsurface waters and between aquatic and terrestrial ecosystems (USFWS, 2000). The evaluation of altered habitat conditions included consideration of changes in the evaluated species' use of available habitats associated with changes in specific habitat variables. The principles of the Standard Assessment Methodology (SAM) propose a technique for analyzing the value of aquatic habitat as it pertains to life-stage responses of focus species. Although the specific models were not used for assessment purposes in this document, the principles and concepts of habitat alteration associated with the Project alternatives were used in the evaluation of potential impacts to fish species of management concern.

Construction activities potentially could require the removal of IWM from the river channel, thus resulting in a loss of refugia from predators and high flows, and causing reductions in pool-forming structures, and sediment and organic matter storage capacity. IWM is of particular importance to healthy riverine ecosystems, and reportedly may be the most important structural component promoting stable fisheries resources. Because IWM has a key role in maintaining both essential habitat complexity and refugia, potential loss of IWM could reduce available habitat quantity and quality.

Shaded Riverine Aquatic (SRA) habitat is defined as the nearshore aquatic area occurring at the interface between a river (or stream) and adjacent woody riparian habitat. SRA habitat is characterized as an area where the adjacent bank is composed of natural, eroding substrates supporting riparian vegetation that either overhangs or protrudes into the water. It also is characterized by the presence of IWM, such as leaves, branches, roots and logs, as well as variable water depths, velocities, and currents. SRA habitat provides valuable feeding areas, escape cover, and reproductive cover for aquatic species (e.g., anadromous salmonids).

To determine the magnitude of potential disturbance and/or removal of SRA habitat associated with construction of the proposed intake/discharge facility, the total amount of available SRA habitat within the construction footprint was first calculated under Existing Conditions. The calculation was based on USFWS, NMFS, and CDFW habitat assessment protocols. According to the USFWS, the amount of available SRA habitat can be quantified through length and width measurements using the following formula:

$$SRA = L * W$$

Where: SRA = amount of available SRA habitat (L = length; W = width)

[4] Entrainment, as it relates to construction activities, occurs when fish volitionally or non-volitionally enter the construction area to be dewatered.

Length is defined as the distance along the riverbank of the area of concern. Width is defined as the average perpendicular distance from the interface of the water and the riverbank, extending out to the outermost extension of either the vegetative canopy overhanging the water or the living and/or dead vegetation within the water, whichever is greater. Width can range from as little as one to two feet, to as great as 50 to 60 feet. The relative width generally is a good indicator of overall habitat value. In most cases, there is a positive correlation between width and habitat value.

Using the dimensions of the proposed construction disturbance area, the impacts assessment estimated the anticipated SRA habitat loss that would occur during Project construction, relative to the Existing Conditions/No Project/No Action Condition. Additionally, the impacts assessment qualitatively evaluated the potential for Project construction (i.e., intake/discharge structure and the cofferdam) to directly remove existing IWM and alter the recruitment potential for IWM by removing SRA habitat.

Predation Risk

Construction activities such as placement of a cofferdam, installation of a fish screen, and installation of a pipeline alignment at various stream crossings may increase the risk of predation on fish due to dewatering, sound disturbance due to increased underwater noise levels, and increased turbidity, all of which could increase predator opportunities or efficiencies.

Specifically, dewatering associated with cofferdam closure reportedly may confine fish and expose them to an increased risk of predation (NMFS, 2000). Typically, fish salvage operations are utilized when construction activities cause dewatering and confinement. However, fish salvage operations also can disorient and/or injure fish, further increasing the risk of predation following removal and subsequent release from the dewatered and/or confined project area (NMFS, 2003). Disorientation caused by noise associated with pile driving can temporarily disrupt normal fish behaviors, thereby increasing the risk of predation (NMFS, 2000; NMFS, 2003). Additionally, construction activities may increase turbidity, which in turn, could affect normal fish behavior. Deviation from normal behavior, associated with increased turbidity, reportedly increases the risk of predation (NMFS, 2003). However, it also has been reported that increased turbidity could potentially decrease piscine predation on fish. In a study conducted in the Fraser River it was found that juvenile Pacific salmon were less likely to encounter and be consumed by piscivorous fish predators in turbid waters relative to clear waters (Gregory and Levings, 1998).

The impact assessment qualitatively evaluated whether Project construction and operation would alter habitat conditions in the Sacramento River and Primary Study Area streams that could potentially increase the risk of predation on fish species of management concern, relative to the Existing Conditions/No Project/No Action Condition.

Fish Passage

Activities associated with Project construction activities could potentially result in fish passage barriers, which could prevent upstream or downstream movement of fish. Construction activities across the CBD and Hunters Creek associated could result in completely or partially blocked stream channels which could physically limit the movement of resident fishes or cause increased turbidity or underwater noise, resulting in altered behavior. Additionally, installation of dams on Funks and Stone Corral creeks would physically limit movement, and potentially interfere with behavior by increasing noise and turbidity during the time period when the ephemeral streams would be flowing. Further, construction activities associated with filling Sites Reservoir could result in limiting movement of resident fishes in Grapevine and Antelope creeks. Therefore, the impact assessment qualitatively evaluated the potential for Project construction to create fish passage barriers in the Sacramento River and Primary Study Area streams, relative to the Existing Conditions/No Project/No Action Condition.

Operations- and Maintenance-related Impacts

The impact assessment methodology for the Primary Study Area addressed the operations and maintenance of facilities associated with the Sites Reservoir Complex, Holthouse Reservoir Complex facilities, and the three primary points of diversion on the Sacramento River. The impact mechanisms evaluated for operations-related impacts included fish screen impingement and entrainment, fish passage associated with water diversions, and temperature effects on the Sacramento River, resulting from Sites Reservoir releases. A detailed description of the assessment methodologies utilized to evaluate potential operations and maintenance impacts on aquatic biological resources in each of these areas is provided below.

Sites Reservoir Complex

Because Sites Reservoir does not yet exist, comparison of operations under the Project alternatives to the Existing Conditions/No Project/No Action Condition was not feasible. Similarly, while maintenance activities associated with the reservoir facilities could have the potential to impact reservoir fisheries resources, no reservoir fishery exists under the Existing Conditions/No Project/No Action Condition. Therefore, no further analysis of potential impacts on fishery resources in the proposed Sites Reservoir was conducted.

However, long-term operation and maintenance of Sites Reservoir could affect aquatic habitat downstream of the Sites and Golden Gate dam sites. The impact assessment qualitatively evaluated the potential impacts of operation and maintenance activities on aquatic habitat downstream of the Sites and Golden Gate dam sites through alteration of flows, increased sedimentation or turbidity, the introduction of hazardous materials and chemicals, and the potential for alteration of aquatic habitats.

Holthouse Reservoir Complex

Funks Reservoir is operated as a regulating afterbay/forebay for the Tehama-Colusa Canal. Under the Project alternatives, Funks Reservoir would be incorporated into the Holthouse Reservoir Complex, which also would function as a regulatory afterbay/forebay for the Tehama-Colusa Canal and a regulatory afterbay for Sites Reservoir. As a regulating afterbay/forebay, Funks Reservoir is operated to receive variable flows and, as a result, monthly storage and elevation fluctuate often. Under the Project alternatives, the Holthouse Reservoir Complex would continue to receive highly variable inflow and would continue to experience frequent surface elevation fluctuations. Therefore, the Project alternatives would not affect monthly mean storage or elevation, relative to the Existing Conditions/No Project/No Action Condition. Consequently, no assessment of potential storage- or elevation-related impacts on fishery resources in the Holthouse Reservoir Complex was conducted.

Sacramento River Points of Diversion

Operations-related impacts from activities in the Primary Study Area include potential changes in flows and water temperatures in the Sacramento River associated with discharge and/or diversions at the proposed Delevan Pipeline Intake/Discharge Facilities and the other points of diversion on the Sacramento River. These potential impacts were included in CALSIM II and Reclamation Temperature modeling outputs (to the extent possible); therefore, impact indicators were included in the operations-related impact indicators for the Sacramento River within the Secondary Study Area and these operational impacts are evaluated in the Secondary Study Area.

Activities associated with operations and maintenance at the Project facilities could affect resident and anadromous fish species by affecting fish migration, increasing the potential for impingement and entrainment, and degrading water quality and available aquatic habitat. Impingement occurs when facility operations cause fish to become trapped on or against the surface of a fish screen due to the diverted flow's approach velocity exceeding fish swimming capability (Department of Fisheries and Oceans, 1995). Screen entrainment is defined as the voluntary or involuntary movement of fish through, under, or around the fish screen resulting in a loss of fish from the population. Entrainment is a function of screen mesh opening size and gaps between the screen frame and intake structure walls.

Fish impingement against the face of a fish screen is typically minimized with standard fish screen placement and design in coordination with NMFS and CDFW. The current standard approach velocity to a fish screen in a river or stream is specified to not exceed 0.33 foot per second. Fish screen design also must account for the time that a fish is exposed to the screen face. The time that a fish is exposed to the screen face is inversely proportional to the relationship between screen length and sweeping velocity (i.e., water velocity parallel to screen face). Exposure time is dependent upon the magnitude of the sweeping velocity and is evaluated on a case-by-case basis.

The Delevan Pipeline Intake/Discharge Facilities would be required to incorporate a fish screen designed to meet all specified NMFS and CDFW design criteria typical of other recent Sacramento fish screen/diversion projects. With incorporation of these criteria and additional site-specific impact minimization measures developed during the design, it is reasonable to assume that impacts on fish resulting from exposure to the fish screens would be minimal. This is consistent with the assumption made by NMFS in its biological opinion on the long-term operations of the CVP and SWP (NMFS, 2009a) where it stated the following:

> "NMFS assumes if fish screens are meeting current screening criteria they are 95 percent effective, or that it is likely that five percent of the fish that come in contact with the fish screen could be killed through repeated contact with the screen, impingement, or contact with the cleaning mechanism. Actual mortality to screens is probably much less, as measured at the RBDD Pilot Pumping Plant (Borthwick and Corwin, 2001 *op.cit*. SWP/CVP operations BA) and are more likely to represent less than one percent of the fish that come in contact with the screen. If the mortality from all screened diversions in the Sacramento River were summed it would be an insignificant amount when compared at the population level."

Because fish screens would be designed to meet NMFS and CDFW design criteria, no further evaluation of direct fish screen mortality is conducted in this EIR/EIS. However, while the fish screen associated with the Delevan Pipeline Intake/Discharge Facilities would be designed to meet all NMFS and CDFW criteria, and diversions would occur at flow rates that would allow adequate approach and sweeping velocities, potential indirect impacts on fish migrating past the screens could occur. For example, increased predation associated with diversion structures has been reported (Vogel et al., 1988). Contact with the fish screen could potentially cause disorientation of a limited number of juvenile salmonids, thereby increasing susceptibility to predation, and screen structures themselves could create hydraulic or physical predator refuges.

Maintenance activities associated with the Project alternatives have the potential to disturb ground surfaces adjacent to the Delevan Pipeline Intake/Discharge Facilities, and to disturb gravels and sediments on the river bottom. Such activities may increase sediment loading and turbidity within the Sacramento River. The impact assessment qualitatively evaluated whether long-term operation and maintenance activities would adversely affect fish through sedimentation associated with screen cleansing or other maintenance activities (e.g., dredging) at Sacramento River diversions, relative to the Existing Conditions/No Project/No Action Condition.

12.3.2.3 Topics Eliminated from Further Analytical Consideration

Because no Project facilities would be constructed or maintained within the Extended Study Area, only operational impacts associated with Alternatives A, B, C and D are discussed in the impacts analysis for the Extended Study Area for the four alternatives.

Because no construction or maintenance activities would occur within the remainder of the Secondary Study Area, only operational impacts associated with Alternatives A, B, C, and D are discussed in the impacts analysis for the reservoirs and waterways included in the Secondary Study Area for the four alternatives. Operations of the pump would increase the rate of diversion from the river by up to 250 cfs. Potential impacts of this increase in diversion on fish and aquatic habitat in the Sacramento River are described under operational impacts in the Secondary Study Area.

The tunnel from Sites Pumping/Generating Plant to Sites Reservoir and Existing Funks Reservoir Dredging (both facilities would be located within the Primary Study Area) were not evaluated because construction, operation, and maintenance of these facilities would occur within the footprint of the existing facility, or would have no associated above-ground disturbance, and therefore, are not anticipated to affect aquatic resources.

Operation and maintenance of the GCID Main Canal Facilities would resume following completion of the Project's construction activities associated with the proposed GCID Main Canal Facilities Modifications, and would have no Project-related impacts on fish or aquatic habitat. Therefore, operation and maintenance impacts associated with this facility are not discussed further.

For the proposed underground pipelines within the Primary Study Area, operations would occur underground and be coordinated remotely; therefore, the impacts of pipeline operation are not discussed.

Within the Project Buffer, no on-the-ground activities would occur during Project operation. Therefore, the impact of Project operation within the Project Buffer is not discussed.

12.3.3 Impacts Associated with Alternative A

A detailed summary of changes in aquatic habitat conditions for cold-water and warm-water fish species in Trinity, Shasta, Oroville, Folsom, and San Luis reservoirs resulting from implementation of Alternative A relative to the Existing Conditions/No Project/No Action Condition is presented in Appendix 12C Fisheries Impact Summary. Appendix 12C also includes a detailed summary of the potential changes in habitat conditions in the rivers and bypasses resulting from implementation of Alternative A relative to the Existing Conditions/No Project/No Action Condition. These changes are presented for each species and life stage in each water body where they are present in the Extended and Secondary study areas. Several species inhabit many different water bodies within the study areas; therefore, the information presented in Appendix 12C Fisheries Impact Summary by water body, species, and life stage are summarized below, by species, to support significance determinations for each species based on the potential for impacts at the population level.

12.3.3.1 Extended and Secondary Study Areas – Alternative A

Construction, Operation, and Maintenance Impacts

Impact Fish-1: A Substantial Adverse Effect (Either Directly, through Habitat Modifications, by Interfering with the Movement of Native Fish Species, or by Impeding the Use of Native Fish Nursery/Rearing Sites) on Any Fish Species of Management Concern, Including Species Identified As a Candidate, Sensitive, or Special-status Species in Local or Regional Plans, Policies, or Regulations, or by CDFW, NMFS, or USFWS.

No direct Project related construction or maintenance activities would occur in the Extended Study Area and the only direct Project-related construction activity that would occur in the Secondary Study Area is the installation of two additional pumps into existing bays at the Red Bluff Pumping Plant. Construction and operational impacts associated with Alternative A relative to the Existing Conditions/No Project/ No Action Condition are described below.

National Wildlife Refuges Receiving Level-4 Water

Fish species known to occur within the Sacramento River NWRs and associated canals are generally expected to be non-native warm-water resident fish species, but may include fish species such as California roach. The NWRs and WAs within the San Joaquin River and Tulare Lake basins that receive Level 4 water deliveries reportedly support warm-water resident fish species in the waterways that supply the refuges. While fish species of management concern are generally not known to occur within the San Joaquin River and Tulare Lake basin NWRs and Wildlife Areas, during infrequent flooding events Sacramento splittail may utilize the San Joaquin River Basin NWRs for spawning.

