Chapter 11
Fisheries and Aquatic Ecosystems

11.1 Affected Environment

This section describes the affected environment related to fisheries and aquatic ecosystems for the dam and reservoir modifications proposed under the SLWRI. For a more in-depth description of the affected environment, see the *Fisheries and Aquatic Ecosystems Technical Report*.

11.1.1 Aquatic Habitat

Shasta Lake and Vicinity

Water resources development, including the construction of dams and diversions, has affected the hydrology, geomorphology, and ecology of the watershed. Before the construction of Shasta Dam, the Sacramento River typically experienced large fluctuations in flow driven by winter storms, with late-summer flows averaging 3,000 cubic feet per second (cfs) or less. These fluctuations and periodic flows moved large amounts of sediment and gravel out of the mountainous tributaries and down the Sacramento River. The completion of Shasta Dam in 1945 resulted in general dampening of historic high and low flows, reducing the timing, magnitude, and duration of winter floods while maintaining higher summer flows between 7,000 and 13,000 cfs. The annual volume of flow in the Sacramento River continues to vary significantly from year to year. However, average monthly flows following the construction of Shasta Dam no longer exhibit pronounced seasonal winter highs and summer lows. This is primarily because of winter flood control operations that have reduced peak flood flows, and summer releases made for water supply purposes.

The current composition and distribution of fish species inhabiting the study area reflect habitat conditions, the historic fishery, the operational effects of Shasta Dam, effects of dams on several of the upstream tributaries, and the introduction of nonnative species.

The distribution and productivity of organisms and aquatic habitats of Shasta Lake are greatly affected by the reservoir's dynamic seasonal surface elevation fluctuations and thermal stratification. The reservoir's flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months and sometimes into the early-summer months, while storing precipitation and snowmelt runoff. During summer months, the relatively warm surface layer favors warm-water fishes such as bass and catfish. Deeper layers are cooler and are suitable for cold-water species. Shasta Lake is classified as a cool-water, mesotrophic, monomictic reservoir because it is moderately productive and has one period of mixing each year, although it never completely turns over (Bartholow et al. 2001). Shasta Lake tributary fish species comprise several native and nonnative species and have been managed to favor naturally produced ("wild") and stocked (hatchery-cultured) native and nonnative trout species (Rode 1989, Moyle 2002, Rode and Dean 2004). Major assemblages of non-fish aquatic animal species include benthic macroinvertebrates and zooplankton communities. Climate conditions and reservoir storage volume are the two most influential factors affecting cold-water habitat and primary productivity in Shasta Lake (Bartholow et al. 2001). Cold-water habitat provided by Shasta Lake is a function of the total storage and associated surface area provided by Shasta Lake. This relationship is influenced by variation in the water surface elevation (WSEL) throughout the year. Variation in WSEL is a function of water demand, water quality requirements, and inflow, and WSEL can change based on the water-year type. Typically, primary production in reservoirs is associated with storage volumes when all other factors are held constant (Stables et al. 1990). Increased storage and the corresponding increase in surface area results in a greater total biomass and a greater abundance of plankton and fish, because available habitat area is increased.

Upper Sacramento River (Shasta Dam to Red Bluff)

This river reach has cool water temperatures because of regulated releases from Shasta and Keswick Dams, and a stable, largely confined channel with little meander. Riffle habitat with gravel substrates and deep pool habitats are abundant in comparison with reaches downstream, although they are still insufficient to support healthy salmonid populations. Immediately below Keswick Dam, the river is deeply incised in bedrock with very limited riparian vegetation and limited functioning riparian ecosystems. Water temperatures are generally cool, even in late summer, because of regulated releases from Shasta and Keswick Dams. Near Redding, the river flows into the valley and the floodplain broadens. Historically, this area appears to have had wide expanses of riparian forests, but much of the river's riparian zone is currently subject to urban encroachment and noxious weed problems. This encroachment becomes quite extensive in the Anderson/Redding area, with homes placed directly within or adjacent to the riparian zone.

Despite net losses of gravel since construction of Shasta Dam, substrates in much of this reach contain gravel needed for spawning by salmonids, mostly derived from the Central Valley Project Improvement Act (CVPIA) gravel augmentation program. This reach provides much of the remaining spawning and rearing habitat of several listed anadromous salmonids, even though the amount of gravel available is insufficient. For this reason, it is one of the most sensitive and important stream reaches in the State.

Three water control structures, Keswick Dam, Anderson-Cottonwood Irrigation District, and Red Bluff Diversion Dam (RBDD), are located along the Sacramento River in this reach. Currently, revisions are being made at RBDD to improve fish passage. The main tributaries to the Sacramento River between Shasta Dam and Red Bluff are Battle, Bear, Clear, Cow, and Cottonwood creeks. The primary land uses along the Sacramento River between Shasta Dam and RBDD are urban, residential, and agricultural.

Lower Sacramento River and Delta

The roughly 300 miles of the Sacramento River can be subdivided into distinct reaches. The reaches in the lower Sacramento and Sacramento–San Joaquin River Delta (Delta) study area are discussed separately because of differences in morphology, water temperature, and aquatic habitat functions.

Sacramento River from Red Bluff Diversion Dam to Colusa In this reach, the Sacramento River functions as a large alluvial river with active meander migration through the valley floor. The river is classified as a meandering river, where relatively stable, straight sections alternate with more sinuous, dynamic sections (Resources Agency 2003). The active channel is fairly wide in some stretches and the river splits into multiple forks at many different locations, creating gravel islands, often with riparian vegetation. Historic bends in the river are visible throughout this reach and appear as scars of the historic channel locations with the riparian corridor and oxbow lakes still present in many locations. The channel remains active and has the potential to migrate in times of high water. Point bars, islands, high and low terraces, instream woody cover, early successional riparian plant growth, and other evidence of river meander and erosion are common in this reach. The channel has varying widths, and aquatic habitats consist of willow riffles, deep runs, deep pools at meander bends, glides, and willow vegetated floodplain areas that become inundated during high flows.

Sacramento River from Colusa to the Delta The general character of the Sacramento River changes drastically downstream from Colusa from a dynamic and active meandering channel to a confined, narrow channel restricted from migration. While setback levees exist along portions of the river upstream from Colusa, the levees become much narrower along the river edge as the river continues south to the Delta. Surrounding agricultural lands encroach directly adjacent to the levees, which have cut the river off from the majority of its riparian corridor, especially on the eastern side of the river. The majority of the levees in this reach are lined with riprap, allowing the river no erodible substrate. The channel width is fairly uniform and river bends are static as a result of confinement by levees. Therefore, aquatic habitats are fairly homogenous because depth profiles and substrate composition are fairly uniform throughout the reach. Multiple water diversion structures in this reach move floodwaters into floodplain bypass areas during high-flow events.

Tributaries to the Lower Sacramento River Lower reaches of primary tributaries are included because of the potential for project effects on flows and associated flow-related effects on fish species of management concern. However, potential changes in flows are diminished in these areas because of operation of upstream CVP and SWP reservoirs and increasing effects of inflows from tributaries and of diversions and flood bypasses.

Lower Feather River Aquatic habitats found in the lower Feather River vary as the river flows from releases at the DWR Oroville Dam facilities down to the confluence with the Sacramento River at Verona. At the upper extent, the approximate 8-mile low-flow (about 600 cfs) section contains mainly riffles and runs, which provide spawning habitat for the majority of Feather River Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*). Also present in the low-flow channel is a series of remnant gravel pit pools/ponds that connect to the main channel. This stretch is fairly confined by levees as it flows through the city of Oroville. From the downstream end of the low-flow channel, the Feather River is fairly active and meanders its way south to Marysville. However, this stretch is bordered by active farmland, which confines the river into an incised channel in certain stretches. Relatively large areas of adjacent farmlands are in the process of being restored to floodplain habitat with the relocation of levees to become setback levees.

Lower American River Flows in the lower American River (below Folsom and Nimbus dams) are generally cold and clear, providing habitat for anadromous and resident fish species. The river is fairly low gradient and is composed of riffle, run, glide, and pool habitats. Dams along the watershed have reduced gravel inputs to the system, but the lower American River contains large gravel bars and forks in many locations, leaving gravel/cobble islands within the channel. The majority of the lower American River is surrounded by the American River Parkway, preserving the surrounding riparian zone. The river channel does not migrate to a large degree because of the geologic composition that has allowed the river to incise deep into sediments, leaving tall cliffs and bluffs adjacent to the river.

Lower San Joaquin and Stanislaus Rivers The lower San Joaquin River is characterized by a relatively wide (approximately 300 feet) channel with little canopy or overhead vegetation and minimal bank cover. Aquatic habitat in the San Joaquin River is characterized primarily by slow-moving glides and pools, is depositional in nature, and has limited water clarity and habitat diversity. Many of the fish species using the lower San Joaquin River use this lower segment of the river to some degree, even if only as a migratory pathway to and from upstream spawning and rearing areas. The lower river also is used by certain fish species (e.g., delta smelt (*Hypomesus transpacificus*)) that make little to no use of areas in the upper segment of the river (see Delta discussion below). Aquatic habitats in the lower Stanislaus River vary longitudinally and provide fish spawning, rearing, and/or migratory habitat for a diverse assemblage of common Central Valley native and nonnative fish species.

Aquatic habitats include riffles, runs, pools, and glides. Floodplain and associated riparian habitat also varies with the development of levees and encroachment of agriculture and urban uses. Flows in both river systems are highly altered and are managed for flood control and water supply purposes.

Sacramento River Floodplain Bypasses There are three major floodplain bypasses – Butte Basin, Sutter Bypass, and Yolo Bypass – with a total of 10 overflow structures along the mainstem Sacramento River (six weirs, three flood relief structures, and an emergency overflow roadway) that provide access to broad, inundated floodplain habitat during wet years.

Unlike other Sacramento River and Delta habitats, floodplains and floodplain bypasses are seasonally dewatered (as high flows recede) during late spring through autumn. This prevents introduced fish species from establishing year-round dominance except in perennial water sources (Sommer et al. 2003). Moreover, many of the native fish are adapted to spawn and rear in winter and early spring (Moyle 2002) during the winter flood pulse. Introduced fish typically spawn during late spring through summer when the majority of the floodplain is not available to them.

Butte Basin The Butte Basin lies east of the Sacramento River and extends from the Butte Slough outfall gates near Meridian to Big Chico Creek near Chico Landing. Flood flows are diverted out of the Sacramento River into the Butte Basin and Sutter Bypass via several designated overflow areas (i.e., low points along the east side of the river) that allow high flood flows to exit the Sacramento River channel.

Sutter Bypass The Sutter Bypass is a narrow floodwater bypass conveying Sacramento River flood flows from the Butte Basin and the Tisdale Weir. The bypass area is an expansive land area in Sutter County used mainly for agriculture. In times of high water, Sacramento River water enters the bypass through the Butte Slough outfall and the Tisdale Weir (when the stage exceeds 45.45 feet) and inundates the bypass with as much as 12 feet of water. The Sutter Bypass, in turn, conveys flows to the lower Sacramento River region at the Fremont Weir near the confluence with the Feather River and into the Sacramento River and the Yolo Bypass (USACE and The Reclamation Board 2002).

Yolo Bypass The Yolo Bypass is an approximate 59,000-acre land area that conveys Sacramento River flood waters around Sacramento during times of high runoff. Flow is diverted from the Sacramento River into the bypass when the stage exceeds 33.5 feet (corresponding to 56,000 cfs at Verona). Diversion of the majority of Sacramento River, Sutter Bypass, and Feather River floodwaters to the Yolo Bypass from Fremont Weir controls Sacramento River flood stages at Verona. During large flood events, up to 80 percent of Sacramento River flows are diverted into the bypass.

Sacramento-San Joaquin Delta The Delta and Suisun Bay, on the western edge of the Delta, are located at the confluence of the Sacramento and San Joaquin rivers and may be considered to represent the most important, complex, and controversial geographic area for both anadromous and resident fisheries production and distribution of California water resources for numerous beneficial uses (Hanson 2009). The Delta's channels are used to transport water from upstream reservoirs to the south Delta, where Federal and State facilities (Jones Pumping Plant and Harvey O. Banks Delta Pumping Plant, respectively) pump water into CVP and SWP canals, respectively.

Environmental conditions in the Delta depend primarily on the physical structure of Delta channels, inflow volume and source, Delta Cross Channel (DCC) operations, Delta exports and diversions, and tides. The CVP affects Delta conditions primarily through control of upstream storage and diversions, Delta exports and diversions, and DCC operations. These factors also determine outflow and the location of the entrapment zone, which is an area of high organic carbon that is critically important to a number of fish and invertebrate species, as well as to the overall ecology of the Delta and Suisun Bay. In addition to these physical factors, environmental conditions such as water temperature, predation, food production and availability, competition with introduced exotic fish and invertebrate species, and pollutant concentrations all contribute to interactive, cumulative conditions that have substantial effects on Delta fish populations.

Water development has changed the volume and timing of freshwater flows through the San Francisco Bay/Sacramento–San Joaquin River Delta (Bay-Delta). Over the past several decades, the volume of the Bay-Delta's freshwater supply has been reduced by upstream diversions, in-Delta use, and Delta exports. As a result, the proportion of Delta outflow depleted by upstream and Delta diversions has grown substantially. In wet years, diversions reduce outflow by 10 to 30 percent. In dry years, diversions may reduce outflow by more than 50 percent.

Water development has also altered the seasonal timing of flows passing into and through the Bay-Delta. Flows have decreased in April, May, and June and have increased slightly during the summer and fall (SFEP 1992). Seasonal flows influence the transport of eggs and young organisms (e.g., zooplankton, fish eggs, larvae) through the Delta and into San Francisco Bay. Flows during April, May, and June play an especially important role in determining the reproductive success and survival of many estuarine species including salmon, striped bass, American shad, delta smelt, longfin smelt, splittail, and others (Stevens and Miller 1983, Stevens et al. 1985, Herbold 1994, Meng and Moyle 1995).

An estimated 25 percent of all warm-water and anadromous sport fishing and 80 percent of California's commercial fishery depend on species that live in or migrate through the Delta. The Delta serves as a migration path for all Central

Valley anadromous species returning to their natal rivers to spawn. Adult Chinook salmon move through the Delta during most months of the year. Salmon and steelhead juveniles depend on the Delta as transient rearing habitat during migration through the system to the ocean and could remain for several months, feeding in marshes, tidal flats, and sloughs. In addition, Delta outflow influences abundance and distribution of fish and invertebrates in the bay through changes to salinity, currents, nutrient levels, and pollutant concentrations. Delta smelt is a key species driving many of the ongoing water management decisions in the Delta.

Trinity River Sacramento River flow is augmented in average water years by transfer of up to 1 million acre-feet of Trinity River water through Clear Creek and Spring Creek tunnels to Keswick Reservoir (Reclamation 2004). Flows in the Trinity River (below Lewiston Dam) are generally cold, providing habitat for anadromous and resident fish species. Aquatic habitats in the river consist of riffle, run, glide, and pool habitats. Fish habitat values have increased in quantity and quality through restoration activities that have taken place over the last several years. Implementation of the Trinity River Restoration Program is expected to further increase the value of the habitat below Lewiston Dam over the next 10 to 15 years (NMFS 2000).

CVP/SWP Service Areas

The CVP/SWP service areas contain primarily highly altered aquatic habitat types, including reservoirs, canals, ditches, and other manmade water conveyance structures/facilities. Agricultural land and urban development are the dominate land uses within these service areas. As a result of all these factors, the aquatic communities that occupy the habitats are highly adapted to these disturbed environments and are dominated by nonnative species.

11.1.2 Fish Species

Special-status aquatic species within the primary and extended study areas are listed in Table 11-1. These include animals that are legally protected or are otherwise considered sensitive by Federal, State, or local resource conservation agencies and organizations, and fish species of primary management concern (recreationally and/or commercially important species). The *Fisheries and Aquatic Ecosystems Technical Report* describes life histories and environmental/habitat requirements of special-status species, and information on seasonal timing of important life stages. The following text describes the fishes in the primary and extended area that include special-status fish as well as other important species.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	DFG	USFS	MSCS Goals		
Central Valley steelhead *Oncorhynchus mykiss*	T			R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Sacramento-San Joaquin River Delta (Delta).
Sacramento winter-run Chinook salmon *Oncorhynchus tshawytscha*	E	E		R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Central Valley spring-run Chinook salmon *Oncorhynchus tshawytscha*	T	T		R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Central Valley fall/late fall-run Chinook salmon *Oncorhynchus tshawytscha*		SSC	S	R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Southern Oregon Northern California Coasts coho salmon *Oncorhynchus kisutch*	T	T			Requires cold, freshwater streams with suitable gravel for spawning; rears in inundated floodplains, edgewater, off-channel habitat, rivers, tributaries, and estuaries.	Occurs in the extended study area in the Trinity River.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	DFG	USFS	MSCS Goals		
Klamath Mountain Province steelhead *Oncorhynchus mykiss*			S		Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta	Occurs in the extended study area in the Trinity River.
Southern DPS of the North American Green sturgeon *Acipenser medirostris*	T			R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Delta smelt *Hypomesus transpacificus*	T	E		R	Spawns in tidally influenced freshwater wetlands and seasonally submerged uplands; rears in seasonally inundated floodplains, tidal marsh, and Delta.	Occurs in the extended study area in the Delta.
Longfin smelt *Spirinchus thaleichthys*		T		R	Primary habitat is the open water of estuaries, both in seawater and freshwater areas, typically in the middle or deeper areas of the water column; spawn in estuaries in fresh or slightly brackish water over sandy or gravel substrates.	Occurs in the extended study area in the Delta.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	DFG	USFS	MSCS Goals		
Sacramento splittail *Pogonichthys macrolepidotus*	DT	SSC		R	Spawning and juvenile rearing from winter to early summer in willow weedy areas inundated during seasonal flooding in the lower reaches and flood bypasses of the Sacramento River, including the Yolo Bypass.	Occurs in the primary and extended study area in the Delta and Sacramento River and tributaries.
Hardhead *Mylopharodon conocephalus*		SSC	S	m	Spawning occurs in pools and side pools of rivers and creeks; juveniles rear in pools of rivers and creeks, and willow to deeper water of lakes and reservoirs.	Occurs in the primary and extended study areas in freshwater portions of Sacramento River and tributaries.
San Joaquin roach *Lavinia symmetricus* sp.		SSC			Spawning occurs in pools and side pools of small rivers and creeks; juveniles rear in pools of small rivers and creeks.	Occurs in the extended study area in the San Joaquin River and tributaries and Delta.
Rough sculpin (*Cottus asperrimus*)					Prefers sand or gravel substrate in cool streams or reservoirs. Spawns in streams.	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in the Pit River and tributaries upstream from Shasta Lake.
Rainbow trout (*Oncorhynchus mykiss*)					Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries.	Occurs in Shasta Lake, Keswick Reservoir, and tributaries.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	DFG	USFS	MSCS Goals		
Redband trout (*Oncorhynchus mykiss stonei*)			S		Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries.	Occurs upstream from McCloud Dam.
Bull trout *Salvelinus confluentus*	T	E			Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries.	Previously found in the McCloud River. Now considered extirpated from California.
California floater *Anodonta californiensis*			S		Potentially occurring in willow areas of clean, clear ponds, lakes and rivers with silty substrate	Potentially occurs in Shasta Lake, Keswick Reservoir, and tributaries.
Nugget pebblesnail *Fluminicola seminalis*			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in large creeks and rivers tributary to Shasta Lake.
Potem pebblesnail *Fluminicola* sp. 14			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in tributaries to Shasta Lake.
Flat-top pebblesnail *Fluminicola* sp. 15			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in tributaries to Shasta Lake.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	DFG	USFS	MSCS Goals		
Shasta pebblesnail *Fluminicola* sp. 16			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in spring complexes associated with the Sacramento River upstream from Shasta Lake.
Disjunct pebblesnail *Fluminicola* sp. 17			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in spring complexes associated with the Sacramento River upstream from Shasta Lake.
Globular pebblesnail *Fluminicola* sp. 18			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in tributaries to Shasta Lake.
Cinnamon juga *Juga* (*Orebasis*) sp. 3			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in spring complexes associated with the Sacramento River upstream from Shasta Lake.
Canary duskysnail *Lyogyrus* sp. 3			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in spring complexes associated with the Pit River upstream from Shasta Lake.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	DFG	USFS	MSCS Goals		
Knobby rams-horn *Vorticefex* sp. 1			M		Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and Vicinity portion of the primary study area in spring complexes associated with the Pit River upstream from Shasta Lake.

Sources: Vogel and Marine 1991, Moyle 2002, Wang 1986, NMFS 2005

Notes:

[1] Legal Status Definitions

Federal Listing Categories (USFWS & NMFS)
- DT Recently delisted from threatened status
- E Endangered (legally protected)
- T Threatened (legally protected)

State Listing Categories (DFG)
- E Endangered (legally protected)
- SSC Species of Special Concern
- T Threatened (legally protected)

U.S. Forest Service (USFS)
- M Survey and Manage
- S Sensitive

Multi-Species Conservation Strategy Goals
- R Recovery. Recover species' populations within the MSCS focus area to levels that ensure the species' long-term survival in nature.
- m Maintain. Ensure that any adverse effects on the species that could be associated with implementation of CALFED actions will be fully offset through implementation of actions beneficial to the species (CALFED 2000).

Key:
Delta = Sacramento-San Joaquin Delta
DFG = California Department of Fish and Game
DPS = Distinct Population Segment
MSCS = CALFED Bay-Delta Program's Multi-Species Conservation Strategy
NMFS = National Marine Fisheries Service
USFS = U.S. Forest Service
USFWS = U.S. Fish and Wildlife Service

Shasta Lake and Vicinity

Shasta Lake fish species include native and nonnative species, which are dominated by mostly introduced warm-water and cold-water species (Weidlein 1971) (Table 11-2). Major assemblages of non-fish aquatic animal species include benthic macroinvertebrates and zooplankton communities.

Table 11-1 lists special-status aquatic species within the primary and extended study areas. These include animals that are legally protected or are otherwise considered sensitive by Federal, State, or local resource conservation agencies and organizations, and fish species of primary management concern (recreationally and/or commercially important species).

Table 11-2. Fish Species Known to Occur in the Primary Study Area

Common Name	Scientific Name	Distribution Within the Primary Study Area		
		Shasta Lake Tributaries	Shasta Lake/ Keswick Reservoir	Sacramento River – Keswick Dam to RBDD
Chinook salmon	*Oncorhynchus tshawytscha*		X	
winter-run				X
spring-run				X
fall-run				X
late fall-run				X
Rainbow trout	*Oncorhynchus mykiss*	X	X	X
Steelhead trout	*Oncorhynchus mykiss*			X
Brown trout	*Salmo trutta*	X	X	X
Green sturgeon	*Acipenser medirostris*			X
White sturgeon	*Acipenser transmontanus*	X	X	X
Pacific lamprey	*Lampetra tridentata*			X
Western brook lamprey	*Lampetra richardsoni*			X
Sacramento sucker	*Catostomus occidentalis*	X	X	X
Sacramento pikeminnow	*Ptychocheilus grandis*	X	X	X
Hardhead	*Mylopharodon conocephalus*	X	X	X
Sacramento blackfish	*Orthodon microlepidotus*	X	X	
California roach	*Hesperolecus symmetricus*	X		X
Speckled dace	*Rhinichthys osculus*	X	X	
Golden shiner	*Notemigonus crysoleucas*	X	X	
Carp	*Cyprinus carpio*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
White catfish	*Ameiurus catus*		X	X
Brown bullhead	*Ameiurus nebulosus*		X	X
Black bullhead	*Ameiurus melas*		X	X
Riffle sculpin	*Cottus gulosus*	X	X	
Prickly sculpin	*Cottus asper*			X
Rough sculpin	*Cottus asperrimus*	X		
Pit sculpin	*Cottus pitensus*	X		
Bigeye marbled sculpin	*Cottus klamathensis macrops*	X		
Largemouth bass	*Micropterus salmoides*		X	
Smallmouth bass	*Micropterus dolomieui*	X	X	X
Spotted bass	*Micropterus punctulatus*	X	X	
Black crappie	*Pomoxis nigromaculatus*		X	
White crappie	*Pomoxis annulauris*		X	
Bluegill sunfish	*Lepomis macrochirus*		X	
Green sunfish	*Lepomis cyanellus*	X	X	
Threadfin shad	*Dorosoma petenense*		X	
Tule perch	*Hysterocarpus traski*	X	X	X
Tui chub	*Siphateles bicolor*	X	X	

Source: Moyle 2002; Reclamation 2004
Key:
DPS = Distinct Population Segment

Cold-Water Species Shasta Lake and its tributaries provide very productive habitats for cold-water fish species, which typically prefer or require temperatures cooler than 70 degrees Fahrenheit (°F). During the cooler months, cold-water species such as rainbow trout, brown trout, and landlocked Chinook salmon may be found rearing throughout the lake; however, these species do not spawn in the lake, preferring to spawn in tributary streams, however, few Chinook salmon stocked in Shasta Lake have ever been observed to spawn in the reservoir tributaries (J. Zustak, USFWS, pers. comm., 2009). During the summer months, these cold-water species may be found rearing in association with the cold, deep hypolimnion and metalimnion layers within the reservoir, although the fish may make frequent forays into the epilimnion to feed on small prey fish and return to cooler depths to digest their prey (Finnell and Reed 1969, Koski and Johnson 2002, Moyle 2002, Quinn 2005).

Native species such as white sturgeon, hardhead, riffle sculpin, Sacramento sucker, and Sacramento pikeminnow tend to reside in cooler water strata in the reservoir and in and near tributary inflows (Moyle 2002). Trout may also congregate near the mouths of the reservoir's tributaries, including the upper Sacramento River, McCloud River, Pit River, and Squaw Creek, at various times of the year seeking thermal refuge, foraging, and spawning, when conditions are favorable for these species.

Hatchery- and pen-reared trout and salmon are stocked in Shasta Lake several times each year to support the sport fishery. About 60,000 pounds of juvenile rainbow trout and about 50,000 subcatchable Chinook salmon are planted annually (S. Baumgartner, DFG, pers. comm., 2008).

Climate conditions and reservoir storage volume are the two most influential factors affecting cold-water habitat and primary productivity in Shasta Lake (Bartholow et al. 2001). Cold-water habitat provided by Shasta Lake is a function of the total storage and associated surface area provided by Shasta Lake. This relationship is influenced by variation in the WSEL throughout the year. Variation in WSEL is a function of water demand, water quality requirements, and inflow, and WSEL can change based on the water-year type. Typically, primary production in reservoirs is associated with storage volumes when all other factors are held constant (Stables et al. 1990). Increased storage and the corresponding increase in surface area results in a greater total biomass and a greater abundance of plankton and fish, because available habitat area is increased.

Warm-Water Species The warm-water fish habitats of Shasta Lake occupy two ecological zones: the littoral (shoreline/rocky/vegetated) and the pelagic (open water) zones. The littoral zone lies along the reservoir shoreline down to the maximum depth of light penetration on the reservoir bottom, and supports populations of spotted bass, smallmouth bass, largemouth bass, black crappie, bluegill, channel catfish, and other warm-water species.

The upper, surface layer of the pelagic zone is the principal plankton-producing region of the reservoir. Plankton comprises the base of the food web for most of the reservoir's fish populations. Operation of the Shasta Dam temperature control device (TCD), which helps conserve the reservoir's cold-water pool by accessing warmer water for storage releases in the winter, spring, and early summer, may reduce zooplankton biomass in the epilimnion. However, operations of the TCD may result in some increased plankton production at deeper levels as a result of a slight warming of the hypolimnetic layers within the reservoir during the fall months (Bartholow et al. 2001).

Warm-water species, such as largemouth bass, smallmouth bass, spotted bass, and other sunfishes, were introduced into Shasta Lake and have become well established with naturally sustaining populations. Spotted bass are currently the dominant warm-water species in Shasta Lake (S. Baumgartner, DFG, pers. comm., 2006). These warm-water fishes feed primarily on invertebrates while young and become predaceous on other fishes, including engaging in some cannibalism, as they grow. In Shasta Lake, threadfin shad, crayfish, and other invertebrates are most abundant in the diets of these fish (Saito et al. 2001). Spawning activity usually begins during late March or April when temperatures rise to around 60°F. Males generally build the nests in sand, fine gravel, rubble, or debris-covered bottoms at depths between 1 and 20 feet, which varies by species. Spotted bass and catfishes typically spawn at greater depths than the other warm-water species in Shasta Lake. Eggs generally hatch in 3 to 5 days at the predominant springtime water temperatures in Shasta Lake, and males guard the eggs and larvae for up to 4 weeks (Moyle 2002). Fry and juveniles disperse into willow water and prefer areas with vegetation and large rubble as protective cover from predators (Moyle 2002, Ratcliff 2006).

The primary factors affecting warm-water fish abundance and production in Shasta Lake include seasonal reservoir fluctuations, availability of high-quality littoral habitat, and annual climate variations (Ratcliff 2006). The effect of sport fishery harvests on Shasta Lake fish populations is not well understood, although it is generally thought that overfishing of naturally reproducing populations by sport fisheries seldom limits fish abundance (Moyle 2002).

Reservoir level fluctuations, associated shoreline erosion, and suppression of shoreline and emergent vegetation are thought to generally be the most significant factors affecting warm-water fish production in reservoirs, including Shasta Lake (Moyle 2002, Ratcliff 2006). Water level variations influence physical, chemical, and biological processes, which in turn affect fish populations. Reservoir drawdowns reduce water depths and influence thermal stratification and the resulting temperature, dissolved oxygen (DO), and water chemistry profiles.

The typical seasonality of reservoir fluctuations on Shasta Lake can affect year-to-year reproductive success of littoral-spawning fishes, especially the black bass species, by influencing nesting behavior (e.g., abandonment of nests) and dewatering of nests containing eggs in years when reservoir levels decline during the spring and early summer months. Under these same conditions, juveniles may be forced to move to areas with less protection from predation or lower food production. In years when the reservoir rises rapidly and/or extensively during the spring and early summer months, submergence of active bass nests by more than 15 to 20 feet often results in high egg mortality (Stuber et al. 1982, Moyle 2002).

Shoreline and littoral vegetation are important warm-water fish habitat components for sustainable fishery production (Ratcliff 2006). Structural diversity (e.g., submerged trees, brush, rock, boulders, and rubble) provides shelter and feeding areas for fish. During construction of the reservoir, many trees and brush fields were cleared prior to inundation. Portions of the Pit River and Squaw Creek arms were not cleared, as evidenced by the large number of inundated trees observable in certain areas. Clearing efforts reduced the potential structural diversity of the inundated habitat. Vegetative clearing in many reservoirs has resulted in rocks, boulders, and man-made features (e.g., bridge pilings, riprap, marinas) being the only structural habitat features available, especially for bass and other warm-water fishes.

Annual reservoir fluctuations create highly variable conditions for establishment and maintenance of shoreline and littoral-zone vegetation and aquatic invertebrate communities that subsequently impose limitations on warm-water fish production. Exposed shoreline reservoir areas generally require 3 to 4 years to reestablish terrestrial vegetation. The absence of established, rooted aquatic vegetation is a common aquatic habitat factor that limits populations and fishery production for many fish species in reservoirs (Ploskey 1986, Moyle 2002).

The Shasta-Trinity National Forest (STNF), in cooperation with other Federal and State agencies and local nongovernmental organizations, has implemented a habitat improvement program at Shasta Lake. The objective of this program is to increase cover for warm-water fish. As the fishery management agency for Shasta Lake, DFG prepared a Draft Management Plan for Shasta Lake in 1991. This plan, which has not been finalized, acknowledges the benefit to warm-water fish of structural enhancement projects.

STNF, DFG, and nongovernmental organizations have used a variety of materials and techniques to construct structural enhancements (e,g., willow planting, brush structures) to provide warm-water fish habitat within the drawdown zone of Shasta Lake. The materials and techniques have varied because of differences in funding, available materials, site conditions (reservoir levels), longevity, and desired outcome.

According to STNF aquatic biologists, brush structures constructed from whiteleaf manzanita (*Arctostaphylos manzanita)* have been the STNF's preferred means of structural enhancement since about 1990. These structures have been constructed in areas where manzanita is available near the shoreline, typically in manner that provides varying degree of structural habitat as water levels change over time. The biologists have indicated that these structures have typically resulted in a threefold to tenfold increase in the abundance of warm-water fish in the treated areas (J. Zustak, USFWS, pers. comm., 2007).

Tributary Species The lower reaches of the tributaries draining to the reservoir provide spawning habitat for adfluvial fishes (i.e., fish that spawn in streams, but rear and grow to maturity in lakes) residing in Shasta Lake, as well as, stream-resident fishes, with rainbow trout the principal game species. Most native fish species found in Shasta Lake may also inhabit the lower reaches of the tributaries. Several tributaries to Shasta Lake (e.g., Squaw Creek[1], Little Backbone Creek) have been subjected to discharge from abandoned upslope copper mines. The Shasta Lake West Watershed analysis (Bachmann 2000) suggests that these creeks are "biologically dead" as a result of acid mine discharge from these mines. This watershed analysis also stated that "fish kills" have occurred in Shasta Lake in the vicinity of such tributaries during high runoff conditions.

The four main tributaries to Shasta Lake, which include the Sacramento River, McCloud River, Squaw Creek, and Pit River, are renowned for their high-quality recreational trout fisheries. Each of these streams drains considerable watershed areas comprising mixed conifer forests in the reaches above Shasta Lake. With the exception of the Pit River, which has a series of hydroelectric project dams that begin immediately upstream from Shasta Lake, each of these tributaries has more than 30 miles of high-quality, fish-bearing riverine habitat between the Shasta Lake and upstream dams on the Sacramento and McCloud rivers and steep headwater reaches on Squaw Creek.

For the most part, land use along the main Shasta Lake tributaries upstream from the reservoir is a mix of federal and privately managed forest and timberlands and except for sparse residential development, several small municipalities, and the hydropower projects on the Pit, McCloud, and Sacramento rivers much of the area is lightly developed. The Sacramento River above Shasta Lake is paralleled by a major interstate highway and railroad transportation corridor. In July 1991, a railroad accident spilled 19,000 gallons of the fumigant pesticide metam sodium into the Sacramento River near the town of Dunsmuir, approximately 35 stream miles upstream from Shasta Lake. Metam sodium is highly toxic and killed aquatic and riparian vegetation, aquatic macroinvertebrates, and fish and amphibians along the entire length of the river to Shasta Lake, where a massive chemical containment and neutralization effort was mounted. Ecological recovery efforts were implemented shortly after this spill incident and populations of fish, aquatic macroinvertebrates, and the vegetation adjacent to the stream have attained levels that appear to be in a natural dynamic equilibrium consistent with full recovery, although some amphibian and mollusk population remained depressed at least 15 years later (Cantara Trustee Council 2007).

There are about 2,903 miles of ephemeral, intermittent, and perennial stream channels that contribute to the main Shasta Lake tributaries within the study

[1] This refers to a stream draining the terrain and entering Shasta Lake northwest of Shasta Dam, a historic mining district; not to be confused with the Squaw Creek drainage forming the "Squaw Creek Arm" of the lake.

area. Most of these sub-tributaries are relatively short and steep and may be classified as confined, headwater channels that contribute water, sediment, and organic and inorganic material to Shasta Lake. Most (64 percent) of these stream channels are intermittent and have a slope greater than 10 percent. About 14 percent of the stream channels are perennial, with slopes of less than 7 percent. In the Pacific coast and Cascade ranges, stream channels with gradients up to about 4 percent to 7 percent and possessing sufficient flows typically exhibit a good potential to support habitation by fish and other aquatic organisms; although, steeper slopes do not necessarily, in and of themselves, preclude habitation by fish, particularly trout, sculpins, and dace (Naiman 1998; Reeves et al. 1998). About 79 percent of the tributaries with good fish-bearing potential in the study area occur within the Sacramento River, Squaw Creek, and Pit River arms (see Chapter 4, “Geology, Geomorphology, Minerals, and Soils,” for more detail).

Most of the lower gradient, potentially fish-bearing reaches of tributary streams to Shasta Lake are near their confluence with the reservoir. The gradient of most of these tributaries rapidly increases upstream from the shoreline, and natural barriers to fish are common. These barriers are most often created by cascades, waterfalls, and steep reaches of stream channel (i.e., greater than 7-percent slope) that are more than one-quarter mile in length. Stream channel data generated from field inventories and analysis using Reclamation’s geographic information system Digital Elevation Model indicate that most barriers on the perennial tributaries occur near the reservoir (see Chapter 4, “Geology, Geomorphology, Minerals, and Soils,” for more detail).

Upper Sacramento River (Shasta Dam to Red Bluff)

Keswick Reservoir The USFWS conducts a propagation and captive broodstock program for endangered winter-run Chinook salmon at the Livingston Stone National Fish Hatchery located at the base of Shasta Dam on the Sacramento River upstream from Keswick Reservoir. The program consists of collecting adult winter-run Chinook salmon from the mainstem Sacramento River, holding and spawning the adults, rearing the juveniles in the hatchery environment and then releasing them back into the mainstem Sacramento River downstream from Keswick Dam. The overriding goal of the programs is to supplement the endangered population and provide an “insurance policy” against extinction. The propagation program (initiated in 1989), and the captive broodstock program (initiated in 1991) are recognized in both of NMFS’s Draft Recovery Plans (1993, 2009) for this endangered species. Water is supplied to the hatchery from Shasta Dam.

Keswick Reservoir is operated by Reclamation as a reregulating facility. Levels in Keswick Reservoir are subject to operational changes at Whiskeytown and Shasta lakes. The reservoir provides habitat for a variety of aquatic organisms, including native and nonnative fish. Table 11-1 includes the fish species known to occur in Keswick Reservoir. In addition to water released from Shasta Dam and Whiskeytown Lake, this reservoir is the recipient of surface flows and sediment from Spring Creek, as well as groundwater, emanating from the Iron Mountain Mine. Additional information on the relationship between Spring Creek and Keswick Reservoir is provided in Chapter 9, "Hazards and Hazardous Materials."

Keswick Dam to Red Bluff The upper Sacramento River (Keswick Dam to Red Bluff) provides vital fish spawning, rearing, and/or migratory habitat for a diverse assemblage of native and nonnative species. Native species present in this reach of the river can be separated into anadromous (i.e., species that spawn in freshwater after migrating as adults from marine habitat) and resident species. Native anadromous species include four runs of Chinook salmon, steelhead, green and white sturgeon (*Acipenser medirostris* and *A. transmontanus*), and Pacific lamprey (*Lampetra tridentata*). Native resident species include Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento splittail, Sacramento sucker (*Catostomus occidentalis*), hardhead (*Mylopharodon conocephalus*), California roach (*Lavinia symmetricus*), and rainbow trout (*O. mykiss*). Nonnative resident species include largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), white and black crappie (*Pomoxis annularis* and *P. nigromaculatus*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), black bullhead (*Ameirus melas*), brown bullhead (*Ameirus nebulosus*), bluegill (*Lepomis* macrochirus), green sunfish (*Lepomois cyanellus*), and golden shiner (*Notemigonus crysaleucas*).

See Table 11-1 for a list of special-status species with the potential to occur in the upper Sacramento River.

Lower Sacramento River and Delta Like the primary study area, habitats in the extended study area also provides vital fish spawning, rearing, and/or migratory habitat for a diverse assemblage of native and nonnative species, many of which are the same as those found in the primary study area (see the *Fisheries and Aquatic Ecosystems Technical Report*), including Chinook salmon, steelhead and sturgeon.

Trinity River The Trinity River provides habitat for Southern Oregon/Northern California Coast coho salmon (*Oncorhynchus kisutch*), Southern Oregon/Northern California Coast Chinook salmon, Klamath Mountains Province steelhead, green sturgeon, white sturgeon, Pacific lamprey, resident rainbow trout, speckled dace, three-spine stickleback, Klamath small scale sucker (*Catostomus rimiculus*), prickly sculpin, and riffle sculpin (*Cottus gulosus*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) American shad, brown bullhead, golden shiner, and green sunfish. Coho salmon and Klamath Mountains Province steelhead are included in this discussion because they are special-status species and CVP and SWP operations in response to changes at Shasta Dam have the potential to affect Trinity River flows.

See Table 11-1 for a list of special-status species with the potential to occur in the Trinity River.

CVP/SWP Service Areas

See Table 11-1 for a list of special-status species with the potential to occur in the CVP/SWP Service Areas.

11.1.3 Aquatic Macroinvertebrates

The constant flow of water in river systems provides an energetically convenient and economical way to disperse to new habitats; this movement downstream is known as drift. Some invertebrates passively enter the drift (e.g., benthic organisms may be entrained in the water column when a large current sweeps through), and others exhibit active drift behavior (individuals actively enter the water column by voluntary actions) (Waters 1965, 1972; Müller 1974; Wiley and Kohler 1984). Macroinvertebrates drift to colonize new habitats (for dispersal of various life stages or to find suitable resources), or leave unsuitable habitats (in response to habitat quality or predation pressure). Drift is one of the most important downstream dispersal mechanisms for macroinvertebrates. Macroinvertebrates drift more commonly in the evening, usually at dusk (Waters 1972, Müller 1974, Wiley and Kohler 1984, Smock 1996).

Drifting invertebrates are the primary source of prey for juvenile fish, including salmonids (Chapman and Bjornn 1969). Juvenile Chinook salmon will often seek refuge in slow-velocity habitats where they can rest and drifting invertebrates will tend to be deposited.

Shasta Lake and Vicinity

Aquatic macroinvertebrates provide an important food base for many fish and wildlife species. In general, published information on the taxonomy, distribution, and abundance of macroinvertebrates in the Sacramento River drainage is limited. A large-scale monitoring effort in 2001 coordinated by DWR from Keswick Dam to Verona on the Sacramento River found that benthic macroinvertebrate diversity and richness decreased as the river moved downstream. The constant flow of water in river systems provides an energetically convenient and economical way to disperse to new habitats; this movement downstream is known as drift. Drift is one of the most important downstream dispersal mechanisms for macroinvertebrates and drifting invertebrates are the primary source of prey for juvenile fish, including salmonids (Chapman and Bjornn 1969).

Invasive Species

New Zealand Mudsnail The New Zealand mudsnail (*Potamopyrgus antipodarum*), known to have been introduced to North America since about 1987 (Bowler 1991), was identified in Shasta Lake at the Bridge Bay Marina on September 10, 2007 (Benson and Kipp 2011). New Zealand mudsnail have also been found lower in the Central Valley, including Sacramento River near Red Bluff, and the American, Mokelumne and Calaveras rivers (Benson and Kipp 2011). This invasive aquatic mollusk is known from a number of other locations within California and can reach densities of over 500,000 snails per square meter. Densities can fluctuate seasonally, with lowest densities coinciding with the freezing winter months (Proctor et al. 2007). New Zealand mudsnails are highly effective competitors and predators of many native North American benthic macroinvertebrates, including other mollusks, crustaceans, and important aquatic insects. Predators of the New Zealand mudsnail include rainbow trout, brown trout, sculpins, and mountain whitefish (Proctor et al. 2007). Unfortunately, snails are capable of passing through the digestive system of fish alive and intact (Bondesen and Kaiser 1949; Haynes et al.1985).

Possible pathways of introduction into Shasta Lake include contaminated recreational watercraft and trailers and recreational water users (Proctor et al. 2007). Other vectors known to spread the snails, such as contaminated livestock, commercial ships, and dredging/mining equipment, are less likely in the case of Shasta Lake's recent invasion given the lack of commercial activities on the lake. If the particular clone detected in Shasta Lake is tolerant of the local conditions, a rapid colonization of the lake and its tributaries could occur through a variety of vectors.

The potential involvement of recreational watercraft and trailers and recreational water users in the translocation of New Zealand mudsnails between State waters is of immediate concern. Enlargement of Shasta Lake could provide a larger perimeter of shoreline accessibility for the snail, but not necessarily increase preferred lake habitats. In lakes in North America, New Zealand mudsnails do not commonly occupy shoreline habitats. Highest densities of New Zealand mudsnails occur between 20-25 meters (m) in Lake Ontario (Proctor et al. 2007).

Quagga Mussel   Quagga mussels (*Dressenia bugensis*), an invasive European aquatic mollusk introduced to North America in ship ballast water and first discovered in Lake Erie in 1989 (Spidle et al. 1994), have not been found in Shasta Lake, to date, but were discovered in California at Lake Havasu in 2007 (Cohen 2007). The DFG has begun monitoring at Lake Shasta for adult mussels and veligers (S. Baumgartner, DFG, pers. comm., 2008). Possible pathways of introduction into Shasta Lake include contaminated recreational watercraft and trailers and recreational water users. The potential involvement of recreational watercraft and trailers and recreational water users in the translocation of quagga mussels between State waters is of immediate concern. Enlargement of Shasta Lake could provide a greater area of deepwater and littoral habitat available for occupation by quagga mussels.

In a 2007 report produced for DFG, Cohen (2007) described the temperature, calcium, pH, DO, and salinity tolerances of quagga mussels in an effort to assess the vulnerability of various California waters to invasion by quagga mussels and zebra mussels. Cohen identified calcium thresholds as the most important environmental factor influencing distribution of zebra mussels in North America and applied similar thresholds for quagga mussels. In an investigation of the upper Sacramento River region, including Whiskeytown Reservoir and the watersheds above Shasta Dam, Cohen found that the McCloud River above Shasta Reservoir and the Pit River near Canby have the proper range of salinity, DO, temperature and calcium (at less than or equal to 12 milligrams per liter to be of low and moderate suitability to invasion by quagga mussels.

Upper Sacramento River (Shasta Dam to Red Bluff)

A large-scale monitoring effort in 2001 coordinated by DWR from Keswick Dam to Verona on the Sacramento River found that benthic macroinvertebrate diversity and richness decreased as the river moved downstream. Oligochaetes, chironomids, and mollusks became more prominent in this reach than in the reach from Keswick Dam to Red Bluff (Sacramento River Watershed Program 2002). More recently, the diurnal feeding habits of juvenile Chinook salmon in the upper Sacramento River (River Mile 193 to River Mile 275) were examined in relation to drifting invertebrates by Petrusso and Hayes (2001). Chironomids and baetids dominated both the drift and stomach contents. Diets of 153 juvenile salmonids were examined; more than 63 percent of the diet was made up of chironomids of all life stages. Baetids comprised 14 percent of the total diet. It was concluded that based on measurements of mean stomach fullness and availability of drifting organisms, there was reasonable feeding opportunity during the sampling period in spring 1996. Mean drift densities ranged from 211 to 2,100 organisms per 100 cubic meters, with an overall mean of 617 organisms per 100 cubic meter (Petrusso and Hayes 2001). Daily mean drift density appeared to show no spatial patterns across the several sites sampled.

Lower Sacramento River and Delta

Aquatic macroinvertebrates provide an important food base for many fish and wildlife species. In general, published information on the taxonomy, distribution, and abundance of macroinvertebrates in the Sacramento River drainage is limited. Current macroinvertebrate monitoring efforts on the Sacramento River have focused on large-basin scale patterns, and survey sites on the mainstem have been at various locations along the study reach. Under the Sacramento River Watershed program, DFG collected snag samples at two sites, one site near Colusa and one site near Hamilton City. Dominant taxa found in fall 1999 at the Hamilton City site include Orthocladiinae, Naididae, Ephemeroptera (*Baetis* and *Acentrella* sp.) and Trichoptera (*Hydropsyche* sp.) (Sacramento River Watershed Program 2002). Schaffter et al. (1983) found no significant difference in abundance of drifting invertebrates near riprapped and natural habitats on the Sacramento River. More than 50 percent of the drift was composed of chironomids, baetids, and aphids. Analysis of fish diets found the same three families in 72 percent of the guts sampled.

A large-scale monitoring effort in 2001 coordinated by DWR from Keswick Dam to Verona on the Sacramento River found that benthic macroinvertebrate diversity and richness decreased as the river moved downstream. Oligochaetes, chironomids, and mollusks became more prominent in this reach than in the reach from Keswick Dam to Red Bluff (Sacramento River Watershed Program 2002). More recently, the diurnal feeding habits of juvenile Chinook salmon in the upper Sacramento River (River Mile 193 to River Mile 275) were examined in relation to drifting invertebrates by Petrusso and Hayes (2001). Chironomids and baetids dominated both the drift and stomach contents. Diets of 153 juvenile salmonids were examined; more than 63 percent of the diet was made up of chironomids of all life stages. Baetids comprised 14 percent of the total diet. It was concluded that based on measurements of mean stomach fullness and availability of drifting organisms, there was reasonable feeding opportunity during the sampling period in spring 1996. Mean drift densities ranged from 211 to 2,100 organisms per 100 cubic meters, with an overall mean of 617 organisms per 100 cubic meter (Petrusso and Hayes 2001). Daily mean drift density appeared to show no spatial patterns across the several sites sampled.

11.2 Regulatory Framework

Several Federal, State, and local agencies have regulatory authority or responsibility over activities that affect aquatic and fisheries resources. These regulatory authorities are described in the following sections.

11.2.1 Federal

Federal Endangered Species Act

Pursuant to the Federal Endangered Species Act (ESA), USFWS and NMFS have authority over projects that may result in take of a Federally listed species. Under the ESA, the definition of “take” is to “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Under Federal regulation, “take” is further defined to include habitat modification or degradation where it would be expected to result in death or injury to listed wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. If the project may affect a Federally listed species, either an incidental take permit, under Section 10(a) of the ESA, or a Federal interagency consultation, under Section 7 of the ESA, is required. USFWS has regulatory jurisdiction over freshwater and estuarine fishes (such as delta smelt), while NMFS has jurisdiction over anadromous and marine species (such as Chinook salmon, steelhead, and green sturgeon).

NMFS Recovery Plan

Under Section 4(f) of the ESA, both NMFS and USFWS are required to publish a recovery plan for each species it lists as threatened or endangered. These plans must have objective and measureable criteria that would help the species be removed from the ESA list, a description of site-specific management actions necessary for the species recovery, and estimates of time and cost to carry out the recommended recovery measures.

In 2009, NMFS published the *Public Draft Recovery Plan for Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and Distinct Population Segments of Central Valley Steelhead* (NMFS 2009). In this recovery plan, NMFS states that the recovery of winter-run Chinook salmon is affected by the Shasta cold-water pool:

> *Although the status of the Sacramento River winter-run Chinook salmon population numbers has shown improvement over the last six years, there is still only one naturally-spawned component of the ESU, and this single population depends on coldwater releases from Shasta Dam on the Sacramento River. Lindley et al. (2007) considers the Sacramento River winter-run Chinook salmon population at a moderate risk of extinction primarily due to the risks associated with only one existing population. The viability of an ESU that is represented by a single population is vulnerable to changes in the environment through a lack of spatial geographic diversity and genetic diversity that result from having only one population. A single catastrophe with effects persisting for four or more years could extirpate the entire Sacramento River winter-run Chinook salmon ESU (Lindley et al. 2007). Such potential catastrophes include volcanic eruption of Mt. Lassen, prolonged drought which depletes the coldwater pool in Shasta Reservoir or some related failure to manage coldwater storage, a spill of toxic materials with effects that persist for four or more years, or a disease outbreak. Moreover, an ESU that is represented by a single population is vulnerable to the limitation in life history and genetic diversity that would otherwise increase the ability of individuals in the population to withstand environmental variation.*

While the action plans surrounding this issue of cold-water pool are focused primarily on reintroduction into the upper watershed (upstream from Shasta Dam), these actions may not be achievable. Improving the cold-water pool could negate any impacts to the species recovery if the reintroduction process is not successful. Additionally, NMFS includes management actions to improve gravel augmentation programs in the upper Sacramento River.

Sustainable Fisheries Act (Essential Fish Habitat)

In response to growing concern about the status of United States fisheries, Congress passed the Sustainable Fisheries Act of 1996 (Public Law 104-297) to amend the Magnuson-Stevens Fishery Conservation and Management Act

(Public Law 94-265), the primary law governing marine fisheries management in the Federal waters of the United States. Under the Sustainable Fisheries Act, consultation is required by NMFS on any activity that might adversely affect essential fish habitat. Essential fish habitat includes those habitats that fish rely on throughout their life cycles. It encompasses habitats necessary to allow sufficient production of commercially valuable aquatic species to support a long-term sustainable fishery and contribute to a healthy ecosystem.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act requires Federal agencies to consult with USFWS, NMFS, and State fish and wildlife resource agencies before undertaking or approving projects that control or modify surface water. The recommendations made by these agencies must be fully considered in project plans by Federal agencies.

Clean Water Act, Section 404

Section 404 of the Clean Water Act (CWA) requires project proponents to obtain a permit from the USACE before performing any activity that involves any discharge of dredged or fill material into “waters of the United States,” including wetlands. Waters of the United States include navigable waters of the United States, interstate waters, all other waters where the use or degradation or destruction of the waters could affect interstate or foreign commerce, tributaries to any of these waters, and wetlands that meet any of these criteria or that are adjacent to any of these waters or their tributaries. Many surface waters and wetlands in California meet the criteria for waters of the United States.