The historical practice of purchasing Level 4 water supplies on interim water transfers would continue under Alternative A. The Project would replace at least some volume of Level 4 water supplies with a more reliable water supply than interim water transfers, but would not change the volume of water delivered to the refuges under either Level 2 or Level 4. Therefore, the provision of an alternate source of wildlife refuge water supply would have no impact on aquatic biological resources, when compared to the Existing Conditions/No Project/No Action Condition.

San Luis Reservoir, Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, Trinity River, Klamath River, Sacramento River, Clear Creek, Feather River, Sutter Bypass, Yolo Bypass, American River, Sacramento-San Joaquin Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay

Reservoir Cold-water Fish Species

Reservoir cold-water fish species are not considered State or federal special-status species but are evaluated for their recreational importance. In addition, populations of some of these species are artificially augmented or sustained through periodic fish stocking programs. Reservoir storage would be similar or increased in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. Specifically, within the Secondary Study Area, end-of-month storage generally would be higher as compared to the Existing Conditions/No Project/No Action Condition from June through December in Shasta Lake, Lake Oroville, and Folsom

Lake because flows released from Sites Reservoir to meet Delta water quality and other downstream water quality criteria would allow for increased storage in these supply reservoirs. Therefore, under Alternative A, potential impacts on reservoir cold-water fish species in the SWP/CVP reservoirs and San Luis Reservoir are considered **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Reservoir Warm-water Fish Species

Reservoir warm-water fish species are not considered State or federal special-status species, but are evaluated for their recreational importance. Reservoir warm-water fish species habitat conditions would be similar or more suitable under Alternative A, relative to the Existing Conditions/No Project/No Action Condition, based on modeling results indicating minor differences in the frequency of monthly water surface elevation reductions of six feet or more during the evaluation period. It is unlikely that a small difference in the number of years with monthly water surface elevation reductions of greater than six feet would have a population level effect on bass and other warm-water fish in these reservoirs; therefore, under Alternative A, potential impacts on reservoir warm-water fish species in Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and San Luis Reservoir are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

Southern Oregon/Northern California Coho Salmon

Potential impacts associated with implementation of Alternative A on Southern Oregon/Northern California coho salmon were evaluated only in the Trinity and Klamath rivers because those are the only water bodies in the Secondary Study Area where this species/ESU is found. Construction activities would not impact Southern Oregon/Northern California coho salmon because construction activities would not occur on the Trinity or Klamath rivers.

In general, habitat conditions in the Trinity River would be similar or more suitable under Alternative A, relative to the Existing Conditions/No Project/No Action Condition because flows generally would be similar during most life stages, while water temperature index values would generally be exceeded less frequently during all life stages (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on the coho salmon population in the Trinity and Klamath rivers. Therefore, under Alternative A, potential impacts on coho salmon in the Trinity and Klamath rivers are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

Upper Klamath-Trinity River Fall-run and Spring-run Chinook Salmon

Potential impacts associated with implementation of Alternative A on Upper Klamath-Trinity River fall-run and spring-run Chinook salmon were evaluated only in the Trinity and Klamath rivers because those are the only water bodies in the Secondary Study Area where this species/ESU is found. Construction activities would not impact Upper Klamath-Trinity River fall-run and spring-run Chinook salmon because construction activities would not occur on the Trinity or Klamath rivers.

In general, during the periods when Chinook salmon are present in the Trinity River, habitat conditions would be similar or more suitable under Alternative A, relative to the Existing Conditions/No Project/No Action Condition because flows generally would be similar but slightly higher during some life stages, and water temperature index values would be generally exceeded less frequently. Early life stage mortality would also be similar under Alternative A (see Appendix 12C Fisheries Impact Summary for a detailed discussion). Overall, Alternative A is likely to have similar effects on the spring-run Chinook salmon population in the Trinity and Trinity rivers as compared to the Existing Conditions/No Project/No Action Condition. Therefore, under Alternative A, potential impacts on spring-run and fall-run Chinook salmon in the Trinity and Klamath rivers are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

Klamath Mountains Province Steelhead

Potential impacts associated with implementation of Alternative A on Klamath Mountains Province steelhead were evaluated only in the Trinity and Klamath rivers because those are the only water bodies in the Secondary Study Area where this species/ESU is found. Flows and water temperatures were evaluated to identify potential changes in Trinity River habitat conditions as a result of operations that could potentially impact steelhead. Construction activities would not impact Klamath Mountains Province steelhead because construction activities would not occur on the Trinity or Klamath rivers.

In general, model outputs for flow and temperature suggest that during the periods when steelhead are present in the Trinity River, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion). Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on the steelhead population in the Trinity and Klamath rivers. Therefore, under Alternative A, potential impacts on steelhead in the Trinity and Klamath rivers are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

Sacramento River Winter-run Chinook Salmon

Construction in the Secondary Study Area would consist of the installation of two additional pumps into existing bays at the Red Bluff Pumping Plant during the annual maintenance period for the Tehama-Colusa Canal. The existing facility is designed to accommodate up to two additional pumps (500 cfs) for Sites Reservoir operations without any construction activities that would cause sedimentation or have the potential for hazardous waste or chemical spills. Therefore, potential construction-related impacts associated with implementation of Alternative A, on winter-run Chinook salmon in the Sacramento River are considered **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Potential operational impacts associated with implementation of Alternative A on Sacramento River winter-run Chinook salmon were evaluated in the Sacramento River, Sutter and Yolo bypasses, and the Delta. In general, during periods when winter-run Chinook salmon are present in the Sutter and Yolo bypasses, and Delta, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. Depending on the year, in years/periods when Project operations were at least in part focused on improving conditions in the Sutter and Yolo bypasses, actions implemented would have a **beneficial impact** with respect to bypass fishery habitat. Habitat conditions in the Sacramento River would be generally more suitable because of increased flows and decreased water temperatures during low flow conditions, increased spawning habitat availability and reduced water temperatures during spawning (see Appendix 12C Fisheries Impact Summary). These improvements in flows and water temperatures would result in reduced early life stage mortality (see Appendix 12H Early Life-Stage Salmon Mortality Modeling) and increased production potential (see Appendix 12I Salmonid

Population Modeling). Together with improved through-Delta survival, this is anticipated to result in increased spawner abundance in the future (see Appendix 12L Weighted Useable Area Analysis).

Overall, the quantitative results from the numerical models suggest that operation under Alternative A would be likely to result in more suitable conditions for winter-run Chinook salmon in the Sacramento River and Delta, resulting in increased production of winter-run Chinook salmon compared to the Existing Conditions/No Project/No Action Condition. Therefore, potential operational impacts on winter-run Chinook salmon are considered **beneficial** when compared to the Existing Conditions/No Project/No Action Condition. Proposed Sacramento River diversions could affect fish migration and increase the potential for fish entrainment or impingement and would be **potentially significant** when compared to the Existing Conditions/No Project/No Action Condition.

Central Valley Spring-run Chinook Salmon

Potential impacts associated with implementation of Alternative A on Central Valley spring-run Chinook salmon were evaluated in the Sacramento River, Clear Creek, Feather River, Sutter and Yolo bypasses, and the Delta. Construction-related impacts on spring-run Chinook salmon would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on spring-run Chinook salmon in the Sacramento River associated with implementation of Alternative A, are considered **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

In general, model outputs for flow and temperature suggest that during periods when spring-run Chinook salmon are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. Depending on the year, in years/periods when Project operations were at least in part focused on improving conditions in the Sutter and Yolo bypasses, actions implemented would have a **beneficial impact** with respect to bypass fishery habitat. Habitat conditions in the Sacramento River would generally be more suitable, and would be similar or improved in Clear Creek relative to the Existing Conditions/No Project/No Action Condition. Specifically, in the Sacramento River flows would be higher and water temperatures would be lower near Keswick Dam where spawning occurs. These conditions are anticipated to result in reduced early life stage mortality (see Appendix 12H Early Life-Stage Salmon Mortality Modeling), and increased production (see Appendix 12I Salmonid Population Modeling). In Clear Creek, water temperatures exceeding the water temperature indices would occur less frequently (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Overall, the quantitative results from the numerical models suggest that operation under Alternative A would be likely to result in similar habitat conditions for spring-run Chinook salmon in the Feather River, Sutter and Yolo bypasses, American River, and Delta; similar or more suitable conditions in Clear Creek; and more suitable conditions in the Sacramento River, resulting in increased production of spring-run Chinook salmon compared to the Existing Conditions/No Project/No Action Condition. Therefore, under Alternative A, potential operational impacts on spring-run Chinook salmon in Clear Creek, Feather River, American River, Sutter Bypass, Yolo Bypass, and Delta are considered **less than significant**; impacts on spring-run Chinook salmon in the Sacramento River are considered **beneficial** when compared to the Existing Conditions/No Project/No Action Condition. Proposed Sacramento River diversions could affect fish migration and increase the potential for fish entrainment or impingement and would be **potentially significant** when compared to the Existing Conditions/No Project/No Action Condition.

Central Valley Fall-run Chinook Salmon

Potential impacts associated with implementation of Alternative A on Central Valley fall-run Chinook salmon were evaluated in the Sacramento River, Clear Creek, Feather River, American River, Sutter and Yolo bypasses, and the Delta. Construction-related impacts on fall-run Chinook salmon would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on fall-run Chinook salmon in the Sacramento River associated with implementation of Alternative A, are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

In general, model outputs for flow and temperature suggest that during periods when fall-run Chinook salmon are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. Depending on the year, in years/periods when Project operations were at least in part focused on improving conditions in the Sutter and Yolo bypasses, actions implemented would have a **beneficial impact** with respect to bypass fishery habitat. However, improvements in habitat conditions may lead to slightly increased production of fall-run Chinook salmon in the Sacramento River in some water year types (Appendix 12I Salmonid Population Modeling). Habitat conditions in Clear Creek would be similar or more suitable because of slightly decreased water temperatures during spawning (Appendix 12E Fisheries Water Temperature Assessment Summary Tables).

Overall, the quantitative results from the numerical models suggest that operation under Alternative A would be likely to result in similar habitat conditions for fall-run Chinook salmon in the Feather and American rivers, Sutter and Yolo bypasses, and the Delta; similar or more suitable conditions in Clear Creek; and increased production in the Sacramento River during some water year types compared to the Existing Conditions/No Project/No Action Condition. Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on fall-run Chinook salmon populations in the water bodies evaluated. Therefore, under Alternative A, operational impacts on fall-run Chinook salmon in the Sacramento River, Clear Creek, Feather River, American River, Sutter Bypass, Yolo Bypass, and Delta are considered **less than significant** when compared to the Existing Conditions/No Project/No Action Condition. Proposed Sacramento River diversions could affect fish migration and increase the potential for fish entrainment or impingement and would be **potentially significant** when compared to the Existing Conditions/No Project/No Action Condition.

Central Valley Late Fall-run Chinook Salmon

Potential impacts associated with implementation of Alternative A on Central Valley late fall-run Chinook salmon were evaluated in the Sacramento River, Clear Creek, Sutter and Yolo bypasses, and the Delta. Construction-related impacts on late fall-run Chinook salmon would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on late fall-run Chinook salmon in the Sacramento River associated with implementation of Alternative A, are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

In general, model outputs for flow and temperature suggest that during periods when late fall-run Chinook salmon are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on late fall-run Chinook salmon populations in the water bodies evaluated. This conclusion is supported by the results of modeling that indicate that production in the Sacramento River would be similar or improved (Appendix 12I Salmonid Population Modeling). Therefore, under Alternative A, operational impacts on late fall-run Chinook salmon in the Sacramento River, Clear Creek, Sutter Bypass, Yolo Bypass, and Delta are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition. Proposed Sacramento River diversions could affect fish migration and increase the potential for fish entrainment or impingement and would be **potentially significant** when compared to the Existing Conditions/No Project/No Action Condition.

Central Valley Steelhead

Potential impacts associated with implementation of Alternative A on Central Valley steelhead were evaluated in the Sacramento River, Clear Creek, Feather River, American River, Sutter Bypass, Yolo Bypass, and the Delta. Construction-related impacts on steelhead would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on steelhead in the Sacramento River associated with implementation of Alternative A, are considered **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

In general, model outputs for flow and temperature suggest that during periods when steelhead are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion). These results are supported by the estimates of WUA (Appendix 12L Weighted Useable Area Analysis) in the Sacramento River, Clear Creek, Feather River, and American River.

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on steelhead populations in the water bodies evaluated. Therefore, under Alternative A, operational impacts on steelhead in the Sacramento River, Clear Creek, Feather River, American River, Sutter Bypass, Yolo Bypass, and Delta are considered **less than significant** when compared to the Existing Conditions/No Project/No Action Condition. Proposed Sacramento River diversions could affect fish migration and increase the potential for fish entrainment or impingement and would be **potentially significant** when compared to the Existing Conditions/No Project/No Action Condition.

Green Sturgeon

Potential impacts associated with implementation of Alternative A on green sturgeon were evaluated in the Trinity River, Sacramento River, Feather River, American River, and the Delta. Construction-related impacts on green sturgeon would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on green sturgeon in the Sacramento River associated with implementation of Alternative A, are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

In general, during periods when green sturgeon are present in the evaluated water bodies, model outputs for flow and temperature suggest that habitat conditions would be similar or more suitable under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. In the Sacramento River, particularly in the lower reaches, habitat conditions would be more suitable as a result of generally higher flows and generally lower water temperatures. In the American River, flows would be slightly higher during most life stages, and water temperatures would be slightly lower during juvenile rearing and emigration (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on green sturgeon populations in the water bodies evaluated. Therefore, under Alternative A, potential operational impacts on green sturgeon in the Trinity River, Sacramento River, Feather River, American River, Yolo Bypass, Sutter Bypass, and Delta are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

White Sturgeon

Potential impacts associated with implementation of Alternative A on green sturgeon were evaluated in the Trinity River, Sacramento River, Feather River, American River, and the Delta. Construction-related impacts on white sturgeon would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on green sturgeon in the Sacramento River associated with implementation of Alternative A, are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

In general, model outputs for flow and temperature suggest that during periods when white sturgeon are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion). Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on white sturgeon populations in the water bodies evaluated. Therefore, for Alternative A, potential impacts on white sturgeon in the Trinity River, Sacramento River, Feather River, Yolo Bypass, Sutter Bypass, and Delta are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Pacific Lamprey

Pacific lamprey are not considered special-status species in California, but are evaluated because the USFWS in Oregon and Washington considers Pacific lamprey to be a species of concern. Potential impacts associated with implementation of Alternative A on Pacific lamprey were evaluated in the Trinity River, Sacramento River, Clear Creek, Feather River, American River, and the Delta. Construction-related impacts on Pacific lamprey would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on Pacific lamprey in the Sacramento River associated with implementation of Alternative A, are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

In general, during periods when Pacific lamprey are present in the evaluated water bodies, model outputs for flow and temperature suggest that habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion). Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on Pacific lamprey populations in the water bodies evaluated. Therefore, for Alternative A, potential impacts on Pacific lamprey in the Trinity River, Sacramento River, Clear Creek, Feather River, American River, and Delta are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

River Lamprey

Potential impacts associated with implementation of Alternative A on river lamprey were evaluated in the Sacramento River, Clear Creek, Feather River, and American River. In general, model outputs for flow and temperature suggest that during periods when river lamprey are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on river lamprey populations in the water bodies evaluated. Overall, under Alternative A, potential operational impacts on river lamprey in the Sacramento River, Clear Creek, Feather River, and American River are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition**.**

Hardhead

Potential impacts associated with implementation of Alternative A on hardhead were evaluated in the Sacramento River, Clear Creek, Feather River, and American River. In general, model outputs for flow and temperature suggest that during periods when hardhead are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on hardhead populations in the water bodies evaluated. Overall, under Alternative A, operational impacts on hardhead in the Sacramento River, Clear Creek, Feather River, and American River are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Delta Smelt

Potential impacts associated with implementation of Alternative A on delta smelt were evaluated in the Delta, although some analyses included model nodes in the lower reaches of the Sacramento River. Construction activities would not impact delta smelt because this species is not found in the Sacramento River near the construction location.

In general, analyses of water temperature, Delta outflow, entrainment, and location of X2 suggest that habitat conditions for delta smelt would be similar or more suitable under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. Specifically, most analyses indicate that habitat conditions would be similar, but the slight downstream movement of X2 location indicates that more suitable habitat conditions may occur during wet, above normal, and below normal water years. The more downstream X2 location during some years could improve juvenile conditions by allowing juveniles to rear in more suitable locations near Suisun and San Pablo bays.

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on the delta smelt population. Therefore, under Alternative A, impacts on delta smelt in the Delta are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Longfin Smelt

Potential impacts associated with implementation of Alternative A on longfin smelt were evaluated in the Delta although some analyses included model nodes in the lower reaches of the Sacramento River. Construction activities would not impact longfin smelt because this species is not found in the Sacramento River near the construction location.

In general, available model outputs for Delta outflow, abundance, and location of X2 suggest that during periods when longfin smelt are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on the longfin smelt population. Therefore, under Alternative A, impacts on longfin smelt in the Delta are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Sacramento Splittail

Potential impacts associated with implementation of Alternative A on splittail were evaluated in the Sacramento River, Feather River, American River, Sutter Bypass, Yolo Bypass, and Delta. In general, model results for flow and temperature suggest that during periods when splittail are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. Depending on the year, in years/periods when Project operations were at least in part focused on improving conditions in the Sutter and Yolo bypasses, actions implemented would have a **beneficial impact** with respect to bypass fishery habitat. In addition, a more detailed analysis in the Yolo Bypass using daily model output indicate that the frequency and duration of inundation flows would be similar under Alternative A relative to the Existing Conditions/No Project/No Action Condition.

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on splittail populations in the water bodies evaluated. Therefore, under Alternative A, potential operational impacts on splittail in the Sacramento River, Feather River, American River, Sutter Bypass, Yolo Bypass, and Delta are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Striped Bass

Striped bass are not considered State or federal special-status species, but are evaluated for their recreational importance. Potential impacts associated with implementation of Alternative A on striped bass were evaluated in the Sacramento River, Feather River, and American River. Construction-related impacts on striped bass would be similar to those described for winter-run Chinook salmon. Therefore, potential construction-related impacts on striped bass in the Sacramento River associated with implementation of Alternative A, are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

In general, model results for flow and temperature suggest that during periods when striped bass are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition. However, habitat conditions in the Sacramento River would be similar or more suitable because of increased flows and a higher probability of water temperatures occurring within the specified range (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on striped bass populations in the water bodies evaluated. Therefore, for Alternative A, potential impacts on striped bass in the Sacramento River, Feather River, and American River are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition**.**

American Shad

American shad are not considered State or federal special-status species, but are evaluated for their recreational importance. Potential impacts associated with implementation of Alternative A on American shad were evaluated in the Sacramento River, Feather River, American River, and the Delta. In general, model results for flow and temperature suggest that during periods when American shad are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition.

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on American shad populations in the water bodies evaluated. Therefore, for Alternative A, potential impacts on American shad in the Sacramento River, Feather River, American River, and Delta are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition**.**

Largemouth Bass

Largemouth bass are not considered State or federal special-status species, but are evaluated for their recreational importance; they also are evaluated as an indicator of potential impacts on other warm-water game fishes. Potential impacts associated with implementation of Alternative A on largemouth bass were evaluated in the Sacramento, Feather, and American rivers. In general, model outputs for flow and temperature suggest that during periods when largemouth bass are present in the evaluated water bodies, habitat conditions would be similar under Alternative A, relative to the Existing Conditions/No Project/No Action Condition (see Appendix 12C Fisheries Impact Summary for a detailed discussion).

Given the similarity of the results, Alternative A and the Existing Conditions/No Project/No Action Condition are likely to have similar effects on largemouth bass populations in the rivers evaluated. Therefore, under Alternative A, potential impacts on largemouth bass in the Sacramento River, Feather River, and American River are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition**.**

Killer Whale

Best available data on the abundance and composition of Central Valley Chinook salmon indicates that approximately 75 percent of all Central Valley-origin Chinook salmon available for consumption by Southern Resident killer whales are produced by Central Valley fall-run Chinook salmon hatcheries (Palmer-Zwhalen and Kormos, 2013). Most Central Valley hatchery fall-run Chinook salmon are released directly into San Francisco Bay, and thus bypass potential impacts from project operations. Even where there might be a nexus with CVP and SWP operations, the purpose of Central Valley fall-run Chinook salmon hatchery programs is to produce large numbers of fish independent of freshwater conditions.

Since fall-run Chinook salmon hatcheries came on-line more than forty years ago, the only period of exceptionally low returns was principally attributed to unusual ocean conditions (Lindley et al., 2007).

Ocean commercial and recreational fisheries annually harvest hundreds of thousands of Chinook salmon. The Northwest Region of NMFS (NMFS, 2009c) used a model that estimates prey reduction associated with the salmon fishery and which considers the metabolic requirements of killer whales and the remaining levels of prey availability. Their analysis concluded that the salmon fishery was not likely to result in jeopardy for Southern Resident killer whales. Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook salmon available for Southern Resident killer whales are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook salmon as a prey base for killer whales would not be appreciably affected by implementation of Alternative A or any of the project alternatives. Therefore, under Alternative A, potential impacts on Southern Resident Killer Whale are considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition**.**

12.3.3.2 Primary Study Area – Alternative A

<u>Construction, Operation, and Maintenance Impacts</u>

The potential impacts of Project facilities that would be located within or adjacent to waterways are described below. Potential impacts associated with the use of existing diversions (i.e., the TCCA Red Bluff and GCID Hamilton City pumping plants) as part of proposed Sites Reservoir operations are discussed as part of the Secondary Study Area discussion.

Sites Reservoir Inundation Area and Dams

Erosion, Sedimentation, and Turbidity

Construction activities associated with the Sites Reservoir Inundation Area and Dams, including clearing and grubbing vegetation, would have the potential to cause erosion and contribute sediment to Funks and Stone Corral creeks downstream of the construction activities. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Erosion and Sediment Control Plan) described in Chapter 3 Description of the Sites Reservoir Project Alternatives and implementation of best management practices (BMPs) during maintenance, potential impacts on fish and aquatic habitats as a result of construction activities would be minimized. Therefore, erosion, sedimentation, and turbidity resulting from the construction of Sites Reservoir and Dams would have a **less-than-significant impact** on fish and aquatic habitats in Funks and Stone Corral creeks.

Once the dams are in place, periodic maintenance activities, and debris and vegetation removal from the dam embankments, could result in temporary increases in sedimentation or organic matter in downstream Stone Corral and Funks creeks. However, implementation of BMPs should minimize this effect, resulting in a **less-than-significant impact** on fish and aquatic habitats in Funks and Stone Corral creeks.

Hazardous Materials and Chemical Spills

Hazardous materials and chemicals in the form of gasoline, engine oil, lubricants, or other fluids used during construction activities could potentially enter Funks and Stone Corral creeks as a result of seepage or accidental spills. During maintenance activities, there is also the potential for chemical or hazardous spills or leakage in these creeks. Accidental discharge of hazardous materials and chemicals could potentially affect fishes that may be present in the immediate vicinity and downstream of the construction and maintenance areas. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Spill Prevention and Control Plan) described in Chapter 3 Description of the Sites Reservoir Project Alternatives, potential impacts on fish and aquatic habitats as a result of construction activities would be minimized. Therefore, the accidental discharge of hazardous materials and chemicals during construction of Sites Reservoir and Dams would have a **less-than-significant impact** on fish and aquatic habitats in Funks and Stone Corral creeks.

Hydrostatic Pressure Waves, Noise, and Vibration

Construction of major dams (Golden Gate and Sites dams on Funks and Stone Corral creeks) and dams elsewhere in the Primary Study Area, could potentially result in noise-related impacts on fish species in Funks and Stone Corral creeks. However, because Funks and Stone Corral creeks would be temporarily re-routed around the construction areas, potential impacts on fish and aquatic resources would be minimized and construction activities are anticipated to result in a **less-than-significant impact** on fish in Funks and Stone Corral creeks from noise and vibration.

Aquatic Habitat Modification

During construction of the dams, a cofferdam would be installed upstream of the Sites and Golden Gate dam sites around the dams' construction work areas to retain storm flows entering the reservoir basin from Funks Creek and Stone Corral Creek. Funks Creek flows would not be maintained between the Golden Gate dam site and the existing Funks Reservoir during the construction period. The reach of Funks Creek that would be temporarily dewatered during construction would be approximately 1.4 miles long. Diverted Funks Creek flows would pass through a pipe at the Sites Dam site and would continue downstream into Stone Corral Creek and flows would be maintained downstream of Funks Reservoir during the entire construction period. Therefore, the temporary dewatering of Funks Creek upstream of Funks Reservoir would have a **less-than-significant impact** on fish and aquatic resources, when compared to the Existing Conditions/No Project/No Action Condition.

Construction of the dams, as well as the filling of Sites Reservoir (1.3 MAF under Alternative A), would result in the direct permanent loss of a total of 25 miles of major tributaries, including approximately 3.9 miles of Stone Corral Creek and approximately 6.5 miles of Funks Creek upstream of Sites and Golden Gate dams. Stone Corral and Funks creeks are characterized by deeply incised channels with little riparian vegetation or instream cover. In addition, water quality is reported to be poor and high in dissolved minerals. While the reaches of these creeks that would be inundated generally have little riparian habitat and are ephemeral (Figure 12-6), some have been found to support native and non-native fish species. Therefore, the loss of these streams is considered a **potentially significant impact**, when compared to the Existing Conditions/No Project/No Action Condition (**Impact Fish-1a**).

Water surface elevation fluctuations may occur within Sites Reservoir once it is constructed and filled, potentially impacting any stocked fisheries that may occur within Sites Reservoir after it becomes operational. However, because no fishery exists in Sites Reservoir under the Existing Conditions/No Project/No Action Condition, there are **no potential impacts on** aquatic biological resources in Sites Reservoir to evaluate.


Stone Corral Creek within the Proposed Sites Reservoir Footprint in the Town of Sites (2/23/2011)


Stone Corral Creek Immediately Downstream of the Proposed Sites Dam Location (2/23/2011)

FIGURE 12-6
Proposed Project Facility Locations
Sites Reservoir Project EIR/EIS

During operation, releases from Sites and Golden Gate dams would maintain flows of up to 10 cfs from October through May in Stone Corral and Funks creeks, respectively, to mimic the ephemeral nature of these streams. Because these flows would be maintained close to natural levels, operational impacts to fish and aquatic habitats in Funks and Stone Corral creeks downstream of Sites and Golden Gate dams would be **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

Fish Passage

Construction of the dams, as well as the filling of Sites Reservoir (1.3 MAF under Alternative A), would physically limit movement, from the streams below the dams and the stream segment above the resulting reservoir. The reaches of these creeks for which fish movements would be limited generally have little riparian habitat and are ephemeral (Figures 12-6 and 12-7), although some of the creeks have been found to support native and non-native fish species. However, the extent to which fish species may move through this area is unknown and movement of these species is not considered an essential behavioral component of their life cycle. Therefore, elimination of fish passage at the Sites Reservoir dams is anticipated to have a **less-than-significant impact**, relative to the Existing Conditions/No Project/No Action Condition.

During operation, releases from Sites and Golden Gate dams would maintain flows of up to 10 cfs from October through May in Stone Corral and Funks creeks, respectively, to mimic the ephemeral nature of these streams. Because these flows would be maintained close to natural levels, the impact to fish passage in Funks and Stone Corral creeks below Sites and Golden Gate dams would be **less than significant,** when compared to the Existing Conditions/No Project/No Action Condition.

Road Relocations and South Bridge

Erosion, Sedimentation, and Turbidity

Construction activities associated with road relocations and construction of the South Bridge in the vicinity of Funks and Stone Corral creeks would have the potential to cause erosion and contribute sediment to the creeks downstream of the construction activities, particularly at the proposed Eastside Road crossing at Funks Creek. Disturbance from maintenance activities, such as road repair, embankment erosion repair, and vegetation control, could result in increased sedimentation and organic matter entering adjacent streams.

However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Erosion and Sediment Control Plan) and implementation of BMPs during maintenance, potential impacts on fish and aquatic habitats as a result of construction and maintenance activities would be minimized. Therefore, erosion, sedimentation, and turbidity resulting from road relocations and the south bridge would have a **less-than-significant impact** on fish and aquatic habitats.

Vehicle use associated with operation of the roads would be confined to the defined road and shoulder areas due to continuous roadside fencing and/or guardrails. Therefore, operation of the roads would be expected to result in a **less-than-significant impact** on fish and aquatic habitats.

Stone Corral Creek Immediately Downstream of the Proposed Sites Dam Location (Looking Upstream) (2/23/2011)

Portion of Funks Creek that would be Inundated by the Proposed Holthouse Reservoir (Looking Downstream from Funks Dam) (2/23/2011)

FIGURE 12-7
Proposed Project Facility Locations
Sites Reservoir Project EIR/EIS

Hazardous Materials and Chemical Spills

Hazardous materials and chemicals in the form of gasoline, engine oil, lubricants, or other fluids used during construction activities could potentially enter Funks and Stone Corral creeks as a result of seepage or accidental spills. During road and bridge maintenance activities, there is also the potential for chemical or hazardous spills or leakage in these creeks. Accidental discharge of hazardous materials and chemicals could affect fishes that may be present in the immediate vicinity and downstream of the construction and maintenance areas. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Spill Prevention and Control Plan), potential impacts on fish and aquatic habitats as a result of construction activities would be minimized. Therefore, the accidental discharge of hazardous materials and chemicals resulting from road relocations and the south bridge would have a **less-than-significant impact** on fish and aquatic habitats when compared to the Existing Conditions/ No Project/No Action Condition.

Hydrostatic Pressure Waves, Noise, and Vibration

Construction of the Eastside Road Bridge over Funks Creek may include pile driving activities, potentially resulting in noise-related impacts on fisheries in Funks Creek, which could adversely affect fish in Funks Creek. However, Funks Creeks would be re-routed away from the construction areas, minimizing potential impacts on fish and aquatic resources; therefore, construction activities are anticipated to result in a **less-than-significant impact** on fish in Funks Creek from noise and vibration.