Clean Water Act, Section 402

CWA Section 402 regulates construction-related stormwater discharges to surface waters through the National Pollutant Discharge Elimination System program, which is administered by the U.S. Environmental Protection Agency. In California, the State Water Resources Control Board (SWRCB) is authorized by the U.S. Environmental Protection Agency to oversee the National Pollutant Discharge Elimination System program through the regional water quality control boards (RWQCB), in this case, the Central Valley RWQCB.

Clean Water Act, Section 401

CWA Section 401(a)(1) specifies that any applicant for a Federal license or permit to conduct any activity that may result in any discharge into navigable waters will provide the Federal licensing or permitting agency with a certification that any such discharge will not violate State water quality standards. The RWQCBs administer the Section 401 program with the intent of prescribing measures for projects that are necessary to avoid, minimize, and mitigate adverse impacts on water quality and ecosystems.

Central Valley Project Improvement Act

Reclamation’s evolving mission was written into law on October 30, 1992, with the passage by Congress and signing by President George H.W. Bush, of Public

Law 102-575, the Reclamation Projects Authorization and Adjustment Act of 1992. Included in the law was Title 34, the CVPIA. The CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement having equal priority with power generation. The following are among the changes mandated by the CVPIA:

- Dedicating 800,000 acre-feet annually to fish, wildlife, and habitat restoration
- Authorizing water transfers outside the CVP service area
- Implementing the Anadromous Fish Restoration Program (AFRP)
- Creating a restoration fund financed by water and power users
- Providing for the Shasta temperature control device
- Implementing fish passage measures at RBDD
- Planning to increase the CVP yield
- Mandating firm water supplies for Central Valley wildlife refuges
- Meeting the Federal trust responsibility to protect fishery resources on the Trinity River

The CVPIA is being implemented on a broad front. The Final Programmatic Environmental Impact Statement for the CVPIA analyzes projected conditions in 2022, 30 years from the CVPIA's adoption in 1992. The Final Programmatic Environmental Impact Statement was released in October 1999, and the CVPIA Record of Decision (ROD) was signed on January 9, 2001.

Operations of the CVP reflect provisions of the CVPIA, particularly Sections 3406(b)(1), (b)(2), and (b)(3). The U.S. Department of the Interior's Decision on Implementation of Section 3406(b)(2) of the CVPIA, October 5, 1999, provides the basis for implementing upstream and Delta actions with CVP delivery capability. The AFRP assumes that Sacramento River water will be acquired under Section 3406(b)(2).

Ecosystem Restoration Program Plan of the CALFED Bay-Delta Program

The mission of the CALFED Bay-Delta Program (CALFED) is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. The program addresses problems in four resource areas: ecosystem quality, water quality, system integrity, and water supply reliability. Programs to address problems in the four resource areas will be designed and integrated to fulfill the CALFED mission.

The goal for ecosystem quality is to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species. The CALFED Ecosystem Restoration Program Plan (ERPP) addresses this goal. The foundation of the ERPP is restoration of ecological processes that are associated with streamflow, stream channels, watersheds, and floodplains. These processes create and maintain habitats essential to the life history of species dependent on the Delta. In addition, the ERPP aims to reduce the effects of stressors that inhibit ecological processes, habitats, and species.

Key restoration actions for Sacramento River fisheries being proposed by this ERPP include the following:

- Enhancing river flows
- Restoring the natural river meander process
- Enhancing riparian and riverine habitats
- Maintaining suitable river temperatures for salmonids
- Reducing fish losses at points of water diversion
- Improving anadromous fish passage at existing barriers
- Maintaining and improving water quality
- Improving hatchery and stocking programs
- Improving management of inland harvest of salmonids

Such restoration actions, when implemented over the next few decades, are expected to increase Sacramento River fish populations, including salmonid populations, over existing conditions. The ERPP establishes similar restoration goals for other major water courses throughout the Central Valley.

Operating Agreements and Constraints

Coordinated Operations Agreement With the goal of using coordinated management of surplus flows in the Delta to improve Delta export and conveyance capability, the Coordinated Operations Agreement (COA) received Congressional approval in 1986 and became Public Law 99-546. The COA, as modified by interim agreements, coordinates operations between the CVP and SWP and provides for the equitable sharing of surplus water supply. The COA requires that the CVP and SWP operate in conjunction to meet State objectives for water quality in the Bay-Delta estuary, except as specified. Under this agreement the CVP and SWP can each contract for the purchase of surplus water supplies from the other, potentially increasing the efficiency of water operations.

The COA specifies two basic conditions for operational purposes: balanced conditions and excess conditions. Balanced water conditions occur when releases from upstream reservoirs plus unregulated flow equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. During balanced water conditions, storage releases required to meet the Sacramento in-basin uses are made 75 percent from the CVP and 25 percent from the SWP. If unstored water is available during balanced conditions, this water is allocated 55 percent to the CVP and 45 percent to the SWP. Excess water conditions occur when Delta inflows (combined releases from upstream reservoirs and unregulated flow) are greater than needed to meet in-basin uses plus export. Under this condition, flow through the Delta is adequate to meet all needs and no coordinated operation between the CVP and SWP is required.

Since 1986, the COA principles have been modified to reflect changes in regulatory standards, facilities, and operating conditions. At its inception, the COA water quality standards were those of the 1978 Water Quality Control Plan; these were subsequently modified in the 1991 Water Quality Control Plan. The adoption of the 1995 Bay-Delta Plan by the SWRCB superseded those requirements. The Environmental Water Account was established by CALFED in 2000 to protect the fish of the Bay-Delta estuary via changes in the operations of the CVP and SWP, without incurring uncompensated cost to the projects' water users. Evolution of the CWA over time has also impacted the implementation of the COA.

Biological Opinions Biological Opinions (BO) are prepared through formal consultation of Section 7 of the ESA (described above) by either NMFS or USFWS in response to a Federal action affecting a listed species. On February 12, 1993, NMFS issued a long-term BO regarding the operational impacts of the CVP on winter-run Chinook salmon (NMFS 1993). Based on Reclamation's *Long-Term Central Valley Project Operations Criteria and Plan* and biological assessment of impacts, the BO concluded that the proposed long-term operations of the CVP and SWP would likely jeopardize the continued existence of winter-run Chinook salmon, and identified "Reasonable and Prudent Alternatives" (RPA) to avoid jeopardy. The RPAs consisted of 13 separate actions that changed the pattern of storage and withdrawal at Shasta, Trinity, and Whiskeytown Reservoirs for the purpose of improving water temperature control and protecting Sacramento River winter-run Chinook salmon (NMFS 1993). Since that time, many of the original RPA actions have been amended or incorporated into the 1995 Water Quality Control Plan Decision 1641. Therefore, these components of the RPA have become part of the baseline conditions.

Actions that have not changed include:

- Water year forecasting based on a 90 percent probability of exceedence

- Maintaining a minimum 3,250 cfs flow below Keswick Dam from October 1 through March 30
- Implementing ramp-down rates for Shasta Dam releases from July 1 through March 31
- Locating temperature compliance points based on annual plans
- Raising RBDD gates between September 15 and May 15 every year
- Monitoring of winter-run Chinook salmon juveniles in the Delta
- Monitoring entrainment loss of winter-run Chinook salmon juveniles at Rock Slough Pumping Plant
- Monitoring of incidental take at the CVP and SWP Delta pumping facilities

On October 22, 2004, NMFS issued a BO regarding effects of the Long-Term Operations Criteria and Plan (OCAP) for the CVP in coordination with the SWP on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, Southern Oregon Northern California Coastal Coho salmon, and Central California Coast steelhead and their designated critical habitat. The 2004 BO supersedes the 1993 BO issued by NMFS. It contains reasonable and prudent measures and terms and conditions that specify all of the following:

- Fisheries monitoring actions
- Augmentation of spawning gravel
- Forecasting of deliverable water management of cold-water supply within reservoirs
- Temperature monitoring
- Adaptive management processes to analyze annual cold-water management
- Minimization of flow fluctuations
- Passage at RBDD
- Operation of gates in the Delta
- Fish screening at pumping facilities
- Numerous other effects minimization measures

With the signing of the Principles for Agreement for the Bay-Delta Plan, USFWS agreed to initiate immediate reconsultation on the BO it had issued on February 4, 1994, which addressed the effects of the combined operations of the CVP and SWP on delta smelt for the period of February 15, 1994, through February 15, 1995. In that opinion, USFWS had concluded that the proposed operations of the CVP and SWP would result in jeopardy; therefore, RPAs were included in the BO, which consisted of specific operational criteria that the CVP and SWP would implement (USFWS 1994).

On March 6, 1995, USFWS issued a revised BO for delta smelt. This opinion states that the proposed long-term combined CVP and SWP operations, as modified by the BO for winter-run Chinook salmon, the Principles for Agreement, and the Bay-Delta Plan (draft at the time), are not likely to jeopardize the continued existence of the threatened delta smelt or adversely modify its critical habitat. The BO identifies water quality standards and operational constraints that would provide benefits to delta smelt.

In response to litigation, the 2004 and 2005 BOs were remanded to USFWS and NMFS for revision, but were not vacated. USFWS and NMFS released revised BOs in 2008 and 2009, respectively. Since the revised BOs continue to be locked in controversy and litigation, the 2004 and 2005 BOs are assumed to be govern operations for SLWRI analysis. Further revised BOs are anticipated prior to the release of the final version of this document; final analysis will consider conditions dictated by the BOs in place at that time.

Real-Time Decision-Making to Assist Fishery Management

Reclamation and DWR work closely with USFWS, NMFS, DFG, and other agencies to coordinate the operation of the CVP and SWP with fishery needs. This coordination is facilitated through several forums, as discussed below.

CALFED Water Operations Management Team The Water Operations Management Team (WOMT) was established to facilitate decision making at the appropriate levels and provide timely support of decisions. This team, which first met in 1999, consists of management-level participants from Reclamation, DWR, USFWS, NMFS, and DFG. The WOMT meets frequently to provide oversight and decision making that must routinely occur within the CALFED Ops Group process. The WOMT relies heavily on other teams and work groups for recommendations on fishery actions. It also utilizes the CALFED Ops Group (see below) to communicate with stakeholders about its decisions. Although the goal of the WOMT is to achieve consensus on decisions, the agencies retain their authorized roles and responsibilities.

CALFED Ops Group The CALFED Ops Group consists of participants from Reclamation, DWR, USFWS, NMFS, DFG, SWRCB, and U.S. Environmental Protection Agency. The CALFED Ops Group generally meets 11 times a year in a public setting to discuss CVP and SWP operations, CVPIA implementation, and coordination with efforts to protect endangered species. The CALFED Ops

Group held its first public meeting in January 1995, and during the next 6 years the group developed and refined its process. The CALFED Ops Group is recognized within SWRCB D-1641 and elsewhere as a forum where agencies can consult and achieve consensus on coordinating CVP and SWP operations with endangered species, water quality, and CVPIA requirements. Decisions made by the CALFED Ops Group have been incorporated into the Delta standards to protect beneficial uses of water (e.g., export/inflow ratios and some closures of DCC gates).

Several teams were established as part of the Ops Group. These teams are described below.

Operations and Fishery Forum The stakeholder-driven Operations and Fishery Forum disseminates information about recommendations and decisions regarding CVP and SWP operations. Forum members are considered the contact people for their respective agencies or interest groups when the CALFED Ops Group needs to provide information about take of listed species or address other topics or urgent issues. Alternatively, the CALFED Ops Group may direct the Operations and Fishery Forum to recommend operational responses to issues of concern raised by member agencies.

Data Assessment Team The Data Assessment Team consists of technical staff members from the agencies and stakeholders. The team meets frequently during the fall, winter, and spring to review and interpret data relating to fish movement, location, and behavior. Based on its assessments and information about CVP and SWP operations, the Data Assessment Team recommends potential changes in operations to protect fish.

B2 Interagency Team The B2 Interagency Team was established in 1999 and consists of technical staff members from the agencies. The team meets weekly to discuss implementation of Section 3406(b)(2) of the CVPIA, which defines the dedication of CVP water supply for environmental purposes. It communicates with the WOMT to ensure coordination with the other operational programs or resource-related aspects of project operations.

Fisheries Technical Teams Several fisheries-specific teams have been established to provide guidance on resource management issues. These teams are described below.

The Sacramento River Temperature Task Group The Sacramento River Temperature Task Group (SRTTG) is a multiagency group formed pursuant to SWRCB Water Right Orders 90-5 and 91-1 to help improve and stabilize the Chinook salmon population in the Sacramento River. Reclamation develops temperature operation plans each year for the Shasta and Trinity Divisions of the CVP. These plans consider impacts of CVP operations on winter-run and other races of Chinook salmon. The SRTTG meets in the spring to discuss biological and operational information, objectives, and alternative operations plans for temperature control, then recommends an operation plan for temperature control. Reclamation then submits a report to SWRCB, generally on or before June 1 each year.

After the operation plan is implemented, the SRTTG may perform additional studies and hold meetings to revise the plan based on updated biological data, reservoir temperature profiles, and operations data. Updated plans may be needed for summer operations to protect winter-run Chinook salmon, or in fall for the fall-run spawning season. If any changes are made to the plan, Reclamation submits a supplemental report to the SWRCB.

Salmon Decision Tree The fishery agencies and project operators use the Chinook Salmon Protection Decision Process to address the often-complex coordination issues surrounding DCC gate operations and the purposes of closures for fishery protection; Delta water quality; and/or export reductions. Inputs such as fish life stage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions. The coordination process has worked well during recent fall and winter DCC operations, and its continued use (in either the present form or a modified version) is expected in the future.

Delta Smelt Working Group The Delta Smelt Working Group was established in 1995 to resolve biological and technical issues regarding delta smelt and to develop recommendations for consideration by USFWS. The working group generally acts when Reclamation and DWR seek consultation with USFWS on delta smelt or when unusual salvage of delta smelt occurs. It also has assisted in developing strategies to improve habitat conditions for delta smelt.

The Delta Smelt Working Group employs a delta smelt decision tree when forming recommendations to send to the WOMT. The working group does not decide what actions will be taken and does not supplant the Data Assessment Team, but merely provides additional advice to the WOMT. The group may propose operations modifications that it believes will protect delta smelt, either by reducing take at the export facilities or by preserving smelt habitat. The decision tree is adapted by the working group as new knowledge becomes available.

American River Operations Work Group In 1996, Reclamation established an operational working group for the lower American River, known as the American River Operations Work Group. Although open to anyone, the working group's meetings generally include representatives from several agencies and organizations with ongoing concerns about management of the lower American River: Reclamation, USFWS, NMFS, DFG, the Sacramento Area Flood Control Agency, the Water Forum, the City of Sacramento, Sacramento County, the Western Area Power Administration, and the Save the

American River Association. The American River Operations Work Group convenes at least monthly to provide fishery updates and reports to enable Reclamation to better manage Folsom Reservoir for fish resources in the lower American River.

San Joaquin River Agreement Technical Committee The San Joaquin River Agreement Technical Committee meets to plan and implement the Vernalis Adaptive Management Plan each year. The committee oversees two subgroups, the Biology subgroup and the Hydrology subgroup, each of which are charged with certain responsibilities. The subgroups must also coordinate their activities within the San Joaquin River Agreement Technical Committee.

DCC Project Work Team The DCC Project Work Team is a multiagency group under CALFED. It determines and evaluates the effects of DCC gate operations on Delta hydrodynamics, water quality, and fish migration. The work team coordinates with the Data Assessment Team and Operations and Fishery Forum to conduct gate experiments; members may be used as a resource to estimate impacts of real-time gate operations.

National Forest Management Act

The National Forest Management Act requires the USFS to prepare the STNF Land and Resources Management Plan (LRMP) that provides the direction to manage the goods and services that are associated with National Forest System lands managed by the STNF. In addition to the requirement for LRMPs, National Forest Management Act also has a specific requirement to "provide for a diversity of plant and animal communities" [16 U.S.C. 1604(g)(3)(B)] as part of their multiple use mandate. The USFS must maintain “viable populations of existing native and desired non-native species in the planning area” (36 CFR. 219.19).

U.S. Forest Service Sensitive Species

The Sensitive Species program is designed to meet the National Forest Management Act requirement to demonstrate the USFS’s commitment to maintaining biodiversity on National Forest System lands. The program is a proactive approach to conserving species to prevent a trend toward listing under the ESA, and to ensure the continued existence of viable, well-distributed populations. A “Sensitive Species” is any species of plant or animal that has been recognized by the Regional Forester to need special management in order to prevent it from becoming threatened or endangered.

Shasta-Trinity National Forest Land and Resource Management Plan

The STNF, LRMP adopted what is commonly referred to as the Northwest Forest Plan, a plan for the management of habitat for late-successional and old-growth forest-related species within the range of the northern spotted owl. The LRMP encompasses all the goals, standards and guidelines established in the 1994 ROD for the Northwest Forest Plan, as a well as establishing Forest goals, standards, and guidelines designed to guide the management of the STNF. As adopted in 1995, this LRMP incorporates the following goals, standards, and guidelines related to aquatic and fisheries resource issues associated with the project site were excerpted from the STNF LRMP (USFS 2003).

Biological Diversity

Goals (LRMP, p. 4-4)

- Integrate multiple resource management on a landscape level to provide and maintain diversity and quality of habitats that support viable populations of plants, fish, and wildlife.

Threatened, Endangered, and Sensitive Species (Plants and Animals)

Goals (LRMP, p. 4-5)

- Monitor and protect habitat for Federally listed Threatened and Endangered and candidate species. Assist in recovery efforts for Threatened and Endangered species. Cooperate with the State to meet objectives for state listed species.

- Manage habitat for sensitive plants and animals in a manner that will prevent any species from becoming a candidate for Threatened and Endangered status.

Wildlife

Goals (LRMP, p. 4-6)

- Meet habitat or population objectives established for management indicators.

- Cooperate with Federal, State, and local agencies to maintain or improve wildlife habitat.

- Maintain natural wildlife species diversity by continuing to provide special habitat elements within Forest ecosystems.

Standards and Guidelines (LRMP, pp. 4-29 through 4-30)

- Consider transplants, introductions, or reintroductions of wildlife species only after ecosystem analysis and coordination with other agencies and the public.

- Develop interpretation/view sites for wildlife viewing, photography, and study. Provide pamphlets, slide shows, and other educational material that enhance the watchable wildlife and other interpretive programs.

- Maintain and/or enhance habitat for Federally listed threatened and endangered or USFS Sensitive species consistent with individual species recovery plans.

U.S. Forest Service Survey and Manage Species

In 1994, the U.S. Bureau of Land Management and USFS adopted standards and guidelines, The Northwest Forest Plan was designed to address human and environmental needs served by the Federal forests of the western part of the Pacific Northwest and Northern California. The development of the Northwest Forest Plan was triggered in the early 1990s by the listing of the northern spotted owl and marbled murrelet as threatened under the ESA.

To mitigate potential impacts to plant and wildlife species that have the potential to occur within the range of the northern spotted owl, surveys are required for species thought to be rare or whose status is unknown due to a lack of information. These species became known as the Survey and Manage species. The Northwest Forest Plan has gone through several revisions since its implementation in 1994, including the elimination of the Survey and Manage Mitigation Measure Standards and Guidelines in 2004. However, these guidelines were re-instated in January 2006 as the result of a court order.

Management Guide for the Shasta and Trinity Units of the Whiskeytown-Shasta-Trinity National Recreation Area

The Management Guide for the Shasta and Trinity Units of the Whiskeytown-Shasta-Trinity National Recreation Area contains management strategies intended to achieve or maintain a desired condition. These strategies take into account opportunities, management recommendations for specific projects, and mitigation measures needed to achieve specific goals. The following strategies related to biological resource issues associated with the project were excerpted from the Management Guide (USFS 2003).

Wildlife (Management Guide, pp. IV-19 through IV-20)

- Management activities will assure population viability for all native and non-native desirable species. Management to insure viability will occur within occupied habitat for bald eagle, peregrine falcon, northern spotted owl, northern goshawk, willow flycatcher, northwestern pond turtle, Pacific fisher, Shasta salamander, and candidate species in accordance with species and/or territory management plans, Forest Orders, and appropriate laws and policy.

- Surveys will continue within potential suitable habitats to determine occupancy status for Threatened, Endangered, sensitive, and candidate species.

- Cooperation will continue with DFG and the USFWS regarding habitat management of wildlife species inhabiting the National Recreation Area. Consultation with USFWS will continue regarding habitat management for threatened and endangered species.

11.2.2 State

California Endangered Species Act

Pursuant to the California Endangered Species Act (CESA), a permit from DFG is required for projects that could result in take of a State-listed threatened or endangered species. Under CESA, "take" is defined as an activity that would directly or indirectly kill an individual of a species, but the definition does not include "harming" or "harassing," as the ESA does. As a result, the threshold for take under CESA is higher than under the ESA (e.g., habitat modification is not necessarily considered take under CESA). Authorization for take of State-listed species can be obtained through a California Fish and Game Code Section 2080.1 Consistency Determination or Section 2081 Incidental Take Permit.

"Fully Protected" Fish Species

California law (Fish and Game Code, Section 5515) also identifies 10 "fully protected fish" that cannot lawfully be "taken," even with an incidental take permit. None of these species are present in the primary study area.

California Fish and Game Code Section 1602—Streambed Alteration

All diversions, obstructions, or changes to the natural flow or bed, channel, or bank of any river, stream, or lake in California that supports wildlife resources are subject to regulation by DFG under Section 1602 of the California Fish and Game Code. Under Section 1602, it is unlawful for any person, governmental agency, or public utility to do the following without first notifying DFG: substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake. A stream is defined as a body of water that flows at least periodically or intermittently through a bed or channel that has banks and supports fish or other aquatic life. This definition includes watercourses with a surface or subsurface flow that supports or has supported riparian vegetation. DFG's jurisdiction within altered or artificial waterways is based on the value of those waterways to fish and wildlife. A DFG streambed alteration agreement must be obtained for any project that would result in an impact on a river, stream, or lake.

California Public Resources Code, Sections 5093.50-5093.70

The California Public Resources Code Sections 5093.50 – 5093.70 were established through 1972 enactment of the Wild and Scenic Rivers Act, which was subsequently amended on several occasions. The essential policy of the State in regard to the matters addressed by the PRC is expressed in Section 5093.50:

> *5093.50 It is the policy of the State of California that certain rivers which possess extraordinary scenic, recreational, fishery, or wildlife values will be preserved in their free-flowing state, together with their immediate environments, for the benefit and*

> *enjoyment of the people of the state. The Legislature declares that such use of these rivers is the highest and most beneficial use and is a reasonable and beneficial use of water within the meaning of Section 2 of Article X of the California Constitution.*

The PRC identifies, classifies, and provides protection for specific rivers or river segments, as approved by the Legislature (much of the text of the PRC is devoted to detailed descriptions of river segment locations). Rivers or river segments that are specifically identified and classified in the PRC comprise the State Wild and Scenic Rivers System. As described in Section 5093.50 of the PRC, rivers or river segments included in the State Wild and Scenic Rivers System must possess “extraordinary scenic, recreational, fishery, or wildlife values”; however, the PRC does not define these “extraordinary values.”

Various amendments to the California Wild and Scenic Rivers Act have been passed, modifying the PRC. Rivers or river segments are added to (or, as in a few past cases, removed from) the System by Legislative action. In 1986, Assembly Bill 3101 (Statutes of 1986, Chapter 894) established a study process to help determine eligibility for potential additions to the State Wild and Scenic Rivers System (Section 5093.547 and Section 5093.548). In 1982, the original mandate in the PRC requiring management plans for designated rivers was eliminated; however, the California Resources Agency is required to coordinate activities affecting the State Wild and Scenic Rivers System with other Federal, State, and local agencies (Section 5093.69).

The PRC has also been modified to protect river segments without formally identifying them as part of the State Wild and Scenic Rivers System. Such protective language for the McCloud River was added to the PRC in Section 5093.542, emphasizing protection of the wild trout fishery in the McCloud River.

California Wild Trout Program

The California Wild Trout Program was established by the California Fish and Game Commission in 1971 to protect and enhance high-quality fisheries sustained by wild strains of trout. The primary purpose of the wild trout program is to identify, enhance, and perpetuate natural and attractive trout fisheries where wild strains of trout are given major emphasis, in contrast to the majority of the State’s accessible waters that are managed by planting domesticated catchable-sized trout on a “put and take” basis (Rode 1989; Rode and Dean 2004). The Commission adopted a wild trout policy that provides for the designation of “aesthetically pleasing and environmentally productive” streams and lakes to be managed exclusively for wild trout, where the trout populations are managed with appropriate regulations to be “largely unaffected by the angling process.”

All designated waters must meet the following policy criteria (Rode 1989, Rode and Dean 2004):

- Be open to public angling
- Be of sufficient size to accommodate a significant number of anglers without overcrowding
- Be able to support, with appropriate angling regulations, wild trout populations of sufficient magnitude to provide satisfactory trout catches in terms of number or size of fish

Designated wild trout waters are required to have a management plan and must be subject to angling restrictions that “emphasize unique values and diversity of opportunity in the geographic area” (Rode 1989, Rode and Dean 2004). Wild trout waters are required to be managed in accordance with the following stipulations:

- Domestic strains of catchable-sized trout will not be planted in designated wild trout waters.
- Hatchery-produced trout of suitable wild and semiwild strains may be planted in designated waters, but only if necessary to supplement natural trout reproduction.
- Habitat protection is of utmost importance for maintenance of wild trout populations. All necessary actions, consistent with State law, will be taken to prevent adverse impacts by land or water development projects affecting designated wild trout waters.

The California Fish and Game Commission in 1976 designated a 10.5-mile river segment immediately below McCloud Dam for special management and habitat protection under the Commission’s wild trout program (Rode 1988).

11.2.3 Regional and Local

County and City Policies and Ordinances

Shasta, Tehama, Glenn, Sutter, Sacramento, and Yolo counties and the cities of Redding, Colusa, and Sacramento have established codes and policies that address protection of natural resources, including fisheries, sensitive species, and aquatic resources, and are applicable to the project.

Shasta County’s general plan emphasizes that the maintenance and enhancement of quality fish and wildlife habitat is critical to the recreation and tourism industry, and acknowledges that any adverse and prolonged decline of these resources could result in negative impacts on an otherwise vibrant industry. The general plan identifies efforts to protect and restore these habitats to sustain the long-term viability of the tourism and recreation industry (Shasta County 2004).

The City of Redding's general plan strives to strike a balance between development and conservation by implementing several measures such as creek-corridor protection and habitat protection (City of Redding 2000).

Tehama County's general plan update provides an overarching guide to future development and establishes goals, policies, and implementation measures designed to address potential changes in county land use and development.

Glenn County's general plan provides a comprehensive plan for growth and development in Glenn County for the next 20 years (2007 through 2027). This plan recognizes that public lands purchased for wildlife preservation generate economic activity as scientists and members of the public come to view and study remnant ecosystems (Glenn County 1993).

The City of Colusa's general plan seeks to promote its natural resources through increased awareness and improved public access (City of Colusa 2007).

Sutter County's general plan contains policies that generally address preservation of aquatic resources.

Sacramento County's general plan contains policies that promote protection of marsh and riparian areas, including specification of setbacks and "no net loss" of riparian woodland or marsh acreage (Sacramento County 1993).

Yolo County's general plan aims to provide an active and productive buffer of farmland and open space separating the Bay Area from Sacramento, and integrating green spaces into its communities.

11.2.4 Federal, State, and Local Programs and Projects

Watershed Conservancies

Several watershed conservancy groups exist within the study area. These include, but may not be limited to Butte Creek, Mill Creek, Deer Creek and Cottonwood Creek Watershed Conservancies. Watershed conservancies tend to focus on developing and implementing conservation efforts on watershed lands.

California Bay-Delta Authority

The California Bay-Delta Authority was established as a State agency in 2003 to oversee implementation of CALFED for the 25 Federal and State agencies working cooperatively to improve the quality and reliability of California's water supplies while restoring the Bay-Delta ecosystem. CALFED Ecosystem Restoration Program has provided a funding source for projects that include those involving acquisition of lands within the Sacramento River Conservation Area (SRCA), initial baseline monitoring and preliminary restoration planning, and preparation of long-term habitat restoration management and monitoring plans.

Cantara Trustee Council

The Cantara Trustee Council administers a grant program that has provided funding for numerous environmental restoration projects in the primary study area, including programs in the Fall River watershed, Sulphur Creek, the upper Sacramento River, Middle Creek, lower Clear Creek, Battle Creek, Salt Creek, and Olney Creek. The Cantara Trustee Council is a potential local sponsor for future restoration actions in the primary study area. The Cantara Trustee Council includes representatives from DFG, USFWS, the Central Valley RWQCB, California Sportfishing Protection Alliance, and Shasta Cascade Wonderland Association.

Resource Conservation Districts

There are numerous resource conservation districts (RCD) within the study area. Once known as soil conservation districts, RCDs were established under California law with a primary purpose to implement local conservation measures. Although RCDs are locally governed agencies with locally appointed, independent boards of directors, they often have close ties to county agencies and the National Resources Conservation Service. RCDs are empowered to conserve resources within their districts by implementing projects on public and private lands and to educate landowners and the public about resource conservation. They are often involved in the formation and coordination of watershed working groups and other conservation alliances. In the Shasta Lake and upper Sacramento River vicinity, districts include the Western Shasta County RCD and the Tehama County RCD. To the east are the Fall River and Pit River RCDs, and to the west and north are the Trinity County and Shasta Valley RCDs.

Riparian Habitat Joint Venture

The Riparian Habitat Joint Venture (RHJV) was initiated in 1994 and includes signatories from 18 Federal, State, and private agencies. The RHJV promotes conservation and the restoration of riparian habitat to support native bird population through three goals:

- Promote an understanding of the issues affecting riparian habitat through data collection and analysis.
- Double riparian habitat in California by funding and promoting on-the-ground conservation projects.
- Guide land managers and organizations to prioritize conservation actions.

RHJV conservation and action plans are documented in the *Riparian Bird Conservation Plan* (RHJV 2004). The conservation plan targets 14 “indicator” species of riparian-associated birds and provides recommendations for habitat protection, restoration, management, monitoring, and policy. The report notes habitat loss and degradation as one of the most important factors causing the decline of riparian birds in California. The RHJV has participated in monitoring efforts within the Sacramento National Wildlife Refuge Complex and other conservation areas. The RHJV's conservation plan identifies lower Clear Creek as a prime breeding area for yellow warblers and song sparrows, advocating a continuous riparian corridor along lower Clear Creek. Other recommendations of the conservation plan apply to the North Delta Off stream Storage Investigation study area.

Sacramento River Advisory Council

In 1986, the California Legislature passed Senate Bill 1086, which called for a management plan for the Sacramento River and its tributaries to protect, restore, and enhance fisheries and riparian habitat in an area stretching from the confluence of the Sacramento River with the Feather River and continuing northward to Keswick Dam. The law established an advisory council that included representatives of Federal and State agencies, county supervisors, and representatives of landowners, water contractors, commercial and sport fisheries, and general wildlife and conservation interests. Responsibilities of the advisory council included development of the *Sacramento River Conservation Area Forum Handbook* to guide management of riparian habitat and agricultural uses along the river (Resources Agency 2003). This action also resulted in formation in May 2000 of the SRCA Forum, a nonprofit, public benefit corporation with a board of directors that includes private landowners and public interest representatives from a seven-county area, an appointee of the California Resources Agency, and ex-officio members from six Federal and State resource agencies. The work of the organization is generally focused on planning actions and river management within the SRCA planning area.

Sacramento River Conservation Area Program

Senate Bill 1086 called for a management plan for the Sacramento River and its tributaries to protect, restore, and enhance both fisheries and riparian habitat. The SRCA Program has an overall goal of preserving remaining riparian habitat and reestablishing a continuous riparian ecosystem along the Sacramento River between Redding and Chico, and reestablishing riparian vegetation along the river from Chico to Verona. The program is to be accomplished through an incentive-based, voluntary river management plan. The Upper Sacramento River Fisheries and Riparian Habitat Management Plan (Resources Agency 1989), identifies specific actions to help restore the Sacramento River fishery and riparian habitat between the Feather River and Keswick Dam. The Sacramento River Conservation Area Forum Handbook (Resources Agency 2003) is a guide to implementing the program. The Keswick Dam-to-Red Bluff portion of the conservation area includes areas within the 100-year floodplain, existing riparian bottomlands, and areas of contiguous valley oak woodland, totaling approximately 22,000 acres. The 1989 fisheries restoration plan recommended several actions specific to the study area:

- Fish passage improvements at RBDD (final Environmental Impact Statement/Environmental Impact Report released May 2008)

- Modification of the Spring Creek Tunnel intake for temperature control (completed)
- Spawning gravel replacement program (ongoing)
- Development of side-channel spawning areas, such as those at Turtle Bay in Redding (ongoing)
- Structural modifications to the Anderson-Cottonwood Irrigation District Dam to eliminate short-term flow fluctuations (completed)
- Maintaining instream flows through coordinated operation of water facilities (ongoing)
- Improvements at the Coleman National Fish Hatchery (partially complete)
- Measures to reduce acute toxicity caused by acid mine drainage and heavy metals (ongoing)
- Various fisheries improvements on Clear Creek (partially complete)
- Flow increases, fish screens, and revised gravel removal practices on Battle Creek (beginning summer 2006)
- Control of gravel mining, improvements of spawning areas, improvements of land management practices in the watershed, and protection and restoration of riparian vegetation along Cottonwood Creek

The Nature Conservancy

The Nature Conservancy (TNC) is a private, nonprofit organization involved in environmental restoration and conservation throughout the United States and the world. TNC approaches environmental restoration primarily through strategic land acquisition from willing sellers and obtaining conservation easements. Some of the lands are retained by TNC for active restoration, research, or monitoring activities, while others are turned over to government agencies such as USFWS or DFG for long-term management. Lower in the Sacramento River basin, TNC has been instrumental in acquiring and restoring lands in the Sacramento River National Wildlife Refuge and managing several properties along the Sacramento River. It also has pursued conservation easements on various properties at tributary confluences, including Cottonwood and Battle creeks.

11.3 Environmental Consequences and Mitigation Measures

11.3.1 Methods and Assumptions

The following sections describe the methods, processes, procedures, and/or assumptions used to formulate and conduct the environmental impact analysis.

This analysis of impacts on fisheries and aquatic ecosystems resulting from implementation of the project alternatives under consideration is based on extensive review of existing documentation that addresses aquatic habitats and fishery resources in the primary and extended study areas, and on water resources modeling analysis.

Summary of Water Resources Modeling

Extensive hydrologic, water temperature, and salmon production and mortality modeling was performed to provide a quantitative basis from which to assess potential operation-related effects of the project alternatives on fisheries resources and aquatic habitats within the primary and extended study areas. Model selection and use for each of the variables were as follows:

- **Hydrologic modeling** – CalSim-II (primary and extended study areas)
- **Water temperature modeling** – Sacramento River water temperature model (primary study area)
- **Salmon production and mortality** – SALMOD (primary study area)

Modeling output provided monthly values for each year of the 82-year period of record modeled for river flows, reservoir storage and elevation, and river water temperatures. The period of record is based on records from 1921 through 2003. River flow and water temperature output was put into weekly form and used in SALMOD to characterize flow- and water temperature-induced production and mortality of salmon under each simulated condition.

The models used in the fisheries analyses (i.e., CalSim-II, Sacramento river water temperature model, and SALMOD) are tools that have been developed for comparative planning purposes, rather than for predicting actual river conditions at specific locations and times. The 82-year period of record for CalSim-II and water temperature modeling provides an index of the kinds of changes that would be expected to occur with implementation of a specified set of operational conditions. Reservoir storage, river flows, water temperature, and salmon survival output for the period modeled should not be interpreted or used as definitive absolutes depicting actual river conditions that would occur in the future. Rather, output for the project alternatives was compared to that for the Existing Condition (2005) and No-Action Alternative (future 2030) alternatives simulation to determine the following:

- Whether reservoir storage or river flows and water temperatures would be expected to change with implementation of the SLWRI alternatives.

- Months in which potential reservoir storage and river flow and water temperature changes could occur.

- Relative magnitude of change that could occur during specific months of particular water-year types, and whether the relative magnitude anticipated would be expected to result in effects on fisheries resources and aquatic habitats within the regional area.

The models used, although mathematically precise, should be viewed as having "reasonable detection limits." Establishing reasonable detection limits is useful in interpreting modeling output for impact assessment purposes, and prevents making inferences beyond the capabilities of the models and beyond an ability to actually measure changes.

Simulated water temperature differences of less than 1°F were lower than the reasonable detection limit. In situ temperature loggers used to collect water temperature data used for the model typically have a precision of ±0.36°F, yielding a potential error of 0.72°F (Deas et al. 1997). Therefore, modeled differences in water temperature of 0.36°F or less could not be consistently detected in the river by actual monitoring of water temperatures. In addition, as mentioned above, output from Reclamation's water temperature models provides a "relative index" of water temperatures under the various operational conditions modeled. Output values indicate whether the water temperatures would be expected to increase, remain unchanged, or decrease, and provide insight regarding the relative magnitude of potential changes under one operational condition compared to another.

The Modeling Appendix provides a more detailed discussion of the modeling process and its application to the project analysis, including (1) the primary assumptions and model inputs used to represent hydrologic, regulatory, structural and operational conditions; and (2) the simulations performed from which effects were estimated. SALMOD is discussed in more detail below.

Modeling Uncertainties and Real-Time Decision-Making A process exists for real-time decision-making on CVP and SWP operations to allow fishery management that promotes flexible decision-making able to be adjusted for uncertainties as outcomes of management actions and other events become better understood.

It should be noted that modeling simulations conducted to support the analysis of the project alternatives do not always capture potential operational changes associated with the human element of real-time decision-making. Therefore, although the modeling is based on operational assumptions that are generally accepted, there may be isolated inaccuracies regarding real-time human decisions on operations to ensure compliance with existing objectives, standards, and/or agreements.

For example, the NMFS BO for the long-term CVP and SWP Operations Criteria and Plan and SWRCB orders require that CVP and SWP operations for the Sacramento River meet specific water temperature criteria. In 1997, construction was completed on the TCD at Shasta Dam. The TCD was designed to selectively withdraw water from elevations within Shasta Lake to better manage water temperatures in the upper river, while allowing power generation. SRTTG is an interagency team that identifies water management alternatives and TCD operations in real time, interprets the availability of cold-water resources in Shasta Lake, and designs an annual/seasonal river temperature compliance strategy, as outlined in SWRCB Water Right Order 90-5 and multiple BOs.

Reservoir Fisheries Analysis

Monthly values for WSEL, surface area, and cold-water storage in Shasta Lake were calculated for 1922 to 2003 using data outputs from CalSim-II. Values were produced for five alternative dam raise scenarios (project alternatives) using a 2005 water supply demand, and a projected 2030 water supply demand for a total of 10 scenarios. Each year of the hydrologic record was categorized as one of five water year categories (wet, above-normal, below-normal, dry, critical) based on the Sacramento River Inflow Index. Model outputs for the last day of each month from February to July (e.g., February 29, March 31) were used for analysis of potential changes in surface area and WSEL. End-of-month values for April, June, August, and October were used to analyze the potential changes in Shasta Lake's cold-water storage. Potential impacts of the enlargement of Shasta Dam and Shasta Lake on the fisheries resources of Shasta Lake were investigated using several habitat-based metrics that are associated with factors known to limit or otherwise regulate warm-water and cold-water reservoir fish populations. The following metrics were computed and used:

- **Surface Area –** Surface area is the metric used to investigate changes in the amount of available littoral (i.e., shoreline) and limnetic (i.e., open water) habitat, which could impact warm-water and cold-water fisheries, under each of the project alternatives. Variations in surface area influence biological productivity (including fish production) because the upper, lighted layer of the pelagic zone is the principal plankton-producing region of the reservoir. Reservoir enlargement may initially produce a "trophic upsurge" phenomenon that occurs in response to terrestrial habitat inundation, nutrient loading, and increases in labile detritus (Kimmel and Groeger 1986). The initial trophic enrichment will decline and stabilize over time as the reservoir ecosystem approaches its natural trophic equilibrium (Kimmel and Groeger 1986). Trophic depression is a response to decreased nutrient loading and decreased labile detritus. Fisheries production experiences a depression in response to the same factors as well as decreases in available terrestrial organic detritus and loss of cover as inundated vegetation deteriorates (Stables et al. 1990).

- **Cold-Water Storage to Surface Area Ratio –** Cold-water storage to surface area ratio (a dimensionless value) is a useful metric for assessing the potential impact of project alternatives on Shasta Lake's cold-water fishery. Stables et al. (1990) suggest that an increase in pelagic and littoral trout habitat accompanied by lake enlargement should lead to higher total fish yield. While increases in water surface area, such as those that might result from reservoir enlargement, can stimulate primary and secondary productivity (Jones and Stokes Associates 1988), access to cold-water refuge can be a limiting factor for cold-water fish production. Therefore, increases in reservoir surface area without proportional increases in cold-water storage are likely to result in little change in cold-water fish production. Conversely, a proportional increase in the cold-water storage to surface area ratio should result in increased cold-water fish productivity.

- **WSEL –**WSEL is a metric that is useful in analyzing the impact of project alternatives on the Shasta Lake warm-water fishery. The timing and duration of WSEL fluctuation can have a great impact on the reproductive success of nearshore spawning fishes (Ploskey 1986). Stable or increasing WSEL during spring months (March through June) can contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of several warm-water species, including the black basses (Lee 1999, Ploskey 1986). Inundation of shoreline habitat may also lead to increased structural diversity and availability of spawning substrate or cover for juvenile fishes, depending on vegetation removal activities (Miranda et al. 1984, Ratcliff 2006). Conversely, reduced or variable WSEL due to reservoir drawdown during spring spawning months can cause reduced spawning success for warm-water fishes through nest dewatering, egg desiccation, and physical disruption of spawning or nest guarding activities (Lee 1999, Ploskey 1986).

WSEL values were obtained from CalSim-II outputs, as described above, and were graphed for each comparison set. Monthly change in surface elevation (monthly change in elevation) was calculated by subtracting the previous month's surface elevation from each month. For example, change in elevation for March was calculated by subtracting the February 29 WSEL from the March 31 WSEL. The relative difference in monthly change in elevation from the basis-of-comparison and the relative percent difference in monthly change in elevation were graphed for each comparison set, with the basis-of-comparison as the Existing Condition in sets one and three, and the No-Action Alternative in set two. The relative difference and relative percent difference in monthly change in elevation between CP3 and CP4 were also graphed for comparison sets one and three.

Surface area values obtained from CalSim-II outputs were graphed for each comparison set. Relative differences in monthly surface area values from the basis-of-comparison were graphed for each comparison set, as described for WSEL.

Cold-Water Storage Values obtained from CalSim-II outputs were divided by surface area outputs to generate monthly cold-water storage to surface area ratios. The cold-water storage to surface area ratios were graphed for comparison set two only. The relative difference and relative percent difference in monthly cold-water storage to surface area ratio from the basis-of-comparison were also calculated and graphed for comparison set two only.

For each metric, CalSim-II projections for monthly change under the Existing Condition were graphed against the No-Action Alternative.

Additionally, graphs were prepared depicting the expected ratio of monthly cold-water storage to surface area, monthly surface area, and expected monthly changes in elevation under 2005 and 2030 water demands (separately) for all water-year types for CP1, CP2, CP3, and CP4 for the Shasta Lake and vicinity portion of the primary study area. For example, in the discussion of potential impacts associated with implementation of CP1 is a graph comparing monthly surface area under CP1 with a 2005 water supply demand to monthly surface area under the Existing Condition, and a separate graph making this comparison for CP1 with a 2030 water supply demand versus the No-Action Alternative.

Values for the three habitat metrics were compared in graphical form to address the following issues:

- How reservoir cold-water storage, WSEL, or the cold-water storage to surface area ratio would be expected to change with implementation of the project alternatives
- Months or seasons when potential changes in the habitat metrics could occur
- Relative magnitude of change that could occur during specific months of particular water-year types, and the potential impacts these changes could have on fisheries resources, aquatic resources, and habitats within the reservoir

All analyses were based on CalSim-II model outputs. CalSim-II is California's primary water operations planning model, used by both Reclamation and DWR. While model sensitivity and accuracy calibrations are still being developed for CalSim-II, the model's widespread use for water planning and management operations in Central California makes it useful and its projections easily comparable between projects. However, model outputs should be used as tools for interpretation of anticipated impacts rather than actual projections (Close et al. 2003).

Tributaries to Shasta Lake

The primary study area is composed of Shasta Dam and Shasta Lake, the lower reaches of the tributaries draining into Shasta Lake, and the Sacramento River downstream to Keswick Dam. Thirteen representative tributary streams to Shasta Reservoir were selected for focused examination as part of this assessment, including the five primary tributaries: Sacramento River, McCloud River, Pit River, Squaw Creek, and Big Backbone Creek.

Considerations for reservoir and tributary fisheries include the following:

- Connectivity to tributary spawning/refuge habitat.
- Potential connectivity to nonfish-bearing streams.
- Potential impacts to special-status species or their habitat from inundation of stream habitat (e.g., through increased turbidity/erosion/sedimentation that may affect connectivity or create a barrier).

Chinook Salmon Between Keswick Dam and Red Bluff Diversion Dam

SALMOD is a computer model that simulates the dynamics of freshwater salmonid populations, but for the SLWRI, SALMOD simulates population dynamics for all four runs of Chinook salmon between Keswick Dam and RBDD. SALMOD was applied to this project because the model had been previously used on the upper Sacramento River (from Keswick Dam to Battle Creek), and has been updated using model parameters and techniques developed for use on the Klamath River and from Sacramento River-specific Chinook salmon information obtained from USFWS and DFG fisheries biologists (Bartholow 2003; Modeling Appendix, Chapter 5). Also, resource agency personnel were presented with the capabilities of the model by John Bartholow (formerly with the U.S. Geological Survey) under contract by Reclamation, and agreed that using SALMOD was the appropriate means of evaluating potential conditions. John Bartholow and John Heasley (contractor to U.S. Geological Survey) were instrumental in extending SALMOD to assess fish production and mortality between Keswick Dam and the RBDD. They also assisted in preparation of the SALMOD description included in the Modeling Appendix, Chapter 5, which contains a detailed discussion of the SALMOD model.

Comprehensive Plans Evaluated SALMOD used weekly streamflow and water temperature to evaluate six different scenarios: the Existing Condition, No-Action Alternative, CP1, CP2, CP3, and CP4. The Existing Condition is based on a 2005 level of development. The No-Action Alternative represents the Future Conditions (2030) without completion of a project to address the objectives of the SLWRI. CP1 is based on a 6.5-foot dam raise; CP2 is based on a 12.5-foot dam raise; and CP3 is based on an 18-foot dam raise. CP4 was developed based on an 18.5-foot dam raise with operations modified to create a more “fish-friendly” environment, with one-third of the reservoir storage dedicated to fish, to either improve flows or water temperatures.

Additional scenarios were evaluated, but not pursued further, due to inconsistencies or lack of achievement of the primary goals of the project.

In the original presentation (August 16, 2005) of the SALMOD model to resource agency personnel, interest was expressed in setting the number of spawning adults at the AFRP production goal for the Sacramento River upstream from the RBDD. The AFRP defined natural production to be that portion of Chinook salmon not produced in hatcheries, and defined total production to be the sum of harvest and escapement. The production goals include adult fish removed from the system due to both sport and commercial fishing in both freshwater and marine environments. Therefore, SALMOD was run using the appropriate number of spawners (Table 11-3).

SALMOD was also conducted using a spawning population based on the 1999 to 2006 average adult return provided by DFG (2011), which documents spawning escapement estimates for each year in the Central Valley. Using this average was expected to result in a more realistic effect of the project operations on salmon under the Existing Condition, and on the premise that the AFRP goals should take the populations closer to a state of carrying capacity. Thus, if a population is already at or nearing carrying capacity, increases in the populations are unlikely. The starting year for calculating the average number of spawners was in 1999 because the effects of the TCD began in 1999, and ended in 2006, which was the extent of collected and processed data.

Populations of 500 or more salmon are considered necessary for accurate results using SALMOD because it is a deterministic model that relies on the "law of large numbers." When populations are "low" (an arbitrary term), mean responses are quickly affected by environmental stochasticity and individual variability, which are factors SALMOD was not designed to address. Therefore, because the 1999 to 2006 average for spring-run Chinook salmon was 207 adult spawners, the criterion of 500 or more fish was not met. However, because of concerns expressed by DFG and USFWS, the spawning population was left at 207 fish for purposes of the model.

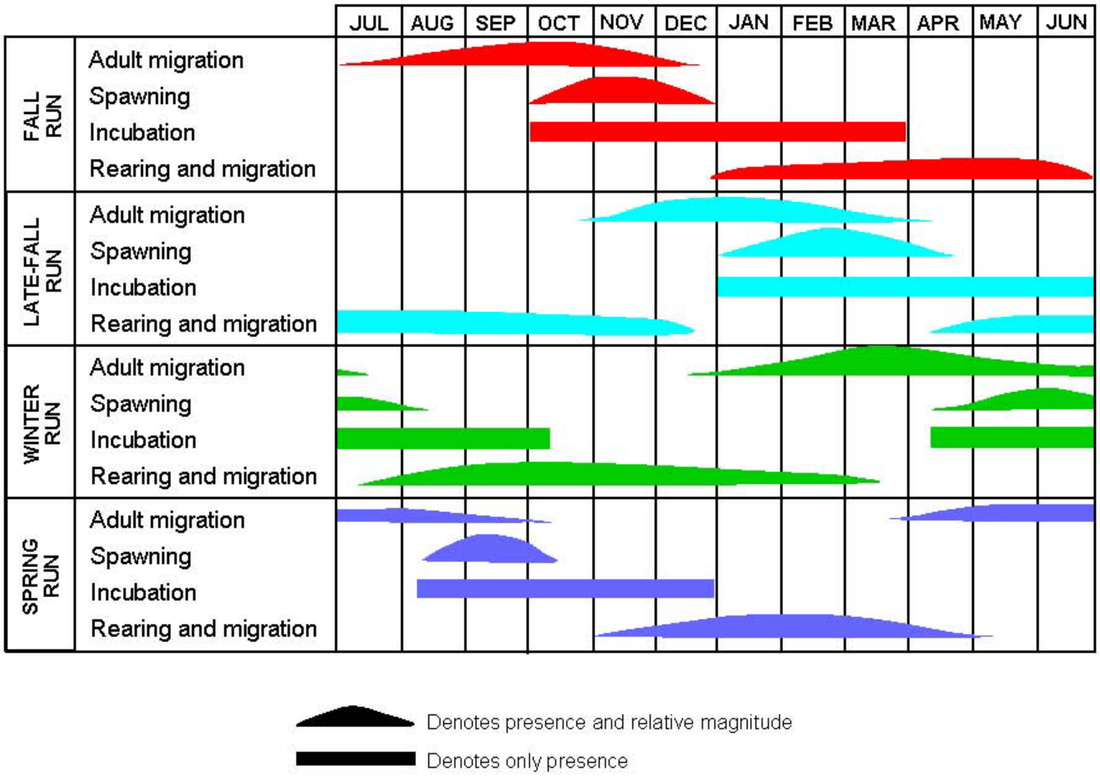
Table 11-3. Number of Spawning Fish Incorporated into SALMOD Model

Reach	Fall-Run	Late Fall-Run	Winter-Run	Spring-Run
California Department of Fish and Game (Grand Tab, 1999 through 2006 average)				
Keswick to ACID	6,658	4,725	3,591	9
ACID to Highway 44 Bridge	4,011	2,096	1,761	39
Highway 44 Bridge to Airport Road Bridge	7,175	3,123	3,041	67
Airport Road Bridge to Balls Ferry Bridge	12,405	2,507	163	36
Balls Ferry Bridge to Battle Creek	8,337	767	9	22
Battle Creek to Jellys Ferry Bridge	12,146	282	9	31
Jellys Ferry Bridge to Bend Bridge	8,789	130	17	3
Bend Bridge to RBDD Inundation Zone	5,044	67	0	0
Total Adult Spawners	**64,565**	**13,697**	**8,591**	**207**
Potential Eggs	**154,955,000**	**32,865,000**	**12,369,000**	**495,000**
U.S. Fish and Wildlife Service (AFRP goals)				
Keswick to ACID	10,218	9,761	19,320	1,003
ACID to Highway 44 Bridge	6,174	4,328	9,455	4,235
Highway 44 Bridge to Airport Road Bridge	10,925	6,447	16,358	7,021
Airport Road Bridge to Balls Ferry Bridge	19,022	6,169	886	3,901
Balls Ferry Bridge to Battle Creek	12,731	1,591	66	2,340
Battle Creek to Jellys Ferry Bridge	18,629	597	26	3,343
Jellys Ferry Bridge to Bend Bridge	13,427	278	106	334
Bend Bridge to RBDD Inundation Zone	7,705	146	0	0
Total Adult Spawners	**98,830**	**28,318**	**46,218**	**22,178**
Potential Eggs	**237,200,000**	**67,960,000**	**66,552,000**	**53,220,000**

Note:
Spawners include males and females.
Key:
ACID = Anderson-Cottonwood Irrigation District
AFRP = Anadromous Fish Restoration Program

SALMOD Output SALMOD produces many forms of output files, but two basic output files – production and mortality (both weekly and annual) – were used in this assessment. Two types of mortality were calculated – those caused by the operations (triggered by changes in flow and water temperature) and those that are nonoperations-related (mortalities caused by factors that would still occur without the project in effect, such as disease, predation, and entrainment). Mortality was calculated for each life stage, from migrating/holding adult to the emigrating juvenile.