Aquatic Habitat Modification

Construction activities associated with road relocations and bridges in the vicinity of Funks and Stone Corral creeks would have the potential to alter aquatic habitat conditions in a number of streams. The largest potential impacts are associated with the crossings along Eastside Road, where it would cross Funks Creek and its tributaries. One Funks Creek tributary crossing in this segment, and another in the Stone Corral Road segment, support some riparian trees. The next largest potential impacts on streams are associated with the crossings of small (5 to 10 feet wide) creeks by Saddle Dam Road and Lurline Road. Streams crossed by Saddle Dam Road (the North Road segment) are tributaries to Hunters Creek, and streams crossed by Lurline Road (the Huffmaster Road to Lurline Road segment) are tributaries to Antelope or Lurline creeks off the southeast end of the reservoir. The reaches of Funks Creek, Stone Corral Creek, and other small streams that may be affected generally have little riparian and aquatic habitat. It is not anticipated that substantial amounts of riparian or aquatic habitat would be permanently removed or substantially affected by road relocations or bridge construction. Therefore, these activities are anticipated to result in a **less-than-significant impact** on fish and aquatic habitat.

Fish Passage

It is expected that activities associated with road relocation and bridge construction in the vicinity of Stone Corral and Funks creeks would occur when the creeks are ponded or dry, or when the creeks are re-routed away from the construction area. Therefore, construction of the Eastside Road Bridge over Funks Creek is not anticipated to substantially affect hydrologic or fish passage conditions within Funks Creek. Construction of any culverts on Funks and Stone Corral creeks would be designed to maintain existing fish passage conditions. Therefore, these activities are anticipated to result in a **less-than-significant impact** on fish passage.

Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant

Erosion, Sedimentation, and Turbidity

Construction activities associated with the Sites Reservoir Inlet/Outlet Structure and the Sites Pumping/Generating Plant along Funks Creek would have the potential to cause erosion and contribute sediment to Funks Creek downstream of the construction activities. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Erosion and Sediment Control Plan), potential impacts on fish and aquatic habitats as a result of construction activities would be minimized. Therefore, erosion, sedimentation, and turbidity resulting from construction of the Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant would have a **less-than-significant impact** on fish and aquatic habitats.

Hazardous Materials and Chemical Spills

Hazardous materials and chemicals in the form of gasoline, engine oil, lubricants, or other fluids used during construction activities could potentially enter Funks Creek as a result of seepage or accidental spills. During construction activities there would also be the potential for chemical or hazardous spills or leakage into Funks Creek. Accidental discharge of hazardous materials and chemicals could potentially affect fishes that may be present in the immediate vicinity and downstream of the construction maintenance area. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Spill Prevention and Control Plan), potential impacts on fish and aquatic habitats as a result of construction activities would be minimized. Therefore, the accidental discharge of hazardous materials and chemicals resulting from construction of the Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant would have a **less-than-significant impact** on fish and aquatic habitats.

Hydrostatic Pressure Waves, Noise, and Vibration

Construction of the Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant may include construction activities that result in noise and vibration effects on fisheries resources in Funks Creek, potentially impacting fish species in Funks Creek. However, Funks Creek would be re-routed away from the construction areas to minimize any potential impacts on fish and aquatic resources. Construction activities are therefore anticipated to result in a **less-than-significant impact** on fish in Funks Creek due to noise or vibration.

Aquatic Habitat Modification

Construction of the Sites Reservoir Outlet Structure would permanently remove approximately 0.5 mile of Funks Creek immediately upstream of the existing Funks Reservoir. As previously discussed, Funks Creek is characterized by deeply incised channels with little riparian vegetation or instream cover. While the reach of Funks Creek that would be removed generally has little riparian habitat and is ephemeral, it has been found to support native and non-native fish species, including California roach, Sacramento blackfish and Sacramento sucker. Aquatic habitat removal and modification associated with the construction of the Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant would result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

Fish Passage

As described above, construction of the inlet/outlet structure would eliminate approximately 0.5 mile of Funks Creek immediately upstream of the existing Funks Reservoir. During construction activities, Funks Creek would be diverted upstream of the inlet/outlet structure construction area, preventing fish passage through the construction area. Funks Creek has been found to support native and non-native fish species. However, the extent to which fish species may move between Funks Reservoir and Funks Creek upstream of Funks Reservoir is unknown and movement of these species is not considered an essential behavioral component of their life cycle. Therefore, the temporary diversion of Funks Creek during construction is anticipated to have a **less-than-significant impact**, relative to the Existing Conditions/No Project/ No Action Condition. Operation and maintenance activities associated with the inlet/outlet structure would be conducted as to not substantially affect fish passage conditions. These activities are anticipated to result in a **less-than-significant impact** on fish in Funks Creek.

Holthouse Reservoir Complex

The Holthouse Reservoir Complex includes the Project features and facilities that are geographically or functionally associated with the Holthouse Reservoir. This complex would be composed of the Holthouse Reservoir inundation area, the dam that would form the reservoir, the Holthouse spillway and stilling basin and spillway bridge, the WAPA transmission line relocation, the approach channel for the Sites pumping/generating plant, existing Tehama-Colusa Main Canal connections, Tehama-Colusa Main Canal construction bypass pipeline, and installation of two additional pumps at the Red Bluff pumping plant.

Erosion, Sedimentation, and Turbidity

Construction of the Holthouse Reservoir Complex would occur adjacent to the existing Funks Reservoir, and thus would have the potential to increase erosion, sedimentation, and turbidity in Funks Creek downstream of the construction area. Dredging activities at Funks Reservoir associated with removal of accumulated sediment would also have the potential to increase sedimentation and turbidity in Funks Creek downstream of Funks Reservoir. Installation of two additional pumps into existing bays at the Red Bluff Pumping Plant would occur during the annual maintenance period for the Tehama-Colusa Canal. The existing facility is designed to accommodate up to two extra pumps (500 cfs) for Sites operations without any construction, operation, or maintenance activities that would cause sedimentation.

Maintenance activities at the Holthouse Reservoir Complex, such as periodic road, vegetation, and fence maintenance, as well as debris removal, would also have the potential to increase erosion and turbidity in Funks Creek downstream of the proposed Holthouse Reservoir. However, maintenance activities at Holthouse Reservoir are anticipated to be similar to existing maintenance activities at Funks Reservoir.

With implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Erosion and Sediment Control Plan) and implementation of BMPs during maintenance, potential impacts on fish and aquatic habitats as a result of construction, operation, and maintenance activities would be minimized. Therefore, erosion, sedimentation, and turbidity resulting from construction, operation, and maintenance of the Holthouse Reservoir Complex would have a **less-than-significant impact** on fish and aquatic habitats.

Hazardous Materials and Chemical Spills

Hazardous materials and chemicals in the form of gasoline, engine oil, lubricants, or other fluids used during construction and maintenance activities could potentially enter Funks Creek as a result of seepage or accidental spills and potentially affect fishes that may be present in the immediate vicinity and downstream of the area.

With implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Spill Prevention and Control Plan) and implementation of BMPs during maintenance, potential impacts on fish and aquatic habitats as a result of construction and maintenance activities would be minimized. Therefore, the accidental discharge of hazardous materials and chemicals resulting from construction, operation, and maintenance of the Holthouse Reservoir Complex would have a **less-than-significant impact** on fish and aquatic habitats.

Hydrostatic Pressure Waves, Noise, and Vibration

Construction of the Holthouse Reservoir Complex may involve construction activities that could result in increased noise and vibration levels in local waterways, resulting in potentially significant impacts on fisheries resources in the construction area.

However, Funks Creek would be re-routed away from the construction area to minimize any potential impacts on fish and aquatic resources; therefore, construction of the Holthouse Reservoir Complex is anticipated to result in a **less-than-significant impact** on fish due to noise and vibration.

Aquatic Habitat Modification

The construction of the dam, spillway, and stilling basin, and the consequent inundation of Holthouse Reservoir, would result in the permanent removal of an approximately 0.8 mile reach of Funks Creek immediately downstream of the existing Funks Reservoir (Figures 12-7). One of the largest potential impacts to aquatic habitat is the inundation of the riparian area supported by Funks Creek downstream of the existing dam outlet, where Funks Creek averages more than 80 feet wide. The remaining length of the Funks Creek channel supports a narrow strip of mature riparian trees that would be lost to construction of these facilities. Aquatic habitat removal and modification within Funks Creek associated with the construction and inundation of Holthouse Reservoir would result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

The construction activities associated with the installation of two additional pumps at the Red Bluff Pumping Plant, and their operation and maintenance, would not affect levels of waters other than the Sacramento River immediately downstream of the pumping plant. Transportation of necessary equipment to install the pump (including a crane) would occur along existing construction or access roads. Dewatering of the afterbay would likely be required, and would occur during regularly scheduled maintenance periods or during the non-irrigation season. Therefore, construction and maintenance activities associated with installation of two additional pumps at the Red Bluff Pumping Plant are not expected to involve any disturbance that would result in a loss or alteration of the river environment.

Holthouse Dam would maintain releases to Funks Creek of up to 10 cfs year round based on a recommendation from CDFW staff. This flow is intended to replace the existing seepage flow on Funks Creek below Funks Dam. Flows released into Funks Creek from Holthouse Reservoir are anticipated to be consistent with flow conditions under the Existing Conditions/No Project/No Action Condition. Therefore, operational and maintenance activities at the Holthouse Reservoir Complex are anticipated to result in a **less-than-significant impact** on fish and aquatic habitats.

Funks Reservoir is operated as a regulating afterbay/forebay for the Tehama-Colusa Canal. Under the Project alternatives, Funks Reservoir would be incorporated into the Holthouse Reservoir Complex, which also would function as a regulatory afterbay/forebay for the Tehama-Colusa Canal and a regulatory afterbay for Sites Reservoir. As a regulating afterbay/forebay, Funks Reservoir is operated to receive variable flows and, as a result, monthly storage and elevation fluctuate often. Under the Project alternatives, the Holthouse Reservoir Complex would continue to receive highly variable inflow and would continue to experience frequent surface elevation fluctuations. Therefore, the Project alternatives would not affect monthly mean storage or elevation, relative to the Existing Conditions/No Project/ No Action Condition and impacts on fisheries resources in Holthouse Reservoir (or the existing Funks Reservoir) would be **less than significant,** when compared to the Existing Conditions/No Project/ No Action Condition.

Fish Passage

Funks Creek would be diverted during construction activities, and Funks Reservoir would be drained during dredging activities. In-stream construction activities also could impede upstream passage of resident fishes because of altered hydrologic conditions. Following completion of construction of the Holthouse Reservoir Complex, it is anticipated that fish passage would be blocked downstream of Holthouse Reservoir. However, because fish passage is currently blocked at the outlet of the existing Funks Reservoir and the reservoir is drained annually under Existing Conditions, these activities are anticipated to result in a **less-than-significant impact** on fish passage.

Holthouse Dam would maintain releases to Funks Creek of up to 10 cfs year round based on a recommendation from CDFW staff. This flow is intended to replace the existing seepage flow on Funks Creek below Funks Dam. Flows released into Funks Creek from Holthouse Reservoir are anticipated to be consistent with flow conditions under the Existing Conditions/No Project/No Action Condition. Therefore, operations at Holthouse Reservoir are anticipated to result in a **less-than-significant impact** on fish passage.

TRR to Funks Creek Pipeline

Erosion, Sedimentation, and Turbidity

Construction of the TRR to Funks Creek Pipeline has the potential to increase erosion, sedimentation, and turbidity within Funks Creek in the vicinity of the proposed pipeline outlet at Funks Creek. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Erosion and Sediment Control Plan), potential impacts on fish and aquatic habitats in Funks Creek as a result of construction activities would be minimized. Therefore, erosion, sedimentation, and turbidity resulting from construction of the TRR to Funks Creek Pipeline would have a **less-than-significant impact** on fish and aquatic habitats.

Discharge operations of water from the TRR to Funks Creek also have the potential to increase turbidity in Funks Creek. However, a velocity dissipater at the outlet of the pipeline is anticipated to minimize potential increases in turbidity in Funks Creek, resulting in a **less-than-significant impact** on fish species of management concern.

Ongoing maintenance activities, such as sediment removal, could also temporarily increase turbidity within Funks Creek. However, maintenance activities at Holthouse Reservoir are anticipated to be similar to existing maintenance activities at Funks Reservoir. In addition, implementation of the environmental commitments included as part of the Project (e.g., Best Management Practices), would ensure that maintenance activities would be conducted in a manner that avoids impacting any aquatic habitat that may have been restored. Flows released into Funks Creek from the TRR Complex are anticipated to be consistent with flow conditions under the Existing Conditions/No Project/No Action Condition, except during emergency conditions and when the TRR is drained for maintenance every 7 to 10 years, when flows may be increased resulting in increased sediment input and erosion. However, release flows would be controlled by an energy dissipater and small concrete structure at the terminal end of the pipeline. Therefore, operational and maintenance activities at the Terminal Regulating Reservoir Complex are anticipated to result in a **less-than-significant impact** on fish and aquatic habitats.

Hazardous Materials and Chemical Spills

Hazardous materials and chemicals in the form of gasoline, engine oil, lubricants, or other fluids used during construction activities could potentially enter Funks Creek as a result of accidental spills. Accidental discharge of hazardous materials and chemicals could potentially affect fishes that may be present in the immediate vicinity and downstream of the construction areas area. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Spill Prevention and Control Plan), potential impacts on fish and aquatic habitats as a result of construction activities would be minimized. Therefore, the accidental discharge of hazardous materials and chemicals resulting from construction of the TRR to Funks Creek Pipeline would have a **less-than-significant impact** on fish and aquatic habitats in Funks Creek.

Delevan Pipeline

The approximately 13.5-mile-long proposed Delevan Pipeline would convey water from the Sacramento River to the proposed Holthouse Reservoir to fill the proposed Sites Reservoir and/or convey water from Holthouse Reservoir to the Sacramento River for releases. The Delevan Pipeline would cross under Hunters Creek near its confluence with the CBD and under the drain itself at the northern end of the drain. Construction of these crossings would include the jack-and-bore of an inverted siphon and likely occur during late fall, after the irrigation season ends and before winter rains begin.

Erosion, Sedimentation, and Turbidity

The Delevan Pipeline would be constructed to convey water from the Sacramento River to Holthouse Reservoir, and also to convey water from Holthouse Reservoir to the Sacramento River. The pipeline would cross under the CBD and Hunters Creek, a tributary to the CBD. Construction activities at the creek crossings would have the potential to increase erosion, sedimentation, and turbidity within the CBD and Hunters Creek. However, construction of these crossings would include the jack-and-bore of an inverted siphon, and with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Erosion and Sediment Control Plan), potential impacts on fish and aquatic habitats in the CBD as a result of construction activities would be minimized. Therefore, erosion, sedimentation, and turbidity resulting from construction of the Delevan Pipeline would have a **less-than-significant impact** on fish and aquatic habitats in the CBD and Hunters Creek.

Hazardous Materials and Chemical Spills

Hazardous materials and chemicals in the form of gasoline, engine oil, lubricants, or other fluids used during construction activities could potentially enter the CBD or Hunters Creek as a result of accidental spills. Accidental discharge of hazardous materials and chemicals could potentially affect fishes that may be present in the immediate vicinity and downstream of the construction area. However, construction of these crossings would include the jack-and-bore of an inverted siphon, and with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Spill Prevention and Control Plan), potential impacts on fish and aquatic habitats as a result of construction activities would be minimized. Therefore, the accidental discharge of hazardous materials and chemicals resulting from construction of the Delevan Pipeline would have a **less-than-significant impact** on fish and aquatic habitats in the CBD and Hunters Creek.

Delevan Pipeline Intake/Discharge Facilities

The proposed Delevan Pipeline Intake/Discharge Facilities were designed to divert water from the Sacramento River to the proposed Holthouse Reservoir for storage in the proposed Sites Reservoir. The facilities would also be used to release water from Sites Reservoir to the Sacramento River for downstream uses and to generate electricity. The proposed facilities at this site would include the following: Flat Plate Fish Screen Structure; Forebay, Levee Tubes, and Afterbay; Pumping/Generating Plant and Electrical Switchyard; Maintenance and Electrical Buildings; and Other Mechanical and Electrical Features.

To isolate the proposed construction area from the Sacramento River, a cellular sheetpile cofferdam would be installed in the river near the location of the fish screen. Approximately 1,200 feet of sheet piles would be required to build the cofferdam. From the river bank at the upstream and downstream ends of the fish screen structure, the cofferdam would extend approximately 40 feet into the water from the river bank. The cofferdam is likely to remain in place throughout facility construction. The area behind the cofferdam would be dewatered prior to construction by pumping water out from behind the cofferdam. After construction of the pump station is complete, the cofferdam would be removed by pulling the sheet piles out of the river.

Erosion, Sedimentation, and Turbidity

Activities associated with construction of the intake/discharge facilities would include clearing and grading, transportation of materials, construction of the cofferdam, dewatering the cofferdam, excavation of the forebay and pumping plant site, construction of a berm/ring levee, construction of the facility structures and fish screen system, removal of the cofferdam, fill and re-grading activities, and restoration of disturbed areas after construction. These activities have the potential to increase erosion, sedimentation, and turbidity near and downstream of the construction site in the Sacramento River. However, with implementation of the environmental commitments included as part of the Project (e.g., SWPPP, Erosion and Sediment Control Plan), potential impacts on fish and aquatic habitats in the Sacramento River as a result of construction activities outside of the in-water work area would be minimized.

Although increased turbidity and suspended sediments would occur intermittently during construction and removal of the cofferdam, water quality conditions would be expected to return to background levels within hours after construction activity is completed. This short-term increased turbidity and suspended sediment concentrations has the potential to adversely affect fish species of management concern that may be in the vicinity. Since site preparation and installation of the cofferdam are most likely to occur during periods of reduced flow within the Sacramento River the likelihood of adverse effects to Chinook salmon, steelhead, and sturgeon is reduced. The turbidity plume resulting from cofferdam installation is not expected to extend across the entire Sacramento River; rather, the plume is expected to extend downstream from the site along one edge of the channel. As a result of the limited distribution of the plume within the river salmonids and other fish species would have the opportunity to readily avoid the plume during either upstream or downstream migration.

The projected localized increase in turbidity during portions of the construction period may result in short-term (hours or days) changes in behavior or distribution of fish species within the immediate vicinity of the site but would not be expected to have adverse effects such as mortality or blockage of migration on fish species of concern such as salmonids and sturgeon. Therefore, erosion, sedimentation, and turbidity resulting from construction of the Delevan Pipeline Intake/Discharge Facilities would have a l**ess-than-significant impact** on fish and aquatic habitats in the Sacramento River.

Operation of the intake/discharge facilities also has the potential to increase turbidity in the Sacramento River in the vicinity of the intake structure, particularly during discharge events; however, the fish screen would act as a velocity dissipater when water is being released to the Sacramento River, minimizing potential increases in turbidity and resulting in **less-than-significant impacts** when compared to the Existing Conditions/No Project/No Action Condition.

Maintenance activities, including periodic sediment removal within the forebay and dredging of the intake channel every few years, would not result in increased turbidity within the Sacramento River, and would have a **less-than-significant impact** on salmon, steelhead, and sturgeon.

Hazardous Materials and Chemical Spills

Hazardous materials and chemicals in the form of gasoline, engine oil, lubricants, or other fluids used during construction activities could potentially enter the Sacramento River as a result of seepage or accidental spills. Accidental discharge of hazardous materials and chemicals could potentially affect fishes that may be present in the immediate vicinity and downstream of the construction area. However, the Project includes a number of environmental commitments (e.g., SWPPP, Spill Prevention and Control Plan), intended to avoid or minimize the potential impacts on fish and aquatic habitats as a result of a hazardous material or chemical spill during construction activities. In addition, compliance with Sections 401 and 404 of the Clean Water Act is required prior to the initiation of construction activities, and it is anticipated that the resultant water quality certifications and permits will contain discharge-control requirements that, indirectly, would avoid or minimize the occurrence of hazardous materials and chemicals from entering the waterway due to seepage or accidental spills. The above measures would be expected to prevent the accidental spill of hazardous materials or chemicals from project construction, and avoid harm to fish in the Sacramento River if a spill should occur. Therefore, the accidental discharge of hazardous materials and chemicals resulting from construction of the Delevan Pipeline Intake/Discharge Facilities would have a **less-than-significant impact** on fish and aquatic habitats in the Sacramento River.

Hydrostatic Pressure Waves, Noise, and Vibration

In-river construction work associated with the Delevan Pipeline Intake/Discharge Facilities (i.e., cofferdam and the intake/discharge structure) would involve equipment and activities that would produce pressure waves, and would create underwater noise and vibration, thereby temporarily altering in-river conditions during Project construction, relative to the Existing Conditions/No Project/No Action Condition. Of particular concern would be the noise associated with pile driving. The cofferdam would be installed by driving interlocking sheet piles into the river bottom with a pile driver beginning at the upstream end of the cofferdam area and proceeding downstream until the cofferdam is complete. If environmental conditions allow, sheet pilings would be vibrated into place during construction of the cofferdam to minimize underwater pressure waves (i.e., instream noise) and subsequent impacts on fish. Vibratory pile drivers use counter-rotating eccentric weights to vertically vibrate the pile and cause the soil surrounding the pile to loosen, allowing the pile to sink under its own weight. Therefore, resultant sound pressure waves would remain below the levels which would result in mortality or physical injury of fish (206 dB Peak and 183 dB Cumulative SEL [Fisheries Hydroacoustic working Group (FHWG), 2008]) and would result in a **less-than-significant impact**.

If an impact hammer was used to drive the pilings, sound levels within a portion of the Sacramento River adjacent to the construction site during pile driving operations have the potential to exceed the peak pressure criterion or the accumulated sound exposure level (SEL). Use of an impact hammer would be minimized to the maximum extent possible. Given the limited and intermittent use of the impact hammer (expected to be hours or days) and the rapid attenuation of sound in water, the area of potential effect is expected to be small and the magnitude of potential adverse effects is expected to be low. Given the uncertainty in the need to use the impact hammer, the resulting sound pressure levels, and the duration when the hammer is in use, the magnitude of effect cannot be predicted with confidence, but is expected to be temporary and localized. Although the potential magnitude of exposure to elevated sound pressure levels and the resulting affects to salmonids and other fish species is expected to be very low, limited use of the impact hammer for cofferdam installation is identified as a **potentially significant impact** (**Impact Fish-1c**).

It was assumed that pile driving of the support piers for the intake structure foundation would occur subsequent to the completion and dewatering of the cofferdam, so that the intake structure construction would be completed within the "dry" confines of the cofferdam. Sound pressure waves generated from construction activities within the confines of the cofferdam are expected to be attenuated to levels below which fish would be adversely affected. As stated in the BO for the Benicia Martinez New Bridge,

> "*Shallow water pile driving in fully dewatered cofferdams (no more than 0.3 m of standing water) are not anticipated to generate sufficient sound pressure levels capable of affecting fish"* (NMFS, 2003).

Therefore, sound pressure waves generated from construction activities within the confines of the cofferdam are considered less than significant and were not further evaluated in the DEIR/EIS.

During landside construction activities associated with the intake facilities, the potential would exist for vibration and pressure waves generated by construction and excavation activities to affect fish species in the Sacramento River. Operation and maintenance activities also may increase ambient underwater noise levels. However, the noise levels produced by both landside construction and excavation activities, and operation and maintenance activities, are not expected to reach a level that would harm juvenile or adult fishes. Because most construction and excavation activities are anticipated to occur above water, the noise levels under water would be much lower than those created in the air, and are anticipated to result in a **less-than-significant impact** on salmon, steelhead, sturgeon, and other species of management concern.

Predation Risk

Placement of the cofferdam associated with construction of the Delevan Pipeline Intake/Discharge Facilities, installation of the fish screen, and installation of the proposed Delevan Pipeline alignment at various stream crossings may increase the risk of predation on fish due to dewatering, sound disturbance due to increased underwater noise levels, and increased turbidity, all of which could increase predator opportunities or efficiencies. In addition, construction of the Delevan Pipeline Intake/Discharge Facilities on the Sacramento River has the potential to provide habitat for non-native piscivorous predators, such as striped bass and centrarchids, which may result in increased predation risk for other fish species of management concern, including outmigrating juvenile salmonids. Increased predation risk associated with the construction of this facility could have a **potentially significant impact** on salmon, steelhead, and sturgeon in the Sacramento River (**Impact Fish-1d**).

Stranding and Entrainment

Construction of the cofferdams, intake facilities, and installation of the fish screens at the proposed intake/discharge facility would require dewatering of the area contained by the cofferdam. Sheet pile placement for cofferdams would occur sequentially starting from the upstream end to the downstream end of the of the in-river footprint area to be enclosed by the cofferdam. If individual fish do not volitionally exit through the partially enclosed cofferdam and return to the river, fish could become trapped within the cofferdam and stranded when area behind the cofferdam is dewatered following its closure. Stranding is not expected to be a concern for adult Chinook salmon, steelhead or sturgeon because: (1) they are strong swimmers; (2) they have the ability to vacate the inside of the cofferdam in the unlikely event that they are trapped within the cofferdam upon closure; and (3) stranded adults can be readily returned to the river in the highly unlikely event of entrapment within the cofferdam. However, juveniles are more likely to become trapped behind the cofferdam prior to its closure. In addition, diversions would result in decreased river flows downstream of the proposed facility, which could result in the potential for impacts to fish movement and increased entrainment or entrapment at the proposed fish screen.

Because juvenile fish species of management concern may be in the vicinity of construction areas and the completed facility year-round, dewatering, in-river work during cofferdam placement and removal, and the proposed diversions during operation could result in fish impingement, entrainment, and stranding, which would result in a **potentially significant impact** (**Impact Fish-1e**).

Aquatic Habitat Modification

Construction of the Delevan Pipeline Intake/Discharge Facilities would include the modification and removal of SRA habitat (Figures 12-8 and 12-9). The loss and degradation of SRA habitat within the construction footprints and within the access routes, staging areas, and storage and disposal areas could result in an impact on fish species through reduction in the quality of fish habitat and removal of important habitat elements. Preliminary estimates using GIS indicate that approximately 1.1 acres of Fremont cottonwood riparian habitat that acts as SRA habitat, and an additional 0.5 acres of Valley Foothill Riparian habitat that may act as a source of IWM inputs to the Sacramento River, would be removed as a result of construction of the intake facilities. During a reconnaissance site visits conducted on February 23, 2011 and February 14, 2017, available woody material was identified in the area. Examples include one piece of IWM (between 6 and 8 inches in diameter and approximately 20 feet long) that was observed protruding from the river surface, and another piece of similar size that was identified immediately adjacent to the bank that could function as IWM at higher flows (Figure 12-9).

Adult, juvenile, and early life stages of salmon and steelhead could be present within and downstream of construction areas year-round in the Sacramento River. Aquatic habitat removal and modification associated with construction of the Delevan Pipeline Intake/Discharge Facilities on the Sacramento River would remove aquatic and riparian habitat, including SRA habitat, resulting in a **potentially significant impact** on salmon and steelhead in the Sacramento River (**Impact Fish-1b**).

Portion of Funks Creek that would be Inundated by the Proposed Holthouse Reservoir (Looking Downstream from Funks Dam) (2/23/2011)

Location of the Proposed Delevan Pipeline Intake Facilities on the Sacramento River (Looking Downstream from the Existing Maxwell Irrigation District Intake) (2/23/2011)

FIGURE 12-8
Proposed Project Facility Locations
Sites Reservoir Project EIR/EIS

Location of the Proposed Delevan Pipeline Intake Facilities on the Sacramento River (Looking Downstream from the Existing Maxwell Irrigation District Intake) (2/23/2011)

FIGURE 12-9
Proposed Project Facility Locations
Sites Reservoir Project EIR/EIS

Maintenance activities may include replacement of existing riprap necessary to protect the conveyance features and facilities, which is anticipated to result in a **less-than-significant impact** on fish species of management concern because no additional habitat would be modified.

Fish Passage

Installation of a cofferdam to facilitate the construction of the intake/discharge facilities could potentially physically impede migrating adults, limiting their ability to reach spawning areas, and could hinder migration of juveniles, potentially exposing them to increased predation and unsuitable aquatic habitat conditions. In-stream construction activities also could impede upstream passage of fishes as a result of altered hydrologic conditions, such as temporarily increased velocities. However, because the cofferdam would only extend a short distance into the waterway (i.e., 40 feet), relative to the entire width of the Sacramento River, it is not anticipated that the movement of juvenile or adult salmon, steelhead, or sturgeon would be substantially affected. Therefore, installation of a cofferdam is anticipated to result in a **less-than-significant impact** on these species in the Sacramento River.

Operation of the Delevan Pipeline Intake/Discharge Facilities would also have the potential to entrain or impinge fry and juvenile salmon and steelhead, as well as affect juvenile fish passage, resulting in a **potentially significant impact** on salmon and steelhead in the Sacramento River with respect to juvenile anadromous fishes' relatively lessened swimming ability.

Temperature Effects on the Sacramento River

Operation of the Delevan Pipeline Intake/Discharge Facilities would include releases from the Project to the Sacramento River, which could have the potential to affect river temperatures downstream of this location. Although most anadromous fish spawning occurs upstream of the proposed facility, some spawning and juvenile rearing have been known to occur in this vicinity. The design of the reservoir facility would include the ability to release water from proposed outlet structures at nine depths. This operation would pull water from various levels of the reservoir (it is assumed that the reservoir would become stratified like all larger reservoirs throughout the Central Valley), with warming in the upper layer of the reservoir occurring in the summer months. Given the Project's operational objective of matching the temperature of released water at the Delevan Pipeline Intake/Discharge Facilities to temperatures in the Sacramento River, or otherwise using the release to protect downstream water temperature for aquatic species, operations of the Delevan Pipeline Intake/Discharge Facilities would involve withdrawing water at suitable depths to manage temperatures.

As shown in Appendix 7F Sites Reservoir Discharge Temperature Modeling, Table ST-4a, releases from Sites Reservoir would not increase water temperatures in the Sacramento River downstream of the facility during the summer and fall in most years/months under Alternative C. Under Alternative A, which was not specifically modeled, potential effects on water temperatures in the Sacramento River downstream of the proposed intake would be less than those estimated under Alternative C because of a smaller Sites Reservoir and smaller discharge facility. The slight changes to water temperatures in the Sacramento River indicated by the model would not be expected to adversely affect fish species of management concern given the infrequency of the changes and the position of the facility downstream of most salmonid spawning habitat in the Sacramento River. Therefore, the potential impacts related to the temperature of water discharged from the Delevan Pipeline Intake/Discharge Facilities into the Sacramento River are considered to be **less than significant**.