SALMOD evaluated five separate life stages of Chinook salmon – adult, egg, fry, presmolt, and immature smolt. Figure 11-1 shows the timing for each life stage. Mortality of adults in SALMOD was calculated during the adult migration and spawning time periods. Mortality of eggs (both eggs and in-gravel alevins) was calculated during the adult migration, spawning, and incubation stages, while fry, presmolts, and immature smolts were calculated during the rearing and migration time period.



Source: Vogel and Marine 1991

Figure 11-1. Approximate Timing of the Four Runs of Chinook Salmon in the Sacramento River

Production SALMOD defines production as follows:

Production = (Potential eggs + entrants) – (prespawn egg mortality + other mortality + residuals)

Where:

- Production is the number of young fish surviving to migrate downstream from the RBDD
- Potential eggs are the number of eggs that could be spawned, providing there is no prespawn mortality of either adult females or eggs *in vivo*
- Entrants are the number of young fish entering the project reach (Keswick Dam to RBDD) from the tributaries
- Mortality is the number of eggs and/or fish that die before leaving the project reach

- Residuals are the number of young fish under 60 mm that, after 52 weeks, have not left the project reach

Mortality The mortality process computed all mortality not explicitly included with one of the other processes. This includes mortality from unsuitable water temperature (Reclamation 1991), population density, superimposition, and eggs while *in vivo* and incubating. In addition, a base mortality for all causes not related to any other process (e.g., entrainment, predation) was also computed.

Categories of mortality calculated in SALMOD include the following and are further described in Chapter 5 of the Modeling Appendix:

- **Nonoperations Related Mortality**
  - **Base (Nonoperational) –** An accounting of mortality of adults, eggs, fry, presmolts, and immature smolts for everything other than what is in the model, or background mortality (mortality that would occur regardless of the project operations) from factors such as predation, disease, etc.
  - **Seasonal (Nonoperational) –** Extra outmigration mortality of presmolts or immature smolts, including diversion-related mortality.
- **Operations-Related Mortality**
  - **Habitat –** Operations-related mortality resulting from forced movement of fry, presmolts, or immature smolts due to habitat constraints.
  - **Temperature –** Operations-related mortality to adults, eggs, fry, presmolts, and/or immature smolts caused by unsuitable water temperatures.
  - **Lost Egg –** Number of eggs lost due to the lack of spawning habitat (a single adult Chinook salmon female cannot spawn because all redds are guarded). It was assumed that these eggs are shed, but as they are alive when leaving the female spawners, they were tallied in the mass balance table. The lack of spawning habitat could be due to lack of spawning gravel, or lower flows precluding access to suitable spawning habitat.
  - ***In Vivo* –** Number of eggs lost because of operations-related water temperature mortality within the female either prior to spawning, or prespawning, thermal mortality in which exposure kills the egg or malformed young fish after spawning.

  - **Incubation –** Number of eggs lost if redds (or portions of redds) are affected by changing egg incubation habitat through the duration of the incubation season due to flushing flows scouring out the redds (occurs at a minimum of 60,000 cfs) or redd dewatering from a drop in streamflows resulting from operations-related actions.

  - **Superimposition –** Number of eggs lost due to new spawning on top of a currently incubating redd resulting from operations-related activities.

- **Analysis –** To evaluate the effects of the project, productions and mortalities were calculated and the differences between the project alternatives and the No-Action Alternative and the Existing Condition were then compared. Most of the years for each run showed minimal differences from the No-Action Alternative, creating an overall average production approaching zero. Each model has its own inherent level of error. In addition, flow data derived from CalSim-II had to be disaggregated from monthly data to weekly, resulting in potential additional error. Because water-year type affects Chinook salmon populations, separate production trends based on water-year type were evaluated for each run.

  Starting populations used in SALMOD were derived from an average population for the years 1999 through 2006, based on the DFG Grandtab table (2011), which lists population estimates on a yearly basis. The AFRP populations were based on the goals identified for the Sacramento River for each run of Chinook salmon.

  Although water year classifications are somewhat arbitrary, and the biological year for each run of Chinook salmon encompasses portions of two separate water years, mortalities caused by operations were separated by water-year types to identify trends, such as changes in mortality in critical water years due to unsuitable water temperatures. Once the years were separated by water-year type, the mortality categories were ranked to determine which mortality category under each alternative was the primary factor affecting production for each run.

  The SLWRI has the greatest variations in project operations from the Existing Condition, No-Action Alternative, and the Comprehensive Plans during critical and dry water years (for further detail, refer to the *Hydrology, Hydraulics and Water Management Technical Report*). Besides providing a more reliable water source for delivery, CP1 through CP5 are able to provide more suitable flows and water temperatures during critical and dry water years. This is shown in increased production and/or decreased operations-related mortalities.

Because CP5 is operated the same as CP3, all results for CP5 are synonymous with CP3 and are not listed in the table of results.

Delta Fisheries

Delta Outflow Water development has changed the volume and timing of freshwater flows through the Bay-Delta. Over the past several decades, the volume of the Bay-Delta's freshwater supply has been reduced by upstream diversions, in-Delta use, and Delta exports. As a result, the proportion of Delta outflow depleted by upstream and Delta diversions has grown substantially. In wet years, diversions reduce outflow by 10 percent to 30 percent. In dry years, diversions may reduce outflow by more than 50 percent.

Water development has also altered the seasonal timing of flows passing into and through the Bay-Delta. Flows have decreased in April, May, and June and have increased slightly during the summer and fall (SFEP 1992). Seasonal flows influence the transport of eggs and young organisms (e.g., zooplankton, fish eggs, larvae) through the Delta and into San Francisco Bay. Flows during the months of April, May, and June play an especially important role in determining the reproductive success and survival of many estuarine species, including salmon, striped bass, American shad, delta smelt, longfin smelt, splittail, and others (Stevens and Miller 1983; Stevens et al. 1985; Herbold 1994; Meng and Moyle 1995).

For purposes of evaluating the potential effect of changes in outflow on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows that were less than 5 percent (plus or minus) relative to the basis-of-comparison would not be expected to result in a significant (detectable) effect on habitat quality or availability. It would also not be expected to result in a significant effect on the transport mechanisms provided by Delta outflow, on resident or migratory fish or the zooplankton and phytoplankton on which they rely for a food resource.

Delta Inflow Changes in upstream reservoir storage have the potential to affect Delta inflow (water entering the Delta). Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly or indirectly affect fish and other aquatic resources.

The comparison includes the estimated average monthly inflow under the basis-of-comparison conditions (Existing Condition and No-Active Alternative), the average monthly flow under each of project alternatives evaluated, and the percentage change between base flows and operations. For purposes of evaluating the potential effect of changes in Delta inflow on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows that were less than 5 percent (plus or minus) relative to the basis-of-comparison would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by Delta inflow, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

Sacramento River Inflow Flow within the Sacramento River has been identified as an important factor affecting the survival of emigrating juvenile Chinook salmon, important to the downstream transport of planktonic fish eggs and larvae such as delta smelt and longfin smelt, striped bass, and shad, and important for seasonal floodplain inundation that has been identified as important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon and steelhead. Sacramento River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in Sacramento River flow as a result of SLWRI alternative operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

For purposes of evaluating the potential effect of changes in Sacramento River inflow on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows less than 5 percent (plus or minus) relative to the basis-of-comparison would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by Sacramento River inflow, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

San Joaquin River Flow at Vernalis Flow within the San Joaquin River has been identified as an important factor affecting the survival of juvenile Chinook salmon migrating downstream from the tributaries through the mainstem San Joaquin River and Delta, important to the downstream transport of planktonic fish eggs and larvae such as striped bass, and important for seasonal floodplain inundation that is considered to be important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon. San Joaquin River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in San Joaquin River flow as a result of SLWRI alternative operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

For purposes of evaluating the potential effect of changes in San Joaquin River flow at Vernalis on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, less than a 5 percent change (plus or minus) relative to the basis-of-comparison, would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by San Joaquin River flow at Vernalis, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

Entrapment Zone and X2 In many segments of the Bay-Delta, but particularly in Suisun Bay and the Delta, salinity is controlled by the balance of saltwater intrusion from San Francisco Bay and freshwater flow from the tributaries to the Delta. By altering the timing and volume of flows, water development has affected salinity patterns in the Delta and in parts of San Francisco Bay (SFEP 1992). Under natural conditions, the Carquinez Strait/Suisun Bay region marked the approximate boundary between saltwater and freshwater in the Bay-Delta during much of the year. In the late summer and fall of drier years, when Delta outflow was minimal, seawater moved into the Delta from San Francisco Bay. Beginning in the 1920s, following several dry years and because of increased upstream storage and diversions, salinity intrusions became more frequent and extensive.

Since the 1940s, releases of freshwater from upstream storage facilities have increased Delta outflows during summer and fall. These flows have correspondingly limited the extent of salinity intrusion into the Delta. Reservoir releases have helped to ensure that the salinity of water diverted from the Delta is acceptable during the summer and late fall for farming, municipal, and industrial uses (SFEP 1992).

Salinity is an important habitat factor in the Bay-Delta. All estuarine species are assumed to have optimal salinity ranges, and their survival may be affected by the amount of habitat available within the species' optimal salinity range. Because the salinity field in the Bay-Delta is largely controlled by freshwater outflows, the level of outflow may determine the surface area of optimal salinity habitat that is available to the species (Hieb and Baxter 1993, Unger 1994).

The transition area between saline waters within the Bay and freshwater within the rivers, frequently referred to as the low salinity zone, is located within Suisun Bay and the western Delta. The low salinity zone has also been associated with the entrapment zone, a region of the Bay-Delta characterized by higher levels of particulates, higher abundances of several types of organisms, and a turbidity maximum. It is commonly associated with the position of the 2 parts per thousand salinity isopleth (X2), but actually occurs over a broader range of salinities (Kimmerer 1992). Originally, the primary mechanism responsible for this region was thought to be gravitational circulation, a circulation pattern formed when freshwater flows seaward over a dense, landward-flowing marine tidal current. However, recent studies have shown that gravitational circulation does not occur in the entrapment zone in all years, nor is it always associated with X2 (Burau et al. 1998). Lateral circulation within the Bay-Delta or chemical flocculation may play a role in the formation of turbidity maximum of the entrapment zone.

As a consequence of higher levels of particulates, the entrapment zone may be biologically significant to some species. Mixing and circulation in this zone concentrates plankton and other organic material, thus increasing food biomass and production. Larval fish such as striped bass, delta smelt, and longfin smelt may benefit from enhanced food resources. Since about 1987, however, the introduced Asian overbite clam population has cropped much of the primary production in the Bay-Delta and there has been virtually no enhancement of phytoplankton production or biomass in the entrapment zone (CUWA 1994).

This region continues to have relatively high levels of invertebrates and larval fish, even though the base of the food chain may not have been enhanced in the entrapment zone during the past decade. Vertical migration of these organisms through the water column at different parts of the tidal cycle has been proposed as a possible mechanism to maintain high abundance in this region, but recent evidence suggests that vertical migration does not provide a complete explanation (Kimmerer et al. 2002).

Although evidence indicates that X2 and the entrapment zone are not as closely related as previously believed (Burau et al. 1998), X2 continues to be used as an index of the location of the entrapment zone and area/or of increased biological productivity. Historically, X2 has varied between San Pablo Bay (River Kilometer 50) during high Delta outflow and Rio Vista (River Kilometer 100) during low Delta outflow. In recent years, it has typically been located between approximately Honker Bay and Sherman Island (River Kilometer 70 to 85). X2 is controlled directly by the volume of Delta outflow, although changes in X2 lag behind changes in outflow. Minor modifications in outflow do not greatly alter X2.

Jassby and Powell (1994) showed that when X2 is in the vicinity of Suisun Bay, several estuarine organisms tend to show increased abundance. However, it is by no means certain that X2 has a direct effect on any of the species. The observed correlations may result from a close relationship between X2 and other factors that affect these species.

Operations of upstream storage reservoirs have the potential to affect the location of X2 as a result of changes in freshwater flows from the upstream tributaries through the Delta. For purposes of evaluating changes in habitat quantity and quality for estuarine species, a significance criterion of an upstream change in X2 location within 1 kilometer (km) of the basis-of-comparison condition was considered to be less than significant. The criterion was applied to a comparison of hydrologic model results for basis-of-comparison conditions and project alternatives, by month and water year, for the months from February through May.

Old and Middle River Reverse Flows Reverse flows occur when Delta exports and agricultural demands exceed San Joaquin River inflow plus Sacramento River inflow through the DCC, Georgiana Slough, and Threemile Slough. The capacities of the DCC, Georgiana Slough, and Threemile Slough are fixed; therefore, if pumping rates exceed that total capacity, plus flows in Old River and Eastside streams, the pumping causes Sacramento River water to flow around the west end of Sherman Island and then eastward up the San Joaquin River. This condition occurs frequently during dry years with low Delta inflows and high levels of export at the CVP and SWP pumps. The reverse flow condition within the lower San Joaquin River is typically referred to as Qwest. As second reverse flow condition occurs within Old and Middle rivers as the rate of water diverted at the CVP and SWP export facilities exceeds tidal and downstream flows within the central region of the Delta.

Reverse flows in Old and Middle rivers, resulting from low San Joaquin River inflows and increased exports to the CVP and SWP, have been identified as a potential cause of increased delta smelt mortality at the CVP and SWP fish facilities within recent years (Simi and Ruhl 2005, Ruhl et al. 2006, Wanger 2007 Case 1:05-cv-01207-OWW-NEW). Results of analyses of the relationship between the magnitude of reverse flows in Old and Middle rivers and salvage of adult delta smelt in the late winter shows a substantial increase in salvage as reverse flows exceed approximately -5,000 cfs. Concerns regarding reverse flows in Old and Middle rivers have also focused on planktonic egg and larval stages of striped bass, splittail, and on Chinook salmon smolts, in addition to delta smelt, and while these species do not spawn to a significant extent in the south Delta, eggs and larvae may be transported into the area by reverse flows in Old and Middle rivers. As discussed previously, these early life stages are generally entrained, since they are too small to be effectively screened from export waters.

Old and Middle river reverse flows have been calculated for project alternatives that equate San Joaquin River flow at Vernalis and exports to Old and Middle river flows. Summaries of Old and Middle river reverse flows are included for Existing Conditions, No-Action and action alternatives, by month and water-year type. The most biologically sensate period when the potential effects of reverse flows could affect delta smelt, Chinook salmon, and many other species extends from the late winter through early summer. For purposes of these analyses, a comparison of reverse flows within Old and Middle rivers under the basis-of-comparison and proposed alternative project operations was prepared for the seasonal period extending from January through June.

CVP and SWP Export Operations Increased exports could increase the risk of entrainment and salvage of resident and migratory fish present in the south Delta, which may include adult delta smelt, juvenile Chinook salmon, steelhead, striped bass, and other species of fish as well as macroinvertebrates and nutrients. Increased exports during drier water years in the summer could result in an increased risk of entrainment and salvage for juvenile delta smelt and salmon (June) and resident warm-water fish such as striped bass, threadfin shad, catfish, and others during the warmer summer months (July through August). Increased exports could also increase the entrainment and removal of phytoplankton, zooplankton, macroinvertebrates, organic material, and nutrients from the Delta.

Estimated Fish Entrainment/Losses Changes in the volume of water exported at the CVP and SWP facilities is assumed to result in a direct proportional increase or decrease in the risk of fish being entrained and salvaged at the facilities. Using information from the hydrodynamic operations model, in combination with information on the densities of various fish species observed at the salvage facilities, an index in the form of a change in the numbers of a fish species theoretically affected by a change in export operations can be developed. Fish lost to entrainment/salvage at the CVP and SWP were estimated based on monthly estimated combined exports. The project alternatives were modeled in CalSim and assume, for each alternative, that the project would be implemented under the Existing Condition, and under the Future Condition. Both the Existing Condition, or "existing base" conditions, and future base conditions, or "future No-Action Alternative" conditions – which assumes no project was implemented, were assessed.

Data sources used to calculate fish losses at the CVP and SWP consisted of 1995 through 2005 monthly average density data, collected by DWR (2006) at the Skinner Fish Facility and at the Jones Fish Facility located at each export facility, respectively. These density data were calculated for delta smelt, longfin smelt, Chinook salmon, steelhead, striped bass, and splittail. Green sturgeon were considered for this analysis; however, they are seldom collected at the fish facilities, and thus, have not been modeled in the entrainment loss estimates. Fish density data was combined with CalSim results export flows modeled.

From CalSim modeling results, average monthly flows, and average flows per each year from 1922 to 2003 in cfs were converted to acre-feet per each month (January through December), and were then multiplied by monthly average densities (number of fish per acre-foot), for each of the selected fish species. Average monthly fish losses calculated for each year were then averaged by water-year type (e.g., wet, above-normal, normal, below-normal, dry, and critical) for each month, as well as an average across all years (all water-year types), for each month. Fish losses, for each species, were totaled across months to show the total fish loss for a given species for an average year (all water-year types), wet, above-normal, normal, below-normal, dry, and critical years.

Fish losses resulting from entrainment were calculated two ways, which both produced identical entrainment indices to represent the change in entrainment based on changes in CVP and SWP exports as a result of the SLWRI alternatives:

- Fish losses were estimated by calculating losses under the base conditions, and then by calculating losses under the project alternative, from CalSim modeling. The total number of fish lost under the base case was subtracted from the number lost under the project alternative, indicating whether a net benefit (negative number) or a net loss (positive number) would result from the project alternatives.

- Fish losses were estimated by calculating losses directly from the "Alt minus Base" modeling results in CalSim.

The general calculation of the change in entrainment/salvage risk is shown below:

A = Density of fish per acre-foot for a given fish species (e.g., delta smelt, longfin smelt, salmon, striped bass, steelhead, splittail)

B = Monthly cfs, by year

C = [B x 1.983 x (number of days/month)] = average monthly exports (for CVP+SWP) for a given year, 1922 to 2003, in acre-feet

D = [A] [C] = Average monthly fish loss, per species, in a given year

D_A = $\sum (C_{1922,} C_{1923} \ldots C_{2003})$ = Average monthly fish losses at the CVP + SWP

D_W = $\sum$ (*wet water years*) = Fish losses, by month, at the CVP + SWP, based on wet water years, 1922 to 2003

D_{AN} = $\sum$ (*above-normal water years*) = Fish losses, by month, at the CVP + SWP, based on above-normal water years, 1922 to 2003

D_N = $\sum$ (*normal water years*) = Fish losses, by month, at the CVP + SWP, based on normal water years, 1922 to 2003

D_{BN} = $\sum$ (*below-normal water years*)) = Fish losses, by month, at the CVP + SWP, based on below-normal water years, 1922 to 2003

D_D = $\sum$ (*dry water years*) = Fish losses, by month, at the CVP + SWP, based on dry water years, 1922 to 2003

D_C = $\sum$ (*critical water years*) = Fish losses, by month, at the CVP + SWP, based on critical water years, 1922 to 2003

E_A = ($D_{A\text{-}JANUARY}$ +$D_{A\text{-}FEBRUARY...}$+ $D_{A\text{-}DECEMBER}$) = Total yearly average fish losses, based on monthly average 1922 to 2003 fish losses

E_W = ($D_{W\text{-}JANUARY}$ +$D_{W\text{-}FEBRUARY...}$+ $D_{W\text{-}DECEMBER}$) = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

E_{AN} = ($D_{AN\text{-}JANUARY}$ +$D_{AN\text{-}FEBRUARY...}$+ $D_{AN\text{-}DECEMBER}$) = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

E_N = ($D_{N\text{-}JANUARY}$ +$D_{N\text{-}FEBRUARY...}$+ $D_{N\text{-}DECEMBER}$) = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

E_{BN} = ($D_{BN\text{-}JANUARY}$ +$D_{BN\text{-}FEBRUARY...}$+ $D_{BN\text{-}DECEMBER}$) = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

E_D = ($D_{D\text{-}JANUARY}$ +$D_{D\text{-}FEBRUARY...}$+ $D_{D\text{-}DECEMBER}$) = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

E_C = ($D_{C\text{-}JANUARY}$ +$D_{C\text{-}FEBRUARY...}$+ $D_{C\text{-}DECEMBER}$) = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

Impact Mechanisms

The project could potentially affect fisheries and aquatic ecosystems through the following impact mechanisms:

- Construction-related impacts:
  - Temporary construction-related loss or degradation of aquatic habitat
- Operations-related impacts, including the following:
  - Flow- and/or water temperature-related impacts on species of primary management concern

  - Geomorphic impacts resulting from reduced frequency, duration, and/or magnitude of ecologically important intermediate and peak flows

- Delta flow-related effects, including the following:

  - Delta outflow and inflow related effects on species of primary management concern

  - Effects related to changes in Sacramento River inflow to the Delta

  - San Joaquin River flow-related effects

  - Effects on species of primary management concern resulting from changes in the location of the entrapment zone and X2

  - Effects resulting from reverse flows in Old and Middle rivers

  - Effects of changes in CVP and SWP exports to fish entrainment and salvage

Potential effects resulting from these impact mechanisms were assessed for fish species of primary management concern (i.e., special-status, ecologically important, and recreationally/commercially important fish species) and important aquatic ecological processes that may be affected by construction activities and/or operation located between Shasta Dam and RBDD (i.e., in the primary study area) and within the extended study area.

Fish species of primary management concern for the upper Sacramento River (Shasta Dam to RBDD) portion of the primary study area include the following:

- Four runs of Chinook salmon (winter-, spring-, fall-, and late fall-run)
- Steelhead
- Green sturgeon
- Sacramento splittail
- American shad
- Striped bass

Fish species of primary management concern for the lower Sacramento River to Delta portion of the extended study area include the same fish identified above but also include delta smelt and exclude American shad.

Fish species of primary management concern for the Trinity River portion of the extended study area include the following:

- Chinook salmon
- Steelhead
- Coho salmon
- Green sturgeon
- White sturgeon

The analysis of potential impacts on primary fish species of management concern considered species life history stages (adult migration, spawning, egg incubation, and juvenile rearing and emigration) and biological requirements. For all fish species of primary management concern in the Sacramento River, evaluation of potential impacts on individual life stages was based on life history descriptions provided in the *Fisheries and Aquatic Ecosystems Technical Report*.

Increased water supplies or increased supply reliability also could reduce a limitation on growth or on other activities that could affect aquatic habitats and fishery resources in the primary and extended study areas, resulting in potentially significant impacts. The impacts of this growth would be analyzed in general plan Environmental Impact Report and in project-level CEQA compliance documents for the local jurisdictions in which the growth would occur. Mitigation of these impacts would be the responsibility of these local jurisdictions, and not of Reclamation. The expected increase in water yield relative to the entire CVP and SWP service areas would be small, however, and assuming that this new yield could be provided to any number of geographic areas within the CVP and SWP service areas, the project's impact on growth that could affect aquatic habitats would be minor.

Similarly, projects potentially affecting most aquatic habitats and listed species would require permits from DFG, USACE, USFWS, and NMFS; it is anticipated that effects on aquatic habitats and listed species would be avoided, minimized, and/or mitigated during those agency consultations. Because the extent, location, and timing of induced growth is currently highly uncertain, and in the future the effects of this growth would be analyzed and mitigated during land use planning and environmental review for specific projects, growth-inducing effects on aquatic habitats and fisheries resources are not discussed further in this chapter.

11.3.2 Criteria for Determining Significance of Effects

An environmental document prepared to comply with NEPA must consider the context and intensity of the environmental effects that would be caused by, or result from, the proposed action. Under NEPA, the significance of an effect is used solely to determine whether an Environmental Impact Statement must be prepared. An environmental document prepared to comply with CEQA must identify the potentially significant environmental effects of a proposed project.

A "[s]ignificant effect of the environment" means a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project (State CEQA Guidelines, Section 15382). CEQA also requires that the environmental document propose feasible measures to avoid or substantially reduce significant environmental effects (State CEQA Guidelines, Section 15126.4(a)).

Significance criteria (sometimes called "thresholds of significance") used in this analysis are based on the checklist presented in Appendix G of the State CEQA Guidelines; factual or scientific information and data; and regulatory standards of Federal, State, and local agencies. These thresholds also encompass the factors taken into account under NEPA to determine the significance of an action in terms of the context and the intensity of its effects.

For the assessment of impacts on fisheries and aquatic ecosystems, habitat indicators for project operations such as water temperature, flows, and important ecological processes have been used to evaluate whether the project alternatives would have an adverse effect on the species and/or species' habitat. For example, exceedence of monthly mean water temperatures identified by NMFS for certain species (e.g., 56ºF at Bend Bridge from April 15 through September 30 for winter-run Chinook salmon) is one such impact on a habitat indicator. Reduction of reservoir WSELs can reduce the availability of nearshore littoral habitat used by warm-water fish for spawning and rearing, thereby reducing spawning and rearing success and subsequent year class strength; therefore, reservoir WSEL is another habitat indicator used. Changes in river flows and water temperatures during certain periods of the year have the potential to affect spawning, fry emergence, and juvenile emigration. Therefore, changes in monthly mean river flows and water temperatures during certain times of the year (during spawning, incubation, and initial rearing) have also been used as habitat impact indicators for species of primary management concern.

The following significance criteria were developed based on guidance provided by the State CEQA Guidelines, and consider the context and intensity of the environmental effects as required under NEPA. Impacts of an alternative on fisheries and aquatic ecosystems would be significant if project implementation would do any of the following:

- Have a substantial adverse effect, either directly or 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 DFG, USFWS, or NMFS.

- Conflict with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or State habitat conservation plan or policies or ordinances protecting biological resources.

- Interfere substantially with the movement of any native resident or migratory fish species or with established habitat, or impede the use of native fish nursery/rearing sites.

- Conflict with a local policy or ordinance that protects aquatic and fishery resources.

- Substantially reduce the habitat of a fish species, cause a fish species to drop below self-sustaining levels, threaten to eliminate a fish or macroinvertebrate community, or substantially reduce the number or restrict the range of an endangered, rare, or threatened fish species.

Significance statements are relative to both the Existing Conditions (2005) and Future Conditions (2030), unless stated otherwise.

11.3.3 Direct and Indirect Effects

This section identifies how aquatic habitats and fish communities could be affected by the project. The project could affect fisheries and aquatic ecosystems through the following:

- Causing construction-related loss or degradation of aquatic habitat in the vicinity of and downstream from Shasta Dam.

- Altering flow regimes and water temperatures downstream from Shasta Dam and downstream from other reservoirs with altered releases.

- Causing a reduction in ecologically important geomorphic processes resulting from reduced frequency and magnitude of intermediate to high flows.

By altering reservoir storage and releases, the project would change flow regimes in downstream waterways. In turn, these alterations to the flow regime could affect fishery resources and important ecological processes on which the fish community depends, particularly their instream and seasonal floodplain habitats along waterways immediately downstream from reservoirs.

No-Action Alternative

Under the No-Action Alternative, the Federal government would take no additional action beyond existing regulatory requirements toward implementing a specific plan to help increase survival of anadromous fish in the Sacramento River, nor would it help address the growing water reliability issues in California. The following discussions highlight the consequences of implementing the No-Action Alternative, as they relate to the objectives of the SLWRI.

Shasta Lake and Vicinity

Impact Aqua-1 (No-Action): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under the No-Action Alternative, dam enlargement activities would not be implemented. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could be affected, however, by changing water supply demand and regulatory conditions, which could in turn affect the amount of nearshore, warm-water habitat in Shasta Lake. This impact would be potentially significant.

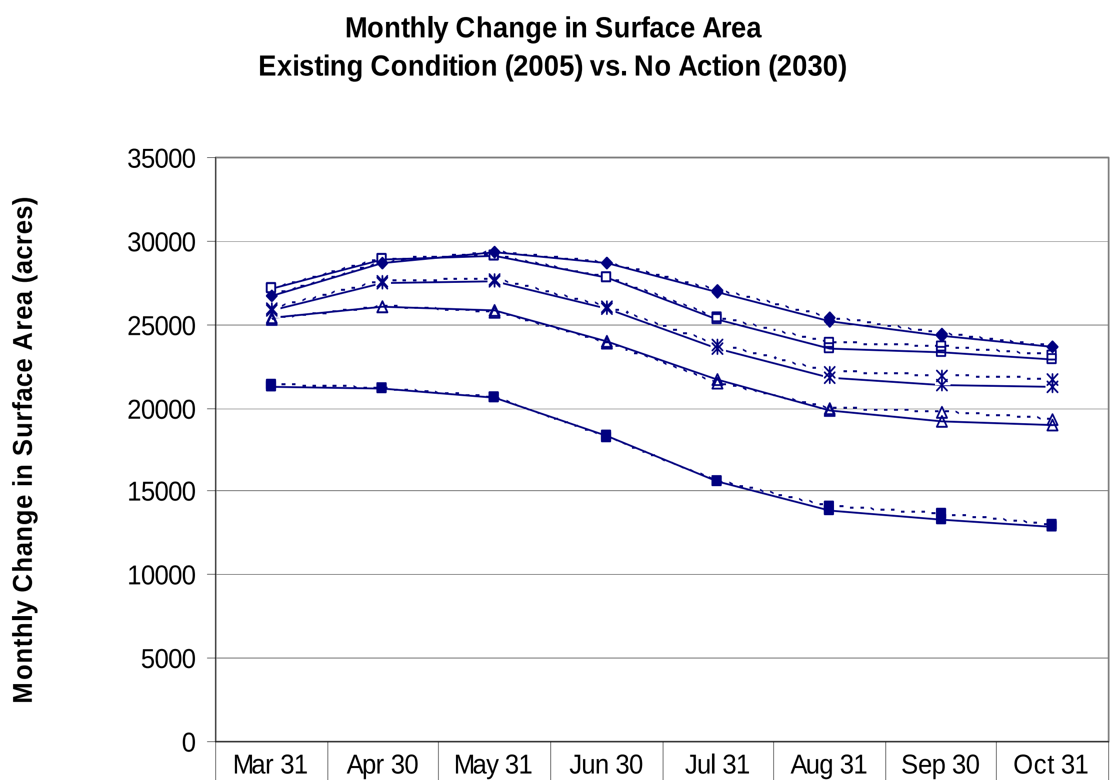
Under the No-Action Alternative with a 2030 water supply demand, the mean surface area of Shasta Lake in all months and all water-year types would be slightly less than under the Existing Condition. The greatest potential decreases would be experienced from September through November in below-normal water years (Figure 11-2). Fluctuations in WSELs are similar for the No-Action Alternative and the Existing Condition for all months except April in a wet water year (Figure 11-3). Overall, the monthly change between March and July trends downward.

Seasonal fluctuations in the surface area and WSEL of Shasta Lake could be affected by changing water supply demand and regulatory conditions. Such fluctuations could have an adverse effect on the quality and quantity of nearshore, warm-warm habitat in the lake. Therefore, this impact would be potentially significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-2 (No-Action): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Under the No-Action Alternative, dam enlargement activities would not be implemented, and no new facilities would be constructed within the vicinity of Shasta Lake. There would be no impact. Mitigation is not required for the No-Action Alternative.

Impact Aqua-3 (No-Action): Effects on Cold-Water Habitat in Shasta Lake Under the No-Action Alternative, dam enlargement activities would not be implemented. Under this alternative, seasonal fluctuations in the ratio of the volume of cold-water storage in Shasta Lake to the surface area of the lake could be affected by changing water supply demand and regulatory conditions, which could affect the amount of cold-water habitat, including habitat for rainbow trout, a USFS sensitive species. This impact would be potentially significant. Mitigation is not required for the No-Action Alternative.

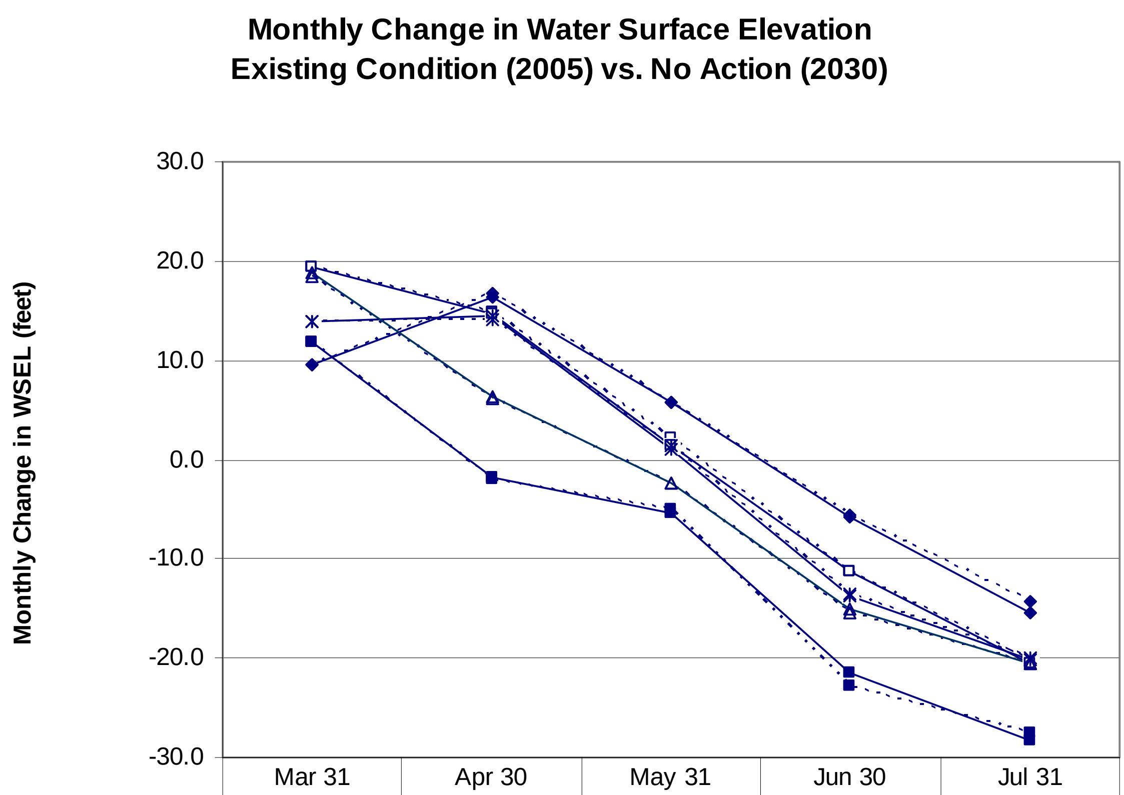
Impact Aqua-4 (No-Action): Effects on Special-Status Aquatic Mollusks Under the No-Action Alternative, dam enlargement activities would not be implemented. Seasonal fluctuations in the surface area and WSEL of Shasta Lake in response to water demand and regulatory conditions could affect special-status aquatic mollusks that may occupy habitat in or near Shasta Lake and its tributaries. These impacts would continue to occur under this alternative. This impact would be less than significant.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26726	28711	29305	28720	27042	25351	24380	23709
EC AN	27096	28851	29102	27792	25377	23881	23648	23105
EC BN	25942	27562	27715	26098	23740	22177	21932	21732
EC D	25311	26013	25724	23891	21531	19954	19778	19310
EC C	21336	21121	20583	18251	15644	14079	13655	12992
NA W	26750	28695	29293	28690	26880	25222	24303	23671
NA AN	27167	28885	29069	27750	25285	23603	23283	22865
NA BN	25820	27477	27594	25947	23571	21815	21422	21291
NA D	25395	26108	25802	24026	21660	19855	19238	19017
NA C	21312	21115	20554	18343	15646	13859	13349	12834

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing conditions
NA = No-Action
W = wet water years

Figure 11-2. Monthly Surface Area (in acres) for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, Existing Condition vs. No-Action Alternative



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9.5	16.7	5.7	-5.6	-14.3
EC AN	19.5	14.9	2.1	-11.2	-20.1
EC BN	13.9	14.0	1.4	-13.6	-19.9
EC D	18.4	6.1	-2.3	-15.5	-20.5
EC C	11.8	-1.9	-5.0	-22.7	-27.5
NA W	9.7	16.3	5.7	-5.8	-15.3
NA AN	19.4	14.7	1.5	-11.3	-20.5
NA BN	13.9	14.4	1.1	-13.8	-20.1
NA D	18.8	6.2	-2.4	-15.0	-20.5
NA C	11.9	-1.7	-5.3	-21.5	-28.3

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
NA = No-Action
W = wet water years
WSEL = water surface elevation

Figure 11-3. Monthly Change in WSEL (in feet) for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, Existing Condition vs. No-Action Alternative

One special-status mollusk, the California floater, occurs in Shasta Lake, and nine other special-status mollusks could occupy seeps, springs, or tributaries surrounding the reservoir. However, information regarding these species' distributions and abundance is limited, which precludes fully quantifying the impacts of the No-Action Alternative on these organisms and their habitat.

Except for the California floater, it is not known if other special-status mollusks occupy habitat in or near Shasta Lake and its tributaries. The California floater is a bivalve that resides in soft sediment on stream and lake beds and, therefore, could be adversely affected by seasonal fluctuations in the WSEL of the lake that currently exists. This impact would be less than significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-5 (No-Action): Effects on Special-Status Fish Species Under the No-Action Alternative, dam enlargement activities would not be implemented. However, one fish species occurring within the primary study area and designated as sensitive by USFS could be affected by seasonal fluctuations in the surface area and WSEL of Shasta Lake in response to changing water demand and regulatory conditions; however, this impact would be less than significant.

The hardhead minnow is designated as sensitive by USFS and is known to occur in Shasta Lake. Two other USFS sensitive species, rough sculpin (in the Pit River) and redband trout (in the upper McCloud River), are known to occur upstream from Shasta Lake, but their presence have not been documented in Shasta Lake or in their respective tributaries within the primary study area. The analysis of the No-Action Alternative therefore excludes consideration of these two special-status species.

Fluctuations in the surface area and WSEL of Shasta Lake under the No-Action Alternative could interfere with the connectivity to riverine habitat preferred by hardhead in tributaries that drain into Shasta Lake. However, access to riverine habitat among all the main tributaries to the reservoir would not likely become any more limiting than under current conditions. Therefore, this impact would be less than significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-6 (No-Action): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under the No-Action Alternative, dam enlargement activities would not be implemented, and tributaries to Shasta Lake would continue to respond to fluctuations in reservoir levels. New barriers would not be created or removed that could impede or facilitate the movement of native and nonnative fish species between Shasta Lake and its tributaries. There would be no impact. Mitigation is not required for the No-Action Alternative.

Impact Aqua-7 (No-Action): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake Under the No-Action Alternative, dam enlargement activities would not be implemented, and there would be no change to spawning and rearing habitat for adfluvial salmonids in low-gradient tributaries to Shasta Lake. There would be no impact. Mitigation is not required for the No-Action Alternative.

Impact Aqua-8 (No-Action): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake Under the No-Action Alternative, dam enlargement activities would not be implemented. Therefore, aquatic connectivity in non-fish-bearing streams would not be affected. There would be no impact. Mitigation is not required for the No-Action Alternative.

Impact Aqua-9 (No-Action): Effects on Water Quality at Livingston Stone Hatchery Under the No-Action Alternative, dam enlargement activities would not be implemented. Therefore, there would be no changes to the water system that supplies high-quality water to the Livingston Stone Hatchery. There would be no impact. Mitigation is not required for the No-Action Alternative.

Upper Sacramento River (Shasta Dam to RBDD)

Impact Aqua-10 (No-Action): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Under the No-Action Alternative, there would be no construction-related loss or degradation of aquatic habitat and no variation in CVP and SWP reservoir storage levels in the upper Sacramento River or tributaries associated with project alternatives. It is anticipated that, if the project alternatives were not implemented, actions to protect the fisheries and aquatic resources would continue under existing regulatory requirements, including other CALFED actions intended to protect and enhance fisheries resources. Therefore, there would be no construction-related impacts on fisheries and aquatic ecosystems associated with the No-Action Alternative. Mitigation is not required for the No-Action Alternative.

Impact Aqua-11 (No-Action): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Under the No-Action Alternative, there would be no construction-related contaminant exposure in the upper Sacramento River or tributaries associated with project alternatives. It is anticipated that, if the project alternatives were not implemented, actions to protect the fisheries and aquatic resources would continue under existing regulatory requirements, including other CALFED actions intended to protect and enhance fisheries resources. Therefore, there would be no construction-related impacts on fisheries and aquatic ecosystems associated with the No-Action Alternative. Mitigation is not required for the No-Action Alternative.

Impact Aqua-12 (No-Action): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon Flow releases would continue to be operated in compliance with existing BOs, which represent the regulatory baseline. However, it is anticipated that climate change would result in an increase in water temperatures in the upper Sacramento River (NMFS 2009), which could make it much more difficult, especially in critical water years, to meet the water temperature requirements needs for all runs of Chinook salmon, particularly winter-run Chinook salmon. As a result, Chinook salmon in the upper Sacramento River could experience potentially significant impacts. Mitigation is not required for the No-Action Alternative.

Impact Aqua-13 (No-Action): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass Flow releases would continue to be operated in compliance with existing BOs, which represent the regulatory baseline. However, it is anticipated that climate change would result in an increase in water temperatures (NMFS 2009). This could make it much more difficult, especially in critical water years, to meet the water temperature requirements needs for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. As a result, fishes in the upper Sacramento River could experience potentially significant impacts. Mitigation is not required for the No-Action Alternative.

Impact Aqua-14 (No-Action): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Under the No-Action Alternative, there would be no change to the geomorphic processes in the upper Sacramento River. Mitigation is not required for the No-Action Alternative.

Lower Sacramento River, Tributaries, Delta and Trinity River Under the No-Action Alternative, there would be no project-related alteration of CVP and SWP reservoir storage levels, river flows, or water temperatures in the lower Sacramento River or Delta. It is anticipated that if the project alternatives were not implemented, actions to protect fisheries and benefit aquatic environments would continue under existing regulatory requirements, including other CALFED actions intended to protect and enhance fisheries resources. Compliance with existing BOs would result in continued pumping curtailments, particularly in dry years. Reclamation and the DWR would continue to attempt to reoperate the CVP and SWP, respectively, to avoid decreased deliveries to export users. Therefore, there would be no project-related impacts changes on fisheries and aquatic ecosystems associated with the No-Action Alternative.

Under the No-Action Alternative, there would be no project-related alteration of CVP and SWP reservoir storage levels, river flows, or water temperatures in the Trinity River. Therefore there would be no impacts associated with the No-Action Alternative to the aquatic resources in the Trinity River.

CVP/SWP Service Areas Under the No-Action Alternative, there would be no project-related change in CVP and SWP operations or deliveries to the CVP and SWP service areas. It is anticipated that if the project alternatives were not implemented, actions to protect fisheries and benefit aquatic environments would continue under existing regulatory requirements, including other CALFED actions and existing BOs intended to protect and enhance fisheries resources.

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

CP1 focuses on increasing water supply reliability while contributing to increased survival of anadromous fish, actions that are consistent with the 2000 CALFED ROD. CP1 consists primarily of raising Shasta Dam by 6.5 feet, an elevation change that would increase the reservoir's full pool elevation by 8.5 feet and would enlarge the total storage space in the reservoir by 256,000 acre-feet. Under CP1, Shasta Dam operational guidelines would continue unchanged, with the additional storage retained for water supply reliability. CP1 would help to reduce future water shortages by increasing the reliability of the water supply in drought and average water years. The increased pool depth and volume would also contribute to maintaining lower seasonal water temperatures and more reliable flows on the upper Sacramento River for anadromous fish.

Shasta Lake and Vicinity

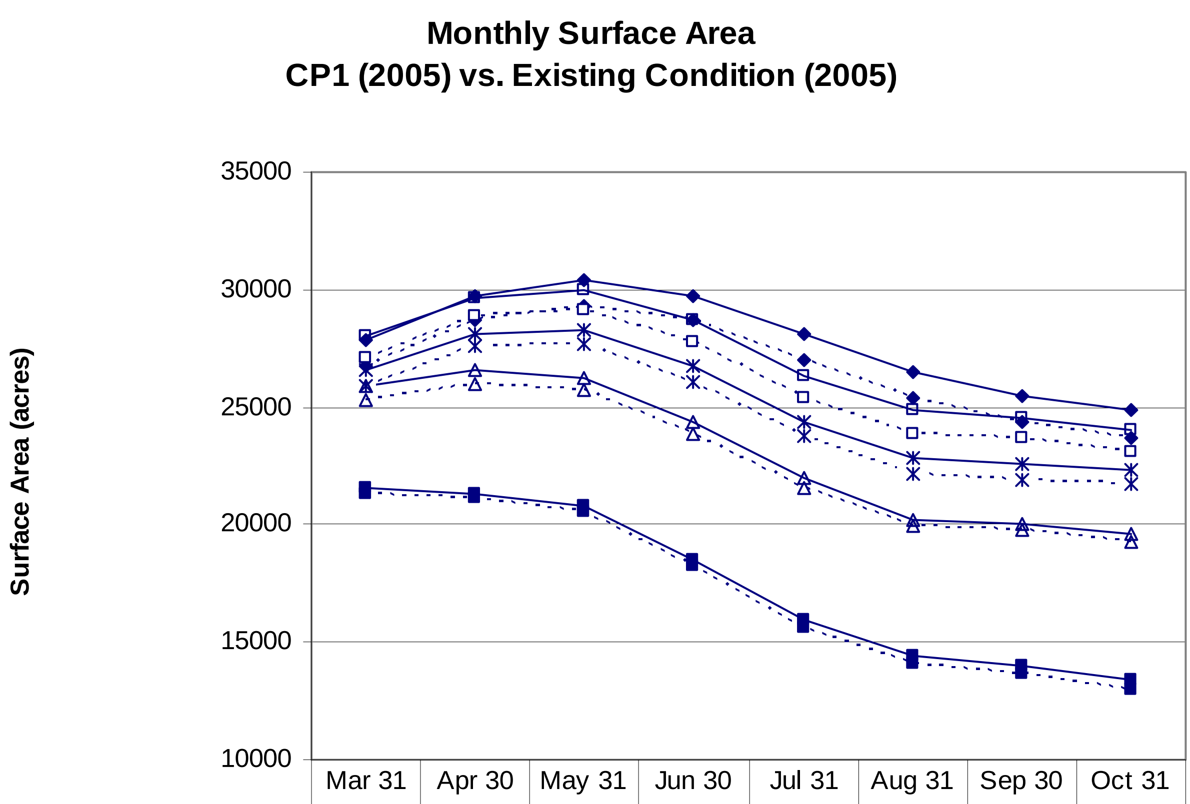
Impact Aqua-1 (CP1): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations   Under CP1, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. Project operations would also result in reduced monthly fluctuations in the WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. The increase in the WSEL will influence riparian vegetation, including willow species planted to enhance lacustrine habitat, likely resulting in some amount of willow mortality. The increase in the WSEL will also influence the effectiveness of the brush structures that have been introduced by the STNF at various locations within the current drawdown zone of Shasta Lake. While the value of these structural improvements will be influenced by an overall increase in the maximum WSEL, these structures will continue to function to varying degrees under the operational conditions established for CP1. These impacts to structural habitat improvements are expected to be localized and will vary as the brush structures age and riparian vegetation readjusts to a new baseline condition. The retention of vegetation along more than 40 percent of the increased shoreline area that would be subject to inundation as a result of CP1 is expected to offset reductions in effective structural habitat improvements for a period of time. The benefits of inundated vegetation will decrease over time (e.g., 10-20 years) as the vegetation decays and the shoreline erosion processes expand into the new drawdown zone. . This impact would be less than significant..

Biological productivity is greatest in the upper, lighted layer of the reservoir, where most plankton production occurs. An increase in the surface area of the reservoir could affect warm-water habitat by increasing the area of littoral (nearshore) habitat, which could result in increased biological productivity. Increased inundation of terrestrial habitat, leading to increased nutrient loading from vegetative debris along the shore for some period of time, could increase plankton production, causing an upsurge in nutritional sources for warm-water species (Kimmel and Groeger 1986).

CalSim-II modeling indicated that the surface area of Shasta Lake would be larger under CP1 with a 2005 water supply demand than under the Existing Condition or under the No-Action Alternative for all five water-year types. The Shasta Lake surface area would be larger under CP1 with a 2030 water supply demand than under the Existing Condition or under the No-Action Alternative in wet, above-normal, and below-normal water years. In dry water years, the surface area under CP1 would be larger than under the No-Action Alternative in all months modeled, and would be larger than the Existing Condition in all months except September, when it would be only 8 acres less; given the size of Shasta Lake, a decrease of 8 acres would be essentially equivalent to the Existing Condition. In critical water years from March through May, which is the beginning of the spawning period for warm-water fishes, the surface area under CP1 with a 2030 water supply demand would be smaller than both the Existing Condition and the No-Action Alternative by an average of 23 acres and 42 acres, respectively, but would be larger at the end of the spawning period (June and July) than both the Existing Condition and the No-Action Alternative. From August until sometime in October in critical water years, the surface area under CP1 with a 2030 water supply demand would continue to be larger than the surface area under the No-Action Alternative, but would be less than the Existing Condition by an average of 160 acres (Figures 11-4 and 11-5).

An increase in the WSEL could benefit fish by increasing the amount and quality of available warm-water habitat in Shasta Lake. According to Ozen and Noble (2002), inundation of a reservoir creates an area that is sparsely populated by fish (i.e., decreases fish density per unit of habitat); the low population numbers stimulate the natural reproductive and growth processes of the fish. The newly inundated vegetation creates temporary cover for shoreline-dwelling fishes. As the vegetation decomposes, it releases nutrients for phytoplankton and periphyton, which are in turn consumed by the fish.