12.3.4 Impacts Associated with Alternative B

Potential impacts on fish species of management concern associated with implementation of Alternative B, relative to the Existing Conditions/No Project/No Action Condition, were evaluated in an identical manner to those described for Alternative A relative to the Existing Conditions/No Project/No Action Condition. Specifically, model results and locations evaluated were identical among alternatives. A detailed discussion of potential changes in aquatic habitat conditions and potential impacts is provided in Appendix 12C Fisheries Impact Summary.

12.3.4.1 Extended and Secondary Study Areas – Alternative B

<u>Construction, Operation, and Maintenance Impacts</u>

Impact Fish-1: A Substantial Adverse Effect (Either Directly, through Habitat Modifications, by Interfering with the Movement of Native Fish Species, or by Impeding the Use of Native Fish Nursery/Rearing Sites) on Any Fish Species of Management Concern, Including Species Identified As a Candidate, Sensitive, or Special-status Species in Local or Regional Plans, Policies, or Regulations, or by CDFW, NMFS, or USFWS.

Potential impacts to fisheries and aquatic resources on the wildlife refuges are discussed under Alternative A relative to the Existing Conditions/No Project/No Action Condition, above, and are applicable to Alternative B relative to the Existing Conditions/No Project/No Action Condition.

Construction-related impacts associated with implementation of Alternative B, relative to the Existing Conditions/No Project/No Action Condition, on all fish species of management concern would be the same as those described for Alternative A relative to the Existing Conditions/No Project/No Action Condition within the Secondary and Extended study areas.

Although there may be differences in effects on the different life stages in the water bodies evaluated (see Appendix 12C Fisheries Impact Summary), the overall operational impacts associated with Alternative B relative to the Existing Conditions/No Project/No Action Condition in each water body would be the same as described for Alternative A relative to the Existing Conditions/No Project/No Action Condition for all of the species evaluated within the Extended and Secondary study areas. Where impacts are identified as "beneficial," the amount or level of potential benefit under Alternative B may differ from the potential benefit under Alternative A, but this cannot be quantified. Similarly, a difference in the level of "potentially significant" impact between alternatives cannot be quantified and no attempt to do so has been made. The overall impacts presented for Alternative B, relative to the Existing Conditions/No Project/No Action Condition, are simply considered to be the same as under Alternative A relative to the Existing Conditions/No Project/No Action Condition.

12.3.4.2 Primary Study Area – Alternative B

<u>Construction, Operation, and Maintenance Impacts</u>

Several Primary Study Area Project facilities would be the same for Alternatives A, B, and C and would require the same construction methods and operation and maintenance activities regardless of alternative. Therefore, construction, operation, and maintenance of these facilities in common would have the same impacts on aquatic biological resources. Facilities under Alternative B that are the same as under Alternative A include:

- Sites Reservoir Inlet/Outlet Structure

- Sites Pumping/Generating Plant
- Holthouse Reservoir Complex
- GCID Main Canal Facilities Modifications
- TRR to Funks Creek Pipeline
- Delevan Pipeline

The Alternative B Sites Reservoir would be larger than the Alternative A reservoir. In addition, Alternative B would replace the Delevan Pipeline Intake/Discharge Facilities with the smaller Delevan Pipeline Discharge Facility. Potential impacts on aquatic biological resources associated with Project features that would differ from Alternative A and any potentially significant impacts on aquatic resources are discussed below.

The road relocation construction disturbance area would differ slightly to serve different sets of dams, but the two alternatives' routes would cross equivalent extents of very small tributary drainages. Alternative B would affect slightly more (0.3 mile) stream miles than Alternative A. This increase is due largely to crossings of creeks associated with salt springs in the area south of the Saddle Dam Recreation Area; only Alternative B's road route traverses this area on its way to Saddle Dams 1 and 2. It is not anticipated that substantial amounts of riparian or aquatic habitat would be permanently removed or substantially affected by road relocations or bridge construction. Therefore, these activities are anticipated to have the same impacts on fish species of management concern as described for Alternative A.

The Alternative B Sites Reservoir would be larger and require the construction of two more saddle dams than the Alternative A reservoir. However, these additional saddle dams would not be located within or adjacent to a waterway. The Alternative B dams would therefore have the same impacts on fish species of management concern as described for Alternative A.

The boundary of the Project Buffer would be the same for Alternatives A and B, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impacts on fish species of management concern as described for Alternative A.

Water release temperatures from Sites Reservoir through the Delevan Pipeline Discharge Facility under Alternative B are expected to be the same as described for releases from the Delevan Pipeline Intake/Discharge Facilities under Alternative A. Alternative B would, therefore, have the same water temperature impacts on fish species of management concern as described for Alternative A.

Sites Reservoir Inundation Area

Aquatic Habitat Modification

Construction of a larger Sites Reservoir would have similar potential impacts on aquatic biological resources as discussed for Alternative A, except that construction of Sites Reservoir (1.8 MAF under Alternative B vs. 1.3 MAF under Alternative A) would eliminate and inundate approximately 4 miles of Stone Corral Creek and 7 miles of Funks Creek upstream of the Sites Reservoir dams, compared to 3.9 miles of Stone Corral Creek and 6.5 miles of Funks Creek under Alternative A. While the reaches of these creeks that would be inundated generally have little riparian habitat and are ephemeral, some have been found to support native and non-native fish species. Therefore, the loss of these streams under Alternative B, is considered a **potentially significant impact** (**Impact Fish-1a**).

Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant

Aquatic Habitat Modification

As described for Alternative A, construction of the Sites Reservoir Outlet Structure would permanently remove approximately 0.5 mile of Funks Creek immediately upstream of the existing Funks Reservoir. Potential impacts on fisheries resources associated with aquatic habitat modification under Alternative B would be similar to those discussed for the Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant under Alternative A and could, therefore, result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

Holthouse Reservoir Complex

Aquatic Habitat Modification

As described for Alternative A, the construction of the dam, spillway, and stilling basin, and the consequent inundation of Holthouse Reservoir would result in the permanent removal of an approximately 0.8 mile reach of Funks Creek immediately downstream of the existing Funks Reservoir Potential impacts on fisheries resources associated with aquatic habitat modification under Alternative B would be similar to those discussed for the Holthouse Reservoir Complex under Alternative A and could, therefore, result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

Delevan Pipeline Discharge Facility

Hydrostatic Pressure Waves, Noise and Vibration

Under Alternative B a cofferdam would be constructed in the Sacramento River along the entire length of the discharge facility (approximately 350 feet in length) and subsequently dewatered to allow for construction of the facility. Potential impacts on fisheries resources associated with the cofferdam construction would be similar to those discussed for the Delevan Pipeline Intake/Discharge Facilities under Alternative A and could, therefore, result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1c**).

Predation Risk

Potential impacts on fisheries resources associated with predation risk during construction, operation, and maintenance of the discharge facility would be similar to those discussed for the intake/discharge facilities under Alternative A. However, because Alternative B would only include a discharge facility without diversion capabilities, the facility footprint would be smaller than the intake/discharge facility under Alternative A. This smaller footprint would reduce the amount of riparian and aquatic habitat affected, and therefore, reduce the potential for non-native predatory fish habitat creation. Despite the reduced potential in comparison to Alternative A, increased predation risk associated with the construction of this facility could have a **potentially significant impact** on fish species of management concern (**Impact Fish-1d**).

Stranding and Entrainment

As described for Alternative A, construction of the cofferdams and installation of the proposed discharge facility would require dewatering of the area contained by the cofferdam. Stranding is not expected to be a concern for adult Chinook salmon, steelhead or sturgeon because: (1) they are strong swimmers; (2) they have the ability to vacate the inside of the cofferdam in the unlikely event that they are trapped within the cofferdam upon closure; and (3) stranded adults can be readily returned to the river in the highly unlikely event of entrapment within the cofferdam. However, juveniles are more likely to become trapped behind the cofferdam prior to its closure. As described for Alternative A, the potential exists for impacts to migration and additional entrainment and impingement of juvenile fish during the diversion of water from the Sacramento River. Because juvenile fish species of management concern may be in the vicinity of construction areas and the facility year-round, dewatering, in-river work during cofferdam placement and removal, and diversions could result in increased fish impingement, entrainment, and stranding, which would result in a **potentially significant impact** (**Impact Fish-1e**).

Aquatic Habitat Modification

The footprint of the smaller discharge facility is estimated to displace approximately 1.5 acres of Fremont Cottonwood riparian habitat that may act as SRA habitat, and approximately 0.1 acre of Valley Foothill Riparian habitat (compared to 1.1 acres and 0.5 acre of Fremont Cottonwood and Valley Foothill Riparian habitat types, respectively, under Alternative A), which may act as a source of IWM inputs to the Sacramento River. The removal of SRA habitat would result in a **potentially significant impact** on fish species of management concern in the Sacramento River (**Impact Fish-1b**).

Fish Passage

As described for Alternative A, installation of a cofferdam for construction of the intake/discharge facilities could physically impede migrating adults, limiting their ability to reach spawning areas, and could hinder the migration of juveniles, potentially exposing them to increased predation and unsuitable aquatic habitat conditions. Because the cofferdam would only extend a short distance into the waterway (i.e., 40 feet), relative to the entire width of the Sacramento River, it is not anticipated that the movement of juvenile or adult salmon, steelhead, or sturgeon would be substantially affected. Therefore, installation of a cofferdam is anticipated to result in a **less-than-significant impact** on these species in the Sacramento River.

As described for Alternative A, operation and maintenance of the proposed Delevan facility is anticipated to result in potential impingement, entrainment, and impacts to fish passage resulting in a **potentially significant impact** on salmon and steelhead in the Sacramento River.

Temperature Effects on the Sacramento River

As described for Alternative A, operation of Sites Reservoir would include the ability to release water from proposed outlet structures at nine depths. Given the number of outlets at varying depths included as part of the Project, operations would allow for withdrawing water at suitable depths to manage the release temperatures and generally match Sacramento River temperatures to the extent possible. Modeling results (see Appendix 7F Sites Reservoir Discharge Temperature Modeling) indicate that releases from Sites Reservoir would not increase water temperatures in the Sacramento River downstream of the facility in most years/months. Therefore, the potential impacts related to the temperature of water discharged from the Delevan Pipeline Intake/Discharge Facilities into the Sacramento River are considered to be **less than significant**.

12.3.5 Impacts Associated with Alternative C

Potential impacts on fish species of management concern associated with implementation of Alternative C, relative to the Existing Conditions/No Project/No Action Condition, were evaluated in an identical manner to those described for Alternative A relative to the Existing Conditions/No Project/No Action Condition. Specifically, model results and locations evaluated were identical among alternatives. A detailed discussion of potential changes in aquatic habitat conditions and potential impacts is provided in Appendix 12C Fisheries Impact Summary.

12.3.5.1 Extended and Secondary Study Areas – Alternative C

Construction, Operation, and Maintenance Impacts

Impact Fish-1: A Substantial Adverse Effect (Either Directly, through Habitat Modifications, by Interfering with the Movement of Native Fish Species, or by Impeding the Use of Native Fish Nursery/Rearing Sites) on Any Fish Species of Management Concern, Including Species Identified As a Candidate, Sensitive, or Special-status Species in Local or Regional Plans, Policies, or Regulations, or by CDFW, NMFS, or USFWS.

Potential impacts to fisheries and aquatic resources on the wildlife refuges are discussed under Alternative A relative to the Existing Conditions/No Project/No Action Condition above, and are applicable to Alternative C relative to the Existing Conditions/No Project/No Action Condition.

Construction-related impacts associated with implementation of Alternative C, relative to the Existing Conditions/No Project/No Action Condition, on all fish species of management concern would be the same as those described for Alternative A relative to the Existing Conditions/No Project/No Action Condition within the Secondary and Extended study areas.

Although there may be differences in effects on the different life stages in the water bodies evaluated (see Appendix 12C Fisheries Impact Summary), the overall operational impacts associated with Alternative C relative to the Existing Conditions/No Project/No Action Condition in each water body, would be the same as described for Alternative A relative to the Existing Conditions/No Project/No Action Condition for all of the species evaluated within the Extended and Secondary study areas. Where impacts are identified as "potentially beneficial," the amount or level of potential benefit under Alternative C may differ from the potential benefit under Alternative A, but this cannot be quantified. Similarly, a difference in the level of "potentially significant" impact between alternatives cannot be quantified, and no attempt to do so has been made. The overall impacts presented for Alternative C, relative to the Existing Conditions/No Project/No Action Condition, are simply considered to be the same as under Alternative A relative to the Existing Conditions/No Project/No Action Condition.

12.3.5.2 Primary Study Area – Alternative C

Construction, Operation, and Maintenance Impacts

Several Primary Study Area Project facilities would be the same for Alternatives A, B, and C, and would require the same construction methods and operation and maintenance activities regardless of alternative. Therefore, construction, operation, and maintenance of these facilities in common would have the same impacts on aquatic biological resources. Facilities under Alternative C that are the same as under Alternative A include:

- Sites Reservoir Inlet/Outlet Structure
- Sites Pumping/Generating Plant
- Holthouse Reservoir Complex
- GCID Main Canal Facilities Modifications
- TRR to Funks Creek Pipeline
- Delevan Pipeline
- Delevan Pipeline Intake/Discharge Facilities

Potential impacts on aquatic biological resources associated with Project features that would differ from Alternative A and any potentially significant impacts on aquatic resources are discussed below.

As under Alternative B, the Alternative C Sites Reservoir would be larger than under Alternative A and require the construction of two more saddle dams (the same as Alternative B). However, these additional saddle dams would not be located within or adjacent to a waterway. The Alternative C dams would therefore have the same impacts on fish species of management concern as described for Alternative A.

The Alternative C saddle dam access roads included in the Road Relocations and South Bridge feature would differ from Alternative A, but Eastside Road would have the same alignment over Funks Creek and would require the same construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impacts on fish species of management concern as described for Alternative A.

The Delevan Pipeline Intake/Discharge Facilities included in Alternative C would be the same as the Alternative A intake facilities. Therefore, the impacts of the intake facilities on fish species of management concern would be the same as described for Alternative A.

The boundary of the Project Buffer would be the same for Alternatives A, B, and C; but, because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impacts on fish species of management concern as described for Alternative A.

Water release temperatures from Sites Reservoir through the Delevan Pipeline Discharge Facility under Alternative C are expected to be the same as described for releases from the Delevan Pipeline Intake/Discharge Facilities under Alternatives A and B. Alternative C would, therefore, have the same water temperature impacts on fish species of management concern as described for Alternative A.

Sites Reservoir Inundation Area

Aquatic Habitat Modification

Construction of a larger 1.8-MAF Sites Reservoir (the same as Alternative B) would have similar potential impacts on aquatic biological resources as discussed for Alternative A, except that construction of Sites Reservoir would eliminate and inundate approximately 4 miles of Stone Corral Creek and 7 miles of Funks Creek upstream of the Sites Reservoir dams, compared to 3.9 miles of Stone Corral Creek and 6.5 miles of Funks Creek under Alternative A. Aquatic habitat removal and modification, specifically the inundation of Funks and Stone Corral creeks associated with the construction of Sites Reservoir under Alternative C, would result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1a**).

Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant

Aquatic Habitat Modification

Construction of the Sites Reservoir Outlet Structure would permanently remove approximately 0.5 mile of Funks Creek immediately upstream of the existing Funks Reservoir. Potential impacts on fisheries resources associated with aquatic habitat modification under Alternative C would be similar to those discussed for the Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant under Alternative A and could, therefore, result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

Holthouse Reservoir Complex

Aquatic Habitat Modification

As described for Alternative A, the construction of the dam, spillway, and stilling basin, and the consequent inundation of Holthouse Reservoir would result in the permanent removal of an approximately 0.8 mile reach of Funks Creek immediately downstream of the existing Funks Reservoir Potential impacts on fisheries resources associated with aquatic habitat modification under Alternative C would be similar to those discussed for the Holthouse Reservoir Complex under Alternative A and could, therefore, result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

Delevan Pipeline Intake/Discharge Facilities

Hydrostatic Pressure Waves, Noise, and Vibration

Under Alternative C a cofferdam would be constructed in the Sacramento River along the entire length of the discharge facility (approximately 1200 feet in length) and subsequently dewatered to allow for construction of the facility. Potential impacts on fisheries resources associated with the cofferdam construction would be similar to those discussed for the Delevan Pipeline Intake/Discharge Facilities under Alternative A and could, therefore, result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1c**).

Predation Risk

As described for Alternative A, placement of the cofferdam associated with construction of the Delevan Pipeline Intake/Discharge Facilities, installation of the fish screen, and installation of the proposed Delevan Pipeline alignment at various stream crossings may increase the risk of predation on fish due to dewatering, sound disturbance due to increased underwater noise levels, increased turbidity and provision of habitat for predators, all of which could increase predator opportunities or efficiencies. Potential impacts on fisheries resources associated with the intake/discharge facilities under Alternative C would be similar to those discussed for Alternative A and could, therefore, result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1d**).

Stranding and Entrainment

As described for Alternative A, construction of the cofferdams, intake facilities, and installation of the fish screens at the proposed intake/discharge facility would require dewatering of the area contained by the cofferdam. Stranding is not expected to be a concern for adult Chinook salmon, steelhead or sturgeon because: (1) they are strong swimmers; (2) they have the ability to vacate the inside of the cofferdam in the unlikely event that they are trapped within the cofferdam upon closure; and (3) stranded adults can be readily returned to the river in the highly unlikely event of entrapment within the cofferdam. However, juveniles are more likely to become trapped behind the cofferdam prior to its closure. In addition, as described for Alternative A, the potential exists for impacts to migration and additional entrainment and impingement of juvenile fish during the diversion of water from the Sacramento River. Because juvenile fish species of management concern may be in the vicinity of construction areas and the facility year-round, dewatering, in-river work during cofferdam placement and removal, and diversions could result in fish impingement, entrainment, and stranding, which would result in a **potentially significant impact** (**Impact Fish-1e**).

Aquatic Habitat Modification

As described above for Alternative A, construction of the Delevan Pipeline Intake/Discharge Facilities would include the modification and removal of SRA habitat. Preliminary estimates using GIS indicate that approximately 1.1 acres of Fremont Cottonwood riparian habitat that acts as SRA habitat, and an additional 0.5 acres of Valley Foothill Riparian habitat that may act as a source of IWM inputs to the Sacramento River, would be removed as a result of construction of the intake facilities. The loss and degradation of SRA habitat within the construction footprints and within the access routes, staging areas, and storage and disposal areas could result in an impact on fish species through reduction in the quality of fish habitat and removal of important habitat elements.

Adult, juvenile, and early life stages of fish species of management concern could be present within and downstream of construction, operation, and maintenance areas year-round in the Sacramento River. Potential impacts on fisheries resources associated with aquatic habitat modification at the intake/discharge facilities would be similar to those discussed for Alternative A and could, therefore, result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1b**).

Fish Passage

As described for Alternative A, installation of a cofferdam for the construction of the intake/discharge facilities could physically impede migrating adults, limiting their ability to reach spawning areas, and could hinder migration of juveniles, potentially exposing them to increased predation and unsuitable aquatic habitat conditions. Because the cofferdam would only extend a short distance into the waterway (i.e., 40 feet), relative to the entire width of the Sacramento River, it is not anticipated that the movement of juvenile or adult salmon, steelhead, or sturgeon would be substantially affected. Therefore, installation of a cofferdam is anticipated to result in a **less-than-significant impact** on these species in the Sacramento River.

As described for Alternative A, operation and maintenance of the proposed Delevan facility is anticipated to result in potential impingement, entrainment, and impacts to fish passage resulting in a **potentially significant impact** on salmon and steelhead in the Sacramento River.

Temperature Effects on the Sacramento River

As described for Alternative A, operation of the reservoir would include the ability to release water from proposed outlet structures at nine depths. Given the number of outlets at varying depths included as part of the Project, operations would allow for withdrawing water at suitable depths to manage the release temperatures and generally match Sacramento River temperatures to the extent possible. As shown in Appendix 7F Sites Reservoir Discharge Temperature Modeling, Table ST-4a, releases from Sites Reservoir would not increase water temperatures in the Sacramento River downstream of the facility during the summer and fall in most years/months. Therefore, the potential impacts related to the temperature of water discharged from the Delevan Pipeline Intake/Discharge Facilities into the Sacramento River are considered to be **less than significant**.

12.3.6 Impacts Associated with Alternative D

Potential impacts on fish species of management concern associated with implementation of Alternative D, relative to the Existing Conditions/No Project/No Action Condition, were evaluated in an identical manner to those described for Alternative A relative to the Existing Conditions/No Project/No Action Condition. Specifically, model results and locations evaluated were identical among alternatives. A detailed discussion of potential changes in aquatic habitat conditions and potential impacts is provided in Appendix 12C Fisheries Impact Summary.

12.3.6.1 Extended and Secondary Study Areas – Alternative D

Construction, Operation, and Maintenance Impacts

Impact Fish-1: A Substantial Adverse Effect (Either Directly, through Habitat Modifications, by Interfering with the Movement of Native Fish Species, or by Impeding the Use of Native Fish Nursery/Rearing Sites) on Any Fish Species of Management Concern, Including Species Identified As a Candidate, Sensitive, or Special-status Species in Local or Regional Plans, Policies, or Regulations, or by CDFW, NMFS, or USFWS.

Potential impacts to fisheries and aquatic resources on the wildlife refuges are discussed under Alternative A relative to the Existing Conditions/No Project/No Action Condition, above, and are applicable to Alternative D relative to the Existing Conditions/No Project/No Action Condition.

Construction-related impacts associated with implementation of Alternative D, relative to the Existing Conditions/No Project/No Action Condition, on all fish species of management concern would be the same as those described for Alternative A relative to the Existing Conditions/No Project/No Action Condition within the Secondary and Extended study areas.

Although there may be differences in effects on the different life stages in the water bodies evaluated (see Appendix 12C Fisheries Impact Summary), the overall operational impacts associated with Alternative D relative to the Existing Conditions/No Project/No Action Condition in each water body would be the same as described for Alternative A relative to the Existing Conditions/No Project/No Action Condition for all of the species evaluated within the Extended and Secondary study areas. These impacts could vary should the California Water Commission choose to acquire a greater or smaller amount of the water diverted and stored within Sites Reservoir, and should the CDFW choose to operate this portion of the water in a manner different to that assumed for this analysis. Such changes could result in greater benefits to some aquatic species and lesser benefits to others. It is anticipated that such changes would be included in the development of permits and authorization of water rights for the Project.

12.3.6.2 *Primary Study Area – Alternative D Relative to the Existing Conditions/No Project/No Action Condition*

Construction, Operation, and Maintenance Impacts

Several Primary Study Area Project facilities would be the same for Alternatives A, B, C, and D and would require the same construction methods and operation and maintenance activities regardless of alternative. Therefore, construction, operation, and maintenance of these facilities in common would have the same impacts on aquatic biological resources. Facilities under Alternative D that are the same as under Alternative A include:

- Sites Reservoir Inlet/Outlet Structure
- Sites Pumping/Generating Plant
- Holthouse Reservoir Complex
- GCID Main Canal Facilities Modifications
- TRR to Funks Creek Pipeline
- Delevan Pipeline Intake/Discharge Facilities

Potential impacts on aquatic biological resources associated with Project features that would differ from Alternative A and any potentially significant impacts on aquatic resources are discussed below.

As under Alternatives B and C, the Alternative D Sites Reservoir would be larger than under Alternative A and require the construction of two more saddle dams (the same as Alternatives B and C) than under Alternative A. However, these additional saddle dams would not be located within or adjacent to a waterway. The Alternative D dams would therefore have the same impacts on fish species of management concern as described for Alternative A.

The South Bridge alignment is similar to Alternative C; however, the alignment varies slightly with an optimized alignment near the east side approach. The different alignment would be within the construction area of the other project alternatives and would not result in additional impacts related to aquatic biological resources.

The proposed North Road would not be constructed under Alternative D, but Eastside Road and Saddle Dam Road would provide access to northern portions of the proposed Sites Reservoir and saddle dams. Gravel connector roads would be built for temporary access from Eastside Road to Holthouse Dam and to Leesville Road to provide access to property on the southern end of Sites Reservoir. The existing Sulphur Gap jeep trail would also be used to provide access to the southern portion of the reservoir for maintenance. The relatively slight differences in roads are not expected to change the potential impacts to aquatic biological resources from those described for the other project alternatives.

Alternative D would include the development of only two recreation areas (Stone Corral Creek Recreation Area and Peninsula Hills Recreation Area) versus five for Alternative C. Alternative D would also include a boat ramp at the western end of the reservoir where the existing Sites Lodoga Road would be inundated. That there would be only two recreation areas under Alternative D would not result in additional impacts related to aquatic resources compared to those described for Alternative C. The road segments providing access to Lurline Headwaters Recreation Area for the other Alternatives would not be required. Alternative D also includes an additional 5.2 miles of roadway from Huffmaster Road to

Leesville Road, which has the potential to affect aquatic resources that would not be affected by Alternatives A and C.

Under Alternative D, the TRR would be slightly smaller (approximately 80 acres smaller for Alternative D); however, this difference is not expected to change the potential impacts to aquatic biological resources from those described for the other project alternatives. In addition, the TRR to Funks Creek Pipeline would be shorter than under the other alternatives; this difference is not expected to change the potential impacts to aquatic biological resources.

For Alternative D, the Delevan Pipeline alignment would be approximately 50 to 150 feet south of the alignment for Alternatives A, B, and C. This alignment takes advantage of existing easements to reduce impacts on local landowners. The shift in alignment is not expected to change the potential impacts to aquatic biological resources from those described for the other project alternatives.

Unlike the other alternatives, Alternative D includes a north-south alignment of the Delevan Overhead Power Line, rather than the east-west alignment between the TRR and the Delevan Pipeline Intake/Discharge Facilities. Alternative D includes a proposed electrical substation west of Colusa in addition to the substation near the Holthouse Reservoir. The Alternative D proposed north-south alignment of the Delevan Overhead Power Line and related substation near the town of Colusa may result in different impacts to aquatic biological resources than the east-west line alignment described above for the other alternatives. The north-south alignment would be approximately 1 mile longer; however, it would be located within an existing transportation and utility corridor along State Route 45 (SR 45), and would result in less impacts than under Alternative C. The installation of the power line and substation would require similar construction methods and operation and maintenance activities as identified for Alternative C, other than the potential incorporation of existing power lines currently along SR 45 into joint facilities for Alternative D.

The Delevan Pipeline Intake/Discharge Facilities included in Alternative D would be the same as the Alternative A facilities. Therefore, the impacts of the intake facilities on fish species of primary management concern (**Impact Fish-1**) would be the same as described for Alternative A.

The boundary of the Project Buffer for alternative D would be the same for Alternatives A, B, and C, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impacts on fish species of management concern as described for Alternative A.

Sites Reservoir Inundation Area

Aquatic Habitat Modification

Construction of a larger 1.8-MAF Sites Reservoir (the same as Alternatives B and C) would have similar potential impacts on aquatic biological resources as discussed for Alternative A, except that construction of Sites Reservoir would eliminate and inundate approximately 4 miles of Stone Corral Creek and 7 miles of Funks Creek upstream of the Sites Reservoir dams, compared to 3.9 miles of Stone Corral Creek and 6.5 miles of Funks Creek under Alternative A. Aquatic habitat removal and modification, specifically the inundation of Funks and Stone Corral creeks associated with the construction of Sites Reservoir under

Alternative D, would result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1a**).

Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant

Aquatic Habitat Modification

Construction of the Sites Reservoir Outlet Structure would permanently remove approximately 0.5 mile of Funks Creek immediately upstream of the existing Funks Reservoir. Potential impacts on fisheries resources associated with aquatic habitat modification under Alternative D would be similar to those discussed for the Sites Reservoir Inlet/Outlet Structure and Sites Pumping/Generating Plant under Alternative A and could, therefore, result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

Holthouse Reservoir Complex

Aquatic Habitat Modification

As described for Alternative A, the construction of the dam, spillway, and stilling basin, and the consequent inundation of Holthouse Reservoir would result in the permanent removal of an approximately 0.8 mile reach of Funks Creek immediately downstream of the existing Funks Reservoir Potential impacts on fisheries resources associated with aquatic habitat modification under Alternative D would be similar to those discussed for the Holthouse Reservoir Complex under Alternative A and could, therefore, result in a **potentially significant impact** on fish and aquatic habitat in Funks Creek (**Impact Fish-1a**).

Delevan Pipeline Intake/Discharge Facilities

Hydrostatic Pressure Waves, Noise, and Vibration

Under Alternative D a cofferdam would be constructed in the Sacramento River along the entire length of the discharge facility (approximately 1200 feet in length) and subsequently dewatered to allow for construction of the facility. Potential impacts on fisheries resources associated with the cofferdam construction would be similar to those discussed for the Delevan Pipeline Intake/Discharge Facilities under Alternative A and could, therefore, result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1c**).

Predation Risk

As described for Alternative A, placement of the cofferdam associated with construction of the Delevan Pipeline Intake/Discharge Facilities, installation of the fish screen, and installation of the proposed Delevan Pipeline alignment at various stream crossings may increase the risk of predation on fish due to dewatering, sound disturbance due to increased underwater noise levels, increased turbidity and provision of habitat for predators, all of which could increase predator opportunities or efficiencies. Potential impacts on fisheries resources associated with the intake/discharge facilities under Alternative D would be similar to those discussed for Alternative A and could, therefore, result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1d**).

Stranding and Entrainment

As described for Alternative A, construction of the cofferdams and intake facilities, and installation of the fish screens at the proposed intake/discharge facility would require dewatering of the area contained by the cofferdam. Stranding is not expected to be a concern for adult Chinook salmon, steelhead, or sturgeon, for the following reasons: (1) they are strong swimmers, (2) they have the ability to vacate the inside of the cofferdam in the unlikely event that they are trapped within the cofferdam upon closure, and (3) stranded adults can be readily returned to the river in the highly unlikely event of entrapment within the cofferdam. However, juveniles are more likely to become trapped behind the cofferdam prior to its closure. In addition, as described for Alternative A, the potential exists for impacts to migration and additional entrainment and impingement of juvenile fish during the diversion of water from the Sacramento River. Because juvenile fish species of management concern may be in the vicinity of construction areas and the facility year-round, dewatering, in-river work during cofferdam placement and removal, and diversions could result in fish impingement, entrainment, and stranding, which would result in a **potentially significant impact (Impact Fish-1e)**.