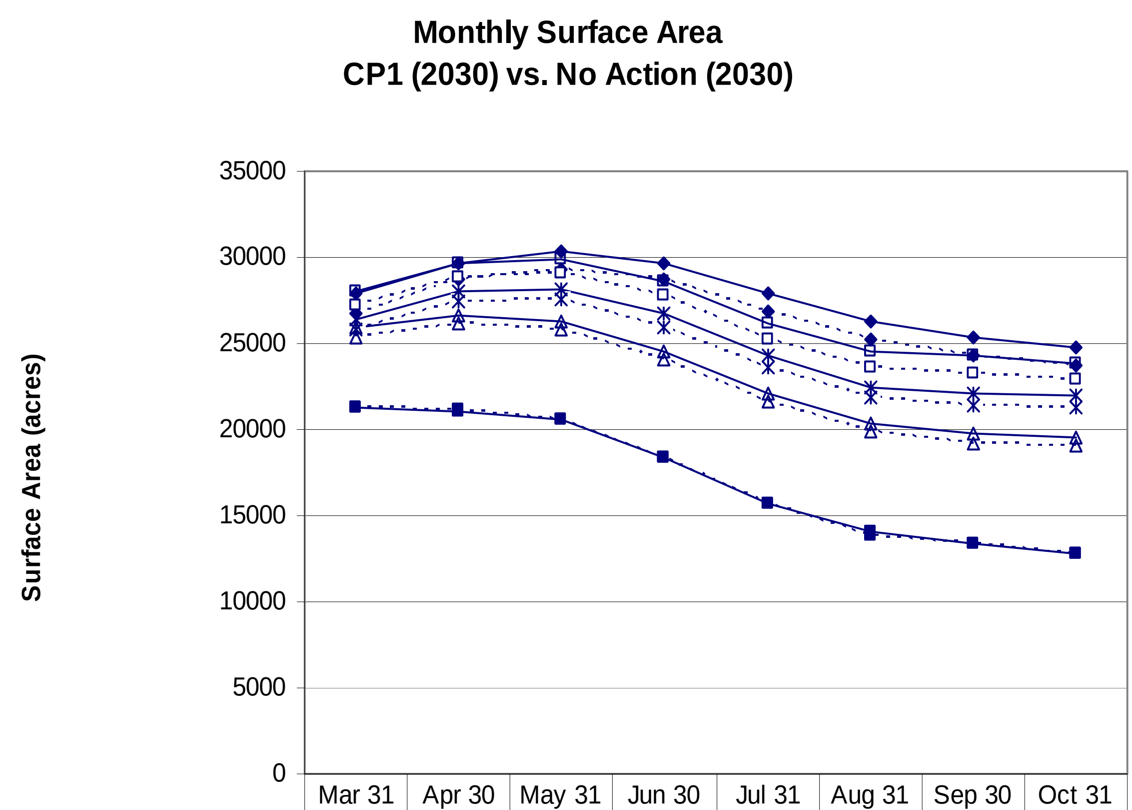
According to CalSim-II modeling, the Shasta Lake WSEL would be higher under CP1 with a 2005 water supply demand than under the Existing Condition or the No-Action Alternative for all five water-year types. The Shasta Lake WSEL would be higher under CP1 with a 2030 water supply demand than under the Existing Condition or under the No-Action Alternative in all but critical water years. In critical water years, the WSEL under CP1 with a 2030 water supply demand would be similar to the No-Action Alternative.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26726	28711	29305	28720	27042	25351	24380	23709
EC AN	27096	28851	29102	27792	25377	23881	23648	23105
EC BN	25942	27562	27715	26098	23740	22177	21932	21732
EC D	25311	26013	25724	23891	21531	19954	19778	19310
EC C	21336	21121	20583	18251	15644	14079	13655	12992
CP1 2005 W	27850	29705	30370	29727	28147	26495	25513	24902
CP1 2005 AN	27996	29642	29954	28684	26319	24871	24533	24009
CP1 2005 BN	26545	28140	28299	26765	24410	22818	22569	22345
CP1 2005 D	25917	26589	26267	24395	21952	20208	20048	19590
CP1 2005 C	21564	21340	20792	18492	15960	14440	14021	13372

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Conditions
W = wet water years

Figure 11-4. Monthly Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 vs. Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26750	28695	29293	28690	26880	25222	24303	23671
NA AN	27167	28885	29069	27750	25285	23603	23283	22865
NA BN	25820	27477	27594	25947	23571	21815	21422	21291
NA D	25395	26108	25802	24026	21660	19855	19238	19017
NA C	21312	21115	20554	18343	15646	13859	13349	12834
CP1 2030 W	27873	29708	30366	29687	27885	26236	25304	24724
CP1 2030 AN	28044	29641	29909	28605	26209	24592	24259	23860
CP1 2030 BN	26418	28039	28190	26686	24326	22480	22090	21949
CP1 2030 D	25980	26642	26306	24517	22134	20328	19770	19541
CP1 2030 C	21294	21089	20531	18360	15695	14050	13362	12843

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

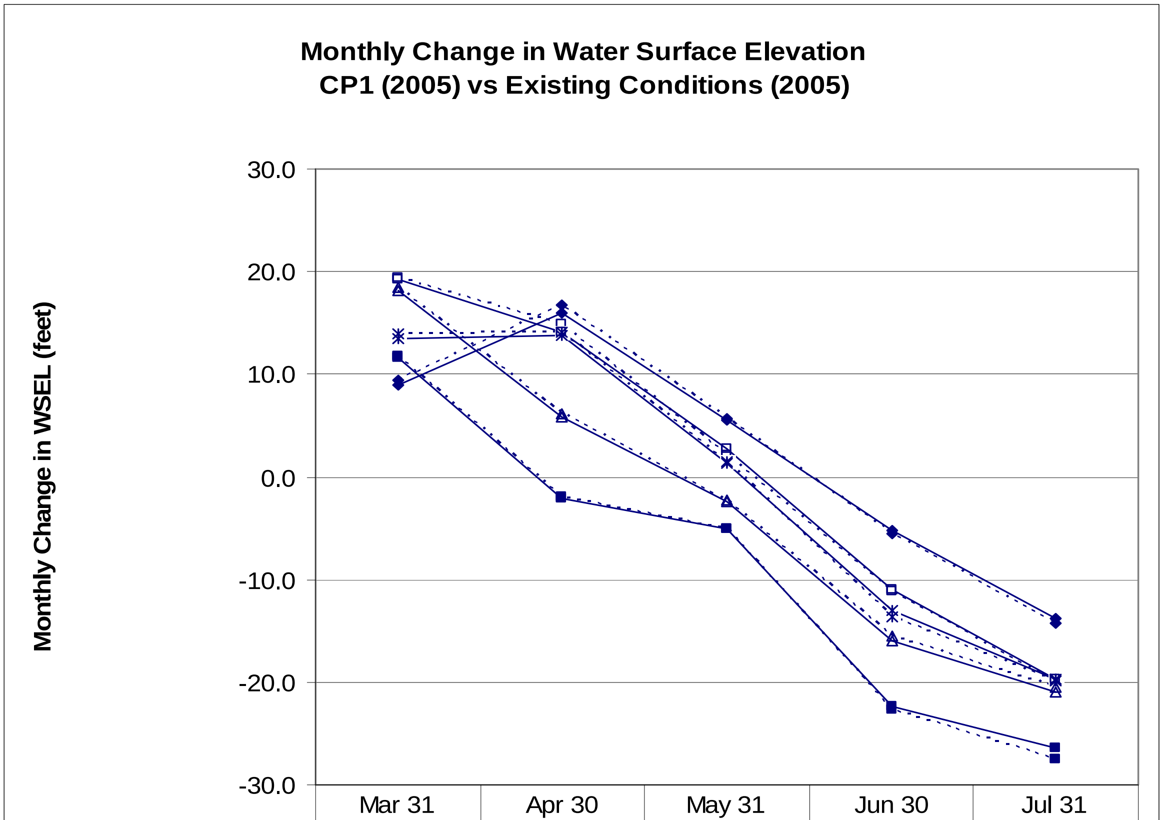
Figure 11-5. Monthly Change in Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 (2030) vs. No-Action Alternative

Rapid rates of increase in WSEL during the critical spring nesting period can lead to such adverse effects as decreased spawning success through nest abandonment or decreased egg survival (Mitchell 1982). Jones and Stokes (1998) reported that mortality approaches 10 percent for eggs in nests submerged under more than 15 feet of water during periods of rapid increase in reservoir elevations.

Rapidly decreasing WSELs can also have an adverse effect on aquatic organisms. According to Lee (1999), the maximum rate of drawdown that would allow a nesting success rate of 10 percent varied between species, with receding water level rates of less than 0.07, less than 0.03, and less than 0.02 feet per day for largemouth, smallmouth, and spotted bass nests, respectively. Lee found that daily drawdown rates of 0.36, 0.36, and 0.72 feet per day for largemouth, smallmouth, and spotted bass, respectively, resulted in 20 percent nest survival. Under CP1, none of the changes in monthly WSEL fluctuation were substantially different from the Existing Condition.

Monthly WSEL fluctuations were compared with projections for water supply demand. For CP1 with a 2005 water supply demand, 20 percent of monthly changes in projected WSELs (i.e., 5 of the 25 total projections made for the 5 months from March through July for all five water-year types) showed increased monthly WSEL fluctuations relative to the Existing Condition and 80 percent showed reduced monthly WSEL fluctuations (Figure 11-6). For CP1 with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSELs showed increased WSEL fluctuations relative to the No-Action Alternative and 64 percent showed reduced monthly WSEL fluctuations (Figure 11-7).

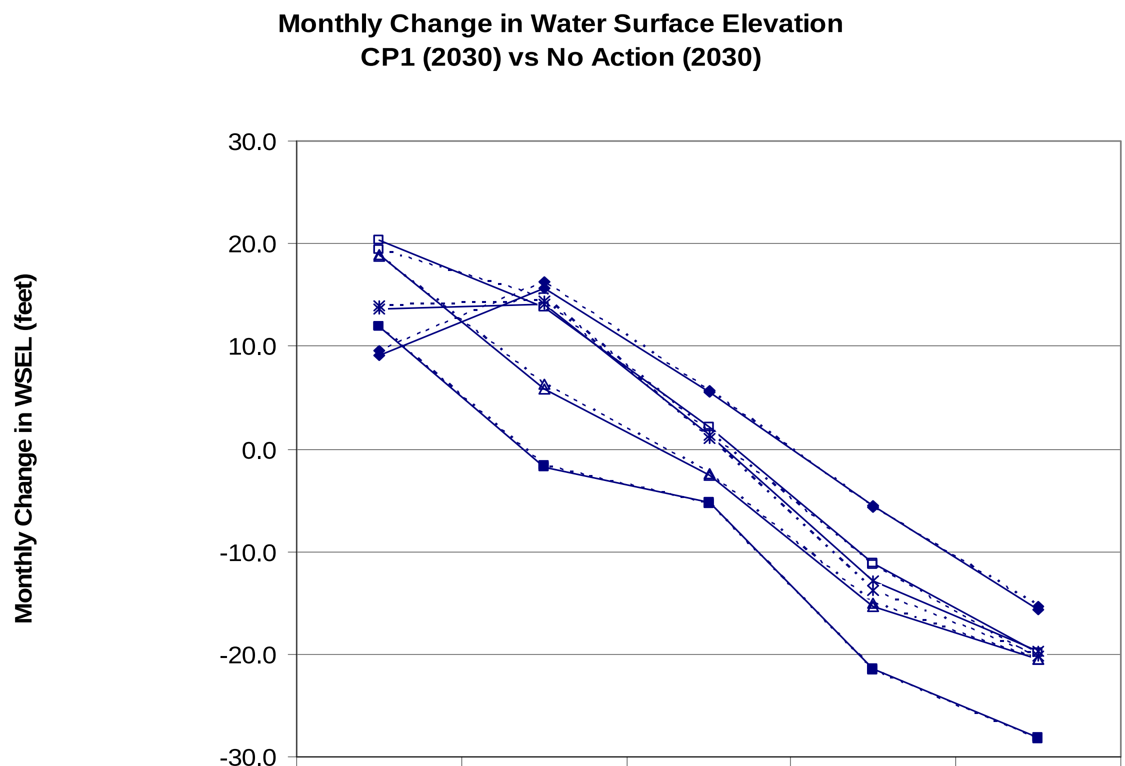
Increases in the overall surface area and WSEL under CP1 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake, although the value of structural and vegetative improvements that currently provide effective structural habitat at specific locations will be decreased to some extent. Overall, CP1 would result in reductions in the magnitude of monthly WSEL fluctuations and would contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water species, and provide for an increase in structural habitat (inundated vegetation) for some period of time. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9.5	16.7	5.7	-5.6	-14.3
EC AN	19.5	14.9	2.1	-11.2	-20.1
EC BN	13.9	14.0	1.4	-13.6	-19.9
EC D	18.4	6.1	-2.3	-15.5	-20.5
EC C	11.8	-1.9	-5.0	-22.7	-27.5
CP1 2005 W	9.0	15.9	5.6	-5.2	-13.8
CP1 2005 AN	19.2	14.1	2.7	-11.0	-19.6
CP1 2005 BN	13.5	13.8	1.4	-13.0	-19.8
CP1 2005 D	18.1	5.9	-2.5	-16.0	-21.0
CP1 2005 C	11.6	-2.1	-5.1	-22.4	-26.4

Key:
AN = above-normal water
BN = below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Conditions
W = wet water years
WSEL = water surface elevation

Figure 11-6. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 vs. Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	9.7	16.3	5.7	-5.8	-15.3
NA AN	19.4	14.7	1.5	-11.3	-20.5
NA BN	13.9	14.4	1.1	-13.8	-20.1
NA D	18.8	6.2	-2.4	-15.0	-20.5
NA C	11.9	-1.7	-5.3	-21.5	-28.3
CP1 2030 W	9.2	15.7	5.5	-5.5	-15.6
CP1 2030 AN	20.3	13.8	2.2	-11.2	-19.9
CP1 2030 BN	13.7	14.2	1.4	-12.9	-19.8
CP1 2030 D	18.9	5.8	-2.6	-15.3	-20.5
CP1 2030 C	12.0	-1.8	-5.2	-21.4	-28.1

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years
WSEL water surface elevation

Figure 11-7. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 vs. No-Action Alternative

Impact Aqua-2 (CP1): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Localized increases in soil erosion and resulting runoff sedimentation, and turbidity resulting from project construction in the vicinity of Shasta Dam and at utility, road, and other facility relocation areas could affect nearshore warm-water habitat. However, the environmental commitments for all action alternatives include the development and implementation of a Construction Management Plan, Erosion and Sediment Control Plan, Stormwater Pollution Prevention Plan, and Revegetation Plan as well as water quality and fisheries conservation measures and compliance with all required permit terms and conditions. These environmental commitments would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

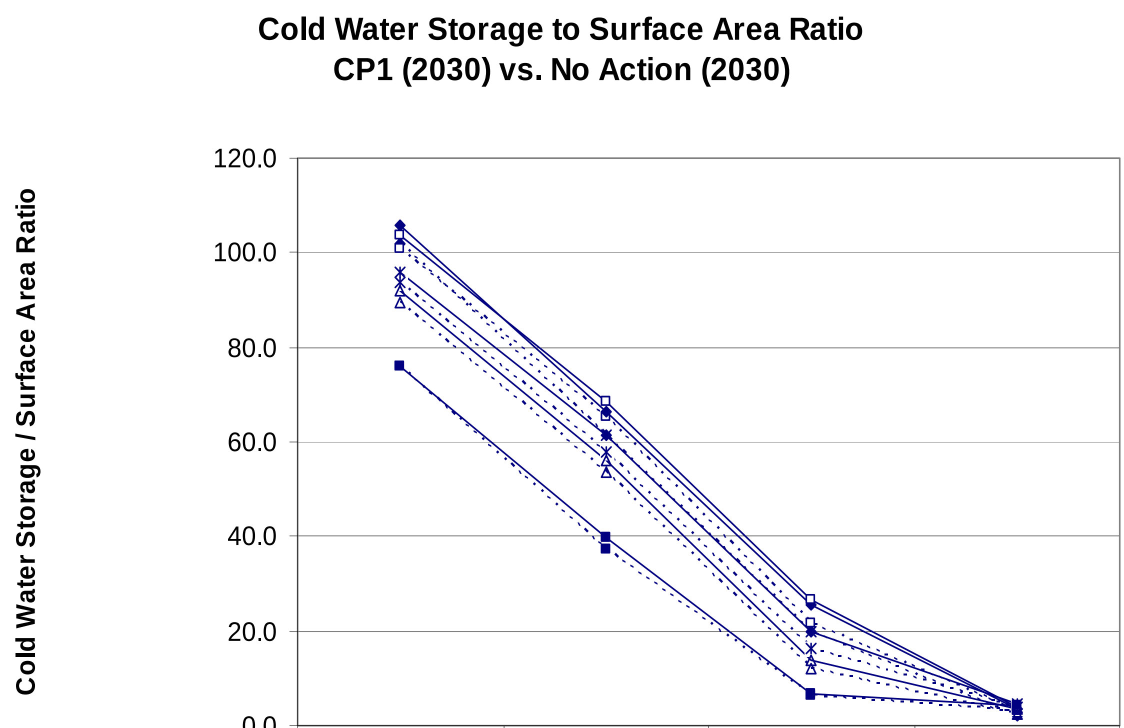
Impact Aqua-3 (CP1): Effects on Cold-Water Habitat in Shasta Lake Under CP1, operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

Access to cold-water refuge can be a limiting factor for the production of cold-water fish, even when the benefits of increased surface area are present. Increases in the surface area of a reservoir without proportional increases in the volume of cold-water storage result in little change to cold-water fisheries production (Jones and Stokes Associates 1988).

CalSim-II modeling showed that under CP1 with a 2030 water supply demand, the ratio of the volume of cold-water storage to surface area was slightly higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occurred between June 30 and August 31, which is the critical holding and rearing period for cold-water fishes in reservoirs; the increases were highest in wet water years (Figure 11-8).

CP1 would increase the availability of suitable habitat for cold-water fish in Shasta Lake. Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-4 (CP1): Effects on Special-Status Aquatic Mollusks Under CP1, habitat for special-status mollusks may become inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that may occupy habitat in or near Shasta Lake and its tributaries. This impact would be potentially significant.



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	102.1	61.5	19.8	2.2
NA AN	100.9	65.2	21.8	3.1
NA BN	93.9	57.9	16.3	3.8
NA D	89.6	53.5	12.0	2.5
NA C	75.8	37.4	6.5	3.2
CP1 2030 W	105.7	66.2	25.6	3.4
CP1 2030 AN	103.7	68.4	26.6	4.0
CP1 2030 BN	95.9	61.5	20.0	4.5
CP1 2030 D	91.8	56.1	14.0	3.4
CP1 2030 C	75.9	39.9	6.9	4.3

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-8. Monthly Cold-water Storage to Surface Area Ratio for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 vs. No-Action Alternative

One special-status mollusk, the California floater, occurs in Shasta Lake, and nine other special-status mollusks could occupy affected seeps, springs, or tributaries. However, information regarding these species' distributions and abundance is limited, which precludes fully quantifying the impacts of CP1 on these organisms and their habitat. Tributary investigations are ongoing and will provide additional information for inclusion in the Final Environmental Impact Statement (FEIS). Except for the California floater, it is not known if other special-status mollusks occupy habitat in or near Shasta Lake and its tributaries. If they do occur in these habitats, they could be adversely affected by increased WSEL and seasonal fluctuations in the surface area under CP1. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP1): Effects on Special-Status Fish Species The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP1 could affect one species designated as sensitive by USFS, the hardhead. This impact would be less than significant.

The hardhead minnow is designated as sensitive by USFS and is known to occur in Shasta Lake. Two other USFS sensitive species, rough sculpin (in the Pit River) and redband trout (in the upper McCloud River), are known to occur upstream from Shasta Lake, but their presence have not been documented in Shasta Lake or in their respective tributaries within the primary study area. The analysis of the CP1 therefore excludes consideration of these special-status species.

Expansion of the surface area of Shasta Lake could be modestly beneficial to hardhead because it could expand the amount of habitat available to this species in the lake. Hardhead prefer low gradient stream habitat, which can be created by the backwater effect of the reservoir within the transition reaches of the main tributaries at their confluence; however, this would not be expected to be much greater than under existing conditions, since reservoir enlargement would simply move the transition reaches farther upstream in the tributaries. Tributary investigations, including an analysis of barriers are ongoing and will provide additional information for inclusion in the FEIS. Although there is some evidence that a physical barrier at the upper end of the Squaw Creek Arm may be modified by an increase in WSEL (J. Zustak, USFWS, pers. comm., 2009), there is no evidence that other barriers exist in a form that would impact this species or its habitat. Pending new information, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP1): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP1, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,080-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information for inclusion in the FEIS. However, based on digital topographic data and stream channel data generated from limited field inventories, no substantial barriers appear to exist between the 1,070-foot and 1,080-foot contours that would be inundated under this alternative. This impact would be less than significant.

Most of the tributaries are too steep (i.e., greater than 7 percent) up to the 1,080-foot contour to be passable by fish; the tributaries that are low-gradient up to the 1,080-foot contour and thus allow fish passage remain low-gradient well upstream from the 1,080-foot contour. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP1): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP1 would result in additional periodic inundation of riverine habitat potentially suitable for spawning and rearing habitat for adfluvial salmonids (trout and land-locked salmon that spawn in streams and rear in lakes) in tributaries to Shasta Lake. In addition to modification of the flow regimes of these affected reaches, changes in the WSEL as a result of CP1 will affect the character and location of substrate (e.g., spawning gravel) at some locations, thereby influencing the suitability and availability of spawning and rearing habitat for adfluvial salmonids. Tributary investigations are ongoing and will provide additional information for inclusion in the FEIS. Only 5.4 miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids would be affected by CP1, which is only about 1.4 percent of the low-gradient habitat upstream from Shasta Lake. This impact would be less than significant.

CP1 would inundate perennial stream reaches with gradients of less than 7 percent that could provide suitable spawning and rearing habitat for adfluvial salmonids. Chapter 4, "Geology, Geomorphology, Minerals, and Soils," discusses the periodic inundation of low-gradient stream reaches. The lengths of low-gradient tributaries to each arm of Shasta Lake that would be periodically affected are as follows:

- Sacramento River Arm 2.2 miles
- McCloud River Arm 1.1 miles
- Pit River Arm 1.0 mile
- Big Backbone Creek Arm 0.5 miles
- Squaw Creek Arm 0.6 miles

Only about 1.4 percent of the low-gradient habitat upstream from Shasta Lake would be periodically inundated. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-8 (CP1): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP1 would result in periodic inundation of varying amounts of non-fish-bearing tributaries to Shasta Lake. Only 12.6 miles of non-fish-bearing tributary habitat would be affected by CP1, which is a length of only about 0.4 percent of non-fish-bearing tributary upstream from Shasta Lake. This impact would be less than significant.

As described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils," CP1 would inundate tributary segments with channel slopes in excess of 7 percent. Although these segments do not typically support salmonid populations, they do provide riparian and aquatic habitat for a variety of organisms and serve as corridors that connect habitat types. The lengths of non-fish-bearing tributaries for each arm of Shasta Lake that would be periodically inundated are as follows:

- Sacramento River Arm 2.9 miles
- McCloud River Arm 2.1 miles
- Pit River Arm 1.8 miles
- Big Backbone Creek Arm 1.3 miles
- Squaw Creek Arm 0.9 miles
- Main Body 3.6 miles

Only 12.6 miles of non-fish-bearing tributary habitat would be periodically inundated under CP1, which is only about 0.4 percent of the habitat upstream from Shasta Lake. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP1): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP1. There would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to RBDD)

Impact Aqua-10 (CP1): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Construction-related activities could temporarily increase sedimentation and turbidity, which would adversely affect aquatic habitats and fish populations within the upper Sacramento River immediately downstream from project construction activities. However, environmental commitments would be in place to reduce these levels. This impact would be less than significant.

Construction activities could disturb sediments and soils within and adjacent to waterways. These activities include increasing the height of the dam, constructing haul roads, using staging areas, and placing of removed material.

Any resulting erosion or disturbance of sediments and soils would temporarily increase turbidity and sedimentation downstream from the construction sites throughout the primary study area if soils are transported in river flows, stormwater runoff, or reservoir water. Construction-related sedimentation and increased turbidity, or other contamination, would be most pronounced in the segment of river from Shasta Dam to Keswick Dam due to the backwater effect that Keswick Reservoir has on flow conditions in the Sacramento River. It is also important to note that Keswick Dam acts as a barrier to upstream migration; therefore, all anadromous fish species are downstream from this facility. (See Chapter 7, “Water Quality,” for additional discussion of this issue.)

Fish population abundance, distribution, and survival have been linked to levels of turbidity and silt deposition. Prolonged exposure to high levels of suspended sediment would create a loss of visual capability in fish in aquatic habitats within the study area, leading to reduced feeding and growth rates; a thickening of the gills, potentially causing the loss of respiratory function; clogging and abrasion of gills; and increases in stress levels, reducing the tolerance of fish to disease and toxicants (Waters 1995). Turbidity also could result in increased water temperature, especially in willow quiet pools, and in turn affect DO levels, both effects thereby stressing respiration.

Also, high levels of suspended sediments would cause the movement and redistribution of fish populations, and could diminish the character and quality of the physical habitat important to fish survival. Once suspended sediment is deposited, it would reduce water depths in stream pools, decreasing the water’s physical carrying capacity for juvenile and adult fish (Waters 1995). Increased sediment loading would degrade food-producing habitat downstream from construction areas. Sediment loading would interfere with photosynthesis of aquatic flora and displace aquatic fauna. Many fish, including salmonids, are sight feeders, and turbid waters reduce the ability of these fish to locate and feed on prey. Some fish, particularly juveniles, likely would become disoriented and leave areas where their main food sources are located, ultimately reducing their growth rates. Prey (e.g., macroinvertebrates) of fish populations would be adversely affected by decline in habitat quality (i.e., water quality and substrate conditions) as a result of increased turbidity, decreased DO content, increased level of pollutants (Coull and Chandler 1992), or (although unlikely) an extreme change in pH or water temperatures (Rundle and Hildrew 1990). Decreases in the diversity and abundance of smaller organisms living on or in the sediments have been associated with smaller sediment grain sizes (Coull 1988) and the associated DO decreases in those sediments (Boulton et al. 1991).

Avoidance of adverse habitat conditions by fish is the most common result of increases in turbidity and sedimentation. Fish will not occupy areas unsuitable for survival unless they have no other option. Some fish, such as bluegill and bass species, will not spawn in excessively turbid water (Bell 1990) and salmonids require gravels that are relatively clean and free of excess amounts of fine sediments. Therefore, if high turbidity results from construction activities, fish species may be precluded from occupying habitat required for specific life stages. In some locations, few opportunities for escape from turbid waters may be available, particularly during lower flow conditions.

Construction-related sedimentation and increased turbidity or other contamination could temporarily degrade water quality and reduce or adversely affect fish habitat and fish populations in localized areas. However, the environmental commitments for all action alternatives include the development and implementation of a Construction Management Plan, Erosion and Sediment Control Plan, Stormwater Pollution Prevention Plan, and Revegetation Plan as well as water quality and fisheries conservation measures and compliance with all required permit terms and conditions. These environmental commitments would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-11 (CP1): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants resulting in adverse effects on aquatic habitats, the aquatic food web, and fish populations, including special-status species, within the primary study area downstream from project construction activities. However, environmental commitments would be in place to reduce the impacts to less than significant.

Potential exists for contaminants such as fuels, oils, other petroleum products, cement, and various chemicals used in construction activities to be introduced accidentally in spills into the water system directly or incrementally through surface runoff from haul routes and construction sites. Contaminants in sufficient concentrations would be toxic to fish and prey organisms (e.g., benthic macroinvertebrates) occupying habitats in the study area or may alter oxygen diffusion rates and cause acute and chronic toxicity to aquatic organisms, thereby reducing growth and survival and/or leading to mortality.

The potential release of hazardous materials into Shasta Lake or the Sacramento River could result in the reduction of aquatic habitats and fish populations if proper procedures are not implemented to contain the discharge. However, the environmental commitments for all action alternatives include the development and implementation of a Construction Management Plan, Erosion and Sediment Control Plan, Stormwater Pollution Prevention Plan, and Revegetation Plan as well as water quality and fisheries conservation measures and compliance with all required permit terms and conditions. These environmental commitments would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-12 (CP1): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon Project operation would result in improved flow and water temperature conditions in the upper Sacramento River for fish species of management concern relative to both the No-Action Alternative and the Existing Condition. This impact would be beneficial.

Winter-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, CP1 had a slight overall average increase in winter-run Chinook salmon production relative to the No-Action Alternative. The maximum increase in production relative to the No-Action Alternative was 43 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 39 percent for CP1 (Attachment 1A of the *Fisheries and Aquatic Ecosystems Technical Report*). Separating production by water-year type to focus on critical water years (when water storage is more reliable) showed a 4 percent increase over the No-Action Alternative. With one exception (1977 at 39 percent decrease), years with the lowest production over the simulation period showed the largest increase in production under CP1 conditions.

Under CP1, critical water years 1924, 1931, 1933, 1934, and 1992 resulted in an increase in winter-run production relative to the No-Action Alternative, ranging from 7 percent to 43 percent. Above-normal water years, 1928, 1954 and 1993, resulted in an increase in production of 3 to 5 percent relative to the No-Action Alternative. Critical water years, 1976 and 1977, resulted in a decrease (4 to 39 percent) in production relative to the No-Action Alternative. One dry water year (1932) showed a decrease in production of 7 percent.

CP1 production was relatively similar to the Existing Condition. The maximum increase in production relative to the Existing Condition was 23 percent for CP1. The largest decrease in production relative to the Existing Condition was 5 percent for CP1 (Attachment 2A of the *Fisheries and Aquatic Ecosystems Technical Report*).

Under CP1, critical water years 1931, 1933, 1934, and 1977 resulted in an increase in winter-run production relative to the Existing Condition ranging from 5 percent to 23 percent. Production in dry water year 1985 and wet water year 1974 decreased by 5 percent.

Based on AFRP population goals, the overall average winter-run Chinook salmon production was similar for CP1 relative to the No-Action Alternative (Attachment 3A of the *Fisheries and Aquatic Ecosystems Technical Report*). The maximum increase in production relative to the No-Action Alternative was 28 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 33 percent for CP1. Years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP1, with one exception – 1977 (34-percent decrease).

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to winter-run under CP1 occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under CP1. Table 11-4 displays the overall mortalities for each Comprehensive Plan that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 1B and 2B of the *Fisheries and Aquatic Ecosystems Technical Report* contain further detail). Mortalities caused by the project decrease as the proposed dam height increases from 6.5 to 18.5 feet.

Table 11-4. Percent Mortality to Winter-Run Chinook Salmon Caused by Nonoperations-Related Effects and Operations-Related Effects Under Each Comprehensive Plan When the Starting Population is Based on the 1999 Through 2006 Average

Plan	% Nonoperations-Related Mortality	% of the Total Mortality	% Operations-Related Mortality	% of the Total Mortality
Future Condition (2030)				
No-Action Alternative	59.8	86.0	9.7	14.0
CP1	60.1	86.6	9.3	13.4
CP2	60.1	86.6	9.3	13.3
CP3, CP5	60.4	87.2	8.9	12.8
CP4	61.1	89.2	7.4	10.8
Existing Condition (2005)				
Existing Condition	59.9	86.6	9.3	13.4
CP1	60.2	87.0	9.0	13.0
CP2	60.2	87.0	9.0	13.0
CP3, CP5	60.3	87.0	9.0	13.0
CP4	61.1	89.3	7.3	10.7

Note:
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

Mortality was separated by operations-related mortality versus nonoperations-related mortality to assess the level of impacts on the four runs of Chinook salmon caused by the actions of the project. Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (changes in flow and/or water temperature). Operations-related mortality is that caused by altering flow and water temperatures.

When removing nonoperations-related mortality, allowing the comparison of mortality for operations-related activities only, fry were the primary life stage affected, but operations-related activities had a greater effect on eggs than on presmolts, and no effect on immature smolts, with both water temperature and flow causing the mortality (Table 11-5).

Table 11-5. Average Annual Mortality Under Each Comprehensive Plan Caused by Project Activities to Winter-Run Chinook Salmon When the Starting Population is Based on the 1999 Through 2006 Average

Plan	Mortality Factor						Total
	Incubation	Eggs – Temperature	Fry Temperature	Fry Habitat	Presmolt Temperature	Presmolt	
Future Condition (2030)							
No-Action Alternative	239,655	286,866	30,102	619,541	17,202	3,737	1,197,103
CP1	248,054	221,542	23,998	631,476	17,488	3,678	1,146,236
CP2	245,208	231,177	27,637	628,045	18,318	3,590	1,153,975
CP3, CP5	251,561	197,624	23,824	609,465	16,196	3,510	1,102,180
CP4	262,729	23,985	3,231	614,146	1,991	3,722	909,804
Existing Condition (2005)							
Existing Condition	292,017	222,215	26,778	580,616	19,566	3,735	1,144,927
CP1	288,104	196,861	24,811	575,402	17,986	3,511	1,106,675
CP2	287,761	208,257	26,780	568,211	19,664	3,601	1,114,274
CP3, CP5	288,275	199,852	26,248	574,694	19,861	3,358	1,112,288
CP4	302,726	26,214	5,064	562,473	4,195	3,545	904,217

Note:
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

In critical water years, mortality to eggs due to unsuitable water temperatures was the primary cause of operations-related mortalities for CP1, followed by mortality to fry (more by flow and density than water temperature), then to eggs from redd dewatering, followed by presmolts (affected first by water temperature then flow) and, finally, immature smolts (affected by flow). Attachments 1C and 2C of the *Fisheries and Aquatic Ecosystems Technical Report* contain tables of mortality to winter-run Chinook salmon sorted by water-year type, and Table 11-6 outlines the ranks classified under each Comprehensive Plan for each water-year type.

In dry water years, mortality to fry when moving to new habitats was the primary cause of operations-related mortalities for all Comprehensive Plans, followed by mortality to eggs due to redd dewatering. Third was the mortality to eggs due to unsuitable water temperatures.

Below-normal, above-normal, and wet water years also had the greatest number of winter-run Chinook salmon perish as fry caused by forced movement to habitat downstream, followed by mortality to eggs due to redd dewatering or scouring, then the loss of eggs from unsuitable water temperatures, and forced movement of presmolts to downstream habitats.

Table 11-6. Mortality Parameters Ranked by Importance for Winter-Run Chinook Salmon by No-Action and Comprehensive Plans by Water-Year Type When the Starting Population Is Based on the 1999 Through 2006 Average

Alternative/Plan Water Year-Type	Mortality Factor							
	Incubation	Super-imposition	Egg – Temperature	Fry – Temperature	Fry – Habitat	Presmolt – Temperature	Presmolt – Habitat	Immature Smolt Habitat
No-Action Alternative								
Critical	3	- / 7	1	4	2	5	6	7 / 8
Dry	2	7 / 6	3	6 / 5	1	5 / 4	4 / 7	8
Below-normal	2		3		1		4	- / 5
Above-normal	2		4		1		3	
Wet	2		4		1		3	
CP1								
Critical	3	- / 6	1	4	2	5	6 / 7	7 / 8
Dry	2	7 / 4	3	5 / 6	1	6 / 5	4 / 7	8
Below-normal	2		4 / 3		1		3 / 4	5 / -
Above-normal	2		4		1		3	
Wet	2	5 / -	4		1		3	
CP2								
Critical	3	8 / 6	1	4	2	5	6	7
Dry	2	6 / 4	3	5 / 6	1	4	7	8
Below-normal	2		3		1		4	5
Above-normal	2		4		1		3	
Wet	2	5 / -	4		1		3	
CP3, CP5								
Critical	3	6	1	4	2	5	7	8
Dry	2	6 / 4	3	5 / 6	1	4	7	8
Below-normal	2		3		1		4	5
Above-normal	2		4		1		3	
Wet	2		4		1		3	
CP4								
Critical	2	- / 6	3	5 / 4	1	4 / 5	6 / 7	7 / 8
Dry	2	4 / 3	3 / 4		1		5	6
Below-normal	2		4		1		3	
Above-normal	2		4		1		3	
Wet	2	5 / -	4		1		3	

Notes:
Blanks and "-" indicate negligible or no mortality occurred as a result of that factor.
In most cases, the NEPA No-Action Alternative is identical to the CEQA Existing Condition. However, when ranking between the two differs, the differences are presented as "Future Condition Rank" / "Existing Condition Rank"
Rank values: 1 = most significant; 5 = least significant
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

Years with the highest operations-related mortality were the same for the No-Action Alternative, Existing Condition, and CP1 (1924, 1931, 1933, 1934, 1977, and 1992). Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991), dry (1930, 1932) or below-normal (1923) water-year type. Years in which the project had the greatest impact on winter-run were also the years in which the lowest production occurs (Attachments 1C and 2C of the *Fisheries and Aquatic Ecosystems Technical Report*).

Based on AFRP population goals, winter-run Chinook salmon mortality caused by operations-related activities decreased under CP1 compared to the No-Action Alternative conditions (Attachment 3B). Under CP1, mortality caused by operations-related activities would decrease from non-operations related mortality by over 10 percent. Under CP1, the greatest mortality to winter-run occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because winter-run Chinook salmon have, overall, a reduced mortality, particularly in critical water years, winter-run Chinook salmon would benefit from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, the overall average spring-run Chinook salmon production for the 82-year period remained relatively similar to the No-Action Alternative and the Existing Condition (Attachments 4A and 5A of the *Fisheries and Aquatic Ecosystems Technical Report*). The maximum increase in production relative to the No-Action Alternative was 109 percent for CP1, while the largest decrease in production relative to the No-Action Alternative was 39 percent for CP1 (Attachment 4A). The maximum increase in production relative to the Existing Condition was 125 percent for CP1, while the largest decrease in production relative to the Existing Condition was 50 percent for CP1 (Attachment 5A of the *Fisheries and Aquatic Ecosystems Technical Report*).

Years in which production was the lowest under the No-Action Alternative typically had the largest increase under CP1 conditions, except for 1934, which had a 15-percent reduction, and 1992, which decreased by 39 percent.

Under CP1, critical water years 1924, 1931, 1933 and 1977 resulted in an increased production relative to the No-Action Alternative ranging from 13 percent to 109 percent. Dry water years, 1925, 1926, and 1932 resulted in increased production (4 percent to 22 percent) relative to the No-Action Alternative. Critical water years 1934, 1992, 1994 and 2001 resulted in a decrease in production relative to the No-Action Alternative (4 percent to 40 percent).

Under CP1, critical water years 1931, 1933, 1934, 1988, 1994, and 2001 resulted in an increased production relative to the Existing Condition ranging from 5 percent to 83 percent. Dry water year 1932 resulted in a substantial increase in production (125 percent) relative to the Existing Condition. Critical water years 1977 and 1992 resulted in a decrease in production relative to the Existing Condition (7 percent to 50 percent).

When using AFRP goals as the spawning population, overall average spring-run Chinook salmon production was similar for CP1 relative to the No-Action Alternative (Attachment 6A of the *Fisheries and Aquatic Ecosystems Technical Report*). The maximum increase in production relative to the No-Action Alternative was 99 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 47 percent for CP1. Years with the lowest production under the No-Action Alternative typically had the largest increase under CP1 conditions, except for 1934, which had a 13-percent reduction, and 1992, which decreased by 47 percent.

<u>Mortality</u>

Based on the 1999 through 2006 population average, the greatest mortality to spring-run occurred to eggs, followed by presmolts, then fry. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-7 displays overall mortalities for each Comprehensive Plan that are caused by nonoperational factors versus those caused by operations (i.e., water temperature, flow) (Attachments 4B and 5B of the *Fisheries and Aquatic Ecosystems Technical Report*). Mortalities caused by the project decreased as the proposed dam height increases from 6.5 to 18.5 feet (Tables 11-7 and 11-8).

Table 11-7. Percent Mortality to Spring-Run Chinook Salmon Caused by Nonoperations-Related and Operations-Related Effects Under the No-Action Alternative and Comprehensive Plans When Starting Population Is Based on the 1999 Through 2006 Average

Alternative/ Plan	% Nonoperations-Related Mortality	% of the Total Mortality	% Operations-Related Mortality	% of the Total Mortality
Future Condition (2030)				
No-Action Alternative	54.8	82.4	11.7	17.6
CP1	55.2	85.3	9.5	14.7
CP2	55.5	86.2	8.9	13.8
CP3, CP5	56.0	86.3	8.9	13.7
CP4	59.0	90.8	6.0	9.2
Existing Condition (2005)				
Existing Condition	54.8	82.4	11.7	17.6
CP1	55.4	85.6	9.3	14.4
CP2	55.4	85.5	8.4	14.5
CP3, CP5	55.8	86.4	8.8	13.6
CP4	58.9	90.6	6.1	9.4

Note: Results derived from SALMOD.
Key: CP = Comprehensive Plan

Table 11-8. Average Annual Mortality Under the No-Action Alternative and Each Comprehensive Plan Caused by Project Activities to Spring-Run Chinook Salmon When Starting Population is Based on 1999 Through 2006 Average

Alternative /Plan	Mortality Factor				
	Prespawn	Incubation	Eggs – Temperature	Fry – Habitat	Total
Future Condition (2030)					
No-Action Alternative	11,899	2,498	43,469	51	57,917
CP1	9,483	2,403	44,440	49	56,375
CP2	10,266	2,419	41,694	49	54,428
CP3, CP5	8,297	2,662	41,289	45	52,293
CP4	425	3,433	26,430	43	30,331
Existing Condition (2005)					
Existing Condition	9,955	2,570	45,554	53	58,132
CP1	8,768	2,567	43,176	56	54,567
CP2	9,683	2,549	43,867	43	56,142
CP3, CP5	10,204	2,661	40,847	42	53,754
CP4	341	3,549	26,649	43	30,582

Note:
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

Only eggs and fry were affected by operation (Table 11-8). Critical water years showed mortality to eggs due to unsuitable water temperatures as the primary cause of operations-related mortalities, followed by mortality to eggs prespawned and during incubation caused by dewatering the redds, then to fry from forced movement to downstream habitats. Attachments 4C and 5C contain tables of mortality to spring-run sorted by water-year type, and Table 11-9 outlines the ranks classified under each Comprehensive Plan for each water-year type.

In dry, below-normal and above-normal water years, all Comprehensive Plans were dominated by egg temperature mortality, followed by mortality resulting from redd dewatering. Mortality to prespawned eggs occurred in only two dry years, not in any below-normal water years. Mortality to fry from forced movement was relatively low and occurred in only a few more years (Table 11-9).

In wet water years, spring-run eggs under conditions created by CP1 were more affected by redd dewatering than by unsuitable water temperatures (Table 11-9).

Table 11-9. Mortality Parameters Ranked by Importance for Spring-Run Chinook Salmon by Comprehensive Plan and Water-Year Type When Starting Population Is Based on 1999 Through 2006 Average

Alternative/Plan Water-Year Type	Mortality Factor			
	Prespawn	Incubation	Egg – Temperature	Fry – Habitat
No-Action Alternative				
Critical	2	3	1	4
Dry	3	2	1	4
Below-normal		2	1	3
Above-normal	4	2	1	3
Wet		2	1	3
CP1				
Critical	2	3	1	
Dry	3	2	1	4
Below-normal		2	1	3
Above-normal	4	2	1	3
Wet		2	1	3
CP2				
Critical	2	3	1	4
Dry	3	2	1	4
Below-normal		2	1	3
Above-normal	4	2	1	3
Wet		1	2	3
CP3, CP5				
Critical	2	3	1	4
Dry	3	2	1	4
Below-normal		2	1	3
Above-normal	4	2	1	3
Wet		1	2	3
CP4				
Critical	3	2	1	4
Dry		2	1	3
Below-normal		2	1	3
Above-normal	4	2	1	3
Wet		1	2	3

Notes:

Blanks indicate no mortality occurred as a result of that factor.

In most cases, the No-Action Alternative is identical to the Existing Condition. However, when ranking between the two differs, the differences are presented as Future Condition Rank / Existing Condition Rank.

Rank values

1 = most significant

5 = last significant

Results derived from SALMOD

Key:

CP = Comprehensive Plan

Years with the highest operations-related mortality were the same for all the Comprehensive Plans: 1924, 1931, 1932, 1933, 1934, 1977, and 1992. Except in 1932 (a dry water year), each of these years was a critical water-year type and was preceded by either a below, dry, or (predominantly) a critical water year. However, years with the lowest mortality varied between all water-year types. Project operations were responsible for years where spring-run Chinook salmon had the lowest mortality, with nearly all the mortality occurring in the egg incubation life stage (Attachments 4C and 5C).

Based on AFRP population goals, spring-run Chinook salmon mortality caused by operations-related activities decreased under CP1 compared to No-Action Alternative conditions (Attachment 6B). Under CP1, the greatest mortality to spring-run occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because spring-run Chinook salmon have, overall, a reduced mortality, particularly in critical water years, spring-run Chinook salmon would benefit from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, the overall average fall-run Chinook salmon production for the 82-year period was similar for CP1 relative to the No-Action Alternative and the Existing Condition (Attachments 7A and 8A). The maximum increase in production relative to the No-Action Alternative was 112 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 7 percent for CP1 (Attachment 7A). In critical, dry, and below-normal water years, years with the lowest production typically had the greatest increase in production resulting from operations-related activities. The maximum increase in production relative to the Existing Condition was 43 percent for CP1. The largest decrease in production relative to the Existing Condition was 38 percent for CP1 (Attachment 8A).

In critical, dry, and below-normal water years, when production was lowest over the simulation period, the increase in production resulting from operations-related activities was greatest. In above-normal and wet water years, however, the lowest production years typically had a slight decrease in production under CP1 conditions relative to the No-Action Alternative.

Under CP1, critical water years 1931, 1933, 1934, and 1977 and dry water year 1932 resulted in increases in production relative to the No-Action Alternative ranging from 6 percent to 113 percent. Below-normal water years, 1937 and 1945, resulted in an increase in production ranging from 13 percent to 18 percent relative to the No-Action Alternative. Only critical water year 1992 and wet water year 1999 resulted in a decrease of 7 percent in production relative to the No-Action.

Under CP1, critical water years 1931 and 1934 resulted in increases in production relative to the Existing Condition ranging from 14 to 43 percent. Dry water years 1926, 1932, 1955, 1964, and 1985 showed an increase production of between 5 and 7 percent relative to the Existing Condition. Below-normal water years 1937 and 1945 resulted in an increase in production (6 to 11 percent) relative to the Existing Condition. Critical water years 1977 and 1992 and wet water years 1969 and 1999 resulted in decreases in production relative to the Existing Condition ranging from 6 percent to 47 percent.

When evaluating the project under AFRP spawning population goals, the overall average fall-run Chinook salmon production was similar for CP1 relative to the No-Action Alternative (Attachment 9A). The maximum increase in production relative to the No-Action Alternative was 94 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 10 percent for CP1. In critical, dry, and below-normal water years, years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP1. In above-normal and wet water years, however, the lowest production years typically remained similar or had a slight decrease in production under CP1 conditions relative to the No-Action Alternative.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to fall-run Chinook salmon under CP1 occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-8 displays the overall mortalities for each alternative that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 7B and 8B). Mortalities caused by the operations-related activities were less under CP1 than under the No-Action Alternative and Existing Condition (Tables 11-10 and 11-11).

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, egg incubation was still the primary life stage affected, but operations-related activities had a greater effect on fry than on presmolts and an even lesser effect on immature smolts. Flow effects triggered a higher percentage of the operations-related mortality (Table 11-11).

In all water-year types, the greatest portion of mortality under CP1 occurred to fry caused by forced movement to downstream habitats. Prespawn, incubation, and superimposition mortality were greater than mortality to eggs caused by unsuitable water temperatures and presmolt habitat movement.

Table 11-10. Percent Mortality to Fall-Run Chinook Salmon Caused by Nonoperations-Related Effects and Operations-Related Effects Under the Comprehensive Plans When Starting Population Is Based on the 1999 Through 2006 Average

Alternative /Plan	% Nonoperations-Related Mortality	% of the Total Mortality	% Operations-Related Mortality	% of the Total Mortality
Future Condition (2030)				
No-Action Alternative	54.4	63.6	31.2	36.4
CP1	54.0	67.0	26.6	33.0
CP2	54.2	67.3	26.3	32.7
CP3, CP5	54.8	67.7	26.2	32.3
CP4	56.0	66.9	27.7	33.1
Existing Condition (2005)				
Existing Condition	54.3	63.5	31.2	36.5
CP1	54.3	63.7	30.9	36.3
CP2	54.8	64.1	30.7	35.9
CP3, CP5	54.8	64.1	30.7	35.9
CP4	56.8	66.8	28.2	33.2

Note:
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

Table 11-11. Average Annual Mortality Under Each Comprehensive Plan Caused by Project Activities to Fall-Run Chinook Salmon When the Starting Population Is Based on 1999 Through 2006 Average

Alternative/ Plan	Mortality Factor									Total
	Prespawn	Incubation	Super-imposition	Eggs – Temperature	Fry Habitat	Presmolt Temperature	Presmolt Habitat	Immature Smolt Temperature	Immature Smolt Habitat	
Future Condition (2030)										
No-Action	6,933,038	8,637,460	11,297,314	751,707	20,454,063	2,616	185,161	1,828	7,986	48,271,173
CP1	5,953,724	8,598,648	10,782,834	842,722	20,842,014	3,478	203,758	2,176	9,423	47,238,777
CP2	6,323,278	8,540,437	10,124,156	757,096	21,173,718	3,207	207,219	2,280	9,320	47,140,711
CP3, CP5	5,247,046	8,176,898	9,816,774	780,596	21,620,408	2,805	197,386	1,779	8,770	45,852,462
CP4	615,999	8,752,615	10,788,926	457,114	22,733,903	3,197	215,680	1,104	12,719	43,581,257
Existing Condition (2005)										
Existing Condition	6,412,279	8,627,932	11,633,303	836,483	20,574,388	3,476	201,791	1,868	9,779	48,301,299
CP1	6,575,997	8,629,625	10,869,399	711,591	20,799,632	3,552	204,478	1,811	9,078	47,805,163
CP2	6,648,591	8,392,873	10,487,388	809,925	21,000,903	3,740	210,743	2,048	8,162	47,564,373
CP3, CP5	7,018,928	8,151,667	10,172,594	731,280	21,302,504	2,528	200,284	1,441	8,505	47,589,731
CP4	739,579	8,813,580	10,872,888	449,679	22,650,162	1,835	232,417	727	13,256	43,774,123

Note:
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

In critical water years, mortality to prespawning females was the primary cause of operations-related mortalities for CP1, followed by mortality to fry due to forced movement, and then to eggs from redd dewatering or scouring and superimposition. Least affected were presmolts and then immature smolts by both water temperatures and forced movement. Attachments 7C and 8C contains tables of mortality to fall-run sorted by water-year type, and Table 11-12 outlines the ranks classified under each Comprehensive Plan for each water-year type.

As with critical water years, dry water years were dominated by mortality to fry due to forced movement downstream, followed by redd dewatering or scouring and redd superimposition. Additional mortality occurred to fall-run Chinook salmon presmolts and immature smolts from both forced movement and unsuitable water temperatures (Table 11-12).

Below-normal and above-normal water years were relatively similar for all Comprehensive Plans. Mortality factors were dominated by mortality to fry due to forced movement downstream, followed by redd superimposition, dewatering, or scouring. Mortality to presmolts caused by forced downstream movement was a greater factor affecting fall-run populations than was egg mortality caused by unsuitable water temperatures, or to immature smolts and fry due to unsuitable water temperatures (Table 11-12).

As with the water-year types discussed above, under wet water year conditions, the majority of mortality also occurred to fry due to forced downstream movement, followed by redd superimposition, and redd dewatering or scouring. Mortality to presmolts and immature smolts from downstream movement were the lowest rates resulting from operations-related activities. Least affected were eggs due to unsuitable water temperatures, both pre- and post-spawn.

Years with the highest mortality were the same for the No-Action Alternative and CP1: 1934, 1935, 1970, 1978, and 1993. With the exception of 1970, each of these years was preceded by a critical water year. Overall, years with the lowest mortality tended to be dry or critical water years (Attachment 7C).

Years with the highest mortality were the same for the Existing Condition and CP1: 1957, 1982, 1985, 1994, and 1997. Overall, years with the lowest mortality tended to be dry or critical water years (Attachment 8C).

Table 11-12. Mortality Parameters Ranked by Importance for Fall-Run Chinook Salmon by the No-Action Alternative or Comprehensive Plan and Water-Year Type When the Starting Population Is Based on the 1999 Through 2006 Average

Alternative/ Plan Water-Year Type	Mortality Factor									
	Prespawn	Incubation	Superimposition	Eggs – Temperature	Fry – Temperature	Fry – Habitat	Presmolt – Temperature	Presmolt – Habitat	Immature Smolt – Temperature	Immature Smolt – Habitat
No-Action Alternative										
Critical	1	3	5	4		2	8	6	9	7
Dry	4	2	3	5	10	1	8	6	9	7
Below-normal	6	3	2	5	10 / 9	1	8	4	9/10	7
Above-normal	4 / 5	2	3	7	10 / -	1	9 / -	5 / 4	8	6
Wet	6	3	2	5		1	8	4	- / 9	7
CP1										
Critical	1	3	5	4		2	8	6	9	7
Dry	4	2	3	5	10	1	8	6	9	7
Below-normal	6 / 7	3	2	5	9	1	8	4	10	7 / 6
Above-normal	5	3	2	7		1		4	8 / -	6
Wet	6 / 7	2 / 3	3 / 2	5		1		4	- / 9	7 / 6
CP2										
Critical	1	3	5	4		2	8	6	9	7 / 8
Dry	4	3 / 2	2 / 3	5	- / 10	1	8	6	9	7
Below-normal	7 / 6	3	2	5	9	1	8	4	10	6 / 7
Above-normal	6 / 5	3	2	7		1		4		5 / 6
Wet	7 / 6	3	2	6 / 5		1	- / 8	4		5 / 7
CP3, CP5										
Critical	1	3	5	4	10 / -	2	8 / 7	6	9	7
Dry	5 / 4	3	2	4 / 5	- / 10	1	9	6	8 / 9	7
Below-normal	7 / 6	3	2	5	- / 9	1	8	4	10	6 / 7
Above-normal	5	3	2	7		1		4		6
Wet	6 / 7	3	2	5		1	- / 8	4		7 / 6
CP4										
Critical	3	2	5	4	10 / -	1	8	6	9	7
Dry	- / 8	2	3	5	9 / 10	1	7	4	8 / 9	6
Below-normal	8 / -	3	2	5 / 6	9 / 8	1	7	4	10/9	6 / 5
Above-normal	5	3	2	7		1		4		6
Wet	7	3	2	6		1	- / 8	4		5

Notes:

Blanks and "-" indicate no mortality occurred as a result of that factor.

In most cases, the No-Action Alternative is identical to the Existing Condition. However, when ranking the ranks between the two differs, the differences are presented as Future Conditions Rank/Existing Condition Rank.

Rank values

1 = most significant

5 = last significant

Results derived from SALMOD.

Key:

CP = Comprehensive Plan

When using AFRP population goals as the spawning population, fall-run Chinook salmon mortality caused by operations-related activities decreased under CP1 compared to No-Action Alternative conditions. Under CP1, mortality caused by operations-related activities would decrease from nonoperations related mortality by more than 13 percent. Under CP2, the greatest mortality to fall-run occurred to the egg incubation life stage, followed by fry, then presmolts, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives (Attachment 9B).

Because fall-run Chinook salmon have, overall, a reduced mortality, fall-run Chinook salmon would benefit from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, overall average late fall-run Chinook salmon production for the 82-year period was similar for CP1 relative to the No-Action Alternative and the Existing Condition. The maximum increase in production relative to the No-Action Alternative was 6 percent for CP1, while the largest decrease in production relative to the No-Action Alternative was 3 percent for CP1 (Attachment 10A). Production remained relatively similar regardless of water-year type.

Overall average late fall-run Chinook salmon production for the 82-year period was similar for CP1 relative to the Existing Condition. The maximum increase in production relative to the Existing Condition was 13 percent for CP1 (1985), while the largest decrease in production relative to the Existing Condition was -5 percent for CP1 (1934) (Attachment 11A).

Under CP1, no critical water years resulted in an increase in production relative to the Existing Condition ranging greater than 5 percent when model noise was removed. Four dry water years (1926, 1961, 1930, and 1985) resulted in a 5 to 13-percent increase in production relative to the Existing Condition. No below-normal, above-normal, or wet water years resulted in a greater than 5-percent difference from the Existing Condition.

When the starting population was the AFRP goal, overall average late fall-run Chinook salmon production was similar for CP1 relative to the No-Action Alternative (Attachment 12A). The maximum increase in production relative to the No-Action Alternative was 8 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 4 percent for CP1. Production remained relatively similar regardless of water-year type.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to late fall-run Chinook salmon under CP1 occurred to the egg incubation life stage, followed by fry, then presmolts and lastly to immature smolts. Nonoperational conditions were primary causes of mortality for all life stage. Table 11-13 displays the overall mortalities for each Comprehensive Plan that are caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 10B and 11B). Mortalities caused by the project decreased for all Comprehensive Plans relative to the No-Action Alternative.

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, fry became the primary life stage affected, and operations-related activities had a greater effect on eggs than on presmolts and an even lesser effect on immature smolts. Most of the mortality occurred as a result of flow conditions rather than water temperature (Table 11-14).

Table 11-13. Percent Mortality to Late Fall-Run Chinook Salmon Caused by Nonoperations-Related and Operations-Related Effects Under the No-Action Alternative and Comprehensive Plans When Starting Population is Based on 1999 Through 2006 Average

Plan	% Nonoperations-Related Mortality	% of the Total Mortality	% Operations-Related Mortality	% of the Total Mortality
Future Condition (2030)				
No-Action Alternative	60.6	78.1	17.0	11.9
CP1	60.6	78.3	16.8	11.7
CP2	60.6	78.3	16.8	11.7
CP3, CP5	60.7	78.4	16.7	11.6
CP4	60.5	78.6	16.5	11.4
Existing Condition (2005)				
Existing Condition	60.5	78.1	17.0	21.9
CP1	60.6	78.2	16.9	21.8
CP2	60.6	78.2	16.9	21.8
CP3, CP5	60.6	78.3	16.8	21.7
CP4	60.5	78.3	16.6	21.7

Note:
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

Table 11-14. Average Annual Mortality Under Each Comprehensive Plan Caused by Project Activities to Late Fall-Run Chinook Salmon When Starting Population Is Based on 1999 Through 2006 Average

Alternative/ Plan	Mortality Factor									Total
	Incubation	Super-imposition	Eggs – Temperature	Fry – Temperature	Fry – Habitat	Presmolt – Temperature	Presmolt – Habitat	Immature Smolt – Temperature	Immature Smolt – Habitat	
Future Condition (2030)										
No-Action Alternative	885,900	1,129,675	18,538	2,873	3,396,805	86,590	16,940	33,034	1,514	5,571,869
CP1	877,958	1,060,236	24,035	1,519	3,438,193	67,196	17,459	33,021	1,717	5,521,334
CP2	864,780	1,027,257	23,665	1,869	3,484,534	73,169	16,561	34,001	1,774	5,527,610
CP3, CP5	851,079	1,033,193	23,418	1,441	3,475,832	60,496	19.058	29,915	1,716	5,477,109
CP4	875,916	1,060,236	25,236	77	3,438,827	6,484	20,580	8,318	2,071	5,437,745
Existing Condition (2005)										
No-Action Alternative	942,064	1,101,169	23,763	2,223	3,409,077	70,182	16,292	35,069	1,678	5,601,517
CP1	906,913	1,050,151	23,965	1,431	3,453,329	62,887	15,249	34,088	1,684	5,549,697
CP2	888,150	1,040,323	24,034	2,169	3,468,156	68,815	16,556	35,221	1,728	5,545,152
CP3, CP5	873,920	1,040,676	24,172	2,104	3,445,358	69,686	18,314	35,778	1,664	5,511,672
CP4	904,730	1,050,151	25,078	24	3,425,210	8,475	20,082	8,746	2,020	5,444,516

Note:
Results derived from SALMOD.
Key:
CP = Comprehensive Plan

Under CP1, mortality to fry resulting from unsuitable water temperatures only occurred at low levels to late fall-run Chinook salmon during critical, dry, and below-normal water years only. In all water-year types, mortality to fry during forced movement to downstream habitats was the primary cause of operations-related mortality.

In critical, dry, and below-normal water years, the causes of operations-related mortality follow similar trends for all alternatives with a few exceptions. In general, the effects of flow (and density) had the greatest effect on mortality. Forced movement of fry resulted in the greatest mortality, followed by flow effects on eggs via scouring, dewatering, or superimposition. Next affected were presmolts and immature smolts by unsuitable water temperatures, and lastly temperature effects on eggs and flow effects on presmolts and immature smolts and fry (Table 11-15).

Wet and above-normal water years were overall similar to critical, dry, and below-normal water years except that mortality to fry due to unsuitable water temperatures disappears.

Years with the highest mortality under CP1 were 1937, 1957, 1982, 1985, 1994 and 1997. Three years were preceded by a wet water year, one was preceded by an above-normal water year, and at least one was preceded by a below-normal water year (Attachments 10C and 11C).

When starting with a spawning population equal to the AFRP goal, late fall-run Chinook salmon mortality caused by the operations-related activities was slightly less under CP1 than under No-Action Alternative conditions (Attachment 12B). Under CP1, mortality caused by operations-related activities would decrease from non-operations related mortality by more than 28 percent. Under CP1, the greatest mortality to late fall-run Chinook salmon occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because late fall-run Chinook salmon have, overall, a reduced mortality, late fall-run Chinook salmon would benefit from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP1): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operations—Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass   Project operation would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

Table 11-15. Mortality Parameters Ranked by Importance for Late Fall-Run Chinook Salmon by Comprehensive Plan and Water-Year Type When Starting Population Is Based on 1999 Through 2006 Average

Alternative/ Plan Water-Year Type	Mortality Factor								
	Incubation	Superimposition	Eggs – Temperature	Fry – Temperature	Fry – Habitat	Presmolt – Temperature	Presmolt – Habitat	Immature Smolt – Temperature	Immature Smolt – Habitat
No-Action Alternative									
Critical	2	4 / 3	6	8	1	3 / 4	7	5	9
Dry	3	2	5 / 6	9	1	4	6	7 / 5	8
Below-normal	3	2	4 / 6	9	1	5	7	6 / 4	8
Above-normal	2	3	5 / 4	9 / -	1	6	4	7	8
Wet	3	2	5		1	7	4	8 / 6	6 / 8
CP1									
Critical	2	3	6	9 / 8	1	4	7	5	8 / 9
Dry	3	2	5	9	1	4	6	7 / 6	8
Below-normal	3	2	4 / 6	- / 9	1	6 / 5	7	5 / 4	8
Above-normal	2	3	5 / 4		1	6 / 5	4	7 / 6	8 / 7
Wet	3	2	5		1	7 / 8	4	6	8 / 7
CP2									
Critical	2	3	6	8	1	4	7	5	9
Dry	3	2	6 / 5	9	1	4	7	5 / 6	8
Below-normal	3	2	4 / 6		1	6 / 5	7	5 / 4	8
Above-normal	2	3	5 / 4		1	7 / 6	4	6 / 7	8
Wet	3	2	5		1	7 / 8	4	6	8 / 7
CP3, CP5									
Critical	2	3	6	8	1	4	7	5	9
Dry	3	2	6 / 5	9	1	4	7	5 / 6	8
Below-normal	3	2	4 / 6	- / 9	1	7 / 5	5	6 / 4	8
Above-normal	2	3	5		1	7 / 6	4	6 / 7	8
Wet	3	2	5		1	7 / 8	4	6	8 / 7
CP4									
Critical	2	3	4	9 / -	1	6 / 5	7	5 / 6	8
Dry	3	2	4	9 / -	1	7 / -	5	6 / -	8 / 6
Below-normal	3	2	4		1	8 / 7	5	7 / 6	6 / 8
Above-normal	2	3	5		1	7 / 8	4	6	8 / 7
Wet	3	2	5		1	8	4	6	7

Notes:

Blanks and "-" indicates no mortality occurred as a result of that factor.

In most cases, the NEPA Future Condition is identical to the CEQA Existing Condition. However, when ranking between the two differs, the differences are presented as Future Condition Rank/ Existing Condition Rank.

Rank values

1 = most significant

5 = last significant

Results derived from SALMOD.

Key:

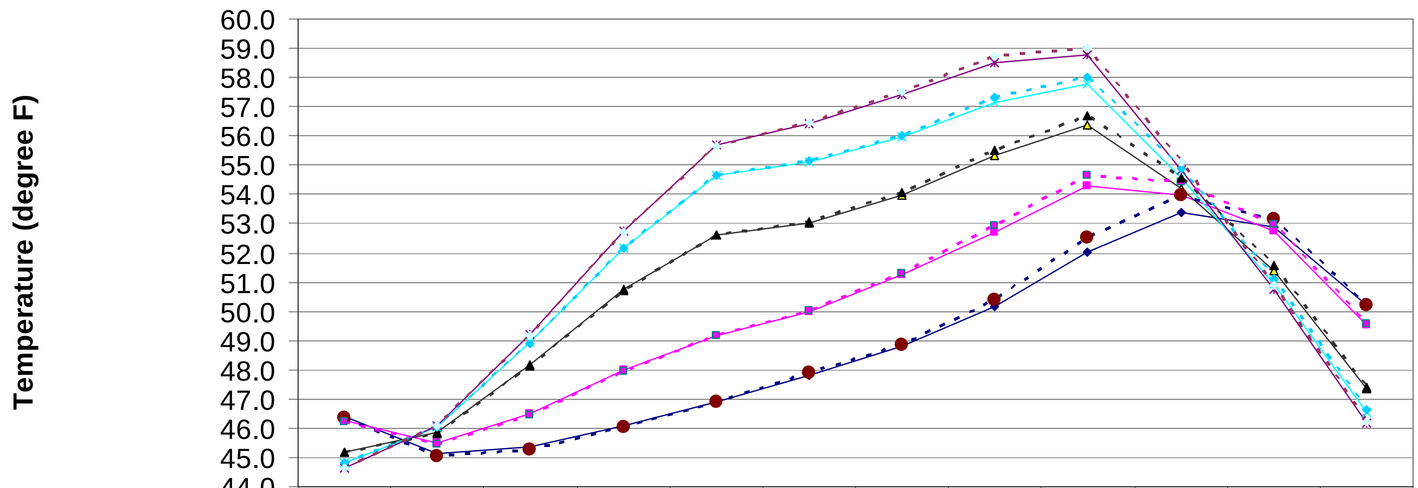
CP = Comprehensive Plan

Flow-Related Effects Monthly mean flows at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP1 would be essentially equivalent (less than 2-percent difference) to flows under the Existing Condition and No-Action Alternative simulated for all months (see the *Hydrology, Hydraulics and Water Management Technical Report*). Potential flow-related effects on fish species of management concern in the upper Sacramento River from this alternative would be minimal. During most years, releases from Shasta Lake would be unchanged. In average and wet years, river flows would decrease slightly in some years during the December-through-February period because of the use of increased capacity within Shasta Lake, usually following an extended dry period. Also, flows (and stages) would increase slightly during the June-through-August period of most years. Although small, this increase would be most pronounced during dry periods, as more water is released from Shasta Dam for water supply reliability purposes. However, also during dry periods, few to no changes would occur in water flows or changes during winter and spring. The average changes in mean monthly flow would be reductions or increases of several percent, although the changes in mean monthly flow would be greater in some years. Nonetheless, differences generally would be small (less than 2 percent). All potential changes in flows and stages would diminish downstream from RBDD because of the increasing effect of inflows from tributaries and of diversions and flood bypasses.

There would be no discernable flow-related effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River related to changes in monthly mean flows under CP1, relative to the Existing Condition and No-Action Alternative. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow-related effects on these fish species would be less than significant.

Water Temperature-Related Effects Monthly mean water temperatures at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP1 would be the same, or fractionally less, than those under the Existing Condition and No-Action Alternative conditions simulated for all months (Figures 11-9 and 11-10) (see also the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). As discussed above, the modeling simulations may not fully account for real-time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some degree. Nevertheless, potential water temperature–related effects on fish species of management concern in the upper Sacramento River from this alternative would be minimal. During most years, annual releases from Shasta Lake would be unchanged.

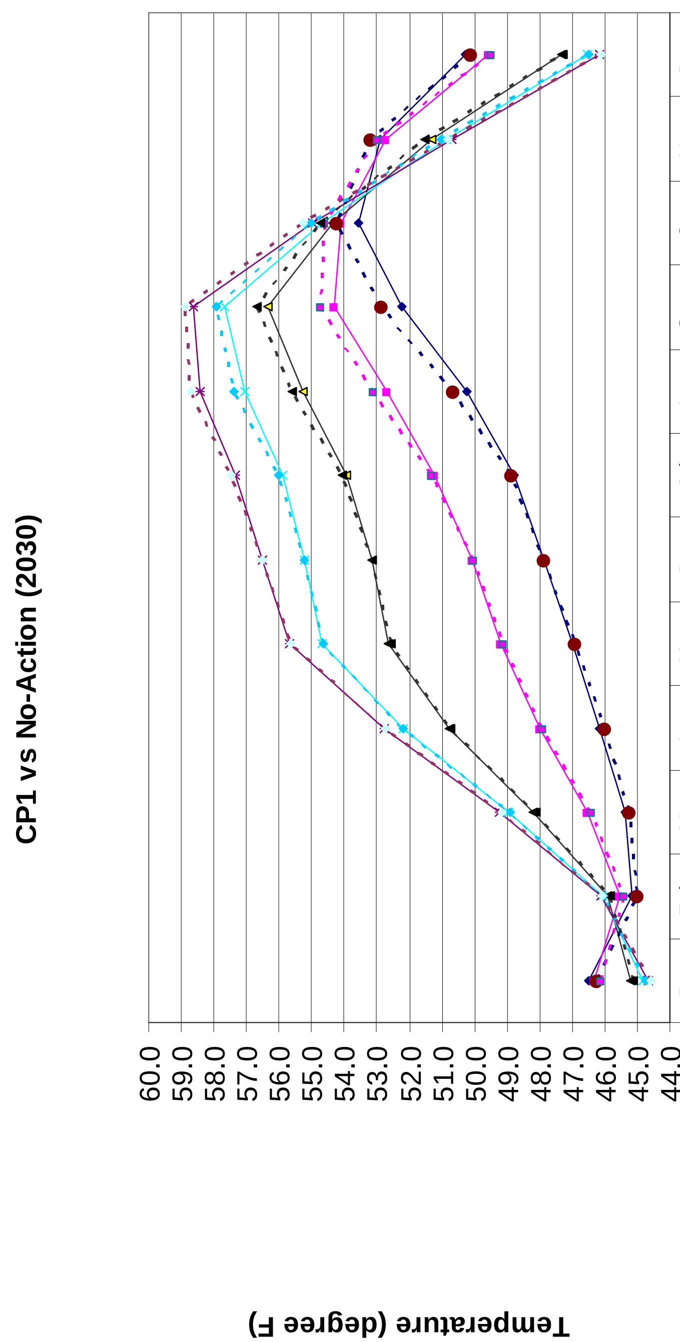
CP1 vs Existing Conditions (2005)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP1_Shasta Dam	46.4	45.1	45.4	46.1	46.9	47.8	48.8	50.2	52.0	53.4	52.9	50.2
CP1_Keswick	46.3	45.5	46.5	48.0	49.2	50.0	51.2	52.7	54.3	54.0	52.7	49.5
CP1_Balls Ferry	45.2	45.9	48.2	50.7	52.6	53.0	54.0	55.3	56.4	54.2	51.4	47.3
CP1_Bend Bridge	44.8	46.1	48.9	52.2	54.7	55.1	55.9	57.1	57.8	54.6	50.9	46.6
CP1_RBDD	44.6	46.1	49.2	52.7	55.7	56.4	57.4	58.5	58.8	54.8	50.7	46.2
EC_Shasta Dam	46.3	45.1	45.3	46.0	46.9	47.9	48.9	50.4	52.5	54.0	53.1	50.2
EC_Keswick	46.2	45.5	46.5	47.9	49.2	50.0	51.3	52.9	54.6	54.4	53.0	49.6
EC_Balls Ferry	45.2	45.8	48.1	50.7	52.6	53.1	54.1	55.5	56.7	54.6	51.6	47.4
EC_Bend Bridge	44.8	46.0	48.9	52.1	54.7	55.2	56.0	57.3	58.0	54.9	51.1	46.6
EC_RBDD	44.6	46.1	49.2	52.7	55.7	56.5	57.5	58.7	59.0	55.1	50.9	46.2

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBDD = Red Bluff Diversion Dam

Figure 11-9. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (Existing Condition)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP1_Below Shasta	46.5	45.2	45.4	46.1	47.0	47.9	48.8	50.2	52.2	53.6	52.9	50.3
CP1_Below Keswick	46.3	45.6	46.5	48.0	49.2	50.1	51.2	52.7	54.3	54.1	52.7	49.6
CP1_Balls Ferry	45.2	45.9	48.2	50.8	52.7	53.1	53.9	55.3	56.3	54.3	51.3	47.3
CP1_Bend Bridge	44.8	46.1	49.0	52.2	54.7	55.2	55.9	57.1	57.7	54.7	50.9	46.5
CP1_RBDD	44.7	46.1	49.2	52.8	55.7	56.5	57.4	58.4	58.6	55.0	50.7	46.2
NA_SHASTA DAM	46.2	45.0	45.2	46.0	46.9	47.9	48.9	50.7	52.8	54.2	53.2	50.1
NA_Keswick	46.1	45.4	46.4	47.9	49.1	50.0	51.3	53.1	54.7	54.6	53.0	49.5
NA_Balls Ferry	45.1	45.8	48.1	50.7	52.6	53.1	54.0	55.6	56.7	54.7	51.5	47.3
NA_Bend Bridge	44.8	46.0	48.9	52.2	54.6	55.2	56.0	57.4	57.9	55.0	51.0	46.5
NA_RBDD	44.6	46.1	49.2	52.7	55.6	56.5	57.5	58.7	58.9	55.3	50.8	46.1

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBDD = Red Bluff Diversion Dam

Figure 11-10. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (No-Action Alternative)

Overall, the greatest cooling effect (less than 1°F) would occur during critical years and during the late summer (i.e., July through September), because of the increased cold-water pool volume within Shasta Lake, even following an extended dry period. This would benefit incubating eggs. All potential changes in flows and stages would diminish downstream from RBDD because of the increasing effect of inflows from tributaries, and of diversions and flood bypasses.

There would be very small water temperature-related effects on steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass in the upper Sacramento River related to slightly cooler monthly mean water temperatures under CP1, relative to the Existing Condition and the No-Action Alternative. Mean monthly water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River. Therefore, water temperature-related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-14 (CP1): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operations could result in the reduction of the magnitude, duration, or frequency of intermediate to large flows that are necessary for channel formation and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate communities. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and shaded riverine aquatic (SRA) habitat. These processes are regulated by the magnitude, duration, and frequency of flows, with relatively large floods providing the energy required to mobilize sediment from the bed, produce meander migration, and create seasonally inundated floodplains. Project operations could result in reduced intermediate to large flows that are necessary for channel formation and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Channel Forming and Maintenance In undisturbed alluvial rivers, channels and bedforms develop in response to flow and sediment loading conditions that may vary by orders of magnitude within a few hours. In many cases, the frequency distribution of flow and sediment supply are such that rivers convey the greatest fraction of their sediment load at an intermediate “dominant” discharge, which is often close to the bankfull flow (Leopold et al. 1964). Although the recurrence interval of bankfull flow varies from river to river, it is often close to 1.5 to 2 years (Leopold et al. 1964). This provides a rational basis for assuming that coarse sediment is routed as bedload during the 1.5-year (Q) flood. Flow regulation of the Sacramento River has reduced its Q1.5 by 30 percent from 86,000 cfs to 61,000 cfs (Kondolf et al. 2000).

Whereas bankfull flow may provide a good first approximation for assessing the threshold for bed mobilization, it is not necessarily indicative of flows that are required to maintain the health of habitats in the alluvial system. For example, it has been estimated that the naturally occurring 5- to 10-year recurrence interval flood may often be required for maintenance of a mobile alternating bar-pool sequence (Trush et al. 2000) – an ecologically desired condition. In the regulated flow regime of the Sacramento River, the 10-year flood has been reduced by 38 percent from 218,000 cfs to 134,000 cfs (Kondolf et al. 2000).

At many locations between Keswick Dam and RBDD, the channel is characterized by bedrock control of its base level and its banks. This implies that, compared to alluvial reaches downstream, the channel in this area has been limited in its ability to adjust hydraulic geometry (i.e., channel width and depth) in response to dam-related changes in flow. Thus, it is possible that the channel is not in balance with the current flow regime, such that typical recurrence intervals of mobilization and bedform alteration are much longer than they were before the dams reduced the magnitude of Q1.5 and Q10. This implies that the bed and point bars may have become static in the postdam era, such that only remnants of gravel of once abundant spawning habitat in this reach remain.

The flow required for mobilization and scour of a channel bed depends in part on the grain-size distribution of the bed sediment. On the Sacramento River, the grain-size distributions of deposits between Keswick Dam and Cottonwood Creek may have increased since construction of Shasta Dam because of winnowing associated with dam-related reductions in sediment supply (Stillwater Sciences 2006). This would tend to increase the threshold for mobilization and scour of the channel bed, even as the frequency of high flows was reduced by operations of Shasta Dam. The hypothesized coarsening of the bed would thus tend to make mobilization of sediment and bedforms even less likely under the regulated flow regime in the upper Sacramento River.

Changes (reductions) in intermediate to large flows in the Sacramento River also has the potential to affect the lower reaches (confluence areas) of tributaries by reducing the backwater effect that the mainstem river has on the lower reaches of the tributaries. A decrease in the frequency, duration, and intensity of intermediate to large flows on the Sacramento River, and associated decrease in the stage elevation of the river surface, could result in increased downcutting in the lower reaches of the tributaries. Downcutting of the lower tributaries could result in bank erosion, channel widening, and the channel becoming disconnected from its floodplain, which in turn could affect riparian recruitment and succession processes.

Meander Migration Suitable spawning habitat on the mainstem currently extends from Keswick Dam to Princeton. Since 1945, Shasta (and later Keswick) Dam has altered mainstem flow and sediment supply, and has thus affected the quantity and grain-size distributions of gravel in the channel bed. This in turn has affected the extent and quality of salmonid spawning habitat. The expected evolution of spawning gravel in the Sacramento River can be summarized in the following three working hypotheses (Stillwater Sciences 2006):

1. Bed coarsening in the upper Sacramento River has occurred and is continuing such that spawning habitat has been progressively reduced in the reach between Keswick Dam and Anderson Bridge, despite the effects of recent gravel augmentation.

2. Bed coarsening has progressed downstream since 1980 and has now reduced spawning habitat area between Anderson Bridge and Cottonwood Creek.

3. Although the concentration of fine sediment in the subsurface has appeared to remain suitably low between Keswick Dam and Cottonwood Creek, it may have become higher in downstream reaches, because of dam-related reductions in large flows coupled with high sediment supply from Cottonwood Creek and local hydraulic conditions (i.e., a break in slope) that promote local deposition, such that successful spawning of fall-run Chinook salmon in reaches below Cottonwood Creek may have been compromised.

Whereas the success of anadromous salmonids depends strongly on gravel dynamics in the mainstem, other fish species of primary management concern rely much more heavily on the dynamics of meander migration, which affects the quality and availability of near- and off-channel habitat such as SRA.

SRA habitat is composed of vegetation and instream tree and shrub debris that provides important fish habitat. SRA habitat is defined as the nearshore aquatic habitat occurring at the interface between a river and adjacent woody riparian habitat. The principal attributes of this cover type are (1) an adjacent bank composed of natural, eroding substrates supporting riparian vegetation that either overhang or protrude into the water, and (2) water that contains variable amounts of woody debris, such as leaves, logs, branches, and roots and has variable depths, velocities, and currents. Riparian habitat provides structure (through SRA habitat) and food for fish species. Shade decreases water temperatures, while low overhanging branches can provide sources of food by attracting terrestrial insects. As riparian areas mature and banks erode, the vegetation sloughs off into the rivers, creating structurally complex habitat consisting of instream woody material that furnishes refugia from predators, creates higher water velocities, and provides habitat for aquatic invertebrates. For these reasons, many fish species are attracted to SRA habitat.

On the upper Sacramento River, actively migrating reaches alternate with stable reaches, which migrate slowly or not at all because they are confined by erosion-resistant geologic deposits or revetment placed to protect adjacent uses. Meander migration and bank erosion occur by progressive channel migration and episodic meander-bend cutoff. Over decadal timescales, cutoffs generally affect less than 10 percent of the actively migrating length of the Sacramento River. Even so, cutoffs can account for well over 20 percent of the integrated lateral channel change, because they affect relatively large areas when they do occur (Stillwater Sciences 2006).

Chute cutoff and progressive migration interact to produce a characteristic pattern of planform development over time. Individual bends evolve greater sinuosity and curvature via progressive channel migration. Cutoffs reduce sinuosity when it exceeds a local threshold for the initiation of cutoff processes. This should produce measurable changes in local geomorphology over time. Averaged over larger timescales, however, changes in morphology in one reach should be balanced by changes in morphology in others, such that the overall pattern of planform geometry for migrating portions of rivers should approach a state of dynamic equilibrium in the absence of human modifications. Recent studies indicate that the sinuosity of cutoff bends is decreasing over time on the Sacramento River (Stillwater Sciences 2006). This suggests that the Sacramento River is not in a state of dynamic equilibrium. The fact that cutoff migration has increased in frequency and is increasingly dominated by partial cutoffs (which affect smaller areas than complete cutoffs) provides further evidence that nonequilibrium conditions may prevail.

Process-based interpretations suggest that potential project alternative-related changes in flow (i.e., reductions in peak flow and overbank discharge) could tend to reduce the frequency of these important geomorphic processes. This would generally be accompanied by a reduction in average sinuosity; however, observations from the Sacramento River indicate that the overall number of channel cutoffs has nevertheless increased in recent times. This supports the hypothesis that the erodibility of banks and floodplains has increased (and thus enhanced the likelihood of cutoff) because of the effects of agricultural clearing of riparian forests on floodplains (Micheli et al. 2004).

Floodplain Inundation Inundation of floodplains reduces floodflow magnitude (i.e., peak volume of flood flows) and promotes exchange of nutrients, organisms, sediment, and energy between the terrestrial and aquatic systems. Flood pulses contribute to high rates of primary productivity in functioning floodplain systems (Junk et al. 1989). On the Sacramento River, floodplains provide important winter and spring spawning and rearing habitats for native fish, such as Sacramento splittail and Chinook salmon (Moyle et al. 2004, Sommer et al. 2001).

Typically, the floodplain immediately adjacent to the river is maintained at an elevation equal to the bankfull stage of the channel, such that discharge magnitudes greater than the bankfull flow inundate the adjacent floodplains (Leopold et al. 1964). As bankfull flow typically has a recurrence interval of Q1.5-2 on alluvial rivers, flow magnitudes greater than the Q1.5 flow event are often assumed to initiate floodplain inundation.

These effects would likely occur along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. Therefore, these impacts would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Tributaries, Delta, and Trinity River

Impact Aqua-15 (CP1): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernable change in mean monthly flow or water temperature conditions in the lower Sacramento River; however, predicted changes in flow in the Feather River, American River, and Trinity River could result in an adverse effect on Chinook salmon, steelhead, coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass, if they were to occur. This impact would be potentially significant.

Monthly mean flows at model locations (i.e., Verona, Freeport) within the lower Sacramento River under CP1 would be comparable to flows under Existing Condition and No-Action Alternative conditions simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). All potential changes in flows diminish rapidly downstream from RBDD because of increasing effect of inflows from tributaries and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the lower Sacramento River from this alternative would be minimal. Differences in mean monthly flow are generally small (less than 2 percent) and within the existing range of variability.

Monthly mean flows at all model locations within the lower Feather River (i.e., below Thermalito Afterbay) and the American River (i.e., near the H Street Bridge in Sacramento) under CP1 would be essentially equivalent (less than 2-percent difference) to flows under the Existing Condition and No-Action Alternative conditions simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). All potential changes in flows are diminished in these areas because of operation of upstream CVP and SWP reservoirs (i.e., Lake Oroville and Folsom Lake) and increasing effects of inflows from tributaries and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the Feather River and American River from this alternative would be minimal and within the existing range of variability. All potential changes in water temperatures in the lower Sacramento River due to small changes in releases would diminish rapidly downstream because of increasing effect of inflows, atmospheric influences, and groundwater. Therefore, flow- and water temperature-related impacts on fish species in the lower Sacramento River would be less than significant.

Effects of altered flow regimes resulting from implementation of CP1 are unlikely to extend into the lower Sacramento River (i.e., downstream from Verona) and Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the CVP and SWP). The guidelines for this management, which are described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with the OCAP to allow ESA coverage by the OCAP permits and BOs. Thus, under CP1, this project is not anticipated to cause an alteration in flow to the Delta nor cause an alteration to water temperatures in the lower Sacramento River and primary tributaries within the extended study area sufficient to cause effects on Chinook salmon, steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the lower Sacramento River or tributaries relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and water temperature-related effects on these fish species would be less than significant.

Monthly mean flows at model locations within the lower Feather River (i.e., below Thermalito Afterbay) and the American River (i.e., near the H Street Bridge in Sacramento) under CP1 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative conditions simulated for most months; however, several months within the modeling record show substantial changes (based on model simulations) to flows in tributaries (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). All potential changes in flows could be reduced in these areas because of real-time operations to meet existing operational rules and operation of upstream CVP and SWP reservoirs (i.e., Lake Oroville and Folsom Lake). Nevertheless, based on predicted changes in flow and associated flow-habitat relationships (including water temperature) for fish, potential flow-related impacts on species of management concern in the American and Feather rivers would be a potentially significant impact.

Similar to the lower Feather River and lower American River, monthly mean flows at all model locations within the Trinity River under CP1 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for most months; however, several months within the modeling record show substantial changes (based on model simulations) to flows in tributaries (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). Based on predicted changes in flow and associated flow-habitat relationships for fish, potential flow-related impacts on species of management concern in the Trinity River would be a potentially significant impact. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP1): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the lower Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

As discussed under Impact Aqua-14 (CP1), sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. These processes are regulated by the magnitude, duration, and frequency of flow, with relatively large flows providing the energy required to mobilize sediment from the bed, produce meander migration, and create seasonally inundated floodplains. Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains (including floodplain bypasses) in the lower Sacramento River.

Relative to the upper Sacramento River, there is significantly less bedrock control between RBDD and Colusa. Consequently, sediment transports and meander migration processes are more pronounced in this more alluvial reach. This is supported by widespread evidence of frequent lateral migration in the upper reaches of the lower Sacramento River (between RBDD and Colusa) (e.g., Micheli et al. 2004). This implies that these reaches of the Sacramento River experience much more frequent bed and bar mobilization than the upper Sacramento River.

As discussed under Impact Aqua-14 (CP1), changes (reductions) in intermediate to large flows in the Sacramento River has the potential to affect the lower reaches (confluence areas) of tributaries by reducing the backwater effect that the mainstem river has on the lower reaches of the tributaries. Decreases in the frequency, duration, and intensity of intermediate to large flows on the Sacramento River, and associated decrease in the stage elevation of the river surface, could result in increased downcutting in the lower reaches of the tributaries. Downcutting of the lower tributaries could result in bank erosion, channel widening, and the channel becoming disconnected from its floodplain, which in turn could affect riparian recruitment and succession processes.

Reaches of the Sacramento River differ in the extent of floodplain inundation. Most of the upper Sacramento River between Keswick Dam and RBDD is also bounded by high banks and terraces, such that there is limited opportunity for floodplain inundation in this reach. Also along the upper reaches of the lower Sacramento River, between Chico Landing and Colusa, the river is bounded by levees that provide flood protection for cities and agricultural areas. However, the levees of this reach of the Sacramento River are for the most part set back from the mainstem channel such that flooding can be significant within the river corridor. In the lower Sacramento River between RBDD and Chico Landing, the mainstem channel is flanked by broad floodplains. Evidence of ongoing sediment deposition of these areas testifies to continued inundation in floodplains in this reach (Buer 1994).

An important attribute of the middle and lower reaches of the Sacramento River is the presence of floodplain bypasses (e.g., Butte Basin, Sutter Bypass, and Yolo Bypass). In winter and spring, agricultural fields and wetland habitats throughout the floodplain bypasses often flood during high flows and are used by Sacramento splittail for spawning and rearing, and by Chinook salmon and steelhead for rearing (Sommer et al. 2001, 2003). For this reason, a key restoration goal of CALFED is to improve the connectivity between rivers and floodplain habitats, including floodplain bypasses, as well as increase the amount of willow-water habitat in the Central Valley (CALFED 2001). Numerous studies have shown that willow water and dense vegetation in these areas provide highly productive rearing areas for numerous species, including Chinook salmon and splittail. Seasonally flooded habitat provides rearing habitat for Chinook salmon and spawning, rearing, and foraging habitat for splittail (Sommer et al. 1997, 2001, 2002; Baxter et al. 1996; USACE 1999). Floodplain habitat offers protection from large piscivorous fish such as striped bass. The temporary nature of the flooded habitat and the protection offered by relatively willow water and dense vegetative cover serve to exclude predatory fish. The productivity of floodplains is generally related to the frequency, timing, water depths, velocities, vegetation, water quality, and duration of inundation relative to the life history and habitat requirements of fish species. Physical conditions (e.g., type and extent of vegetation, soil conditions, and drainage patterns) may also contribute to habitat quality.

Flooded vegetation provides an abundant source of food, including detrital material, insect larvae, crustaceans, and other invertebrates. Juvenile Chinook salmon and splittail apparently forage among a variety of vegetation types, including trees, brush, and herbaceous vegetation, but their relative importance, alone or in combination, is unknown. Juvenile Chinook salmon that rear in seasonally flooded habitat have higher survival and growth rates than juveniles that remain in the main river channel to rear (USACE 1999, Sommer et al. 2001). The increased growth rate may be related to the higher water temperatures in the willow water in this habitat, and the higher associated rate of production of invertebrates, which are a substantial source of food for rearing juveniles, and of the grasses that support the invertebrates. Increases in the area available to juveniles could also reduce competition for food and space, and could reduce the likelihood of encounters with predators (Sommer et al. 2001). In addition, juvenile Chinook salmon that grow faster are likely to migrate downstream sooner, which helps to reduce the risks of predation and competition in freshwater systems.

In summary, CP1 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These impacts would likely occur along the upper reaches of the lower Sacramento River. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. These impacts would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP1): Effects to Delta Fishery Habitat Resulting from Changes to Delta Outflow Based on the results of hydrologic modeling comparing Delta outflow under basis-of-comparison conditions, and under CP1 under the Existing Condition and No-Action Alternative, CP1 would have a less than significant impact on Delta fisheries and hydrologic transport processed within the Bay-Delta.

Results of the comparison of Delta outflows are summarized by month and water-year type in Table 11-16. The comparison includes the estimated average monthly outflow under the basis-of-comparison conditions (Existing Condition and No-Action Alternative), the average monthly flow under CP1, and the percentage change between base flows and CP1 operations. Results of the analysis (Table 11-16) showed that Delta outflows were observed to be slightly lower under many of the CP1 operations, and slightly higher than basis-of-comparison conditions depending on month and water-year type. However, none of the changes were greater than 5 percent. Based on the results of this comparison of CP1, it was concluded that CP1 would have a less than significant impact on Delta fisheries and hydrologic transport processed within the Bay-Delta under Existing Condition and No-Action Alternative. Based on results of this analysis, it was concluded that CP1 would result in a less than significant impact on Delta fisheries as a consequence of changes in Delta outflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-16. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP1

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	40,954	40,655	-0.7	40,167	39,963	-0.5
	W	84,978	84,638	-0.4	83,595	83,228	-0.4
	AN	47,101	46,375	-1.5	46,322	45,812	-1.1
	BN	19,833	19,847	0.1	19,369	19,420	0.3
	D	11,374	11,059	-2.8	10,881	10,717	-1.5
	C	8,434	8,310	-1.5	8,111	8,208	1.2
February	Average	52,699	52,168	-1.0	52,341	52,230	-0.2
	W	98,900	98,341	-0.6	98,330	98,012	-0.3
	AN	61,653	60,825	-1.3	60,800	60,420	-0.6
	BN	35,173	35,031	-0.4	35,441	35,289	-0.4
	D	20,356	19,574	-3.8	19,894	20,197	1.5
	C	12,605	12,351	-2.0	12,628	12,663	0.3
March	Average	42,610	42,461	-0.3	42,117	41,986	-0.3
	W	79,254	79,231	0.0	78,370	78,447	0.1
	AN	53,361	52,998	-0.7	52,361	51,980	-0.7
	BN	23,126	22,882	-1.1	23,136	23,060	-0.3
	D	18,943	18,735	-1.1	18,596	18,223	-2.0
	C	10,697	10,691	-0.1	10,749	10,719	-0.3
April	Average	27,104	27,061	-0.2	27,096	27,033	-0.2
	W	49,818	49,777	-0.1	49,806	49,753	-0.1
	AN	27,420	27,353	-0.2	27,778	27,474	-1.1
	BN	19,001	18,987	-0.1	18,938	18,925	-0.1
	D	12,735	12,659	-0.6	12,516	12,514	0.0
	C	8,586	8,575	-0.1	8,600	8,600	0.0
May	Average	20,470	20,430	-0.2	20,288	20,213	-0.4
	W	37,736	37,691	-0.1	37,173	37,146	-0.1
	AN	22,276	22,010	-1.2	22,205	21,893	-1.4
	BN	14,200	14,211	0.1	14,080	13,948	-0.9
	D	9,422	9,471	0.5	9,436	9,446	0.1
	C	5,141	5,146	0.1	5,306	5,303	0.0

Table 11-16. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
June	Average	13,104	13,096	-0.1	13,055	13,058	0.0
	W	23,675	23,685	0.0	23,303	23,343	0.2
	AN	12,563	12,594	0.2	12,587	12,580	-0.1
	BN	8,735	8,590	-1.7	9,027	8,775	-2.8
	D	6,611	6,686	1.1	6,656	6,787	2.0
	C	5,580	5,527	-1.0	5,615	5,656	0.7
July	Average	7,927	7,970	0.5	8,291	8,295	0.0
	W	11,228	11,240	0.1	11,501	11,493	-0.1
	AN	9,085	9,183	1.1	10,040	10,033	-0.1
	BN	7,314	7,390	1.0	7,897	7,962	0.8
	D	5,330	5,398	1.3	5,477	5,505	0.5
	C	4,229	4,205	-0.5	4,271	4,206	-1.5
August	Average	4,501	4,538	0.8	4,458	4,466	0.2
	W	5,233	5,228	-0.1	4,961	4,957	-0.1
	AN	4,000	4,000	0.0	4,039	4,039	0.0
	BN	4,000	4,000	0.0	4,144	4,166	0.5
	D	4,491	4,640	3.3	4,547	4,557	0.2
	C	4,017	4,059	1.0	4,017	4,043	0.7
September	Average	5,595	5,576	-0.3	5,262	5,277	0.3
	W	10,498	10,480	-0.2	9,510	9,497	-0.1
	AN	3,781	3,776	-0.1	3,464	3,507	1.2
	BN	3,516	3,445	-2.0	3,405	3,426	0.6
	D	3,050	3,051	0.0	3,277	3,308	1.0
	C	3,025	3,024	0.0	3,000	3,020	0.7
October	Average	5,313	5,288	-0.5	5,023	5,000	-0.5
	W	7,040	6,975	-0.9	6,464	6,384	-1.2
	AN	4,540	4,508	-0.7	4,335	4,298	-0.9
	BN	4,624	4,607	-0.4	4,427	4,456	0.7
	D	4,388	4,399	0.2	4,257	4,274	0.4
	C	4,534	4,538	0.1	4,434	4,424	-0.2
November	Average	9,688	9,538	-1.5	9,238	9,176	-0.7
	W	15,113	15,055	-0.4	14,412	14,349	-0.4
	AN	11,060	10,498	-5.1	10,265	9,969	-2.9
	BN	6,529	6,237	-4.5	6,248	6,158	-1.4
	D	6,755	6,742	-0.2	6,474	6,552	1.2
	C	4,648	4,671	0.5	4,631	4,631	0.0

Table 11-16. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
December	Average	22,933	22,736	-0.9	22,289	22,182	-0.5
	W	47,953	47,299	-1.4	46,800	46,448	-0.8
	AN	18,119	18,219	0.5	17,859	17,845	-0.1
	BN	13,712	13,674	-0.3	12,890	12,719	-1.3
	D	8,645	8,578	-0.8	8,366	8,467	1.2
	C	5,728	5,845	2.0	5,460	5,553	1.7

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-18 (CP1): Effects to Delta Fishery Habitat Resulting from Changes to Delta Inflow Changes in upstream reservoir storage have the potential to affect Delta inflow. Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. Based on the results of hydrologic modeling comparing Delta inflow under Existing Condition, No-Action Alternative, and CP1, CP1 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta.

Results of the comparison of Delta inflows under the Existing Condition and No-Action Alternative with CP1 are summarized by month and water-year type in Table 11-17. The comparison includes the estimated average monthly inflow under the basis-of-comparison conditions, the average monthly flow under CP1, and the percentage change between base flows and CP1 operations. Delta inflows were observed to be slightly lower under many of the CP1 operations and slightly higher than basis-of-comparison conditions, depending on month and water-year type. None of the Existing Condition or No-Action Alternative comparisons with CP1 exceeded 5 percent. Based on the results of this comparison of CP1, it was concluded that CP1 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta as a consequence of changes in Delta inflow relative to the Existing Condition and No-Action Alternative. Mitigation for this impact is not needed, and thus not proposed.

Table 11-17. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP1

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	50,193	49,947	-0.5	49,674	49,453	-0.4
	W	93,590	93,289	-0.3	92,710	92,362	-0.4
	AN	56,641	55,937	-1.2	55,935	55,434	-0.9
	BN	30,176	30,197	0.1	29,939	29,942	0.0
	D	21,201	20,978	-1.1	20,927	20,768	-0.8
	C	16,560	16,544	-0.1	16,312	16,296	-0.1
February	Average	61,147	60,787	-0.6	60,691	60,684	0.0
	W	108,058	107,635	-0.4	107,699	107,477	-0.2
	AN	70,137	69,461	-1.0	69,901	69,434	-0.7
	BN	44,310	44,261	-0.1	43,831	43,751	-0.2
	D	28,791	28,136	-2.3	28,157	28,183	0.1
	C	18,694	18,866	0.9	18,099	19,052	5.3
March	Average	50,938	50,912	0.1	50,576	50,442	-0.3
	W	88,045	88,083	0.0	87,612	87,639	0.0
	AN	63,252	62,915	0.5	62,667	62,323	-0.5
	BN	32,287	32,250	0.1	31,760	31,781	0.1
	D	26,931	27,009	-0.3	26,504	26,109	-1.5
	C	15,999	15,998	0.0	16,299	16,242	-0.3
April	Average	33,715	33,658	-0.2	33,832	33,785	-0.1
	W	57,897	57,861	-0.1	58,185	58,150	-0.1
	AN	35,063	34,909	-0.4	35,403	35,145	-0.7
	BN	26,022	26,004	-0.1	25,955	25,938	-0.1
	D	17,991	17,905	-0.5	17,853	17,879	0.1
	C	12,534	12,528	0.0	12,653	12,646	-0.1
May	Average	27,783	27,742	-0.1	27,762	27,703	-0.2
	W	47,155	47,107	-0.1	46,817	46,795	0.0
	AN	30,016	29,706	-1.0	30,446	30,066	-1.2
	BN	21,135	21,161	0.1	21,177	21,092	-0.4
	D	15,555	15,618	0.4	15,529	15,629	0.6
	C	9,671	9,682	0.1	9,827	9,797	-0.3
June	Average	23,254	23,304	0.2	23,559	23,576	0.1
	W	35,726	35,778	0.1	35,503	35,571	0.2
	AN	23,868	23,981	0.5	24,400	24,347	-0.2
	BN	18,814	18,585	-1.2	20,111	19,837	-1.4
	D	15,726	15,915	1.2	15,789	16,120	2.1
	C	12,089	12,187	0.8	12,516	12,365	-1.2
July	Average	18,889	19,216	1.7	20,470	20,603	0.6
	W	23,568	23,697	0.5	24,661	24,754	0.4
	AN	19,796	20,029	1.2	22,429	22,513	0.4
	BN	18,549	19,026	2.6	21,709	21,710	0.0
	D	16,344	16,960	3.8	17,176	17,597	2.5
	C	12,058	12,303	2.0	12,928	12,918	-0.1

Table 11-17. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
August	Average	18,889	19,216	1.7	16,281	16,353	0.4
	W	23,568	23,697	0.5	17,995	18,050	0.3
	AN	19,796	20,029	1.2	17,543	17,576	0.2
	BN	18,549	19,026	2.6	17,273	17,315	0.2
	D	16,344	16,960	3.8	15,167	15,304	0.9
	C	12,058	12,303	2.0	11,816	11,905	0.8
September	Average	16,480	15,522	-5.8	16,625	16,703	0.5
	W	23,176	18,137	-21.7	22,459	22,448	0.0
	AN	15,742	14,259	-9.4	15,814	15,890	0.5
	BN	14,961	15,030	0.5	15,198	15,247	0.3
	D	12,749	14,061	10.3	14,118	14,329	1.5
	C	10,076	13,887	37.8	10,220	10,329	1.1
October	Average	15,542	15,522	-0.1	14,833	14,816	-0.1
	W	18,176	18,137	-0.2	17,270	17,276	0.0
	AN	14,399	14,259	-1.0	13,708	13,534	-1.3
	BN	15,010	15,030	0.1	14,436	14,365	-0.5
	D	13,980	14,061	0.6	13,490	13,531	0.3
	C	13,942	13,887	-0.4	13,153	13,225	0.5
November	Average	19,409	19,356	-0.3	19,043	19,024	-0.1
	W	26,007	25,963	-0.2	25,720	25,589	-0.5
	AN	20,432	19,994	-2.1	19,604	19,502	-0.5
	BN	16,833	16,608	-1.3	16,510	16,485	-0.1
	D	15,836	15,990	1.0	15,453	15,664	1.4
	C	12,458	12,659	1.6	12,354	12,322	-0.3
December	Average	33,195	33,020	-0.5	32,657	32,578	-0.2
	W	58,863	58,219	-1.1	58,092	57,725	-0.6
	AN	28,400	28,684	1.0	28,098	28,147	0.2
	BN	23,545	23,608	0.3	22,831	22,643	-0.8
	D	19,116	18,932	-1.0	19,010	19,060	0.3
	C	14,756	14,875	0.8	14,041	14,391	2.5

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-19 (CP1): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow Project operation would result in a variable response in Sacramento River flow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year. This impact would be less than significant.

Flow within the Sacramento River has been identified as an important factor affecting the survival of emigrating juvenile Chinook salmon; important to the downstream transport of planktonic fish eggs and larvae such as delta and longfin smelt, striped bass and shad; and important for seasonal floodplain inundation that has been identified as important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon and steelhead. Sacramento River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in Sacramento River flow as a result of CP1, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

Results of hydrologic modeling, by month and year type, for Sacramento River flow are presented in Table 11-18. Results of these analyses show a variable response in Sacramento River flow with CP1 operations resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water-year type. One comparison showed a change greater than 5 percent between the basis-of-comparison and an alternative. The model river flow under the future condition for CP1 in a critical year in February was greater than 5 percent from the basis-of-comparison; however, in this case, the river flow under CP1 was higher than the basis-of-comparison and would not be expected to result in an adverse fishery impact, but rather would be expected to contribute to improved habitat conditions under this low-flow condition. All other comparisons between the basis-of-comparison and CP1 operations were less than 5 percent. Based on these results it was concluded that the impact of CP1 on fish habitat and transport mechanisms within the lower Sacramento River and Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 11-18. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP1

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	34,680	34,529	-0.4	34,363	34,270	-0.3
	W	56,231	56,064	-0.3	55,714	55,693	0.0
	AN	44,117	43,775	-0.8	44,049	43,706	-0.8
	BN	25,272	25,291	0.1	25,024	25,027	0.0
	D	18,166	17,941	-1.2	17,888	17,728	-0.9
	C	14,298	14,283	-0.1	14,028	14,012	-0.1
February	Average	40,650	40,378	-0.7	40,345	40,429	0.2
	W	61,746	61,643	-0.2	61,676	61,759	0.1
	AN	51,527	50,846	-1.3	51,346	50,878	-0.9
	BN	34,676	34,629	-0.1	34,309	34,230	-0.2
	D	24,116	23,401	-3.0	23,562	23,589	0.1
	C	15,834	16,007	1.1	15,345	16,255	5.9
March	Average	35,093	35,098	0.0	35,018	34,935	-0.2
	W	52,808	52,875	-0.1	52,720	52,745	0.0
	AN	47,679	47,394	0.6	47,821	47,721	-0.2
	BN	25,629	25,592	0.1	25,210	25,231	0.1
	D	22,908	23,054	-0.6	22,615	22,290	-1.4
	C	13,443	13,441	0.0	13,907	13,850	-0.4
April	Average	24,190	24,141	-0.2	24,317	24,276	-0.2
	W	39,645	39,633	0.0	39,901	39,887	0.0
	AN	26,322	26,169	-0.6	26,721	26,462	-1.0
	BN	18,746	18,728	-0.1	18,673	18,655	-0.1
	D	13,900	13,814	-0.6	13,782	13,807	0.2
	C	10,362	10,356	-0.1	10,534	10,525	-0.1
May	Average	20,098	20,057	-0.2	20,119	20,060	-0.3
	W	32,904	32,856	-0.1	32,639	32,617	-0.1
	AN	22,928	22,618	-1.4	23,355	22,975	-1.6
	BN	14,923	14,949	0.2	14,997	14,912	-0.6
	D	12,055	12,118	0.5	12,060	12,160	0.8
	C	7,622	7,634	0.2	7,821	7,791	-0.4
June	Average	17,718	17,768	0.3	18,092	18,109	0.1
	W	24,331	24,384	0.2	24,141	24,210	0.3
	AN	17,986	18,099	0.6	18,678	18,624	-0.3
	BN	15,806	15,577	-1.5	17,160	16,886	-1.6
	D	14,015	14,202	1.3	14,146	14,476	2.3
	C	10,907	11,005	0.9	11,406	11,254	-1.3

Table 11-18. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	Water Year	Base Flow (cfs)	Flow (cfs)	Percent Change	Base Flow (cfs)	Flow (cfs)	Percent Change
July	Average	15,270	15,597	2.1	16,870	17,002	0.8
	W	16,088	16,216	0.8	17,160	17,252	0.5
	AN	16,682	16,915	1.4	19,335	19,419	0.4
	BN	16,500	16,976	2.9	19,698	19,699	0.0
	D	14,988	15,602	4.1	15,871	16,291	2.6
	C	11,077	11,322	2.2	11,974	11,964	-0.1
August	Average	12,649	12,881	1.8	13,790	13,862	0.5
	W	13,724	13,719	0.0	13,840	13,895	0.4
	AN	12,721	12,938	1.7	15,183	15,216	0.2
	BN	12,319	12,543	1.8	15,145	15,187	0.3
	D	13,162	13,780	4.7	13,769	13,904	1.0
	C	9,865	10,055	1.9	10,738	10,826	0.8
September	Average	13,697	13,703	0.0	13,863	13,942	0.6
	W	18,936	18,938	0.0	18,242	18,232	-0.1
	AN	13,088	13,102	0.1	13,160	13,236	0.6
	BN	12,543	12,408	-1.1	12,817	12,866	0.4
	D	10,847	10,939	0.8	12,238	12,448	1.7
	C	8,577	8,619	0.5	8,737	8,846	1.2
October	Average	12,719	12,750	0.2	12,068	12,052	-0.1
	W	14,766	14,891	0.8	14,040	14,050	0.1
	AN	12,049	11,905	-1.2	11,379	11,206	-1.5
	BN	12,322	12,342	0.2	11,758	11,687	-0.6
	D	11,249	11,330	0.7	10,747	10,788	0.4
	C	11,619	11,563	-0.5	10,823	10,895	0.7
November	Average	15,858	15,805	-0.3	15,501	15,486	-0.1
	W	21,159	21,118	-0.2	20,878	20,745	-0.6
	AN	17,210	16,774	-2.5	16,355	16,284	-0.4
	BN	13,687	13,459	-1.7	13,377	13,356	-0.2
	D	12,805	12,959	1.2	12,475	12,686	1.7
	C	10,129	10,328	2.0	10,012	9,979	-0.3
December	Average	26,148	26,050	-0.4	25,710	25,697	-0.1
	W	44,908	44,551	-0.8	44,459	44,263	-0.4
	AN	22,225	22,410	0.8	21,941	22,051	0.5
	BN	19,129	19,191	0.3	18,434	18,246	-1.0
	D	16,164	15,983	-1.1	16,042	16,102	0.4
	C	12,587	12,705	0.9	11,848	12,199	3.0

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-20 (CP1): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis Project operation would result in no discernable change in San Joaquin River flows at Vernalis, and, therefore, no effect on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta from CP1 relative to No-Action Alternative and the Existing Condition.