Aquatic Habitat Modification

As described above for Alternative A, construction of the Delevan Pipeline Intake/Discharge Facilities would include the modification and removal of SRA habitat. Preliminary estimates using GIS indicate that approximately 1.1 acres of Fremont Cottonwood riparian habitat that acts as SRA habitat, and an additional 0.5 acres of Valley Foothill Riparian habitat that may act as a source of IWM inputs to the Sacramento River, would be removed as a result of construction of the intake facilities. The loss and degradation of SRA habitat within the construction footprints and within the access routes, staging areas, and storage and disposal areas could result in an impact on fish species through reduction in the quality of fish habitat and removal of important habitat elements.

Adult, juvenile, and early life stages of fish species of management concern could be present within and downstream of construction, operation, and maintenance areas year-round in the Sacramento River. Potential impacts on fisheries resources associated with aquatic habitat modification at the intake/discharge facilities would be similar to those discussed for Alternative A and could, therefore, result in a **potentially significant impact** on fish species of management concern (**Impact Fish-1b**).

Fish Passage

As described for Alternative A, installation of a cofferdam for the construction of the intake/discharge facilities could physically impede migrating adults, limiting their ability to reach spawning areas, and could hinder migration of juveniles, potentially exposing them to increased predation and unsuitable aquatic habitat conditions. Because the cofferdam would only extend a short distance into the waterway (i.e., 40 feet), relative to the entire width of the Sacramento River, it is not anticipated that the movement of juvenile or adult salmon, steelhead, or sturgeon would be substantially affected. Therefore, installation of a cofferdam is anticipated to result in a **less-than-significant impact** on these species in the Sacramento River.

As described for Alternative A, operation and maintenance of the proposed Delevan facility is anticipated to result in potential impingement, entrainment, and impacts to fish passage resulting in a **potentially significant impact** on salmon and steelhead in the Sacramento River.

Temperature Effects on the Sacramento River

As described for Alternative A, operation of the reservoir would include the ability to release water from proposed outlet structures at nine depths. Given the number of outlets at varying depths included as part of the Project, operations would allow for withdrawing water at suitable depths to manage the release temperatures and generally match Sacramento River temperatures to the extent possible. As shown in Appendix 7F Sites Reservoir Discharge Temperature Modeling, Table ST-4b, releases from Sites Reservoir would not increase water temperatures in the Sacramento River downstream of the facility during the summer and fall in most years/months. Therefore, the potential impacts related to the temperature of water discharged from the Delevan Pipeline Intake/Discharge Facilities into the Sacramento River are considered to be **less than significant**.

12.4 Mitigation Measures

Mitigation measures are provided below and summarized in Table 12-8 for the impacts that have been identified as potentially significant.

Table 12-8
Summary of Mitigation Measures for Sites Reservoir Project Impacts on Aquatic Biological Resources

Impact	Associated Project Facility	LOS Before Mitigation	Mitigation Measure	LOS After Mitigation
Impact Fish-1: A Substantial Adverse Effect (Either Directly, through Habitat Modifications, by Interfering with the Movement of Native Fish Species, or by Impeding the Use of Native Fish Nursery/Rearing Sites) on Any Fish Species of Management Concern, Including Species Identified as a Candidate, Sensitive, or Special-status Species in Local or Regional Plans, Policies, or Regulations, or by CDFW, NMFS, or USFWS.				
Impact Fish-1a: Aquatic Habitat Modification – Stone Corral and Funks Creeks	Sites Reservoir Inundation Area, Sites Dams, Sites Reservoir Inlet/Outlet Structure, Sites Pumping/ Generating Plant, Holthouse Reservoir Complex, Delevan Pipeline, Delevan Pipeline Intake/Discharge Facilities	Potentially Significant	Mitigation Measure Fish-1a: Implement Habitat Restoration Actions – Stone Corral and Funks Creeks	Less Than Significant
Impact Fish-1b: Aquatic Habitat Modification – Sacramento River	Delevan Pipeline Intake/Discharge Facilities	Potentially Significant	Mitigation Measure Fish-1b: Implement Habitat Restoration Actions – Sacramento River	Less Than Significant
Impact Fish-1c: Hydrostatic Pressure Waves, Noise, and Vibration – Delevan Facilities	Delevan Pipeline Intake/Discharge Facilities	Potentially Significant	Mitigation Measure Fish-1c: Perform In-water Pile Driving July through September during Daylight Hours – Sacramento River	Less Than Significant

Impact	Associated Project Facility	LOS Before Mitigation	Mitigation Measure	LOS After Mitigation
Impact Fish-1d: Predation Risk – Delevan Facilities	Delevan Pipeline Intake/Discharge Facilities	Potentially Significant	Mitigation Measure Fish-1d: Design Fish Screen in Compliance with NMFS and CDFW Criteria – Sacramento River	Less Than Significant
Impact Fish-1e: Stranding, Impingement, and Entrainment – Delevan Facilities	Delevan Pipeline Intake/Discharge Facilities	Potentially Significant	Mitigation Measure Fish-1e: Prepare and Implement a Fish Salvage and Rescue Plan – Sacramento River Mitigation Measure Fish-1f: Sites Reservoir Diversion Restrictions for Pulse Flow Protection and Entrainment Minimization	Less Than Significant
Impact Fish-1f: Modification of Pulse Flows and Entrainment during Diversions at the Delevan Facilities	Delevan Pipeline Intake/Discharge Facilities	Potentially Significant	Mitigation Measure Fish-1f: Sites Project Diversion Restrictions for Pulse Flow Protection and Entrainment Minimization	Less Than Significant

Note:

LOS = level of significance

Mitigation Measure Fish-1a: Implement Habitat Restoration Actions – Stone Corral and Funks Creeks

Mitigation would be implemented to minimize temporary and permanent impacts associated with the inundation of up to 4 miles of Stone Corral and miles of 7 Funks associated with the filling of Sites Reservoir. Restoration and compensatory mitigation for these portions of these streams would include the following based on coordination and consultation with the USACE, CDFW, and USFWS:

- A waters and wetland mitigation and monitoring plan shall be developed by a qualified biologist in coordination with USACE, CDFW, and USFWS that details mitigation and monitoring obligations for temporary and permanent impacts to waters and wetlands and other waters as a result of construction activities. The plan shall quantify the total acreage lost, describe mitigation ratios for lost habitat, annual success criteria, mitigation sites, monitoring and reporting requirements, and site specific plans to compensate for wetland losses resulting from the project.
- Purchase or dedication of land to provide wetland preservation, restoration or creation as necessary depending on availability and suitability of on-site options. If restoration is available and feasible, then a ratio of at least 2:1 shall be used. If a wetland needs to be created, at least a 3:1 ratio shall be implemented to offset losses. Where practical and feasible, onsite mitigation shall be implemented including the potential enhancement and restoration of upstream and/or downstream portions of Stone Corral and Funks creeks that would not be inundated by the Project.

Mitigation Measure Fish-1b: Implement Habitat Restoration Actions – Sacramento River

Mitigation would be implemented to minimize temporary and permanent impacts to the portion of the Sacramento River associated with the Delevan Pipeline Intake/Discharge Facilities. Restoration and compensatory mitigation for this portion of the river would include the following based on coordination and consultation with the USACE, CDFW, and USFWS:

- A waters and wetland mitigation and monitoring plan shall be developed by a qualified biologist in coordination with USACE, CDFW, and USFWS that details mitigation and monitoring obligations for temporary and permanent impacts to waters and wetlands and other waters as a result of construction activities (see **Mitigation Measure Fish-1a**).
- As mitigation for loss of riparian and SRA habitat on the Sacramento River, degraded habitat shall be restored to provide riparian and/or SRA habitat at or near the areas affected by construction of the intake/discharge facilities at a ratio of 2:1. Proposed restoration activities are anticipated to include the removal of non-native vegetation as necessary and re-vegetation with native riparian species to provide SRA and/or riparian habitat. As a component of SRA habitat, riparian tree species such as alders, cottonwoods and willows, shall be planted as determined in coordination with the USACE, CDFW, and USFWS.
- Given the importance of instream woody material (IWM) to juvenile fishes in the Sacramento River, all IWM needing to be removed as part of the project shall be identified and recorded by a qualified biologist, and such material returned to the river (if practical), or be replaced with a functional equivalent. Specific restoration actions (including replacement of material at least a 1:1 ratio) shall include planting approach and monitoring of restoration sites and shall be included in the waters and wetland mitigation and monitoring (see **Mitigation Measure Fish-1a**) prepared in coordination with CDFW, USFWS, the USACE and other regulatory agencies as appropriate.

Mitigation Measure Fish-1c: Perform In-water Pile Driving during Daylight Hours

In-water pile driving shall only occur during daylight hours. To avoid impacts on most fish species of primary management concern, sheet pile installation and in-stream heavy equipment activity shall be coordinated with NMFS, USFWS, Reclamation, and CDFW to avoid and or minimize potential impacts. In-water pile driving shall only occur in accordance with the timing restrictions identified in the NMFS Biological Opinion to protect salmonids. Coordination with NMFS related to the Biological Opinion shall identify a preferred in-river construction work window in part based on the cessation of the out-migration of juvenile salmon and before the initiation of the upstream migration of adults returning to spawn as determined necessary in coordination with NMFS and CDFW. If feasible depending on substrate conditions, a vibratory hammer shall be used, and pile driving shall commence at low energy levels and slowly build to impact force. In addition, underwater sound levels shall be monitored to ensure that pile driving activities do not create underwater sound levels that would result in direct injury or mortality (FHWG, 2008).

Mitigation Measure Fish-1d: Design Fish Screen in Compliance with NMFS and CDFW Criteria

Fish screens at the Delevan Pipeline Intake/Discharge Facilities shall be designed to comply with NMFS and CDFW salmonid screening criteria. NMFS and CDFW approach velocity criteria have been established to minimize changes in swimming behavior and fish contact with the screen. The Delevan

Pipeline Intake/Discharge Facilities shall be designed to meet all screening criteria in coordination with NMFS and CDFW.

Mitigation Measure Fish-1e: Prepare and Implement a Fish Salvage and Rescue Plan

The fish screen at the Delevan Pipeline Intake/Discharge Facilities shall be designed to comply with NMFS and CDFW fish screening criteria (**Mitigation Measure Fish 1-d**). In addition, a Fish Salvage and Rescue Plan to be implemented during construction of the Delevan Pipeline Intake/Discharge Facilities shall be developed and approved by NMFS and CDFW prior to initiation of construction activities, and will include the following measures based on coordination with NMFS and CDFW:

- Progress of installation of the cofferdam and the schedule for dewatering and would be coordinated with the construction contractor and fishery biologist to allow for the rescue to occur when water depths are approximately 2 feet (0.6 meters).
- Cofferdam construction shall be completed at the downstream end to minimize the potential for entrainment of salmonids and sturgeon within the enclosed cofferdam.
- A qualified fisheries biologist shall sample the closed cofferdam to ensure that no salmonids of sturgeon have been trapped within the cofferdam.

All rescued salmonids and sturgeon shall be removed and returned to the river. The fisheries biologist shall note the number of individuals entrained, the number of individuals relocated, and the date and time of collection and relocation.

One of more of the following NMFS-approved capture techniques shall be used: dip net, seine, throw net, minnow trap, or hand.

Electrofishing may be used if NMFS and CDFW have reviewed the biologist's qualifications and provided written approval.

The fisheries biologist shall be empowered to halt work activity and to recommend measures for avoiding adverse effects to salmonids and sturgeon and their habitat.

Mitigation Measure Fish 1f: Sites Project Diversion Restrictions for Pulse Flow Protection and Entrainment Minimization

To address the potential for impacts to anadromous fish migration and impacts resulting from fish exposure to the proposed diversion facilities, the Project shall establish and fund an ongoing juvenile salmon trapping program and data collection network to collect real-time data to inform the operation of Sites diversions on behalf of minimizing potential fish impacts. The program shall be developed in coordination with CDFW and NMFS, and designed to augment and draw from other ongoing fish and environmental data collection efforts in the Sacramento River. The data collection and monitoring program is intended to inform the ongoing refinement of fish protection operations.

Based on proposed ongoing monitoring for fish presence, the Project shall protect naturally occurring, storm-induced pulse flows in the Sacramento River from October through May to minimize mortality of out-migrating juvenile winter-, spring-, fall- and late fall-run Chinook salmon, and steelhead. Fish protection shall be accomplished by managing diversions at the three Project diversion points during those pulse flow events that stimulate an important spike in juvenile salmon out-migration.

When a pulse in flow is followed by a rapid increase in juvenile salmon downstream migration, as detected by the monitoring program, the Sites Project will do the following:

- Manage diversions to limit potential impacts to juvenile salmon in the Sacramento River. The allowable level of diversion will be determined based on the results of fish monitoring and flow conditions, and different diversion rates may be assigned to operations during daylight and nighttime hours.
- The above limitations will apply to each diversion, and operations at each facility will be managed independently to fine-tune fish protection, to the extent possible. The limitations on diversion will remain in effect until real-time monitoring associated with that facility indicates that the out-migration pulse in juvenile salmon has past.

Pulse flows during periods of peak out-migration are expected to provide flow continuity between the upper and lower Sacramento River that will help support fish migration. It is recognized that research regarding the benefits of pulse flows is ongoing, and results of the Project monitoring program as well as further research and adaptive management will be needed to refine the pulse flow protection strategy. This measure is expected to reduce potential mortality of juvenile salmon from the Sites Project during their peak out-migration periods by accomplishing the following: (1) minimizing the effects on fish exposed to the diversion facilities, (2) minimizing diversion-related effects on survival, and (3) minimizing reductions in migration travel time.

For impact analysis and simulation modeling purposes, pulse flow events are assumed to be initiated when the 3-day trailing average Bend Bridge flow exceeds 15,000 cfs. Such an event would be considered a “qualified” event limiting diversion if the pulse flow was greater than 15,000 cfs for 7 to 10 days[1]. A pulse flow event would be considered terminated under the following conditions: (1) the 3-day trailing average flow remained greater than 15,000 cfs for 7 to 10 days after initiation (constituting a qualified pulse event), or (2) the 3-day trailing average flow dropped below 15,000 cfs before reaching the 7-day duration (not a qualified event). Up to one qualified pulse event would be recognized in each month during the pulse protection period to minimize potential impacts on fish migration. Diversions to Sites Reservoir storage would be restricted under the following conditions: (1) pulse conditions exist at Bend Bridge, and a qualified pulse event has not already occurred within the given month, and (2) Bend Bridge flows were less than 25,000 cfs during the pulse event (flows above 25,000 cfs are considered to provide lesser benefits to fish migration).

Implementation of **Mitigation Measures Fish-1a, Fish-1b, Fish-1c, Fish-1d, Fish-1e, and Fish-1f** would reduce the level of significance of Project impacts on aquatic biological resources to **less than significant**.