Flow within the San Joaquin River has been identified as an important factor affecting the survival of juvenile Chinook salmon migrating downstream from the tributaries through the mainstem San Joaquin River and Delta; important to the downstream transport of planktonic fish eggs and larvae such as striped bass; and important for seasonal floodplain inundation that is considered to be important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon. San Joaquin River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in San Joaquin River flow as a result of CP1 operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

Results of the comparative analysis of CalSim-II, by month and year-type, for the Existing Condition and CP1 for San Joaquin River flow are summarized in Table 11-19. Results of these analyses show that CP1 would have no effect on seasonal flows under existing conditions within the San Joaquin River. Similarly, modeling results showed that CP1 would have no effect on flows or fish habitat under Future Conditions. Therefore, CP1 would have no effect on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta under CP1 relative to the Existing Condition and No-Action Alternative. Mitigation for this impact is not needed, and thus not proposed.

Table 11-19. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP1

		Existing Condition	CP1 (Existing Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	4,772	4,772	0.00
	W	9,255	9,254	0.00
	AN	4,339	4,339	0.00
	BN	2,971	2,971	0.00
	D	2,084	2,084	0.00
	C	1,624	1,624	0.00
February	Average	6,434	6,433	0.00
	W	11,637	11,637	0.00
	AN	6,271	6,271	0.00
	BN	5,742	5,740	0.00
	D	2,506	2,506	0.00
	C	2,020	2,021	0.00
March	Average	6,339	6,338	0.00
	W	12,420	12,419	0.00
	AN	5,792	5,791	0.00
	BN	4,539	4,538	0.00
	D	2,372	2,372	0.00
	C	1,760	1,760	0.00
April	Average	6,006	6,006	0.00
	W	10,455	10,455	0.00
	AN	5,976	5,976	0.00
	BN	5,241	5,241	0.00
	D	3,050	3,050	0.00
	C	1,722	1,722	0.00
May	Average	6,022	6,022	0.00
	W	10,991	10,991	0.00
	AN	5,420	5,420	0.00
	BN	4,987	4,987	0.00
	D	2,895	2,896	0.00
	C	1,752	1,752	0.00
June	Average	4,631	4,631	0.00
	W	9,577	9,576	0.00
	AN	4,946	4,946	0.00
	BN	2,320	2,321	0.00
	D	1,478	1,480	0.10
	C	1,022	1,022	0.00
July	Average	3,221	3,222	0.00
	W	6,646	6,646	0.00
	AN	2,779	2,779	0.00
	BN	1,755	1,755	0.00
	D	1,260	1,261	0.00
	C	895	895	0.00

Table 11-19. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP1 (contd.)

		Existing Condition	CP1 (Existing Condition)	
Month	Water Year	Base Flow (cfs)	Flow (cfs)	Percent Change
August	Average	2,113	2,114	0.00
	W	3,350	3,350	0.00
	AN	2,010	2,010	0.00
	BN	1,827	1,828	0.00
	D	1,347	1,348	0.10
	C	1,021	1,022	0.00
September	Average	2,366	2,366	0.00
	W	3,433	3,434	0.00
	AN	2,293	2,293	0.00
	BN	2,077	2,077	0.00
	D	1,764	1,764	0.00
	C	1,368	1,368	0.00
October	Average	2,486	2,486	0.00
	W	2,915	2,915	0.00
	AN	2,099	2,099	0.00
	BN	2,428	2,428	0.00
	D	2,417	2,417	0.00
	C	2,113	2,113	0.00
November	Average	2,561	2,561	0.00
	W	3,311	3,311	0.00
	AN	2,104	2,104	0.00
	BN	2,334	2,334	0.00
	D	2,315	2,315	0.00
	C	2,026	2,026	0.00
December	Average	2,561	2,561	0.00
	W	3,311	3,311	0.00
	AN	2,104	2,104	0.00
	BN	2,334	2,334	0.00
	D	2,315	2,315	0.00
	C	2,026	2,026	0.00

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-21 (CP1): Reduction in Low Salinity Habitat Conditions Resulting from an Upstream Shift in X2 *Location* Project operation would result in a less than 0.5 km movement upstream or downstream from the X2 location. This impact would be less than significant.

Operations of upstream storage reservoirs have the potential to affect the location of X2 as a result of changes in freshwater flows from the upstream tributaries through the Delta. For purposes of evaluating changes in habitat quantity and quality for estuarine species, a significance criterion of an upstream change in X2 location within 1 km of the basis-of-comparison condition was considered to be less than significant. The criterion was applied to a comparison of hydrologic model results for basis-of-comparison conditions and CP1, by month and water year, for February through May. Results of the comparison for the Existing Condition versus CP1 are summarized in Table 11-20. These results showed that changes in X2 location under CP1 were less than 1 km (all were less than 0.5 km) with both variable upstream and downstream movement of the X2 location, depending on month and water year. These results are consistent with model results for Delta outflow that showed a less than significant change in flows under CP1.

Results of a comparative analysis of changes in X2 location between the No-Action Alternative and CP1 assuming future operating conditions are also summarized in Table 11-20. Results of these comparisons showed very little difference (less than 0.2 km) in the X2 location between the No-Action Alternative and CP1. Based on these results, it was concluded that CP1 would have a less than significant impact on low salinity habitat conditions within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-20. X2 Under Existing Conditions, No-Action Alternative, and CP1

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Conditions)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
February	Average	65	66	20.00	66	65	0.00
	W	55	55	10.00	55	55	0.00
	AN	61	61	10.00	61	61	10.00
	BN	68	68	0.00	68	68	0.00
	D	73	74	50.00	73	73	0.00
	C	77	77	20.00	77	77	-20.00
March	Average	65	65	10.00	65	65	0.00
	W	56	56	0.00	56	56	0.00
	AN	60	60	10.00	60	60	10.00
	BN	68	68	10.00	68	68	0.00
	D	72	72	30.00	72	72	10.00
	C	77	77	10.00	77	77	0.00
April	Average	68	68	0.00	68	68	0.00
	W	59	59	0.00	59	59	0.00
	AN	64	64	10.00	64	64	10.00
	BN	70	70	0.00	70	70	0.00
	D	74	74	10.00	74	74	0.00
	C	78	78	0.00	78	78	0.00
May	Average	71	71	0.00	71	71	0.00
	W	62	62	0.00	62	62	0.00
	AN	67	67	10.00	67	67	10.00
	BN	72	72	0.00	72	72	10.00
	D	76	76	0.00	76	76	0.00
	C	83	83	0.00	82	82	0.00

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-22 (CP1): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers Project operation would result in an increase of reverse flows in Old and Middle rivers. The increase in reverse flows would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses. This impact would be potentially significant.

Results of the analysis showed several occurrences when reverse flows within Old and Middle rivers were greater under CP1 than basis-of-comparison conditions by more than 5 percent. These events occurred typically in dry and critical water years, which would be expected as a result of greater export operations under CP1. During February, operations under CP1 resulted in an increase in reverse flow greater than 5 percent during critical years (Table 11-21). Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase from approximately 4,300 cfs under the basis-of-comparison in a critical water year to approximately 4,700 cfs would not be expected to result in a significant increase in adverse impacts to delta smelt. Juvenile Chinook salmon and steelhead are migrating through the Delta during February, and an increase in average monthly reverse flows of 300 to 400 cfs would be expected to increase the potential risk of increased mortality. However, given the tidal volumes and hydrodynamics of the Old and Middle river region, it is not expected that the change in reverse flows in February in a critical year would result in a detectable change in fish survival. The majority of juvenile Chinook salmon emigrating from the San Joaquin River typically migrate downstream later in dry years and would not be expected to occur in high numbers within Old and Middle rivers in February.

The increase in reverse flows estimated to occur under CP1 in critical years in June, and under critical, dry, and below-normal years in July, exceeded 5 percent. The increased reverse flows in June of critical years occurred at a time of the year when water temperatures in the Delta were elevated and juvenile Chinook salmon or steelhead would not be expected to occur in the area. Juvenile delta smelt may occur in the area in June; however, a change in Old and Middle river flows of approximately 100 to 200 cfs may result in a small increase in their vulnerability to CVP and SWP salvage, but this increase is expected to be less than significant. As water temperatures increase in the Delta during June and July, the majority of delta smelt are located farther downstream in Suisun Bay where water temperatures are more suitable. The increase in reverse flows estimated from modeling in June of a critical year and in July of below-normal, dry, and critical years would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses as a result of increased reverse flows. The increased reverse flows in low-flow years would be expected to result in a low, but potentially significant, increase in mortality for resident warm-water fish inhabiting the south Delta under CP1 relative to the Existing Condition.

Table 11-21. Old and Middle River Reverse Flows for Existing Conditions, No-Action Alternative, and CP1

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	-6,592	-6,629	-0.6	-6,968	-6,955	0.2
	W	-5,026	-5,053	-0.5	-5,624	-5,638	-0.3
	AN	-7,598	-7,612	-0.2	-7,828	-7,831	0.0
	BN	-7,717	-7,717	0.0	-8,042	-8,004	0.5
	D	-7,540	-7,604	-0.8	-7,880	-7,883	0.0
	C	-6,243	-6,330	-1.4	-6,402	-6,316	1.3
February	Average	-4,930	-5,059	-2.6	-4,996	-5,076	-1.6
	W	-3,582	-3,683	-2.8	-3,857	-3,931	-1.9
	AN	-5,663	-5,777	-2.0	-6,276	-6,210	1.1
	BN	-5,723	-5,791	-1.2	-5,301	-5,357	-1.1
	D	-6,175	-6,265	-1.5	-6,211	-5,998	3.4
	C	-4,326	-4,658	-7.7	-4,004	-4,714	-17.7
March	Average	-3,975	-4,067	-2.3	-4,148	-4,145	0.1
	W	-2,052	-2,095	-2.1	-2,394	-2,355	1.6
	AN	-5,528	-5,548	-0.4	-5,933	-5,960	-0.5
	BN	-5,264	-5,421	-3.0	-4,948	-5,021	-1.5
	D	-5,245	-5,460	-4.1	-5,313	-5,295	0.3
	C	-3,181	-3,187	-0.2	-3,479	-3,458	0.6
April	Average	-1,984	-1,974	0.5	-2,049	-2,059	-0.5
	W	-1,525	-1,528	-0.2	-1,709	-1,722	-0.7
	AN	-2,825	-2,758	2.4	-2,791	-2,826	-1.3
	BN	-2,488	-2,485	0.1	-2,460	-2,455	0.2
	D	-2,098	-2,089	0.4	-2,128	-2,142	-0.7
	C	-1,382	-1,386	-0.3	-1,447	-1,438	0.7
May	Average	-1,649	-1,648	0.1	-1,729	-1,740	-0.6
	W	-1,147	-1,144	0.2	-1,265	-1,269	-0.3
	AN	-2,312	-2,278	1.5	-2,627	-2,575	2.0
	BN	-1,693	-1,704	-0.7	-1,755	-1,790	-2.0
	D	-2,088	-2,098	-0.5	-2,026	-2,091	-3.2
	C	-1,364	-1,369	-0.4	-1,361	-1,338	1.7
June	Average	-2,858	-2,902	-1.5	-3,210	-3,220	-0.3
	W	-2,219	-2,251	-1.4	-2,387	-2,409	-0.9
	AN	-3,532	-3,594	-1.8	-4,011	-3,975	0.9
	BN	-3,752	-3,686	1.8	-4,578	-4,561	0.4
	D	-3,341	-3,428	-2.6	-3,476	-3,629	-4.4
	C	-1,801	-1,915	-6.3	-2,194	-2,045	6.8

Table 11-21. Old and Middle River Reverse Flows for Existing Conditions, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (Existing Condition)		No-Action Alternative	CP1 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
July	Average	-3,942	-4,160	-5.5	-4,813	-4,912	-2.1
	W	-3,493	-3,583	-2.6	-4,027	-4,104	-1.9
	AN	-3,967	-4,070	-2.6	-5,167	-5,237	-1.4
	BN	-4,733	-5,040	-6.5	-6,665	-6,616	0.7
	D	-4,859	-5,279	-8.7	-5,378	-5,680	-5.6
	C	-2,592	-2,795	-7.8	-3,154	-3,197	-1.4

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Results of the comparison of Old and Middle river reverse flows are summarized in Table 11-21. Results of the analysis show that in the majority of years and months, reverse flows under CP1 do not exceed basis-of-comparison conditions by more than 5 percent. CP1 exceeded basis-of-comparison conditions during February of a critical year by approximately 700 cfs. The increase in reverse flows would be expected, particularly in a critical year, to contribute to an increase in the potential for losses of adult delta smelt and other species, which is considered to be potentially significant. During June in a critical water year, under CP1, the magnitude of reverse flows was reduced more than 5 percent but would be expected to contribute to a less than significant biological benefit based on both the low reverse flow under the basis-of-comparison and under CP1. An increase in reverse flow above the basis-of-comparison of approximately 300 to 600 cfs during dry years in July would be expected to contribute to an increase in the risk of losses to resident warm-water fish species. Increased reverse flows in July would not be expected to adversely affect delta or longfin smelt, juvenile Chinook salmon, or steelhead based on their seasonal migration patterns and geographic distribution. The potential increase in losses during February and July under future operating conditions is considered to be potentially significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

Impact Aqua-23 (CP1): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports Proposed operations may result in an increase in CVP and SWP exports, which is assumed to result in a direct proportional increase in the risk of fish being entrained and salvaged at the facilities. This is a considered a less than significant impact to Chinook salmon, steelhead, and longfin smelt. This is considered a potentially significant impact to delta smelt, striped bass, and splittail. Future operations of the SWP and CVP export facilities would continue to be managed and regulated in accordance with incidental take limits established for each of the protected fish by USFWS, NMFS, and DFG.

Results of the entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-22 for CP1. The initial modeling was conducted using average fish densities developed from past fish salvage monitoring at the SWP and CVP export facilities. Average monthly water exports were used in the analysis based on hydrologic simulation modeling. The indices of the potential risk of entrainment for some species, such as Chinook salmon, were not estimated separately for each species (e.g., winter-run Chinook salmon) in these initial analyses. If the proposed project is developed in the future a more detailed species-specific analysis of potential changes in fish salvage losses, in addition to an assessment of the population-level effects on each species, would be required for use as a basis for developing a biological assessment and BOs and incidental take permits for project operations. These indices were calculated for wet, above-normal, below-normal, dry, and critical water-year types, and for an average across all years (no water-year type specified). The total numbers of fish lost annually, by species, are presented in Attachment 13. The difference between the non-operations related and operations related fish mortality is represented as the entrainment index, shown in the tables, to represent the effect of project operations on each fish species for the CVP and SWP.

The greatest change in the risk of entrainment at the CVP and SWP export facilities would be expected to occur in dry and critical water-year types when export rates are increased, especially during February and summer months. Entrainment indices as a result of CP1 operations show a relatively minor increase, on average, in salvage for most species (e.g., delta smelt, steelhead, Chinook salmon, and longfin smelt). Although the risk of entrainment showed both increases and decreases depending on species and water-year type, the general trend was a small incremental increase in the risk of entrainment/salvage losses at the CVP and SWP export facilities when compared to the Existing Condition. Species with relatively lower abundance at the CVP and SWP, such as longfin smelt, during months of the highest exports, would appear to be less affected by CP1 operations, with entrainment indices representing a net benefit as a result of CP1 relative to the Existing Condition. Species with relatively higher abundance at the CVP and SWP fish facilities, such as splittail and striped bass, show increased mortality due to higher exports during June and July, as these species are generally collected at their highest abundances during these months. Chinook salmon entrainment, whose mortality at the facilities is highest during February, March, and June, appears to increase as a result of generally higher project export rates during these months when compared to the Existing Condition.

Table 11-22. Entrainment at the CVP and SWP facilities Under Existing Conditions, No-Action Alternative, and CP1

Species	Water Year	CP1 Minus Existing Condition	Percent Change	CP1 Minus No-Action Alternative	Percent Change
Delta Smelt	Average	243	0.3	217	0.3
	W	126	0.1	158	0.2
	AN	-191	-0.2	-802	-0.9
	BN	61	0.1	414	0.6
	D	605	1.1	1,395	2.5
	C	599	1.9	-636	-2.0
Salmon	Average	526	0.5	332	0.3
	W	351	0.3	260	0.2
	AN	-157	-0.1	-665	-0.5
	BN	316	0.3	481	0.5
	D	991	1.2	1,024	1.2
	C	1,136	2.3	277	0.6
Longfin Smelt	Average	-5	-0.0	44	0.3
	W	-6	-0.0	22	0.1
	AN	-155	-0.9	-165	-0.9
	BN	38	0.3	121	0.8
	D	41	0.3	246	2.1
	C	27	0.4	-93	-1.4
Steelhead	Average	51	1.1	26	0.5
	W	39	0.7	28	0.5
	AN	35	0.7	-22	-0.4
	BN	26	0.5	14	0.3
	D	47	1.1	-61	-1.4
	C	128	4.1	213	7.0
Striped Bass	Average	22,122	1.7	8,913	0.6
	W	10,057	0.6	7,950	0.5
	AN	17,172	1.2	-189	0.0
	BN	14,246	1.1	-3,684	-0.2
	D	43,219	3.8	39,951	3.4
	C	30,758	4.6	-11,763	-1.6
Splittail	Average	4,308	1.6	1,686	0.6
	W	2,276	0.6	1,791	0.5
	AN	3,375	1.1	-1,088	-0.3
	BN	1,089	0.4	-863	-0.3
	D	8,546	3.7	10,151	4.3
	C	7,044	6.1	-5,495	-4.0

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
CVP = Central Valley Project
D = dry
SWP = State Water Project
W = wet

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent from Existing Condition in wet, above-normal, and below-normal water years and an increase in risk ranging from approximately 1 to 4 percent (Table 11-22) during dry and critical water years. The risk of increased losses of delta smelt was greatest in the dry years with a net reduction in losses under CP1 relative to the No-Action Alternative. Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations are small, the delta smelt population abundance is currently at such critically low levels that even a small increase in the risk of losses is considered to be potentially significant. The increase in risk is also expected to contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for Chinook salmon under CP1 follow a similar pattern to that described for delta smelt. Overall, CP1 resulted in a small increase in the risk of losses relative to both the Existing Condition and No-Action Alternative. The loss index for salmon under CP1 also showed increased risk in wet, below-normal, dry, and critical years. Given the numbers of juvenile Chinook salmon produced each year in the Central Valley, the relatively small incremental increase in the risk of entrainment/salvage at the CVP and SWP export facilities is considered to be a less than significant direct effect but would contribute incrementally to the overall cumulative factors affecting juvenile Chinook salmon survival within the Delta and population dynamics of the stocks.

The estimated change in the risk of longfin smelt entrainment/salvage compared with the Existing Condition and No-Action Alternative shows small positive and negative changes depending on water-year type (Table 11-22). These small changes in the risk of entrainment are considered to be less than significant.

The estimated change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities under CP1 are summarized in Table 11-22. The small positive and negative changes in risk under wet, above-normal, below-normal, and dry water years are considered to be less than significant. The increase in risk of steelhead losses in critical water years is considered to be less than significant based on the abundance of juvenile steelhead migrating through the Delta, but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The predicted increase in potential entrainment risk for steelhead under critically dry water years represents an initial estimate of the change (percentage) between the proposed project operations and the existing conditions and no-project alternatives and does not allow the predicted losses to be evaluated at the population-level. As noted above, more detailed modeling and analysis of potential steelhead losses would be required as part of preparing a project-specific analysis of entrainment losses for use in the Section 7 biological assessment and BOs for future project operations and incidental take of steelhead. As part of this more detailed analysis additional actions may be identified to further reduce and avoid potential adverse effects to steelhead.

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-22. The change in risk in wet, above-normal, and below-normal water years are considered to be less than significant based on the abundance of striped bass but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The losses of juvenile striped bass increased substantially under dry and critical year conditions, which would be expected with an increase in exports during the summer months. Under existing conditions, the risk of increased losses ranged from 3.8 to 7.6 percent (approximately 30,000 to 60,000 fish), which is considered to be potentially significant. The increased losses under the three alternatives, particularly in drier water years when juvenile striped bass production is lower, would be expected to contribute to the cumulative effects of factors affecting juvenile striped bass survival in the Delta.

Results of the risk estimates for juvenile splittail losses relative to the Existing Condition and No-Action Alternative show a pattern similar to other species (Table 11-22). The increased risk index was 1.3 percent or less in wet, above-normal, and below-normal water years, and was considered to be a less than significant impact. The loss index increased during dry and critically dry water years. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect of abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower within the Delta in dry years. The increased risk of losses in drier years was considered to be potentially significant. The increased losses would also contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP1) is considered to be less than significant for Chinook salmon, steelhead, and longfin smelt, but potentially significant for delta smelt, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

CVP/SWP Service Areas

Impact Aqua-24 (CP1): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes Project implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, hydrologic effects in tributaries and reservoirs with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. Changes in hydrology could affect aquatic habitats that provide habitat for the fish communities. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

Project implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River;

however, the hydrologic effects in tributaries (e.g., San Joaquin River, canals) and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology and reservoir levels could affect aquatic habitats that provide habitat for the fish communities, but these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP1 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and the resulting flows downstream from those reservoirs, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

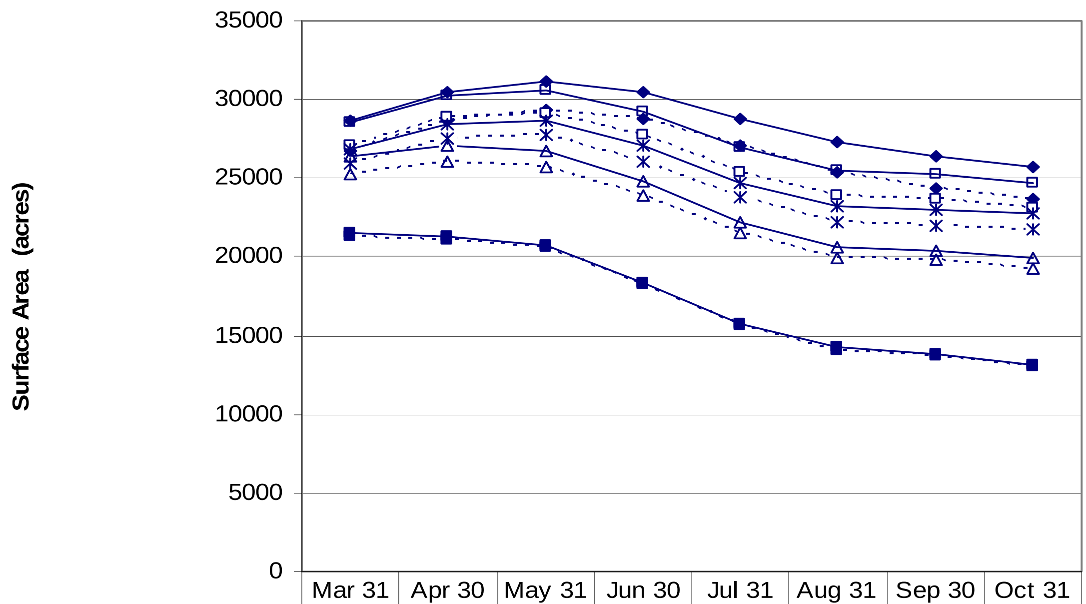
Like CP1, CP2 focuses on enlargement of Shasta Dam and Reservoir consistent with the goals of the 2000 CALFED ROD, and was formulated for the primary purposes of increased water supply reliability and increased survival of anadromous fish. CP2 consists of raising Shasta Dam by 12.5 feet, an elevation change that would increase the full pool by 14.5 feet and enlarge the total storage space in the reservoir by 443,000 acre-feet. This alternative would help reduce future shortages by increasing the reliability of the water supply in drought and average years. The increased cold-water pool also would contribute to improved seasonal water temperatures on the upper Sacramento River for anadromous fish.

Shasta Lake and Vicinity

Impact Aqua-1 (CP2): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP2, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. CP2 operations would also result in reduced monthly fluctuations in WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. Similar to CP1, the value of existing structural improvements would be diminished, large areas of the shoreline would not be cleared, and the vegetation along these sections will be inundated periodically. In the short term, this vegetation will provide warm-water lacustrine habitat, with decay expected to occur over several decades. This impact would be less than significant.

This impact would be similar to Impact Aqua-1 (CP1), but the surface area would be larger under the 12.5-foot dam raise than under the 6.5-foot dam raise. CalSim-II modeling shows that the surface area of Shasta Lake would be larger under the CP2, the Existing Condition or No-Action Alternative in all five water-year types (Figures 11-11 and 11-12).

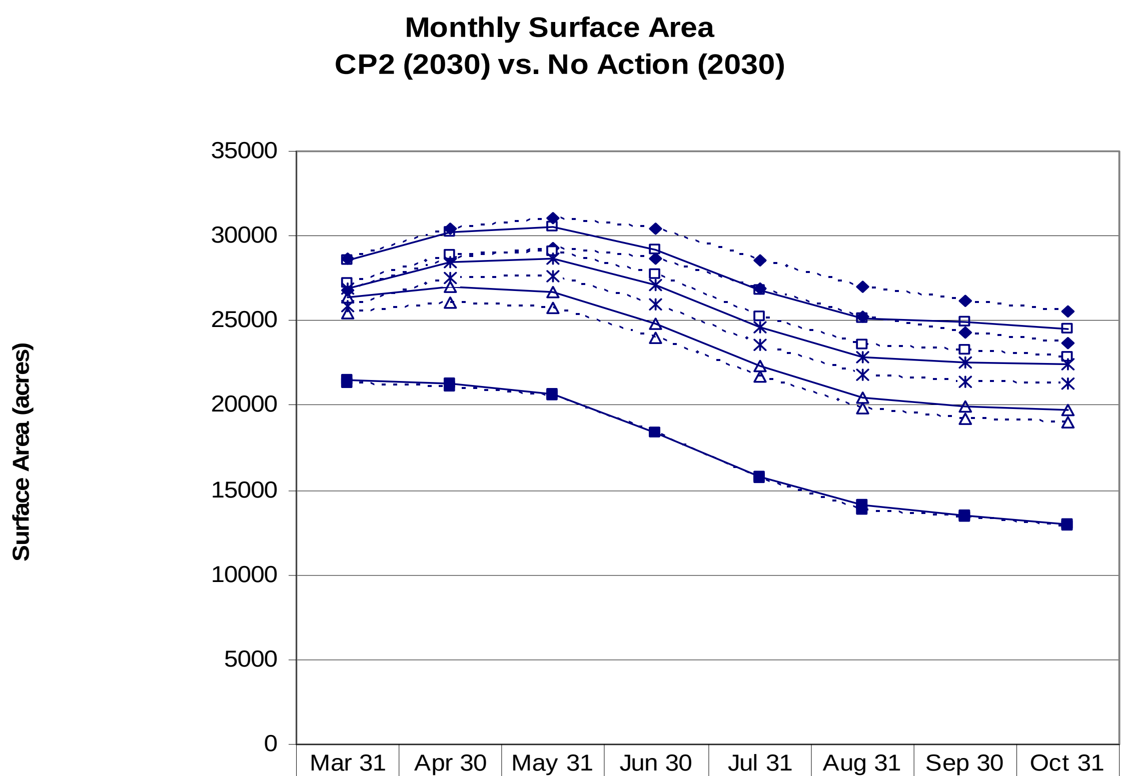
Monthly Surface Area
CP2 (2005) vs. Existing Condition (2005)



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26726	28711	29305	28720	27042	25351	24380	23709
EC AN	27096	28851	29102	27792	25377	23881	23648	23105
EC BN	25942	27562	27715	26098	23740	22177	21932	21732
EC D	25311	26013	25724	23891	21531	19954	19778	19310
EC C	21336	21121	20583	18251	15644	14079	13655	12992
CP2 2005 W	28606	30433	31102	30434	28778	27306	26362	25753
CP2 2005 AN	28544	30216	30548	29228	26913	25510	25230	24701
CP2 2005 BN	26877	28480	28643	27100	24742	23178	22984	22742
CP2 2005 D	26361	27035	26700	24768	22246	20560	20388	19960
CP2 2005 C	21498	21255	20702	18349	15757	14224	13815	13176

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-11. Monthly Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 vs. Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26750	28695	29293	28690	26880	25222	24303	23671
NA AN	27167	28885	29069	27750	25285	23603	23283	22865
NA BN	25820	27477	27594	25947	23571	21815	21422	21291
NA D	25395	26108	25802	24026	21660	19855	19238	19017
NA C	21312	21115	20554	18343	15646	13859	13349	12834
CP2 2030 W	28629	30435	31091	30389	28531	27024	26143	25571
CP2 2030 AN	28582	30210	30520	29152	26803	25176	24889	24474
CP2 2030 BN	26848	28467	28614	27063	24666	22887	22549	22392
CP2 2030 D	26372	27035	26682	24780	22291	20477	19905	19682
CP2 2030 C	21510	21295	20713	18372	15783	14127	13522	13031

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-12. Monthly Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 vs. No-Action

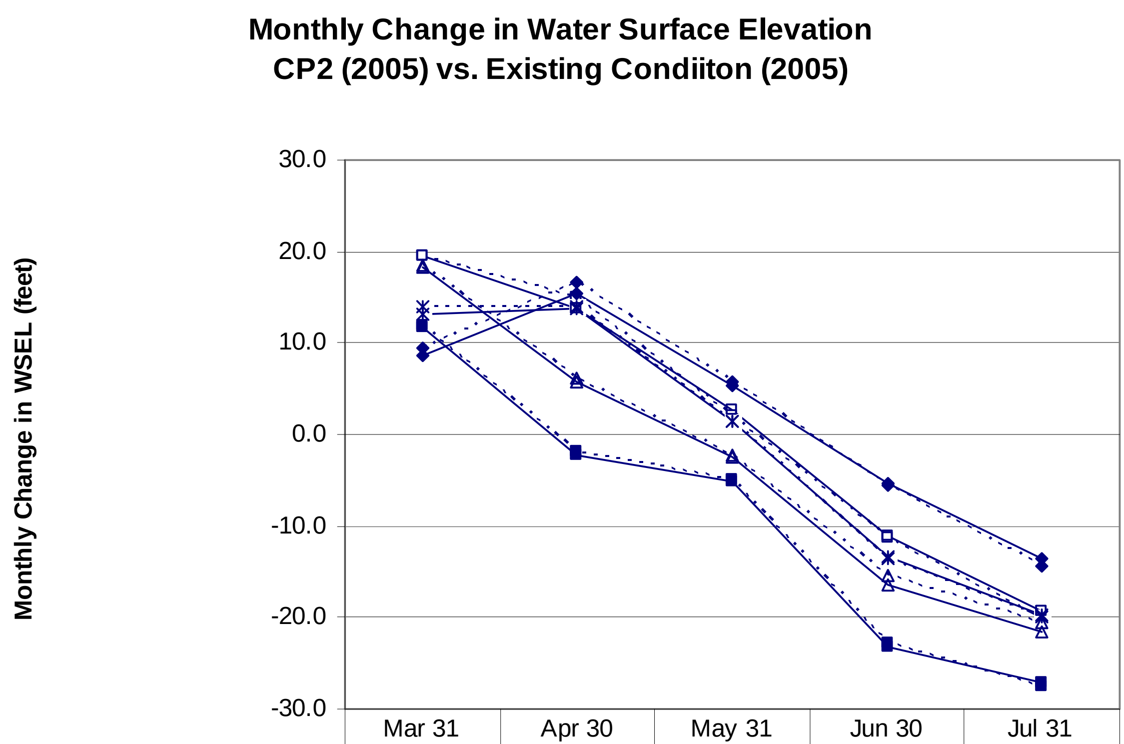
Monthly WSEL fluctuations were compared with projections for water supply demand. For CP2, with a 2005 water supply demand, 20 percent of monthly changes in projected WSEL (i.e., 5 of the 25 total projections made for the 5 months from March through July for all five water-year types) showed increased monthly WSEL fluctuations relative to the Existing Condition and 80 percent showed reduced monthly WSEL fluctuations (Figure 11-13). For CP2, with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSEL showed increased WSEL fluctuations relative to the No-Action Alternative and 64 percent showed reduced monthly WSEL fluctuations (Figure 11-14). Under CP2, none of the changes in monthly WSEL fluctuation is different enough from the Existing Condition to warrant the investigation of daily WSEL fluctuation.

Increases in the overall surface area and WSEL under CP2 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations could contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water fish species. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-2 (CP2): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Localized increases in soil erosion and resulting runoff sedimentation, and turbidity resulting from project construction in the vicinity of Shasta Dam and at utility, road, and other facility relocation areas could affect nearshore warm-water habitat. This impact would be similar to Impact Aqua-2 (CP1). However, CP2 would have a larger project footprint and would take longer to implement. However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-3 (CP2): Effects on Cold-Water Habitat in Shasta Lake Under CP2, operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

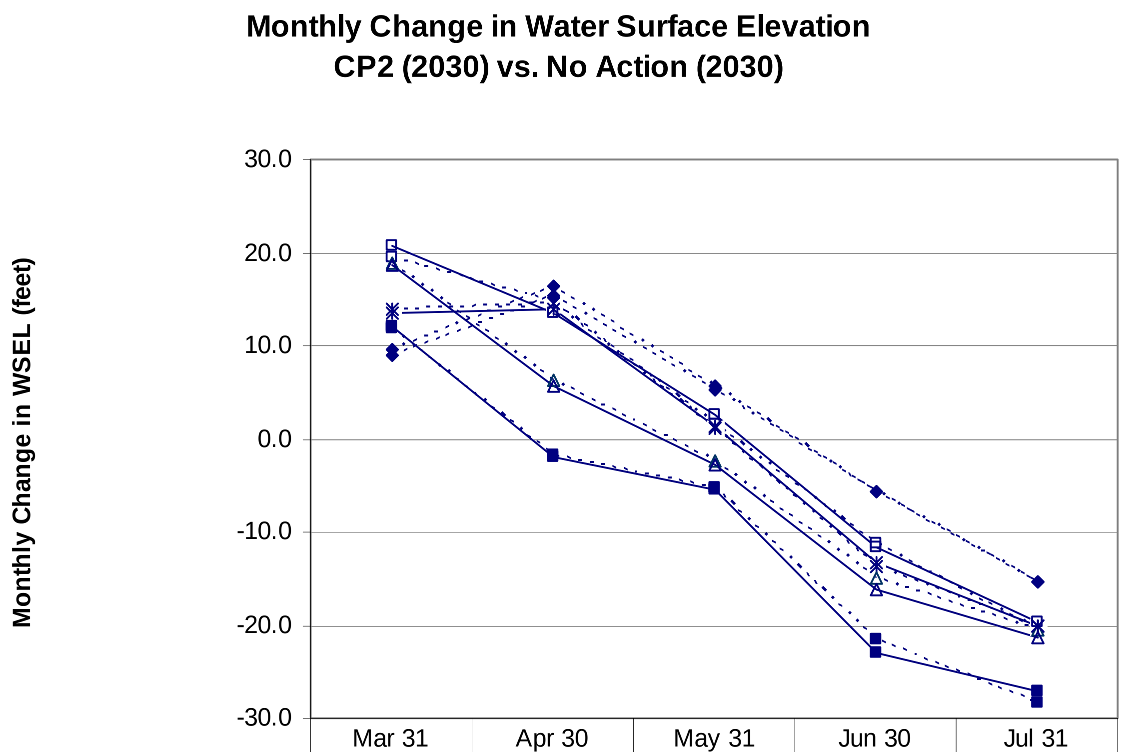
This impact would be similar to Impact Aqua-3 (CP1). However, it would be of greater magnitude owing to a greater increase in the ratio of the volume of cold water storage in the lake to the surface area of the lake. CalSim-II modeling shows that under CP2 with a 2030 water supply demand, the ratio of cold-water storage to surface area is higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occur between June 30 and August 31, which is the critical holding and rearing period for cold-water fishes in reservoirs, and the increases are greatest in wet and above-normal water years (Figure 11-15).



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9.5	16.7	5.7	-5.6	-14.3
EC AN	19.5	14.9	2.1	-11.2	-20.1
EC BN	13.9	14.0	1.4	-13.6	-19.9
EC D	18.4	6.1	-2.3	-15.5	-20.5
EC C	11.8	-1.9	-5.0	-22.7	-27.5
CP2 (2005) W	8.7	15.5	5.3	-5.4	-13.6
CP2 (2005) AN	19.6	13.8	2.8	-11.2	-19.4
CP2 (2005) BN	13.2	13.7	1.5	-13.3	-19.7
CP2 (2005) D	18.2	5.8	-2.6	-16.4	-21.6
CP2 (2005) C	11.8	-2.3	-5.2	-23.2	-27.2

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

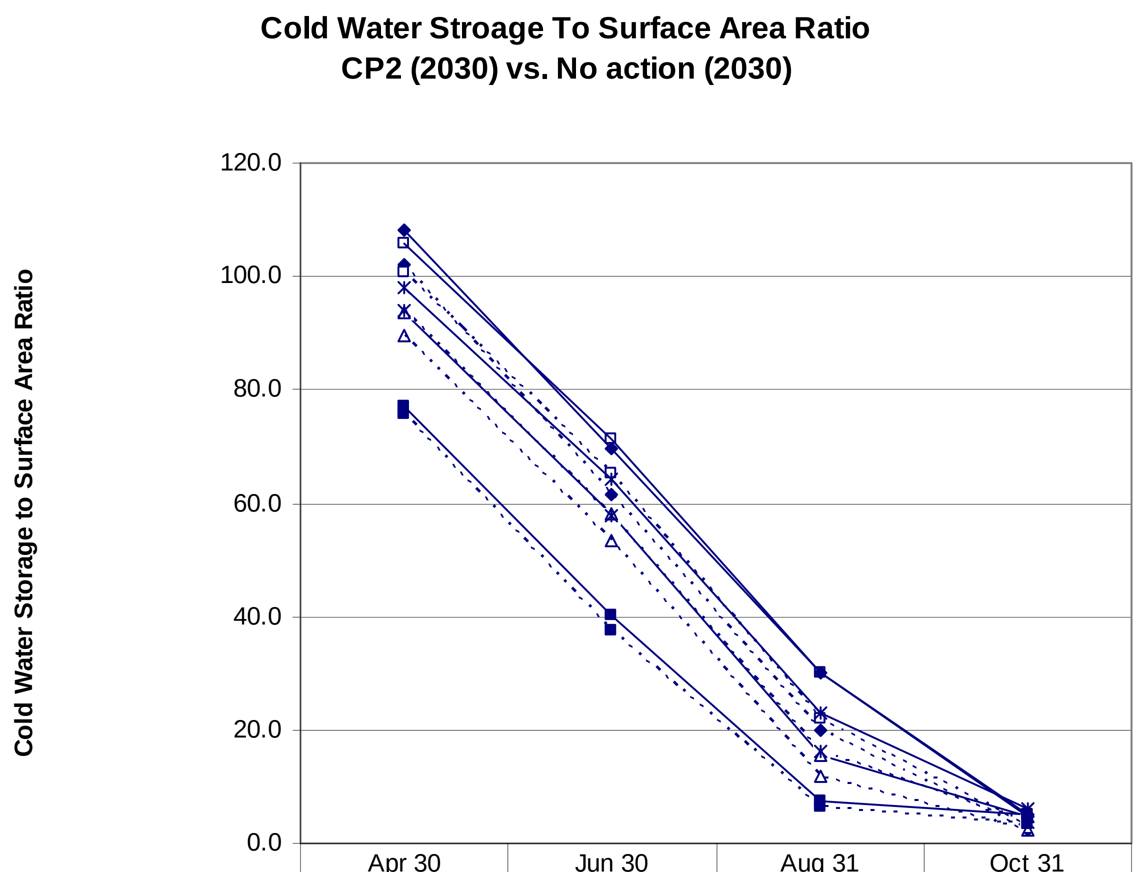
Figure 11-13. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 vs. Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	9.7	16.3	5.7	-5.8	-15.3
NA AN	19.4	14.7	1.5	-11.3	-20.5
NA BN	13.9	14.4	1.1	-13.8	-20.1
NA D	18.8	6.2	-2.4	-15.0	-20.5
NA C	11.9	-1.7	-5.3	-21.5	-28.3
CP2 (2030) W	8.9	15.3	5.2	-5.7	-15.3
CP2 (2030) AN	20.8	13.6	2.5	-11.6	-19.8
CP2 (2030) BN	13.4	14.0	1.3	-13.3	-20.0
CP2 (2030) D	18.7	5.7	-2.7	-16.1	-21.3
CP2 (2030) C	12.0	-1.9	-5.5	-23.0	-27.1

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-14. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 vs. No-Action



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	102.1	61.5	19.8	2.2
NA AN	100.9	65.2	21.8	3.1
NA BN	93.9	57.9	16.3	3.8
NA D	89.6	53.5	12.0	2.5
NA C	75.8	37.4	6.5	3.2
CP2 2030 W	108.2	69.6	30.0	4.7
CP2 2030 AN	105.9	71.4	30.2	5.1
CP2 2030 BN	97.9	64.1	23.1	6.1
CP2 2030 D	93.6	58.1	15.7	4.8
CP2 2030 C	76.9	40.3	7.5	5.2

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-15. Monthly Cold-water Storage to Surface Area Ratio for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 vs. Existing Condition

CP2 would increase the availability of suitable habitat for cold-water fish in Shasta Lake. Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-4 (CP2): Effects on Special-Status Aquatic Mollusks Under CP2, habitat for special-status mollusks could become inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that may occupy habitat in or near Shasta Lake and its tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP2): Effects on Special-Status Fish Species The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP2 could affect one species designated as sensitive by USFS, the hardhead. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP2): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP2, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,084-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. However, based on digital topographic data and stream channel data generated from field inventories, there do not appear to be any substantial barriers between the 1,070-foot and 1,084-foot contours that would be inundated under this alternative. This impact would be less than significant.

This impact would be similar to Impact Aqua-6 (CP1). However, the maximum inundation level would be higher under CP2. Most of the tributaries are too steep (i.e., greater than 7 percent) up to the 1,084-foot contour to be passable by fish; the tributaries that are low-gradient up to the 1,084-foot contour, and thus allow fish passage remain low-gradient well upstream from this contour. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP2): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP2 would result in additional periodic inundation of potential spawning and rearing habitat for adfluvial salmonids in low-gradient tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. A total of 7.4 miles of low-gradient reaches that could provide some spawning and rearing habitat for adfluvial salmonids would be affected by CP2, which is only about 1.8 percent of the low-gradient habitat upstream from Shasta Lake. This impact would be less than significant.

As described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils," CP2 would inundate perennial reaches with gradients of less than 7 percent that could provide potentially suitable spawning and rearing habitat for adfluvial salmonids. The lengths of low-gradient tributaries to each arm of Shasta Lake that would be periodically inundated are as follows:

- Sacramento River Arm 3.1 miles
- McCloud River Arm 1.4 miles
- Pit River Arm 1.4 miles
- Big Backbone Creek Arm 0.6 miles
- Squaw Creek 0.9 miles

This impact would be similar to Aqua-7 (CP1). However, it would periodically inundate a larger amount of habitat in low-gradient reaches to Shasta Lake, but the total amount inundated would be only 1.8 percent of the low-gradient habitat upstream from the lake. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-8 (CP2): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP2 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. Only 17.3 miles of non-fish-bearing tributary habitat would be affected by CP2, which is only about 0.7 percent of this habitat upstream from Shasta Lake. This impact would be less than significant.

As described in Chapter 4, CP2 would inundate tributary segments with channel slopes in excess of 7 percent. Although these segments do not typically support salmonid populations, they do provide riparian and aquatic habitat for a variety of organisms and serve as corridors that connect habitat types. The lengths of non-fish-bearing tributaries for each arm of Shasta Lake that would be periodically inundated are as follows:

- Sacramento River Arm 3.9 miles
- McCloud River Arm 2.8 miles
- Pit River Arm 2.5 miles
- Big Backbone Creek Arm 1.8 miles
- Squaw Creek Arm 1.3 miles
- Main Body 5.0 miles

This impact would be similar to Aqua-8 (CP1). However, it would periodically inundate a larger amount of habitat in low-gradient reaches to Shasta Lake, but the total amount inundated would be only 0.7 percent of the low-gradient habitat upstream from the lake. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP2): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP2. There would be no impact.

This impact is the same as Impact Aqua-9 (CP1) and there would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to RBDD)

Impact Aqua-10 (CP2): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Construction-related increases in sediments and turbidity would adversely affect aquatic habitats and fish populations within the upper Sacramento River immediately downstream from project construction activities. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater because of the increased activity associated with a 12.5-foot raise compared to a 6.5-foot raise. However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-11 (CP2): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants, resulting in adverse effects on aquatic habitats, the aquatic food web, and fish populations, including special-status species, within the primary study area downstream from project construction activities. However, environmental commitments would be in place to reduce the impacts to less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater because of the increased activity associated with a 12.5-foot raise compared to a 6.5-foot raise. The potential release of hazardous materials into Shasta Lake or the Sacramento River could result in the reduction of aquatic habitats and fish populations if proper procedures are not implemented to contain the discharge. However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-12 (CP2): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon Project operation would result in improved flow and water temperature conditions in the upper Sacramento River for fish species of management concern. This impact would be beneficial.

Winter-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, the overall average winter-run production for the 82-year period was similar for CP2 relative to the No-Action Alternative and the Existing Condition (Attachments 1A and 2A). The maximum increase in production relative to the No-Action Alternative was 44 percent for CP2, while the largest decrease in production relative to the No-Action Alternative was 29 percent under CP2 (Attachment 1A). The maximum increase in production relative to the Existing Condition was 34 percent for CP2, while the largest decrease in production relative to the Existing Condition was 4 percent under CP2 (Attachment 2A).

With one exception (1977 at -32 percent), years with the lowest production over the simulation period showed the largest increase in production under CP2 conditions.

Under CP2, critical water years 1924, 1931, and 1934 had substantial increases in production relative to the No-Action Alternative for winter-run Chinook salmon, ranging from 8 percent to 65 percent. Dry water year 1944 had a substantial increase (7 percent) compared to the No-Action Alternative. Critical water year 1977 had a decrease in production of around 32 percent, and dry water year 1932 had a decrease in production of 7 percent.

Under CP2, critical water years 1924, 1933, and 1977 had increases in production relative to the Existing Condition for winter-run Chinook salmon, ranging from 5 percent to 23 percent. Only one below-normal water year, 1936, had a substantial increase (5 percent) compared to the Existing Condition. No years had decreases in production greater than 5 percent.

When the spawning population was set at AFRP goal, the overall average winter-run Chinook salmon production was similar for CP2 relative to the No-Action Alternative (Attachment 3A). The maximum increase in production relative to the No-Action Alternative was 28 percent for CP2. The largest decrease in production relative to the No-Action Alternative was 20 percent for CP2. All years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP2, with one exception, 1977, a 20-percent decrease.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to winter-run Chinook salmon under CP2 occurred to the egg incubation life stage, followed by fry, and lastly to presmolts and immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-4 displays the overall mortalities for each

Comprehensive Plan that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 2B and 3B). Mortalities caused by the project decrease as the proposed dam height increases from 6.5 to 18.5 feet.

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, fry were the primary life stage affected, but operations-related activities had a greater effect on eggs than on presmolts and no effect on immature smolts. The same trends for each alternative were observed, with the bulk of the mortality affecting the fry and egg incubation life stages, and both water temperature and flow causing mortality (Table 11-5).

In critical water years, mortality to eggs due to unsuitable water temperatures was the primary cause of operations-related mortalities for CP2, followed by mortality to fry (more by flow and density than water temperature), then to eggs from redd superimposition, followed by presmolts (affected first by temperature then flow), and then immature smolts (affected by flow). Attachments 2C and 3C contain tables of mortality to winter-run sorted by water-year type, and Table 11-6 outlines the rankings classified under each Comprehensive Plan for each water-year type.

In dry water years, mortality to fry when moving to new habitats was the primary cause of operations-related mortalities for all Comprehensive Plans, followed by mortality to eggs due to redd superimposition. Third was mortality to eggs due to unsuitable water temperatures, followed by mortality to presmolts while moving to new habitats.

Below-normal, above-normal, and wet water years also had the greatest number of winter-run perish as fry caused by forced movement to habitat downstream, followed by mortality to eggs due to redd superimposition, then the loss of eggs from unsuitable water temperatures, and forced movement of presmolts to downstream habitats.

Years with the highest mortality were the same for the No-Action Alternative and the Existing Condition and CP2, and were 1924, 1931, 1933, 1934, 1977, and 1992. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991), dry (1930, 1932) or below-normal (1923) water-year type. Years with the lowest mortality varied between all water-year types. Years in which the project has the greatest effect on winter-run were also years in which the lowest production occurred (Attachments 2C and 3C).

When the spawning population was set at the AFRP goal, winter-run Chinook salmon mortality caused by operations-related activities decreased under CP2 compared to No-Action Alternative conditions. Under CP2, mortality caused by operations-related activities would decrease from non-operations related mortality by over 10 percent. Under CP2, the greatest mortality to winter-run occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because winter-run Chinook salmon have, overall, a reduced mortality, winter-run Chinook salmon would benefit from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, similar to CP1, overall average spring-run Chinook salmon production for CP2 remained relatively close to the No-Action Alternative and the Existing Condition (Attachments 4A and 5A). The maximum increase in production relative to the No-Action Alternative was 37 percent for CP2. The largest decrease in production relative to the No-Action Alternative was 21 percent under CP2 (Attachment 4A). The maximum increase in production relative to the Existing Condition was 49 percent for CP2 in 1932. The largest decrease in production relative to the Existing Condition was 49 percent under CP2 in 1977 (Attachment 5A).

Under CP2, critical water years 1924, 1931, 1977, 1992, and 1994 had increases in production relative to the No-Action Alternative, ranging from 13 to 37 percent. Dry water years 1925 and 1932, and below-normal water year 1959, had increases in production ranging from 6 percent to 10 percent. Critical water year 1934 had a decrease in production of 21 percent.

Under CP2, six critical water years (1924, 1933 1934, 1992, 1994, 2001) had substantial increases in production relative to the Existing Condition, ranging from 6 percent to 19 percent. Two dry water years, 1932 and 2002, had increases ranging from 6 percent to 70 percent compared to the Existing Condition. One below-normal water year (1959) had a 7 percent increase in production relative to the No-Action Alternative. Two critical water years (1977 and 1988) and one dry water year (1926) resulted in decreases in production relative to the Existing Condition (6 percent to 49 percent).

When the spawning population equaled the AFRP goal, overall average spring-run Chinook salmon production was similar for CP2 relative to the No-Action Alternative (Attachment 6A). The maximum increase in production relative to the No-Action Alternative was 100 percent for CP2. The largest decrease in production relative to the No-Action Alternative was 32 percent for CP2. Years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP2, with one exception, 1934, a 33-percent decrease.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to spring-run Chinook salmon under CP2 occurred to eggs, followed by presmolts, then fry. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-7 displays the overall mortalities for each Comprehensive Plan that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 4B and 5B). Mortalities caused by CP2 decrease as the proposed dam height increases from 6.5 to 18.5 feet (Tables 11-7 and 11-8). When removing nonoperations-related mortality, leaving mortality due to operations-related activities, only eggs and fry were affected (Table 11-8).

Similar to the No-Action Alternative, critical water years had mortality to eggs due to unsuitable water temperatures as the primary cause of operations-related mortalities, followed by mortality to eggs both prespawned and during incubation caused by dewatering the redds, then to fry from forced movement to downstream habitats. Attachments 4C and 5C contains tables of mortality to spring-run Chinook salmon sorted by water-year type. Table 11-11 outlines the rankings classified under each Comprehensive Plan for each water-year type based.

In dry, below-normal and above-normal water years, CP2 was dominated by egg temperature mortality, followed by mortality resulting from redd dewatering. Mortality to prespawned eggs occurred in only two dry years but no below-normal water years. Mortality to fry from forced movement was relatively low in only several more years (Table 11-9).

In wet water years, spring-run eggs under conditions created by CP2 were more affected by redd dewatering than by unsuitable water temperatures (Table 11-9).

Years with the highest operations-related mortality were the same for all the Comprehensive Plans and were 1924, 1931, 1932, 1933, 1934, 1977, and 1992. Except for 1932 (a dry water year), each of these years was a critical water-year type and was preceded by either a below, dry, or (predominantly) a critical water year. However, years with the lowest mortality varied between all water-year types. Years in which the project had the greatest impact on spring-run Chinook salmon were also years in which the lowest production occurred, with nearly all of the mortality occurring in the egg incubation life stage (Attachments 4C and 5C).

When the spawning population was equal to the AFRP goal, spring-run Chinook salmon mortality caused by the operations-related activities decreased under CP2 compared to No-Action Alternative conditions (Attachment 6B). Under CP2, mortality caused by operations-related activities would decrease from non-operations related mortality by over 34 percent. Under CP2, the greatest mortality to spring-run occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because spring-run Chinook salmon have, overall, a reduced mortality, spring-run Chinook salmon would benefit from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

<u>Production</u>

Based on the 1999 through 2006 population average, overall average fall-run Chinook salmon production for the simulation period was similar for CP2 relative to the No-Action Alternative and the Existing Condition (Attachments 7A and 8A). The maximum increase in production relative to the No-Action Alternative was 83 percent for CP2. The largest decrease in production relative to the No-Action Alternative was 8 percent under CP2 (Attachment 7A). The maximum increase in production relative to the Existing Condition was 44 percent for CP2. The largest decrease in production relative to the Existing Condition was 34 percent under CP2 (Attachment 8A).

In critical, dry, and below-normal water years, when production was lowest over the simulation period, the increase in production resulting from operations-related activities was greatest. In above-normal and wet water years, however, the lowest production years typically had a slight decrease in production under CP2 conditions relative to the No-Action Alternative.

Under CP2, critical water years 1931, 1934, and 1977 had increases in production relative to the No-Action Alternative, ranging from 8 to 83 percent. Four dry water years (1926, 1932, 1955, and 1964) had between 5 and 12 percent increases in production compared to the No-Action Alternative. Production increased by 9 percent to 47 percent in below-normal water years 1937 and 1945 relative to the No-Action Alternative. Below-normal water year 1979 and wet water year 1999 resulted in a decreased production relative to the No-Action Alternative of between 6 and 8 percent.

Under CP2, critical water year 1924 and dry water years 1926, 1939, and 1964 had increases in production relative to the Existing Condition of between 6 and 44. Three below-normal water years (1937, 1945 and 1950) had an increase in production relative to the Existing Condition of 6 percent to 30 percent. One critical (1977), one below-normal (1979), one above-normal (1957) and five wet (1969 and 1999) water years resulted in decreased production relative to the Existing Condition of between 5 and 34 percent.

When the spawning population was equal to the AFRP goal, overall average fall-run Chinook salmon production was similar for CP2 relative to the No-Action Alternative (Attachment 9A). The maximum increase in production relative to the No-Action Alternative was 81 percent for CP2. The largest decrease in production relative to the No-Action Alternative was 6 percent for CP2. In critical, dry, and below-normal water years, years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP2. In above-normal and wet water years, however, the lowest production years typically had a slight decrease in production under CP2 conditions relative to the No-Action Alternative. In above-normal and wet water years, however, the lowest production years typically remained similar or had a slight decrease in production under CP1 conditions relative to the No-Action Alternative.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to fall-run Chinook salmon under CP2 occurs to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages. Table 11-8 displays the overall mortalities for each alternative that were caused by nonoperational factors versus those caused by the operations (i.e., water temperature and flow) (Attachments 7B and 8B). Mortalities caused by operations-related activities were lower for CP2 than for the No-Action Alternative (Tables 11-10 and 11-11).

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, egg incubation was still the primary life stage affected, but operations-related activities had a greater effect on fry than on presmolts and an even lesser effect on immature smolts. The same trends for each Comprehensive Plan were observed, with the bulk of the mortality affecting the egg incubation life stage, with flow triggering more of the mortality (Table 11-11).

In all water-year types the greatest portion of mortality occurred to fry caused by forced movement to downstream habitats. Prespawn, incubation, and superimposition mortality were greater than mortality to eggs caused by unsuitable water temperatures and presmolt habitat movement.

In critical water years, CP2 show the same general trend in mortality factors as the No-Action Alternative and Existing Condition, except CP2 had greater mortality during the prespawn phase, than to fry caused by forced movement. Least affected were presmolts and then immature smolts by both water temperatures and forced movement. Attachments 7C and 8C contain tables of mortality to fall-run sorted by water-year type, and Table 11-12 outlines the rankings classified under each Comprehensive Plan for each water-year type.

As with critical water years, dry water years were dominated by mortality to fry due to forced movement downstream, followed by redd dewatering or scouring and redd superimposition. There was additional mortality to fall-run Chinook salmon presmolts and immature smolts from both forced movement and unsuitable water temperatures (Table 11-12).

Below-normal and above-normal water years were relatively similar for CP2 compared with the No-Action Alternative and the Existing Condition. The mortality factors were dominated by mortality to fry due to forced movement downstream, followed by redd superimposition, dewatering or scouring. Mortality to presmolts caused by forced downstream movement was a greater factor affecting fall-run populations than was egg mortality caused by unsuitable water temperatures or mortality to immature smolts and fry due to unsuitable water temperatures (Table 11-12).

As with the water-year types discussed above, under wet water year conditions, the majority of the mortality also occurred to fry due to forced downstream movement, followed by redd superimposition, and redd dewatering or scouring, mortality to presmolts and immature smolts from downstream movement were the lowest mortality rates resulting from operations-related activities. Least affected were eggs due to unsuitable water temperatures, both prespawn and postspawn.

Years with the highest mortality were the same for CP2 as for the No-Action Alternative and CP1: 1934, 1935, 1970, 1978, and 1993. With the exception of 1970, each of these years was preceded by a critical water year. Overall, years with the lowest mortality tended to be dry or critical water years.

Years with the highest mortality were the same for CP2 as for the Existing Condition and CP1: 1957, 1982, 1985, 1994, and 1997. Overall, years with the lowest mortality tended to be dry water years.

When the spawning population was set at the AFRP goal, fall-run Chinook salmon mortality caused by the operations-related activities decreased under CP2 compared to No-Action Alternative conditions (Attachment 9B). Under CP2, mortality caused by operations-related activities would decrease from non-operations related mortality by 14 percent. Under CP2, the greatest mortality to fall-run Chinook salmon occurred to the egg incubation life stage, followed by fry, then presmolts, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because fall-run Chinook salmon have, overall, a reduced mortality, fall-run Chinook salmon would benefit from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, overall average late fall-run Chinook salmon production for the 82-year period was similar for CP2 relative to the No-Action Alternative and the Existing Condition (Attachments 10A and 11A). The maximum increase in production relative to the No-Action Alternative was 8 percent for CP2. The largest decrease in production relative to the No-Action Alternative was 6 percent under CP2 (Attachment 10A). The maximum increase in production relative to the Existing Condition was 14 percent for CP2 in 1985. The largest decrease in production relative to the Existing Condition was 5 percent under CP2 (Attachment 11A).

Under CP2, production increased for critical water year 1976, dry water years 1926 and 1985, and below-normal water year 1923 by 6 to 7 percent relative to the No-Action Alternative. One dry (1944) had decreased production of 6 percent compared to the No-Action Alternative.

Under CP2, two dry water years (1926 and 1985), and one wet water year (1975) had increases (ranging from 5 to 14 percent) compared to the Existing Condition. No year had decreases greater than 5 percent compared to the Existing Condition.

When the spawning population equaled the AFRP goal, overall average late fall-run Chinook salmon production was similar for CP2 relative to the No-Action Alternative (Attachment 12A). The maximum increase in production relative to the No-Action Alternative was 12 percent for CP2. The largest decrease in production relative to the No-Action Alternative was 7 percent for CP2. Production remained relatively similar regardless of water-year type.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to late fall-run Chinook salmon under CP2 occurred to the egg incubation life stage, followed by fry, then presmolts, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under CP2. Table 11-13 displays overall mortalities for each Comprehensive Plan that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 10B and 11B). Mortalities caused by the project decreased for all Comprehensive Plans relative to the No-Action Alternative.

When removing nonoperations-related mortality, allowing the comparison of mortality for operations-related activities only, fry became the primary life stage affected, and operations-related activities had a greater effect on eggs than on presmolts, and an even lesser effect on immature smolts. Most of the mortality occurred as a result of flow conditions rather than water temperature (Table 11-14).

Mortality to fry resulting from unsuitable water temperatures only occurred at low levels to late fall-run during critical, dry, and below-normal water years. In all water-year types, under CP2, mortality to fry during forced movement to downstream habitats was the primary cause of operations-related mortality.

In critical, dry, and below-normal water years, the causes of operations-related mortality follow similar trends for all Comprehensive Plans with a few exceptions. In general, the effects of flow (and density) had the greatest effect on mortality. Forced movement of fry resulted in the greatest mortality, followed by flow effects on eggs via scouring, dewatering, or superimposition. Next affected were presmolts and immature smolts by unsuitable water temperatures, and lastly temperature effects on eggs and flow effects on presmolts and immature smolts and fry (Table 11-15).

Wet and above-normal water years were overall similar to critical, dry, and below-normal water years except that mortality to fry due to unsuitable water temperatures disappeared.

Years with the highest mortality were the same as for the No-Action Alternative, Existing Condition, and CP1. All water-year types were covered. Three years were preceded by a wet water year, one preceded by an above-normal water year, and at least one below-normal water year (Attachments 10C and 11C).

When the spawning population was equal to the AFRP goal, late fall-run Chinook salmon mortality caused by the operations-related activities was slightly less under CP2 than under No-Action Alternative conditions. Under CP2, mortality caused by operations-related activities would decrease from non-operations related mortality by 29 percent. Under CP2, the greatest mortality to late fall-run occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives (Attachment 12B).

Because late fall-run Chinook salmon have, overall, a reduced mortality, late fall-run Chinook salmon would benefit from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP2): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass Project operation would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

This impact would be similar to Impact Aqua-13 (CP1). The impact could be greater because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam.

Flow-Related Effects Similar to CP1, monthly mean flows at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP2 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). Potential flow-related effects on fish species of management concern in the upper Sacramento River from this alternative would be minimal. All potential changes in flows and stages would diminish rapidly downstream from RBDD because of the increasing effect of inflows from tributaries and of diversions and flood bypasses.

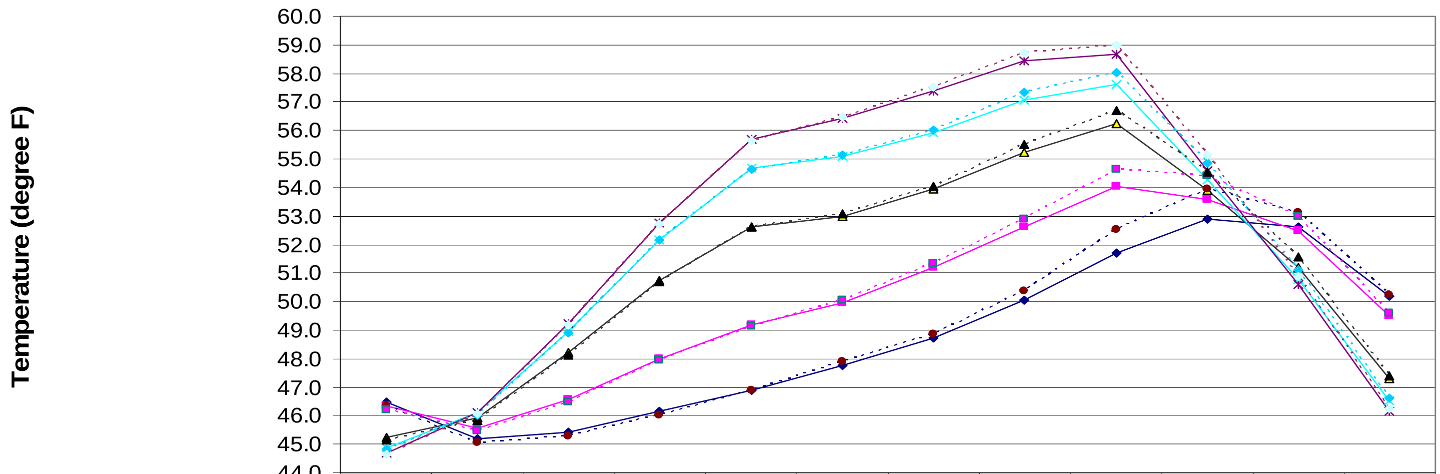
There would be no discernable flow-related effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River related to changes in monthly mean flows under CP2, relative to the Existing Condition and No-Action Alternative. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow-related impacts on these fish species would be less than significant.

Water Temperature-Related Effects Similar to CP1, monthly mean water temperatures at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP2 would be the same or fractionally less than those under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-16 and 11-17) (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). As discussed above, the modeling simulations may not fully account for real-time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some varying degree. Nevertheless, potential water temperature-related effects on fish species of management concern in the upper Sacramento River from CP2 would be minimal. During most years, releases from Shasta Lake would be unchanged.

Overall, the greatest cooling effect (less than 1°F) would occur during critical years and during the late summer (i.e., July through September), because of the increased cold-water pool volume within Shasta Lake, even following an extended dry period. All potential changes in flows and stages would diminish downstream from RBDD because of increasing effect of inflows from tributaries and of diversions and flood bypasses.

There would be very small water temperature-related effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River related to slightly cooler monthly mean water temperatures under CP2, relative to the Existing Condition and the No-Action Alternative. Mean monthly water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River. Therefore, water temperature-related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP2 vs Existing Conditions (2005)

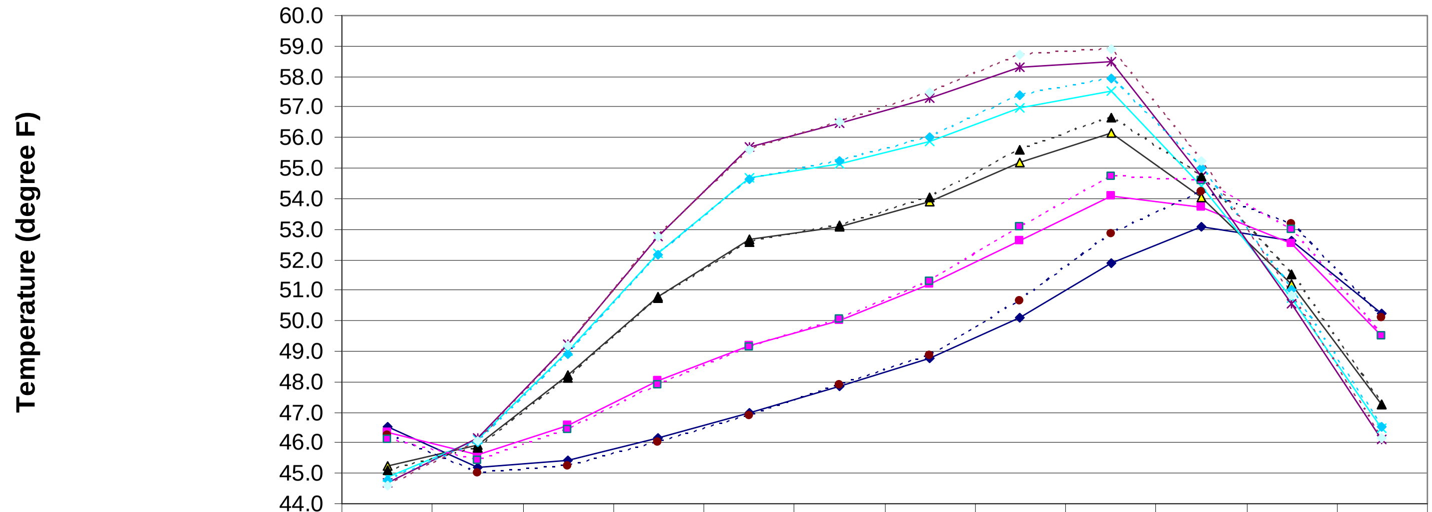


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP2_Below Shasta	46.5	45.2	45.4	46.1	46.9	47.8	48.7	50.1	51.7	52.9	52.6	50.2
CP2_Below Keswick	46.3	45.6	46.6	48.0	49.2	50.0	51.2	52.6	54.1	53.6	52.5	49.5
CP2_Balls Ferry	45.2	45.9	48.2	50.8	52.6	53.0	53.9	55.2	56.2	53.9	51.2	47.3
CP2_Bend Bridge	44.9	46.1	49.0	52.2	54.7	55.1	55.9	57.1	57.6	54.3	50.8	46.5
CP2_RBDD	44.7	46.1	49.2	52.7	55.7	56.4	57.4	58.5	58.7	54.6	50.6	46.2
EC_SHASTA DAM	46.3	45.1	45.3	46.0	46.9	47.9	48.9	50.4	52.5	54.0	53.1	50.2
EC_Keswick	46.2	45.5	46.5	47.9	49.2	50.0	51.3	52.9	54.6	54.4	53.0	49.6
EC_Balls Ferry	45.2	45.8	48.1	50.7	52.6	53.1	54.1	55.5	56.7	54.6	51.6	47.4
EC_Bend Bridge	44.8	46.0	48.9	52.1	54.7	55.2	56.0	57.3	58.0	54.9	51.1	46.6
EC_RBDD	44.6	46.1	49.2	52.7	55.7	56.5	57.5	58.7	59.0	55.1	50.9	46.2

Key:
CP = Comprehensive Plan
EC = Existing condition
RBDD = Red Bluff Diversion Dam

Figure 11-16. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (Existing Condition)

CP2 vs No-Action (2030)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP2_Below Shasta	46.5	45.2	45.4	46.2	47.0	47.8	48.7	50.1	51.9	53.1	52.6	50.2
CP2_Below Keswick	46.4	45.6	46.6	48.0	49.2	50.0	51.2	52.6	54.1	53.7	52.5	49.5
CP2_Balls Ferry	45.2	45.9	48.2	50.8	52.7	53.1	53.9	55.2	56.2	54.0	51.2	47.3
CP2_Bend Bridge	44.9	46.1	49.0	52.2	54.7	55.2	55.9	57.0	57.5	54.4	50.7	46.5
CP2_RBDD	44.7	46.1	49.2	52.8	55.7	56.5	57.3	58.3	58.5	54.7	50.6	46.1
NA_SHASTA DAM	46.2	45.0	45.2	46.0	46.9	47.9	48.9	50.7	52.8	54.2	53.2	50.1
NA_Keswick	46.1	45.4	46.4	47.9	49.1	50.0	51.3	53.1	54.7	54.6	53.0	49.5
NA_Balls Ferry	45.1	45.8	48.1	50.7	52.6	53.1	54.0	55.6	56.7	54.7	51.5	47.3
NA_Bend Bridge	44.8	46.0	48.9	52.2	54.6	55.2	56.0	57.4	57.9	55.0	51.0	46.5
NA_RBDD	44.6	46.1	49.2	52.7	55.6	56.5	57.5	58.7	58.9	55.3	50.8	46.1

Key:
CP = Comprehensive Plan
EC = Existing condition
RBDD = Red Bluff Diversion Dam

Figure 11-17. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (No-Action Alternative)

Impact Aqua-14 (CP2): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows CP2 operations could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large floods providing the energy required to mobilize sediment from the river bed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. CP2 operations could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

CP2 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

These impacts would likely occur along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. These impacts would be potentially significant within the primary study area. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Delta

Impact Aqua-15 (CP2): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernable change in mean monthly flow or water temperature conditions in the lower Sacramento River; however, predicted changes in flow in the Feather River, American River, and Trinity River could result in an adverse effect on Chinook salmon, steelhead, coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass if they were to occur. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and increased cold-water pool) to be stored behind the raised dam.

Similar to CP1, monthly mean flows at model locations (i.e., Verona, Freeport) within the lower Sacramento River under CP2 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative conditions simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). All potential changes in flows diminish rapidly downstream from RBDD because of the increasing effect of inflows from tributaries and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the lower Sacramento River from this alternative would be minimal. Differences in mean monthly flow are generally small (less than 2 percent) and within the existing range of variability. All potential changes in water temperatures in the lower Sacramento River due to small changes in releases would diminish rapidly downstream because of increasing effect of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts on fish species in the lower Sacramento River would be less than significant.

Also similar to CP1, monthly mean flows at all model locations within the lower Feather River, the American River, and Trinity River under CP2 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for most months; however, there are several months within the modeling record that show substantial changes (based on model simulations) to flows in tributaries (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). All potential changes in flows could be diminished in these areas per existing operational rules and because of operation of upstream reservoirs (i.e., Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects of inflows from tributaries and of diversions and flood bypasses. Nevertheless, based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts on species of management concern in the American, Feather, and Trinity rivers could occur and would be a potentially significant impact.

All potential changes in water temperatures in the lower Sacramento River and primary tributaries (i.e., Feather River and American River) due to altered releases from reservoirs diminished downstream because of the increasing effect of inflows, and atmospheric and groundwater influences.

As under CP1, effects of altered flow regimes resulting from implementation of CP2 are unlikely to extend into the lower Sacramento River and Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the SWP and the CVP). The guidelines for this management, which are described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with the OCAP to allow coverage by the OCAP permits and BOs. Thus, under CP2, this project is not anticipated to cause an alteration in flow to the Delta nor cause an alteration to water temperatures in the lower Sacramento River and primary tributaries within the extended study area sufficient to cause discernable effects on Chinook salmon, steelhead, green sturgeon, Sacramento splittail, American shad or striped bass relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and temperature-related effects on these fish species would be less than significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP2): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows CP2 operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the lower Sacramento River and lowermost (confluence) areas of tributaries) would be a potentially significant impact.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large floods providing the energy required to mobilize sediment from the bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

CP2 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These impacts would likely occur along the upper reaches of the lower Sacramento River. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. These impacts would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP2): Effects to Delta Fishery Habitat Resulting from Changes to Delta Outflow Based on results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP2, CP2 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta.

Results of the comparison of Delta outflows between CP2 and the Existing Condition and No-Action Alternative are summarized by month and water-year type in Table 11-23. The comparison includes the estimated average monthly outflow under the basis-of-comparison conditions, the average monthly flow under CP2, and the percentage change between base flows and CP2 operations. Results of the analysis (Table 11-23) showed that Delta outflows were observed to be slightly lower under many of the CP2 operations as well as slightly higher than basis-of-comparison conditions, depending on month and water-year type. However, none of the changes were larger than 5 percent. Based on the results of this comparison of CP2, it was concluded that CP2 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta relative to the No-Action Alternative and Existing Condition. Based on results of this analysis, it was concluded that CP2 would result in a less than significant effect on fish habitat as a consequence of changes in Delta outflow relative to the Existing Condition. Mitigation for this impact is not needed, and thus not proposed.

Table 11-23. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP2

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	40,954	40,634	-0.8	40,167	39,981	-0.5
	W	84,978	84,587	-0.5	83,595	83,446	-0.2
	AN	47,101	46,386	-1.5	46,322	45,596	-1.6
	BN	19,833	19,855	0.1	19,369	19,409	0.2
	D	11,374	11,023	-3.1	10,881	10,631	-2.3
	C	8,434	8,308	-1.5	8,111	8,219	1.3
February	Average	52,699	52,162	-1.0	52,341	51,984	-0.7
	W	98,900	98,153	-0.8	98,330	97,729	-0.6
	AN	61,653	60,663	-1.6	60,800	60,056	-1.2
	BN	35,173	35,099	-0.2	35,441	35,064	-1.1
	D	20,356	19,700	-3.2	19,894	20,172	1.4
	C	12,605	12,612	0.1	12,628	12,259	-2.9
March	Average	42,610	42,408	-0.5	42,117	41,994	-0.3
	W	79,254	79,245	0.0	78,370	78,416	0.1
	AN	53,361	52,855	-0.9	52,361	52,025	-0.6
	BN	23,126	22,952	-0.8	23,136	23,101	-0.2
	D	18,943	18,511	-2.3	18,596	18,233	-2.0
	C	10,697	10,696	0.0	10,749	10,735	-0.1
April	Average	27,104	27,073	-0.1	27,096	27,037	-0.2
	W	49,818	49,771	-0.1	49,806	49,740	-0.1
	AN	27,420	27,347	-0.3	27,778	27,479	-1.1
	BN	19,001	19,032	0.2	18,938	18,908	-0.2
	D	12,735	12,665	-0.6	12,516	12,543	0.2
	C	8,586	8,611	0.3	8,600	8,633	0.4
May	Average	20,470	20,414	-0.3	20,288	20,183	-0.5
	W	37,736	37,678	-0.2	37,173	37,133	-0.1
	AN	22,276	21,908	-1.7	22,205	21,699	-2.3
	BN	14,200	14,224	0.2	14,080	13,948	-0.9
	D	9,422	9,476	0.6	9,436	9,459	0.2
	C	5,141	5,141	0.0	5,306	5,303	-0.1

Table 11-23. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
June	Average	13,104	13,063	-0.3	13,055	13,071	0.1
	W	23,675	23,683	0.0	23,303	23,344	0.2
	AN	12,563	12,414	-1.2	12,587	12,591	0.0
	BN	8,735	8,585	-1.7	9,027	8,746	-3.1
	D	6,611	6,674	1.0	6,656	6,840	2.8
	C	5,580	5,510	-1.2	5,615	5,684	1.2
July	Average	7,927	7,956	0.4	8,291	8,309	0.2
	W	11,228	11,239	0.1	11,501	11,489	-0.1
	AN	9,085	9,168	0.9	10,040	10,093	0.5
	BN	7,314	7,387	1.0	7,897	7,934	0.5
	D	5,330	5,362	0.6	5,477	5,554	1.4
	C	4,229	4,186	-1.0	4,271	4,206	-1.5
August	Average	4,501	4,548	1.0	4,458	4,475	0.4
	W	5,233	5,223	-0.2	4,961	4,955	-0.1
	AN	4,000	4,000	0.0	4,039	4,037	0.0
	BN	4,000	4,000	0.0	4,144	4,153	0.2
	D	4,491	4,670	4.0	4,547	4,580	0.7
	C	4,017	4,090	1.8	4,017	4,093	1.9
September	Average	5,595	5,566	-0.5	5,262	5,271	0.2
	W	10,498	10,471	-0.3	9,510	9,469	-0.4
	AN	3,781	3,765	-0.4	3,464	3,501	1.1
	BN	3,516	3,436	-2.3	3,405	3,424	0.6
	D	3,050	3,047	-0.1	3,277	3,325	1.5
	C	3,025	3,000	-0.8	3,000	3,016	0.5
October	Average	5,313	5,284	-0.5	5,023	5,016	-0.1
	W	7,040	6,976	-0.9	6,464	6,430	-0.5
	AN	4,540	4,544	0.1	4,335	4,253	-1.9
	BN	4,624	4,589	-0.8	4,427	4,459	0.7
	D	4,388	4,376	-0.3	4,257	4,273	0.4
	C	4,534	4,528	-0.1	4,434	4,480	1.1
November	Average	9,688	9,528	-1.7	9,238	9,168	-0.7
	W	15,113	15,048	-0.4	14,412	14,308	-0.7
	AN	11,060	10,463	-5.4	10,265	10,008	-2.5
	BN	6,529	6,240	-4.4	6,248	6,151	-1.6
	D	6,755	6,703	-0.8	6,474	6,553	1.2
	C	4,648	4,707	1.3	4,631	4,637	0.1

Table 11-23. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
December	Average	22,933	22,670	-1.1	22,289	22,005	-1.3
	W	47,953	47,211	-1.5	46,800	46,141	-1.4
	AN	18,119	17,944	-1.0	17,859	17,467	-2.2
	BN	13,712	13,547	-1.2	12,890	12,565	-2.5
	D	8,645	8,700	0.6	8,366	8,452	1.0
	C	5,728	5,823	1.6	5,460	5,593	2.4

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-18 (CP2): Effects to Delta Fishery Habitat Resulting from Changes to Delta Inflow Changes in upstream reservoir storage have the potential to affect Delta inflow. Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. Based on the results of hydrologic modeling comparing Delta inflow under CP2 to the Existing Condition and No-Action Alternative, CP2 would have a less than significant impact on Delta fisheries and hydrologic transport processed within the Bay-Delta.

Results of the comparison of Delta inflows between the No-Action Alternative, Existing Condition, and CP2 are summarized by month and water-year type in Table 11-24. The comparison includes the estimated average monthly inflow under the basis-of-comparison conditions, the average monthly flow under CP2, and the percentage change between base flows and CP2 operations. Delta inflows were observed to be slightly lower under many of the CP2 operations and slightly higher than basis-of-comparison conditions, depending on month and water-year type. None of the comparisons between the basis-of-comparison conditions and CP2 exceeded 5 percent. Based on the results of this comparison of CP2, it was concluded that CP2 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-24. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP2

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	50,193	49,933	-0.5	49,674	49,461	-0.4
	W	93,590	93,236	-0.4	92,710	92,583	-0.1
	AN	56,641	55,947	-1.2	55,935	55,123	-1.5
	BN	30,176	30,205	0.1	29,939	29,949	0.0
	D	21,201	20,957	-1.1	20,927	20,675	-1.2
	C	16,560	16,574	0.1	16,312	16,308	0.0
February	Average	61,147	60,789	-0.6	60,691	60,472	-0.4
	W	108,058	107,441	-0.6	107,699	107,165	-0.5
	AN	70,137	69,377	-1.1	69,901	69,139	-1.1
	BN	44,310	44,371	0.1	43,831	43,585	-0.6
	D	28,791	28,161	-2.2	28,157	28,233	0.3
	C	18,694	19,218	2.8	18,099	18,695	3.3
March	Average	50,938	50,803	-0.3	50,576	50,415	-0.3
	W	88,045	88,068	0.0	87,612	87,628	0.0
	AN	63,252	62,650	-1.0	62,667	62,144	-0.8
	BN	32,287	32,258	-0.1	31,760	31,795	0.1
	D	26,931	26,713	-0.8	26,504	26,096	-1.5
	C	15,999	15,982	-0.1	16,299	16,264	-0.2
April	Average	33,715	33,671	-0.1	33,832	33,810	-0.1
	W	57,897	57,853	-0.1	58,185	58,145	-0.1
	AN	35,063	34,901	-0.5	35,403	35,134	-0.8
	BN	26,022	26,046	0.1	25,955	25,916	-0.2
	D	17,991	17,917	-0.4	17,853	17,997	0.8
	C	12,534	12,573	0.3	12,653	12,687	0.3
May	Average	27,783	27,728	-0.2	27,762	27,656	-0.4
	W	47,155	47,090	-0.1	46,817	46,778	-0.1
	AN	30,016	29,595	-1.4	30,446	29,847	-2.0
	BN	21,135	21,177	0.2	21,177	21,092	-0.4
	D	15,555	15,623	0.4	15,529	15,576	0.3
	C	9,671	9,708	0.4	9,827	9,814	-0.1
June	Average	23,254	23,311	0.2	23,559	23,622	0.3
	W	35,726	35,776	0.1	35,503	35,570	0.2
	AN	23,868	23,801	-0.3	24,400	24,356	-0.2
	BN	18,814	18,664	-0.8	20,111	19,855	-1.3
	D	15,726	15,957	1.5	15,789	16,224	2.8
	C	12,089	12,269	1.5	12,516	12,494	-0.2

Table 11-24. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
July	Average	18,889	19,194	1.6	20,470	20,666	1.0
	W	23,568	23,703	0.6	24,661	24,781	0.5
	AN	19,796	20,002	1.0	22,429	22,639	0.9
	BN	18,549	18,996	2.4	21,709	21,636	-0.3
	D	16,344	16,808	2.8	17,176	17,913	4.3
	C	12,058	12,424	3.0	12,928	12,775	-1.2
August	Average	18,889	19,194	1.6	16,281	16,369	0.5
	W	23,568	23,703	0.6	17,995	18,005	0.1
	AN	19,796	20,002	1.0	17,543	17,643	0.6
	BN	18,549	18,996	2.4	17,273	17,288	0.1
	D	16,344	16,808	2.8	15,167	15,509	2.3
	C	12,058	12,424	3.0	11,816	11,768	-0.4
September	Average	16,480	16,485	0.0	16,625	16,739	0.7
	W	23,176	23,169	0.0	22,459	22,423	-0.2
	AN	15,742	15,740	0.0	15,814	15,921	0.7
	BN	14,961	14,802	-1.1	15,198	15,304	0.7
	D	12,749	12,849	0.8	14,118	14,445	2.3
	C	10,076	10,164	0.9	10,220	10,353	1.3
October	Average	15,542	15,509	-0.2	14,833	14,873	0.3
	W	18,176	18,141	-0.2	17,270	17,338	0.4
	AN	14,399	14,232	-1.2	13,708	13,584	-0.9
	BN	15,010	15,008	0.0	14,436	14,456	0.1
	D	13,980	14,029	0.4	13,490	13,556	0.5
	C	13,942	13,889	-0.4	13,153	13,283	1.0
November	Average	19,409	19,379	-0.2	19,043	19,038	0.0
	W	26,007	25,956	-0.2	25,720	25,576	-0.6
	AN	20,432	19,929	-2.5	19,604	19,488	-0.6
	BN	16,833	16,666	-1.0	16,510	16,439	-0.4
	D	15,836	16,001	1.0	15,453	15,692	1.6
	C	12,458	12,809	2.8	12,354	12,474	1.0
December	Average	33,195	32,980	-0.7	32,657	32,419	-0.7
	W	58,863	58,111	-1.3	58,092	57,412	-1.2
	AN	28,400	28,483	0.3	28,098	27,869	-0.8
	BN	23,545	23,371	-0.7	22,831	22,491	-1.5
	D	19,116	19,184	0.4	19,010	19,024	0.1
	C	14,756	14,928	1.2	14,041	14,492	3.2

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-19 (CP2): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow CP2 operation would result in a variable response in Sacramento River flow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water-year type. This impact would be less than significant.

Results of hydrologic modeling, by month and water-year type, comparing Sacramento River flow under CP2 relative to the Existing Condition and No-Action Alternative are presented in Table 11-25. Results of these analyses show a variable response in Sacramento River flow with CP2 operations resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water-year types. All comparisons between the basis-of-comparison and CP2 operations were less than 5 percent. Based on these results it was concluded that the impact of CP2 on fish habitat and transport mechanisms within the lower Sacramento River and Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 11-25. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP2

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	34,680	34,513	-0.5	34,363	34,237	-0.4
	W	56,231	56,092	-0.2	55,714	55,732	0.0
	AN	44,117	43,587	-1.2	44,049	43,514	-1.2
	BN	25,272	25,302	0.1	25,024	25,034	0.0
	D	18,166	17,926	-1.3	17,888	17,635	-1.4
	C	14,298	14,312	0.1	14,028	14,027	0.0
February	Average	40,650	40,452	-0.5	40,345	40,274	-0.2
	W	61,746	61,636	-0.2	61,676	61,609	-0.1
	AN	51,527	50,768	-1.5	51,346	50,582	-1.5
	BN	34,676	34,725	0.1	34,309	34,064	-0.7
	D	24,116	23,492	-2.6	23,562	23,639	0.3
	C	15,834	16,358	3.3	15,345	15,941	3.9
March	Average	35,093	34,987	-0.3	35,018	34,901	-0.3
	W	52,808	52,864	0.1	52,720	52,735	0.0
	AN	47,679	47,124	-1.2	47,821	47,495	-0.7
	BN	25,629	25,588	-0.2	25,210	25,244	0.1
	D	22,908	22,758	-0.7	22,615	22,277	-1.5
	C	13,443	13,426	-0.1	13,907	13,872	-0.3
April	Average	24,190	24,157	-0.1	24,317	24,301	-0.1
	W	39,645	39,635	0.0	39,901	39,883	0.0
	AN	26,322	26,161	-0.6	26,721	26,452	-1.0
	BN	18,746	18,769	0.1	18,673	18,633	-0.2
	D	13,900	13,826	-0.5	13,782	13,926	1.0
	C	10,362	10,401	0.4	10,534	10,567	0.3

Table 11-25. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
May	Average	20,098	20,043	-0.3	20,119	20,013	-0.5
	W	32,904	32,839	-0.2	32,639	32,601	-0.1
	AN	22,928	22,507	-1.8	23,355	22,757	-2.6
	BN	14,923	14,965	0.3	14,997	14,912	-0.6
	D	12,055	12,123	0.6	12,060	12,105	0.4
	C	7,622	7,660	0.5	7,821	7,808	-0.2
June	Average	17,718	17,776	0.3	18,092	18,155	0.3
	W	24,331	24,382	0.2	24,141	24,209	0.3
	AN	17,986	17,918	-0.4	18,678	18,634	-0.2
	BN	15,806	15,657	-0.9	17,160	16,904	-1.5
	D	14,015	14,245	1.6	14,146	14,579	3.1
	C	10,907	11,086	1.6	11,406	11,383	-0.2
July	Average	15,270	15,574	2.0	16,870	17,064	1.2
	W	16,088	16,222	0.8	17,160	17,278	0.7
	AN	16,682	16,888	1.2	19,335	19,545	1.1
	BN	16,500	16,946	2.7	19,698	19,625	-0.4
	D	14,988	15,450	3.1	15,871	16,605	4.6
	C	11,077	11,442	3.3	11,974	11,821	-1.3
August	Average	12,649	12,921	2.1	13,790	13,878	0.6
	W	13,724	13,684	-0.3	13,840	13,850	0.1
	AN	12,721	12,965	1.9	15,183	15,284	0.7
	BN	12,319	12,656	2.7	15,145	15,160	0.1
	D	13,162	13,811	4.9	13,769	14,108	2.5
	C	9,865	10,198	3.4	10,738	10,690	-0.4
September	Average	13,697	13,701	0.0	13,863	13,977	0.8
	W	18,936	18,929	0.0	18,242	18,207	-0.2
	AN	13,088	13,087	0.0	13,160	13,267	0.8
	BN	12,543	12,384	-1.3	12,817	12,923	0.8
	D	10,847	10,946	0.9	12,238	12,564	2.7
	C	8,577	8,660	1.0	8,737	8,870	1.5
October	Average	12,719	12,738	0.1	12,068	12,109	0.3
	W	14,766	14,896	0.9	14,040	14,112	0.5
	AN	12,049	11,879	-1.4	11,379	11,255	-1.1
	BN	12,322	12,321	0.0	11,758	11,777	0.2
	D	11,249	11,298	0.4	10,747	10,812	0.6
	C	11,619	11,566	-0.5	10,823	10,952	1.2
November	Average	15,858	15,828	-0.2	15,501	15,501	0.0
	W	21,159	21,110	-0.2	20,878	20,732	-0.7
	AN	17,210	16,710	-2.9	16,355	16,271	-0.5
	BN	13,687	13,523	-1.2	13,377	13,310	-0.5
	D	12,805	12,970	1.3	12,475	12,715	1.9
	C	10,129	10,479	3.5	10,012	10,131	1.2

Table 11-25. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
December	Average	26,148	26,031	-0.4	25,710	25,571	-0.5
	W	44,908	44,475	-1.0	44,459	43,996	-1.0
	AN	22,225	22,290	0.3	21,941	21,901	-0.2
	BN	19,129	18,955	-0.9	18,434	18,094	-1.8
	D	16,164	16,236	0.4	16,042	16,066	0.1
	C	12,587	12,759	1.4	11,848	12,300	3.8

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-20 (CP2): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis Project operation would result in no discernable change in San Joaquin River flows at Vernalis, and therefore no impact to Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta would occur under CP2 relative to the No-Action Alternative or Existing Condition.

Results of the comparative analysis of model results, by month and water-year type, for basis-of-comparison conditions and CP2 for San Joaquin River flow under existing conditions are summarized in Table 11-26. Results of these analyses show that the proposed CP2 would have no effect on seasonal flows compared with Existing Conditions within the San Joaquin River. Similarly, modeling results showed that CP2 would have no effects on flows or fish habitat compared to the No-Action Alternative. Based on these results it was concluded that CP2 would have no impact on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-26. San Joaquin River Flow at Vernalis Under Existing Conditions and CP2

		Existing Condition	CP2 (Existing Condition	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	4,772	4,772	0.0
	W	9,255	9,254	0.0
	AN	4,339	4,339	0.0
	BN	2,971	2,971	0.0
	D	2,084	2,084	0.0
	C	1,624	1,624	0.0
February	Average	6,434	6,433	0.0
	W	11,637	11,637	0.0
	AN	6,271	6,271	0.0
	BN	5,742	5,741	0.0
	D	2,506	2,506	0.0
	C	2,020	2,021	0.0
March	Average	6,339	6,338	0.0
	W	12,420	12,419	0.0
	AN	5,792	5,791	0.0
	BN	4,539	4,538	0.0
	D	2,372	2,372	0.0
	C	1,760	1,760	0.0
April	Average	6,006	6,006	0.0
	W	10,455	10,455	0.0
	AN	5,976	5,976	0.0
	BN	5,241	5,241	0.0
	D	3,050	3,050	0.0
	C	1,722	1,722	0.0
May	Average	6,022	6,022	0.0
	W	10,991	10,991	0.0
	AN	5,420	5,420	0.0
	BN	4,987	4,987	0.0
	D	2,895	2,896	0.0
	C	1,752	1,752	0.0
June	Average	4,631	4,631	0.00
	W	9,577	9,576	0.00
	AN	4,946	4,946	0.00
	BN	2,320	2,321	0.00
	D	1,478	1,480	0.10
	C	1,022	1,022	0.10
July	Average	3,221	3,222	0.00
	W	6,646	6,646	0.00
	AN	2,779	2,779	0.00
	BN	1,755	1,755	0.00
	D	1,260	1,261	0.00
	C	895	896	0.00
August	Average	2,113	2,114	0.00
	W	3,350	3,350	0.00
	AN	2,010	2,010	0.00
	BN	1,827	1,827	0.00
	D	1,347	1,348	0.10
	C	1,021	1,022	0.10

Table 11-26. San Joaquin River Flow at Vernalis Under Existing Conditions and CP2 (contd.)

		Existing Condition	CP2 (Existing Condition	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
September	Average	2,366	2,366	0.00
	W	3,433	3,434	0.00
	AN	2,293	2,293	0.00
	BN	2,077	2,077	0.00
	D	1,764	1,764	0.00
	C	1,368	1,368	0.00
October	Average	2,486	2,486	0.00
	W	2,915	2,915	0.00
	AN	2,099	2,099	0.00
	BN	2,428	2,428	0.00
	D	2,417	2,417	0.00
	C	2,113	2,113	0.00
November	Average	2,561	2,561	0.00
	W	3,311	3,311	0.00
	AN	2,104	2,104	0.00
	BN	2,334	2,334	0.00
	D	2,315	2,315	0.00
	C	2,026	2,026	0.00
December	Average	2,561	2,561	0.00
	W	3,311	3,311	0.00
	AN	2,104	2,104	0.00
	BN	2,334	2,334	0.00
	D	2,315	2,315	0.00
	C	2,026	2,026	0.00

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-21 (CP2): Reduction in Low Salinity Habitat Conditions Resulting from an Upstream Shift in X2 *Location* CP2 operation would result in less than 0.5 km movement upstream or downstream from the X2 location. This impact would be less than significant.

The 1 km X2 criterion was applied to a comparison of CalSim-II results for the Existing Condition and No-Action Alternative and CP2, by month and water-year type, for February through May. Results of the comparison between Existing Condition and CP1 are summarized in Table 11-27. These results showed that changes in X2 location under CP2 were less than 1 km (all were less than 0.4 km) with both variable upstream and downstream movement of the X2 location, depending on month and water-year type. These results are consistent with model results for Delta outflow that showed a less than significant change in flows.

Table 11-27. X2 Under Existing Conditions, No-Action Alternative, and CP2

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	No-Action (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
February	Average	65	65	20.0	66	66	0.0
	W	55	55	10.0	55	55	10.0
	AN	61	61	20.0	61	61	10.0
	BN	68	68	0.0	68	68	0.0
	D	73	74	40.0	73	73	0.0
	C	77	77	10.0	77	77	10.0
March	Average	65	65	10.0	65	65	10.0
	W	56	56	0.0	56	56	0.0
	AN	60	60	10.0	60	60	10.0
	BN	68	68	0.0	68	68	0.0
	D	72	72	30.0	72	72	10.0
	C	77	77	0.0	77	77	0.0
April	Average	68	68	0.0	68	68	0.0
	W	59	59	0.0	59	59	0.0
	AN	64	64	10.0	64	64	10.0
	BN	70	70	0.0	70	70	0.0
	D	74	74	10.0	74	74	0.0
	C	78	78	0.0	78	78	0.0
May	Average	71	71	0.0	71	71	0.0
	W	62	62	0.0	62	62	0.0
	AN	67	67	0.0	67	67	0.0
	BN	72	72	0.0	72	72	0.0
	D	76	76	0.0	76	76	0.0
	C	83	83	0.0	82	82	0.0

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Results of a comparative analysis of changes in X2 location between the Existing Condition and No-Action Alternative and CP2 conditions are summarized in Table 11-27. Results of these comparisons showed very little difference (less than 0.1 km) in the X2 location between the No-Action Alternative and CP2. Based on these results, it was concluded that CP2 would have a less than significant impact on low salinity habitat conditions within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-22 (CP2): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in the Old and Middle Rivers CP2 operation would result in an increase of reverse flows in

Old and Middle rivers. The increase in reverse flows would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses. This impact would be potentially significant.

Results of the analysis showed several occurrences when reverse flows within Old and Middle rivers were greater than basis-of-comparison conditions by more than 5 percent. These events occurred typically in dry and critical water years, which would be expected as a result of greater export operations under CP2. During February (Table 11-28), operations under CP2 resulted in an increase in reverse flow greater than 5 percent during critical years. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase from approximately 4,300 cfs under the basis-of-comparison in a critical water year to approximately 4,700 cfs would not be expected to result in a significant increase in adverse effects to delta smelt. Juvenile Chinook salmon and steelhead are migrating through the Delta during February, and an increase in average monthly reverse flows of 300 to 400 cfs would be expected to increase the potential risk of increased mortality. However given the tidal volumes and hydrodynamics of the Old and Middle river region it is not expected that the change in reverse flows in February in a critical year would result in a detectable change in fish survival. The majority of juvenile Chinook salmon emigrating from the San Joaquin River typically migrate downstream later in dry years and would not be expected to occur in high numbers within Old and Middle rivers in February.

The increase in reverse flows estimated to occur under CP2 in critical water years in June and under critical, dry, and below-normal years in July exceeded 5 percent. The increased reverse flows in June of critical water years occurred at a time of the year when water temperatures in the Delta were elevated and juvenile Chinook salmon or steelhead would not be expected to occur in the area. Juvenile delta smelt may occur in the area in June; however a change in Old and Middle rivers flow of approximately 100 to 200 cfs may result in a small increase in their vulnerability to CVP and SWP salvage, but this increase is expected to be less than significant. As water temperatures increase in the Delta during June and July, the majority of delta smelt are located further downstream in Suisun Bay where temperatures are more suitable. The increase in reverse flows estimated from the modeling in June of a critical year and in July of below-normal, dry, and critical years would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses as a result of increased reverse flows. The increased reverse flows in low-flow years would be expected to result in a low, but potentially significant, increase in mortality for resident warm-water fish inhabiting the south Delta under CP2 relative to the Existing Condition.

Table 11-28. Old and Middle Rivers Reverse Flows for Existing Conditions, No-Action Alternative, and CP2

		Existing Condition	CP2 (Existing Condition)		No-Action Alternative	CP2 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	-6,592	-6,635	-0.7	-6,968	-6,947	0.3
	W	-5,026	-5,052	-0.5	-5,624	-5,641	-0.3
	AN	-7,598	-7,610	-0.2	-7,828	-7,758	0.9
	BN	-7,717	-7,720	0.0	-8,042	-8,019	0.3
	D	-7,540	-7,617	-1.0	-7,880	-7,878	0.0
	C	-6,243	-6,354	-1.8	-6,402	-6,317	1.3
February	Average	-4,930	-5,066	-2.7	-4,996	-5,103	-2.1
	W	-3,582	-3,679	-2.7	-3,857	-3,910	-1.4
	AN	-5,663	-5,836	-3.1	-6,276	-6,263	0.2
	BN	-5,723	-5,827	-1.8	-5,301	-5,403	-1.9
	D	-6,175	-6,189	-0.2	-6,211	-6,055	2.5
	C	-4,326	-4,726	-9.3	-4,004	-4,748	-18.6
March	Average	-3,975	-4,025	-1.2	-4,148	-4,118	0.7
	W	-2,052	-2,074	-1.0	-2,394	-2,371	1.0
	AN	-5,528	-5,454	1.3	-5,933	-5,788	2.4
	BN	-5,264	-5,375	-2.1	-4,948	-5,000	-1.0
	D	-5,245	-5,408	-3.1	-5,313	-5,278	0.7
	C	-3,181	-3,170	0.3	-3,479	-3,463	0.4
April	Average	-1,984	-1,974	0.5	-2,049	-2,075	-1.3
	W	-1,525	-1,527	-0.1	-1,709	-1,729	-1.1
	AN	-2,825	-2,756	2.4	-2,791	-2,815	-0.8
	BN	-2,488	-2,482	0.2	-2,460	-2,452	0.4
	D	-2,098	-2,093	0.2	-2,128	-2,210	-3.9
	C	-1,382	-1,393	-0.8	-1,447	-1,445	0.2
May	Average	-1,649	-1,649	0.0	-1,729	-1,727	0.1
	W	-1,147	-1,141	0.5	-1,265	-1,266	-0.1
	AN	-2,312	-2,271	1.8	-2,627	-2,557	2.7
	BN	-1,693	-1,705	-0.7	-1,755	-1,790	-2.0
	D	-2,088	-2,098	-0.5	-2,026	-2,039	-0.7
	C	-1,364	-1,393	-2.1	-1,361	-1,351	0.8
June	Average	-2,858	-2,933	-2.6	-3,210	-3,246	-1.1
	W	-2,219	-2,251	-1.4	-2,387	-2,408	-0.8
	AN	-3,532	-3,594	-1.8	-4,011	-3,974	0.9
	BN	-3,752	-3,751	0.0	-4,578	-4,597	-0.4
	D	-3,341	-3,470	-3.8	-3,476	-3,667	-5.5
	C	-1,801	-1,990	-10.5	-2,194	-2,124	3.2
July	Average	-3,942	-4,153	-5.3	-4,813	-4,949	-2.8
	W	-3,493	-3,588	-2.7	-4,027	-4,127	-2.5
	AN	-3,967	-4,060	-2.4	-5,167	-5,287	-2.3
	BN	-4,733	-5,018	-6.0	-6,665	-6,580	1.3
	D	-4,859	-5,191	-6.8	-5,378	-5,884	-9.4
	C	-2,592	-2,903	-12.0	-3,154	-3,087	2.1

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Results of the comparison of Old and Middle river reverse flows are summarized in Table 11-28. Results of the analysis show that in the majority of years and months reverse flows under CP2 do not exceed basis-of-comparison conditions by more than 5 percent. CP2 exceeded basis-of-comparison conditions during February of a critical year by approximately 700 cfs. The increase in reverse flows would be expected, particularly in a critical year, to contribute to an increase in the potential for losses of adult delta smelt and other species, which is considered to be potentially significant. During June in a critical water year under CP2, the magnitude of reverse flows was reduced more than 5 percent but would be expected to contribute to a less than significant biological benefit based on both the low reverse flow under the basis-of-comparison and under CP2. An increase in reverse flow above the basis-of-comparison of approximately 300 to 600 cfs during dry years in July would be expected to contribute to an increase in the risk of losses to resident warm-water fish species. Increased reverse flows in July would not be expected to adversely affect delta or longfin smelt, juvenile Chinook salmon, or steelhead based on their seasonal migration patterns and geographic distribution. The potential increase in losses relative to the No-Action Alternative during February and July under future operating conditions is considered to be potentially significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

Impact Aqua-23 (CP2): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP2 operations may result in an increase in CVP and SWP exports, which is assumed to result in a direct proportional increase in the risk of fish being entrained and salvaged at the facilities. This is considered a less than significant impact to Chinook salmon, steelhead, and longfin smelt. This is considered a potentially significant impact to delta smelt, striped bass, and splittail. Future operations of the SWP and CVP export facilities would continue to be managed and regulated in accordance with incidental take limits established for each of the protected fish by USFWS, NMFS, and DFG.

Results of the entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-29 for CP2. The initial modeling was conducted using average fish densities developed from past fish salvage monitoring at the SWP and CVP export facilities. Average monthly water exports were used in the analysis based on hydrologic simulation modeling. The indices of the potential risk of entrainment for some species, such as Chinook salmon, were not estimated separately for each species (e.g., winter-run Chinook) in these initial analyses. If the proposed project is developed in the future a more detailed species-specific analysis of potential changes in fish salvage losses, in addition to an assessment of the population-level effects on each species, would be required for use as a basis for developing a biological assessment and Section 7 BOs and incidental take permits for project operations. These indices were calculated for wet, above-normal, below-normal, dry, and critical water-year types, and for an average across all years (no water-year type specified). The total numbers of fish lost annually, by species, are presented in Attachment 13. The difference between fish losses under CP2 relative to the No-Action Alternative and the Existing Condition is represented as the entrainment index, shown in the tables, to represent the effect of project operations on each fish species at the CVP and SWP facilities.

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent from Existing Condition in wet, above-normal, and below-normal water years and an increase in risk ranging from approximately 1 to 4 percent during dry and critical water years (Table 11-29). The greatest increase in risk (3.9 percent) was estimated for CP2 in a critical year.

The risk of increased losses of delta smelt relative to the No-Action Alternative was greatest in the dry years with a net reduction in losses under CP2 in critical water years (Table 11-29). Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations are small, the delta smelt population abundance is currently at such critically low levels that even a small increase in the risk of losses is considered to be potentially significant. The increase in risk is also expected to contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for salmon follows a similar pattern to that described for delta smelt (Table 11-29). Overall, the CP2 results in a small increase in the risk of losses compared with both the No-Action Alternative and Existing Condition. The change in risk was less than 5 percent in wet, above-normal, and below-normal water years under CP2 compared with the Existing Condition, and is considered to be less than significant. The risk index increased from 1.1 percent to 3.7 percent in dry and critical years with the greatest increase observed for CP2 (3.7 percent). The loss index for salmon compared with No-Action Alternative also showed increased risk in wet, below-normal, dry, and critical years. Given the numbers of juvenile Chinook salmon produced each year in the Central Valley the relatively small incremental increase in the risk of entrainment/salvage at the CVP and SWP export facilities is considered to be a less than significant impact but would contribute incrementally to the overall cumulative factors affecting juvenile Chinook salmon survival within the Delta and population dynamics of the stocks.

The estimated change in the risk of longfin smelt entrainment/salvage under CP2 compared with the No-Action Alternative and Existing Condition shows small positive and negative changes depending on water-year type (Table 11-27). These small changes in the risk of entrainment are considered to be less than significant.

Table 11-29. Entrainment at the CVP and SWP Facilities under Existing Conditions, No-Action Alternative, and CP2

Species	Water Year	CP2 Minus Existing Condition	Percent Change	CP2 Minus No-Action Alternative	Percent Change
Delta Smelt	Average	370	0.5	134	0.2
	W	80	0.1	110	0.1
	AN	-283	-0.3	-1,082	-1.2
	BN	283	0.4	539	0.8
	D	713	1.3	897	1.6
	C	1,236	3.9	-218	-0.7
Salmon	Average	607	0.6	320	0.3
	W	269	0.2	229	0.2
	AN	-283	-0.2	-1,136	-0.9
	BN	524	0.5	645	0.6
	D	940	1.1	880	1.1
	C	1,824	3.7	753	1.5
Longfin Smelt	Average	1	0.0	7	0.0
	W	-19	-0.1	13	0.1
	AN	-183	-1.0	-241	-1.3
	BN	44	0.3	121	0.8
	D	44	0.4	105	0.9
	C	117	1.8	-40	-0.6
Steelhead	Average	55	1.2	33	0.7
	W	37	0.7	22	0.4
	AN	52	1.0	-23	-0.4
	BN	38	0.8	32	0.7
	D	25	0.6	-42	-1.0
	C	159	5.1	227	7.5
Striped Bass	Average	26,280	2.0	14,635	1.0
	W	9,779	0.6	8,882	0.5
	AN	16,390	1.2	2,825	0.2
	BN	22,063	1.7	-800	-0.1
	D	44,113	3.9	57,936	4.9
	C	50,092	7.6	8,033	-1.1
Splittail	Average	5,491	2.0	3,025	1.0
	W	2,286	0.6	1,955	0.5
	AN	3,183	1.0	-778	-0.2
	BN	3,439	1.3	198	0.1
	D	9,220	4.0	13,642	5.7
	C	11,545	9.9	-3,480	-2.5

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
W = wet

The estimated change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-29. The small positive and negative changes in risk under wet, above-normal, below-normal, and dry water years are considered to be less than significant. The increase in risk of steelhead losses in critical water years is considered to be less than significant based on the abundance of juvenile steelhead migrating through the Delta, but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The predicted increase in potential entrainment risk for steelhead under critically dry water years represents an initial estimate of the change (percentage) between the proposed project operations and the existing conditions and no-project alternatives and does not allow the predicted losses to be evaluated at the population-level. As noted above, more detailed modeling and analysis of potential steelhead losses would be required as part of preparing a project-specific analysis of entrainment losses for use in the Section 7 biological assessment and BOs for future project operations and incidental take of steelhead. As part of this more detailed analysis additional actions may be identified to further reduce and avoid potential adverse effects to steelhead.

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities is summarized in Table 11-29. The change in risk in wet, above-normal, and below-normal water years is considered to be less than significant based on the abundance of striped bass, but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The losses of juvenile striped bass increased substantially under dry and critical year conditions, which would be expected with an increase in exports during the summer months. Compared with the Existing Condition, the risk of increased losses ranged from 3.8 percent to 7.6 percent (approximately 30,000 to 60,000 fish), which is considered to be potentially significant. The increased losses, particularly in drier water years when juvenile striped bass production is lower, would be expected to contribute to the cumulative effects of factors affecting juvenile striped bass survival in the Delta.

Results of the risk estimates for juvenile splittail losses show a pattern similar to other species (Table 11-29). The increased risk index was 1.3 percent or less in wet, above-normal, and below-normal water years, and was considered to be a less than significant effect. The loss index increased during dry and critically dry water years. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect of abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower within the Delta in dry years. The increased risk of losses in drier years was considered to be potentially significant. The increased losses would also contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP1) is considered to be less than significant for Chinook salmon, steelhead, and longfin smelt, but potentially significant for delta smelt, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

CVP/SWP Service Areas

Impact Aqua-24 (CP2): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes Project implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats that provide habitat for the fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The impact could be greater because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP2 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and the resulting flows downstream from those reservoirs would be small and well within range of variability that commonly occurs in these reservoirs and downstream. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP3 – 18.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply

CP3 would be similar to CP1 and CP2. It focuses on the greatest practical enlargement of Shasta Dam and Reservoir consistent with the goals of the 2000 CALFED ROD, and was formulated for the primary purposes of increased water supply reliability and increased survival of anadromous fish. CP3 consists of raising Shasta Dam by 18.5 feet, an elevation change that would increase the full pool by 20.5 feet and enlarge the total storage space in the reservoir by 634,000 acre-feet to 5.19 million acre-feet. CP3 would help reduce future shortages by increasing the reliability of the water supply in drought and average years. The increased pool depth and volume would also contribute to improving seasonal water temperatures on the upper Sacramento River for anadromous fish.

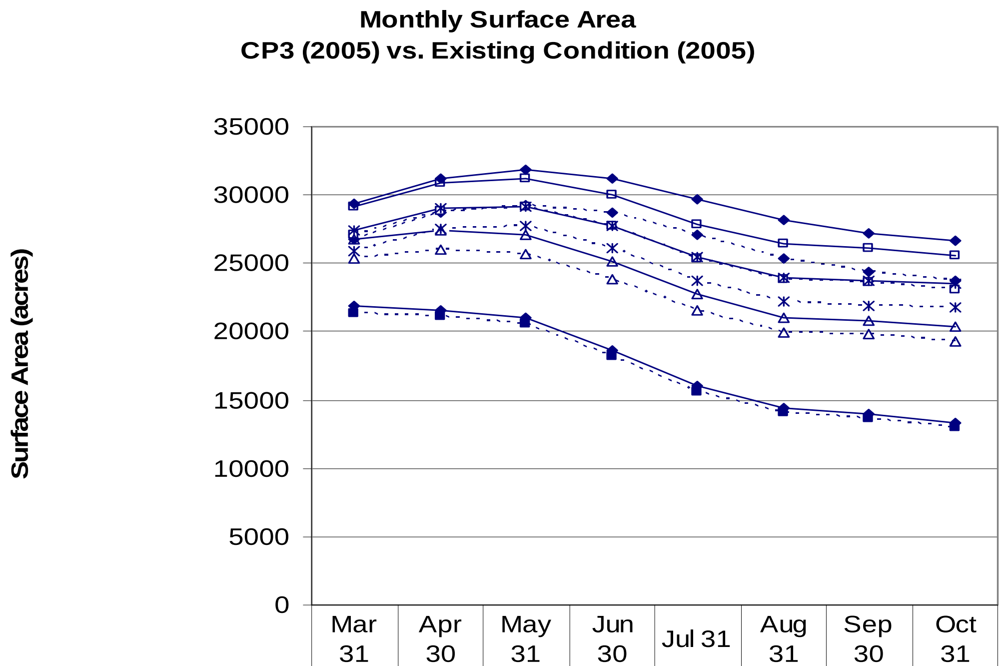
Shasta Lake and Vicinity

Impact Aqua-1 (CP3): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP3, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. CP3 operations would also result in reduced monthly fluctuations in WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. Similar to CP-1 the value of existing structural habitat improvements would be diminished to varying degrees, large areas of the shoreline would not be cleared, and the vegetation along these sections will be inundated periodically. In the short term, this vegetation will provide warm-water lacustrine habitat, with decay expected to occur over several decades. This impact would be less than significant.

This impact would be similar to Impacts Aqua-1 (CP1 and CP2), but the surface area would be larger under the 18.5-foot dam raise than under the 6.5-foot and 12.5-foot dam raises. CalSim-II modeling shows that the surface area of Shasta Lake would be larger under CP3 for both a 2005 and a 2030 water supply demand than under the Existing Condition or the No-Action Alternative in all five water-year types (Figures 11-18 and 11-19).

Monthly WSEL fluctuations were compared with projections for water supply demand. For CP3, with a 2005 water supply demand, 20 percent of monthly changes in projected WSELs (i.e., 5 of the 25 total projections made for the 5 months from March through July for all five water-year types) showed increased monthly WSEL fluctuations relative to the Existing Condition and 80 percent showed reduced monthly WSEL fluctuations (Figure 11-20). For CP3, with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSELs showed increased WSEL fluctuations relative to the No-Action Alternative and 64 percent showed reduced monthly WSEL fluctuations (Figure 11-21). Under CP3, none of the changes in monthly WSEL fluctuation are different enough from the Existing Condition to warrant the investigation of daily WSEL fluctuation.

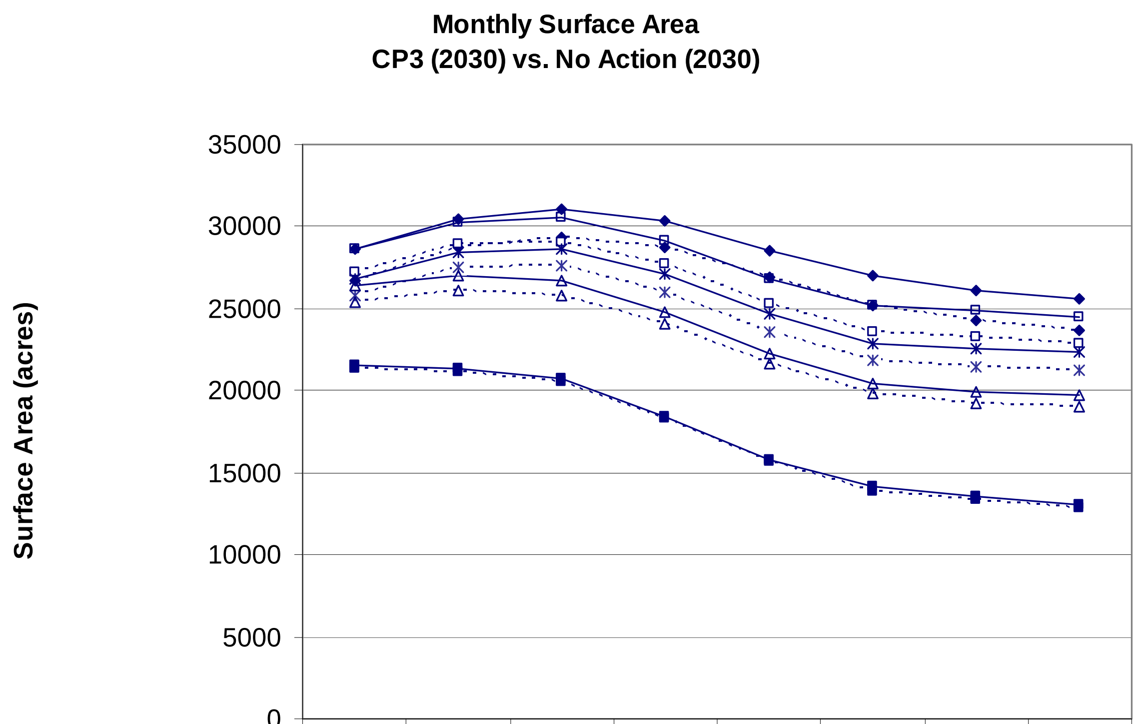
Increases in the overall surface area and WSEL under CP3 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations could contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water fish species. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26726	28711	29305	28720	27042	25351	24380	23709
EC AN	27096	28851	29102	27792	25377	23881	23648	23105
EC BN	25942	27562	27715	26098	23740	22177	21932	21732
EC D	25311	26013	25724	23891	21531	19954	19778	19310
EC C	21336	21121	20583	18251	15644	14079	13655	12992
CP3 2005 W	29363	31182	31826	31219	29643	28173	27205	26604
CP3 2005 AN	29193	30843	31177	29991	27806	26424	26111	25570
CP3 2005 BN	27456	29021	29174	27690	25493	23921	23725	23502
CP3 2005 D	26772	27435	27070	25160	22738	20993	20810	20385
CP3 2005 C	21851	21608	21058	18654	16013	14387	13944	13312

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
EC = Existing Condition
D = dry water years
W = wet water years

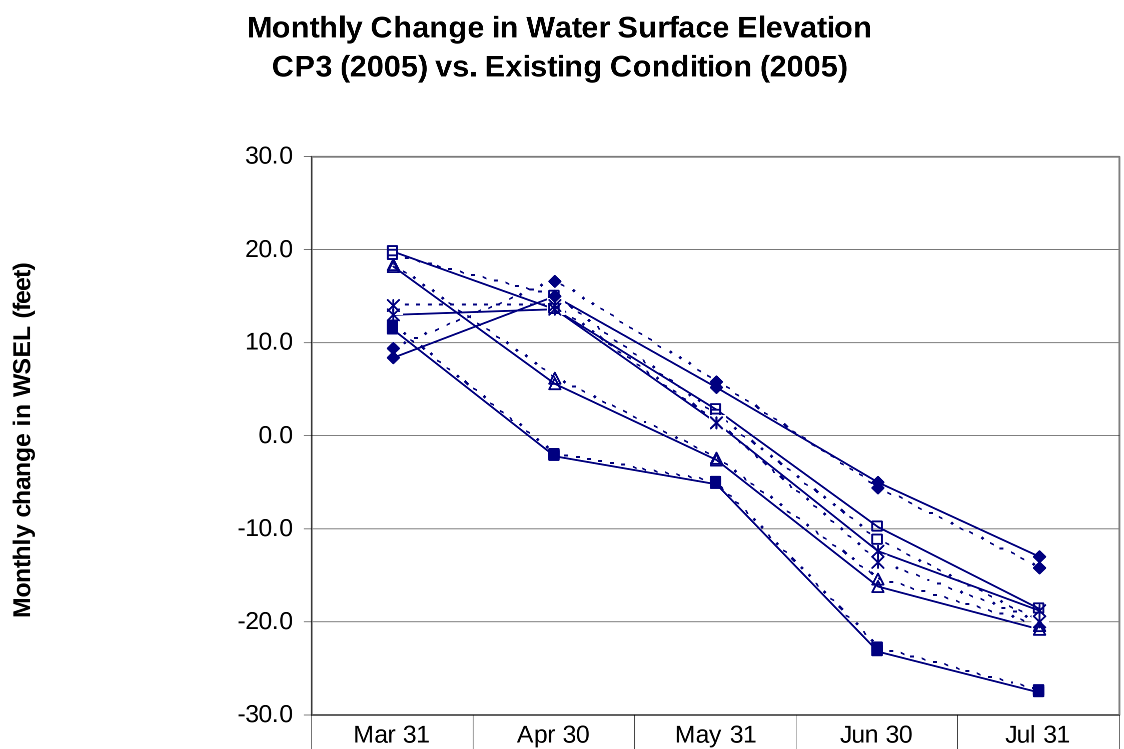
Figure 11-18. Monthly Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 vs. Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26750	28695	29293	28690	26880	25222	24303	23671
NA AN	27167	28885	29069	27750	25285	23603	23283	22865
NA BN	25820	27477	27594	25947	23571	21815	21422	21291
NA D	25395	26108	25802	24026	21660	19855	19238	19017
NA C	21312	21115	20554	18343	15646	13859	13349	12834
CP3 2030 W	28629	30435	31091	30389	28531	27024	26143	25571
CP3 2030 AN	28582	30210	30520	29152	26803	25176	24889	24474
CP3 2030 BN	26848	28467	28614	27063	24666	22887	22549	22392
CP3 2030 D	26372	27035	26682	24780	22291	20477	19905	19682
CP3 2030 C	21510	21295	20713	18372	15783	14127	13522	13031

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

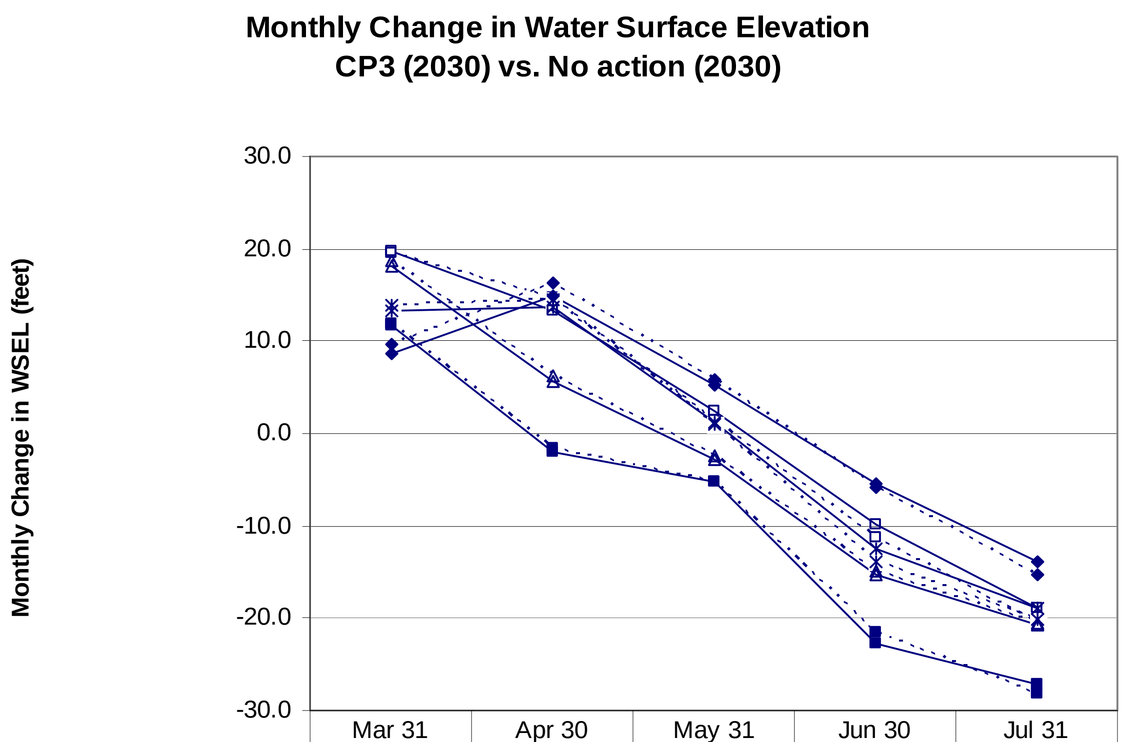
Figure 11-19. Monthly Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 vs. No-Action Alternative



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9.5	16.7	5.7	-5.6	-14.3
EC AN	19.5	14.9	2.1	-11.2	-20.1
EC BN	13.9	14.0	1.4	-13.6	-19.9
EC D	18.4	6.1	-2.3	-15.5	-20.5
EC C	11.8	-1.9	-5.0	-22.7	-27.5
CP3 (2005) W	8.4	15.1	5.3	-5.1	-13.1
CP3 (2005) AN	19.9	13.6	2.7	-9.7	-18.5
CP3 (2005) BN	12.9	13.5	1.4	-12.4	-18.7
CP3 (2005) D	18.3	5.5	-2.7	-16.2	-20.8
CP3 (2005) C	11.4	-2.1	-5.1	-23.2	-27.6

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-20. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 vs. Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	9.7	16.3	5.7	-5.8	-15.3
NA AN	19.4	14.7	1.5	-11.3	-20.5
NA BN	13.9	14.4	1.1	-13.8	-20.1
NA D	18.8	6.2	-2.4	-15.0	-20.5
NA C	11.9	-1.7	-5.3	-21.5	-28.3
CP3 (2030) W	8.6	14.9	5.2	-5.4	-13.9
CP3 (2030) AN	19.8	13.3	2.5	-9.8	-18.9
CP3 (2030) BN	13.2	13.8	1.3	-12.4	-19.0
CP3 (2030) D	18.2	5.6	-2.8	-15.3	-20.7
CP3 (2030) C	11.6	-1.9	-5.3	-22.7	-27.2

Key:
AN = above-normal water
BN = below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-21. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 vs. No-Action Alternative

Impact Aqua-2 (CP3): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Localized increases in soil erosion and resulting runoff sedimentation, and turbidity resulting from project construction in the vicinity of Shasta Dam and at utility, road, and other facility relocation areas could affect nearshore warm-water habitat. However, the environmental commitments for all action alternatives would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

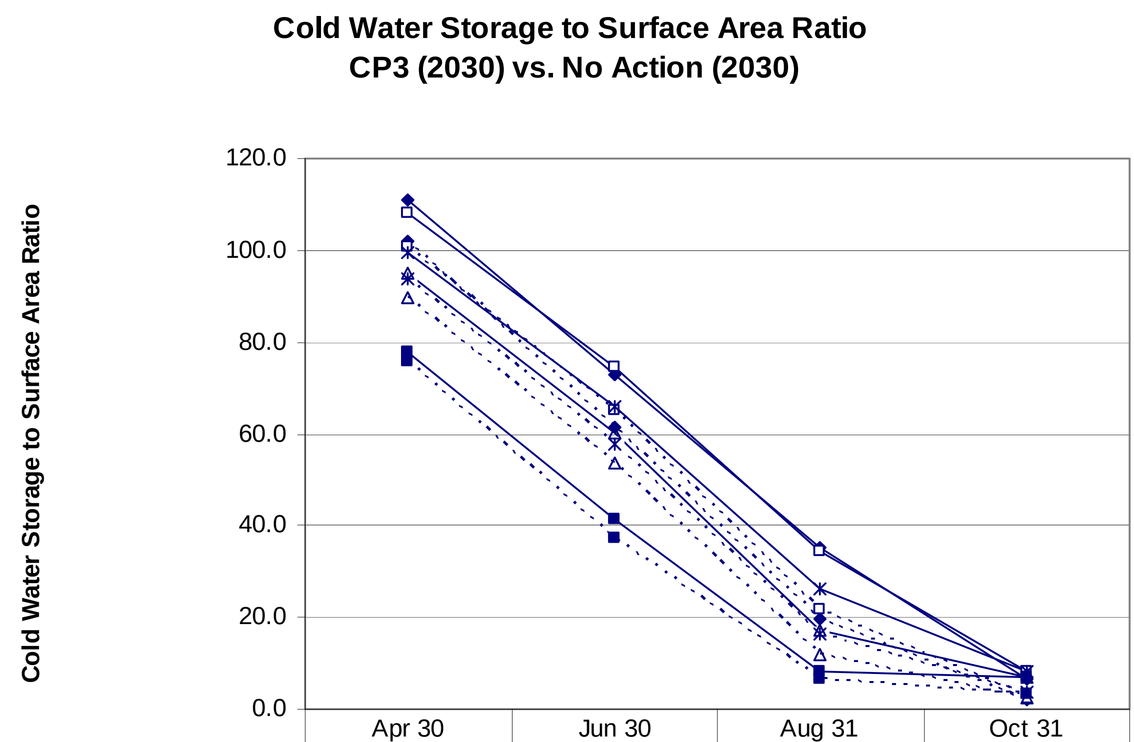
Impact Aqua-3 (CP3): Effects on Cold-Water Habitat in Shasta Lake Operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

This impact would be similar to Impacts Aqua-3 (CP1 and CP2). However, it would be of greater magnitude owing to a greater increase in the ratio of the volume of cold-water storage in the lake to the surface area of the lake. CalSim-II modeling shows that under CP3 with a 2030 water supply demand, the ratio of cold-water storage to surface area is higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occurred between June 30 and August 31, which is the critical holding and rearing period for cold-water fishes in reservoirs, and are greatest in wet, above-normal, and below-normal water years (Figure 11-22).

CP3 would increase the availability of suitable habitat for cold-water fish in Shasta Lake. Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-4 (CP3): Effects on Special-Status Aquatic Mollusks Under CP3, habitat for special-status mollusks could be inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. This impact would be potentially significant.

This impact would be similar to Impacts Aqua-4 (CP1 and CP2). However, a larger area would be inundated under CP3, which could result in an increase in impacts to these species and their habitat. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could adversely affect special-status mollusks that may occupy habitat in or near Shasta Lake and its tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	102.1	61.5	19.8	2.2
NA AN	100.9	65.2	21.8	3.1
NA BN	93.9	57.9	16.3	3.8
NA D	89.6	53.5	12.0	2.5
NA C	75.8	37.4	6.5	3.2
CP3 2030 W	110.9	73.0	35.2	6.7
CP3 2030 AN	108.1	74.4	34.6	8.2
CP3 2030 BN	99.5	66.1	26.3	8.1
CP3 2030 D	94.9	60.0	17.4	7.1
CP3 2030 C	78.0	41.6	8.2	6.8

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-22. Monthly Cold-water Storage to Surface Area Ratio for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 vs. Existing Condition

Impact Aqua-5 (CP3): Effects on Special-Status Fish Species The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP3 could affect one species designated as sensitive by USFS, the hardhead. This impact would be less than significant.

This impact would be similar to Impact Aqua-5 (CP1 and CP2), but its magnitude would be greater owing to an increase in surface area and WSEL and expansion of the area subject to inundation. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP3): Creation or Removal of Barriers to Fish between Tributaries and Shasta Lake Under CP3, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,090-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. However, based on digital topographic data and stream channel data generated from field inventories, there do not appear to be any substantial barriers between the 1,070-foot and 1,090-foot contours that would be inundated under this alternative. This impact would be less than significant.

This impact would be similar to Impacts Aqua-6 (CP1 and CP2). However, the maximum inundation level would be higher under this alternative. Most of the tributaries are too steep (i.e., greater than 7 percent) up to the 1,090-foot contour to be passable by fish; the tributaries that are low-gradient up to the 1,090-foot contour, and thus, allow fish passage remain low-gradient well upstream from this contour. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP3): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP3 would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in the Sacramento River, McCloud River, Pit River, Big Backbone Creek, and Squaw Creek upstream from Shasta Lake. Eleven miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids would be affected by CP2, which is only about 2.8 percent of the low-gradient habitat upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant.

As described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils,”CP3 would inundate perennial reaches with gradients of less than 7 percent that could provide spawning and rearing habitat for adfluvial salmonids.

The lengths of low-gradient tributaries to each arm that would be periodically inundated are as follows:

- Sacramento River Arm 4.0 miles
- McCloud River Arm 2.7 miles
- Pit River Arm 1.9 miles
- Big Backbone Creek Arm 1.1 miles
- Squaw Creek Arm 1.3 miles

This impact would be similar to Aqua-7 (CP1 and CP2). However, it would periodically inundate a larger amount of habitat in low-gradient reaches to Shasta Lake, but the total amount inundated would be only 2.8 percent of the low-gradient habitat upstream from the lake. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-8 (CP3): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP3 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. Only 24.0 miles of non-fish-bearing tributary habitat would be affected by CP3, which is only about 1 percent of the total length of non-fish-bearing tributaries upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant.

As described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils” CP3 would inundate tributary segments with channel slopes in excess of 7 percent. Although these segments do not typically support salmonid populations, they do provide riparian and aquatic habitat for a variety of organisms and serve as corridors that connect habitat types. The lengths of non-fish-bearing tributaries for each arm of Shasta Lake that would be periodically inundated are as follows:

- Sacramento River Arm 5.5 miles
- McCloud River Arm 4.1 miles
- Pit River Arm 3.5 miles
- Big Backbone Creek Arm 2.7 miles
- Squaw Creek Arm 1.9 miles
- Main Body 6.3 miles

This impact would be similar to Aqua-8 (CP1 and CP2). However, it would periodically inundate a larger amount of habitat in high-gradient reaches to Shasta Lake, but the total amount inundated would be only 1 percent of the non-fish-bearing tributaries upstream from the lake. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP3): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP3. There would be no impact.

This impact is the same as Impact Aqua-9 (CP1), and there would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to RBDD)

Impact Aqua-10 (CP3): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River during Construction Activities Construction-related increases in sediments and turbidity would adversely affect aquatic habitats and fish populations within the upper Sacramento River immediately downstream from project construction activities. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise. However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed

Impact Aqua-11 (CP3): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants, resulting in adverse effects on aquatic habitats, the aquatic food web, and fish populations, including special-status species, within the primary study area downstream from project construction activities. This impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed

Impact Aqua-12 (CP3): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon Project operation would result in improved overall flow and water temperature conditions in the upper Sacramento River for fish species of management concern. This impact would be beneficial.

Winter-Run Chinook Salmon

<u>Production</u>

Based on the 1999 through 2006 population average, overall average winter-run production for the 82-year period was similar for CP3 relative to the No-Action

Alternative and the Existing Condition (Attachments 1A and 2A). The maximum increase in production relative to the No-Action Alternative was 74 percent for CP3, and the largest decrease in production relative to the No-Action Alternative was 5 percent (Attachment 1A). The maximum increase in production relative to the Existing Condition was 27 percent for CP3 in 1977, and the largest decrease in production relative to the Existing Condition was 8 percent in 1931 (Attachment 2A).

With one exception (1977, a 3 percent decrease), years with the lowest production over the simulation period had the largest increase in production under CP3 conditions.

Under CP3, critical water years 1924, 1931, 1933, and 1934, and dry water year 1944 had increases in production compared to the No-Action Alternative, ranging from 8 to 74 percent.

Under CP3, critical water years (1924, 1934, 1977, 1992) had increases in production compared to the Existing Condition, ranging from 5 to 27 percent. One critical (1931), and one above-normal (1978) water year had decreases in production of 5 and 8 percent.

When the spawning population equaled the AFRP goal, overall average winter-run Chinook salmon production was similar for CP3 relative to the No-Action Alternative (Attachment 3A). The maximum increase in production relative to the No-Action Alternative was 42 percent for CP3. The largest decrease in production relative to the No-Action Alternative was 8 percent for CP3. Years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP3.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to winter-run Chinook salmon under CP3 occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-4 displays the overall mortalities for each Comprehensive Plan that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 1B and 2B). Mortalities caused by the project decrease as the proposed dam height increases from 6.5 to 18.5 feet.

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, fry were the primary life stage affected, but operations-related activities had a greater effect on egg incubation than on presmolts and no effect on immature smolts. The same trends for each Comprehensive Plan were observed, with the bulk of the mortality affecting the fry and egg incubation life stages, and both water temperature and flow causing the mortality (Table 11-5).

In critical water years, mortality to eggs due to unsuitable water temperatures was the primary cause of operations-related mortalities for CP3, followed by mortality to fry (more by flow and density than water temperature), then to eggs from redd superimposition, followed by presmolts (affected first by water temperature then flow) and then immature smolts (affected by flow). Attachments 1C and 2C contains tables of mortality to winter-run Chinook salmon sorted by water-year type, and Table 11-6 outlines the ranks classified under each Comprehensive Plan for each water-year type.

In dry water years, mortality to fry when moving to new habitats was the primary cause of operations-related mortalities for CP3, as for the No-Action Alternative, followed by mortality to eggs due to redd superimposition. Third was the mortality to eggs due to unsuitable water temperatures, and then followed by mortality to presmolts while moving to new habitats.

Below-normal, above-normal, and wet water years also had the greatest number of winter-run Chinook salmon perish as fry caused by forced movement to habitat downstream, followed by mortality to eggs due to redd superimposition, then the loss of eggs from unsuitable water temperatures, and forced movement of presmolts to downstream habitats.

Years with the highest mortality were the same for the No-Action Alternative and CP1 through CP3: 1924, 1931, 1933, 1934, 1977, and 1992. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991), dry (1930 and 1932), or below-normal (1923) water-year type. Years in which CP3 had the greatest impact on winter-run were also the years in which the lowest production occurred (Attachments 1C and 2C).

When the spawning population equaled the AFRP goal, winter-run Chinook salmon mortality caused by the operations-related activities decreased under CP3 compared to No-Action Alternative conditions (Attachment 3B). Under CP3, mortality caused by operations-related activities would decrease from non-operations related mortality by 11 percent. Under CP3, the greatest mortality to winter-run Chinook salmon occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because winter-run Chinook salmon have, overall, a reduced mortality, winter-run Chinook salmon would benefit from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

<u>Production</u>

Based on the 1999 through 2006 population average, overall average spring-run Chinook salmon production for the 82-year period remained relatively close to the No-Action Alternative and Existing Condition. The maximum increase in production relative to the No-Action Alternative was 162 percent for CP3. The largest decrease in production relative to the No-Action Alternative was 8 percent for CP3 (Attachment 4A). The maximum increase in production relative to the Existing Condition was 121 percent for CP3. The largest decrease in production relative to the Existing Condition was 79 percent for CP3 (Attachment 5A).

Under CP3, critical water years 1924, 1931, 1933, 1977, 1988, 1992, and 1994 had increases in production compared to the No-Action Alternative, ranging from 6 to 162 percent. Dry water years 1925, 1926, and 1932, and below-normal water year 1959 resulted in increases in production over the No-Action Alternative ranging from 5 to 118 percent. Wet water year 1969 resulted in a production decrease of around 8 percent.

Under CP3, five critical water years (1924, 1933, 1934, 1992, and 2001) had increases in production compared to the Existing Condition, ranging from 6 to 121 percent. Two dry water years (1932 and 2002) resulted in increases over the Existing Condition ranging from 6 to 70 percent. Two below-normal water years (1935 and 1959), and one above-normal water year (2000), had increases in production ranging from 5 to 8 percent. Three critical water years (1931, 1977 and 1988), and one wet water year (1969) had decreases in production relative to the Existing Condition ranging from 8 to 79 percent.

When the spawning population equaled the AFRP goal, overall average spring-run Chinook salmon production was similar for CP3 relative to the No-Action Alternative (Attachment 6A). The maximum increase in production relative to the No-Action Alternative was 123 percent for CP3. The largest decrease in production relative to the No-Action Alternative was 8 percent for CP3. Years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP3.

<u>Mortality</u>
Based on the 1999 through 2006 population average, the greatest mortality to spring-run Chinook salmon under CP3 occurred to the eggs, followed by presmolts, then fry. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by nonoperational factors versus those caused by the operations (i.e., water temperature and flow) (Attachments 4B and 5B). Mortalities caused by the project decrease as the proposed dam height increases from 6.5 to 18.5 feet (Tables 11-7 and 11-8). When removing nonoperations-related mortality, leaving mortality due to operations-related activities, only eggs and fry were affected (Table 11-8).

Critical water years under CP3 had mortality to eggs due to unsuitable water temperatures as the primary cause of operations-related mortalities, followed by mortality to prespawned eggs and during incubation caused by dewatering the redds, and then to fry from forced movement to downstream habitats. Attachments 4C and 5C contain tables of mortality to spring-run sorted by water-year type, and Table 11-9 outlines the rankings classified under each Comprehensive Plan for each water-year type.

In dry, below-normal, and above-normal water years, CP3 was dominated by egg temperature mortality, followed by mortality resulting from redd dewatering. Mortality to prespawned eggs occurred in only two dry years but not in any below-normal water years. Mortality to fry from forced movement was relatively low in only several more years (Table 11-9).

In wet water years, spring-run eggs under conditions created by CP3 were more affected by redd dewatering than by unsuitable water temperatures (Table 11-9).

Years with the highest operations-related mortality were the same for all the Comprehensive Plans: 1924, 1931, 1932, 1933, 1934, 1977, and 1992. Except 1932 (a dry water year), each of these years was a critical water-year type and was preceded by either a below-normal, dry, or (predominantly) a critical water year. However, years with the lowest mortality varied between all water-year types. Years in which the project had the greatest impact on spring-run Chinook salmon were also years in which the lowest production occurred, with nearly all of the mortality occurring in the egg incubation life stage (Attachments 4C and 5C).

When the spawning population equaled the AFRP goal, spring-run Chinook salmon mortality caused by operations-related activities decreased under CP3 compared to No-Action Alternative conditions (Attachment 6B). Under CP3, mortality caused by operations-related activities would decrease from non-operations related mortality by over 35 percent. Under CP3, the greatest mortality to spring-run Chinook salmon occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because spring-run Chinook salmon have, overall, a reduced mortality, spring-run Chinook salmon would benefit from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

<u>Production</u>

Based on the 1999 through 2006 population average, overall average fall-run Chinook salmon production for the 82-year period was similar between CP3 and the No-Action Alternative and the Existing Condition (Attachments 7A and 8A). The maximum increase in production relative to the No-Action Alternative was 148 percent for CP3 while the largest decrease in production relative to the No-Action Alternative was 9 percent (Attachment 7A). The maximum increase in production relative to the Existing Condition was 59 percent for CP3. The largest decrease in production relative to the Existing Condition was 69 percent for CP3 (Attachment 8A).

In critical, dry, and below-normal water years, when production was lowest over the simulation period, the increase in production resulting from operations-related activities was greatest. In above-normal and wet water years, however, the lowest production years typically had a slight decrease in production under CP1 conditions relative to the No-Action Alternative.

Under CP3, critical water years 1931, 1933, 1934, and 1977 had increases in production relative to the No-Action Alternative, ranging from 8 to 148 percent. Dry water years 1926, 1932, 1939, 1955, and 1964, and below-normal water years 1937 and 1945 had an 8 to 76 percent increase in production compared to the No-Action Alternative. Above-normal water years 1957 and 1945, and 1999, a wet water year had decreases in overall production relative to the No-Action Alternative, from 6 to 17 percent.

Under CP3, critical water years 1924 and 1934 had increases in production relative to the Existing Condition, ranging from 14 to 37 percent. Five dry water years (1926, 1939, 1955, 1964, and 1985) increased production by 7 to 57 percent compared to the Existing Condition. Three below-normal water years, 1937, 1945, and 1950, had increases in production relative to the Existing Condition, from 5 to 60 percent. Critical water years 1931 and 1977 had decreased production relative to the Existing Condition from 27 to 69 percent. One below-normal (1979) and one above-normal (1957) and four wet (1941, 1942, 1969, and 1999) water years resulted in a substantial decrease in production relative to the Existing Condition ranging from 5 to 17 percent.

When the spawning population equaled the AFRP goal, overall average fall-run Chinook salmon production was similar for CP3 relative to the No-Action Alternative (Attachment 9A). The maximum increase in production relative to the No-Action Alternative was 150 percent for CP3. The largest decrease in production relative to the No-Action Alternative was 9 percent for CP3. In critical, dry, and below-normal water years, years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP3. In above-normal and wet water years, however, the lowest production years typically remained similar or had a slight decrease in production under CP3 conditions relative to the No-Action Alternative.

<u>Mortality</u>
Based on the 1999 through 2006 population average, the greatest mortality to fall-run Chinook salmon under CP3 occurs to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-10 displays the overall mortalities for each alternative that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 7B and 8B).

Mortalities caused by the operations-related activities were greatest under the No-Action Alternative and lowest under CP3, but CP1 had a slightly lower mortality than CP2 (Tables 11-10 and 11-11).

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, egg incubation was still the primary life stage affected, but operations-related activities had a greater effect on fry than on presmolts and an even lesser effect on immature smolts. The same trends for each Comprehensive Plan were observed, with the bulk of the mortality affecting the egg incubation life stage, and flow triggering more of the mortality (Table 11-11).

In all water-year types, under all Comprehensive Plans, the greatest portion of mortality occurred to fry caused by forced movement to downstream habitats. Prespawn, incubation, and superimposition mortality were greater than mortality to eggs caused by unsuitable water temperatures and presmolt habitat movement.

In critical water years, mortality to eggs during the prespawn phase was the primary cause of operations-related mortalities for CP3, followed by mortality to eggs prior to spawning, and then to fry caused by forced movement. Least affected were presmolts and then immature smolts by both water temperatures and forced movement. Attachments 7C and 8C contain tables of mortality to fall-run sorted by water-year type, and Table 11-12 outlines the ranks classified under each Comprehensive Plan for each water-year type.

As with critical water years, dry water years were dominated by mortality to fry due to forced movement downstream, followed by redd dewatering or scouring and redd superimposition. Additional mortality occurred to fall-run Chinook salmon presmolts and immature smolts from both forced movement and unsuitable water temperatures (Table 11-12).

Below-normal and above-normal water years were relatively similar for all Comprehensive Plans. The mortality factors were dominated by mortality to fry due to forced movement downstream, followed by redd superimposition, dewatering or scouring. Mortality to presmolts caused by forced downstream movement was a greater factor affecting fall-run Chinook salmon populations than was egg mortality caused by unsuitable water temperatures or to immature smolts and fry due to unsuitable water temperatures (Table 11-12).

As with the water-year types discussed above, under wet water year conditions, the majority of the mortality also occurred to fry due to forced downstream movement, followed by redd superimposition, and redd dewatering or scouring. Mortality to presmolts and immature smolts from downstream movement was the lowest mortality rates resulting from operations-related activities. Least affected were eggs due to unsuitable water temperatures, both pre- and post-spawn.

Years with the highest mortality were the same for the No-Action Alternative, CP1, CP2, and CP3: 1934, 1935, 1970, 1978, and 1993. With the exception of 1970, each of these years was preceded by a critical water year. Overall, years with the lowest mortality tended to be dry or critical water years.

Years with the highest mortality were the same for the Existing Condition, CP1, CP2, and CP3: 1957, 1982, 1985, 1994, and 1997. Overall, years with the lowest mortality tended to be dry or critical water years.

When the spawning population equaled the AFRP goal, fall-run Chinook salmon mortality caused by operations-related activities decreased under CP3 compared to No-Action Alternative conditions (Attachment 9B). Under CP3, mortality caused by operations-related activities would decrease from non-operations related mortality by over 15 percent. Under CP3, the greatest mortality to fall-run Chinook salmon occurred to the egg incubation life stage, followed by fry, then presmolts, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because fall-run Chinook salmon have, overall, a reduced mortality, fall-run Chinook salmon would benefit from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, overall average late fall-run Chinook salmon production for the 82-year period was similar to CP3 and the No-Action Alternative and the Existing Condition (Attachments 10A and 11A). The maximum increase in production relative to the No-Action Alternative was 11 percent for CP3, while the largest decrease in production relative to the No-Action Alternative was 5 percent for CP3 (Attachment 10A). The maximum increase in production relative to the Existing Condition was 18 percent for CP3, while the largest decrease in production relative to the Existing Condition was 7 percent for CP3 (Attachment 11A).

Under CP3, dry water years 1926, 1930, 1932, and 1985 had greater than 7 to 11 percent increases in production compared to the No-Action Alternative. No decreases in production greater than 5 percent occurred.

Under CP3, three dry (1926, 1955, and 1985), had greater than 5 percent increases in production compared to the Existing Condition. One wet water year (1983) had a 6 percent increase relative to the Existing Condition. One critical water year (1976), and one wet water year (1984) had substantial decreases in production over the Existing Condition by 5 to 7 percent.

When the spawning population equaled the AFRP goal, overall average late fall-run Chinook salmon production was similar for CP3 relative to the No-

Action Alternative (Attachment 12A). The maximum increase in production relative to the No-Action Alternative was 27 percent for CP3. The largest decrease in production relative to the No-Action Alternative was 5 percent for CP3. In critical, dry, below-normal, and above-normal water years, years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP3, with two exceptions – 1994 and 1937 (1 percent decrease for both). In wet water years, however, the lowest production years typically remained similar or had a slight decrease in production under CP3 conditions relative to the No-Action Alternative.

<u>Mortality</u>

Based on the 1999 through 2006 population average, the greatest mortality to late fall-run under CP3 occurred to the egg incubation life stage, followed by fry, then presmolts and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-13 displays the overall mortalities for each Comprehensive Plans that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 10 B and 11B). Mortalities caused by the project decreased for all Comprehensive Plans relative to the No-Action Alternative.

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, fry became the primary life stage affected, and operations-related activities had a greater effect on eggs than on presmolts and an even lesser effect on immature smolts. Most of the mortality occurred as a result of flow conditions rather than water temperature (Table 11-14).

Under all Comprehensive Plans, mortality to fry resulting from unsuitable water temperatures only occurred at low levels to late fall-run Chinook salmon during critical, dry and below-normal water years only. In all water-year types, under all Comprehensive Plans, mortality to fry during forced movement to downstream habitats was the primary cause of operations-related mortality.

In critical, dry, and below-normal water years, the causes of operations-related mortality follow similar trends for all Comprehensive Plans, with a few exceptions. In general, the effects of flow (and density) had the greatest effect on mortality. Forced movement of fry resulted in the greatest mortality, followed by flow effects on eggs via scouring, dewatering, or superimposition. Next affected were presmolts and immature smolts by unsuitable water temperatures, and lastly temperature effects on eggs and flow effects on presmolts and immature smolts and fry (Table 11-15).

Wet and above-normal water years were overall similar to critical, dry, and below-normal water years except that mortality to fry due to unsuitable water temperatures disappear.

Years with the highest mortality were the same for all the Comprehensive Plans and were 1937, 1957, 1973, 1982, 1994, and 1997. All water-year types were covered. Two years were preceded by a wet water year, one preceded by an above-normal water year, and two by a below-normal water year (Attachments 10C and 11C).

When the spawning population equaled the AFRP goal, late fall-run Chinook salmon mortality caused by operations-related activities was slightly less under CP3 than under No-Action Alternative (Attachment 12B). Under CP3, mortality caused by operations-related activities would decrease from non-operations related mortality by 29 percent. Under CP3, the greatest mortality to late fall-run Chinook salmon occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because late fall-run Chinook salmon have, overall, a reduced mortality, late fall-run Chinook salmon would benefit from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP3): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operation—Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass CP3 operation would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

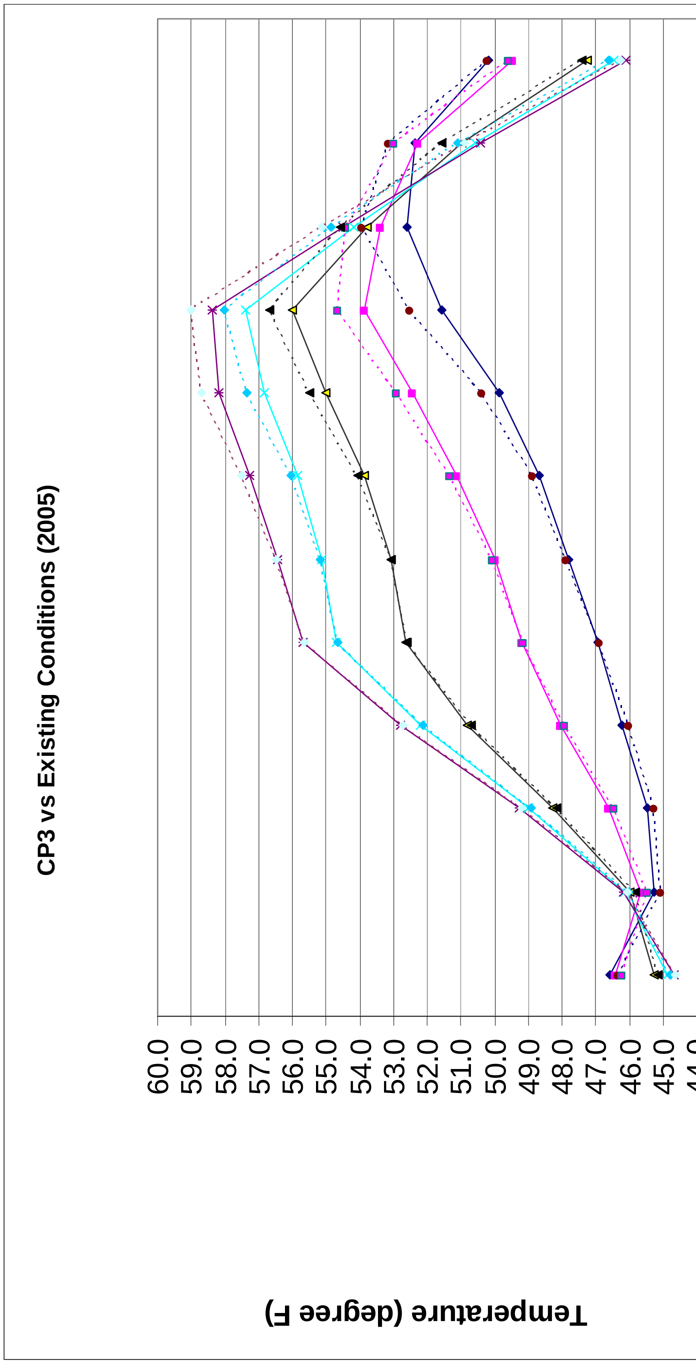
This impact would be similar to Impact Aqua-13 (CP1). The impact could be greater because of the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise.

Flow-Related Effects Similar to CP1, monthly mean flows at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP3 would be essentially equivalent to flows (less than 4 percent) under the Existing Condition and No-Action Alternative conditions simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). Potential flow-related effects on fish species of management concern in the upper Sacramento River would be minimal. All potential changes in flows and stages would diminish rapidly downstream from RBDD because of increasing effect of inflows from tributaries, and of diversions and flood bypasses.

There would be no discernable flow-related effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River related to changes in monthly mean flows under CP3, relative to the Existing Condition and No-Action Alternative. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Flow-related effects on these fish species would be less than significant.

Water Temperature-Related Effects Similar to CP1, monthly mean water temperatures at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP3 would be the same or fractionally lower than those under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-23 and 11-24) (see also the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). As discussed above, the modeling simulations may not fully account for real-time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some degree. Nevertheless, potential water temperature-related effects on fish species of management concern in the upper Sacramento River from CP3 would be minimal. During most years, annual releases from Shasta Dam would be unchanged. On average, the greatest cooling effect (less than 1°F) occurs during critical years and during the late summer (i.e., July to September), because of the increased cold-water pool volume within Shasta Lake, even following an extended dry period. All potential changes in flows and stages would diminish downstream from RBDD because of the increasing effect of inflows from tributaries, and of diversions and flood bypasses.

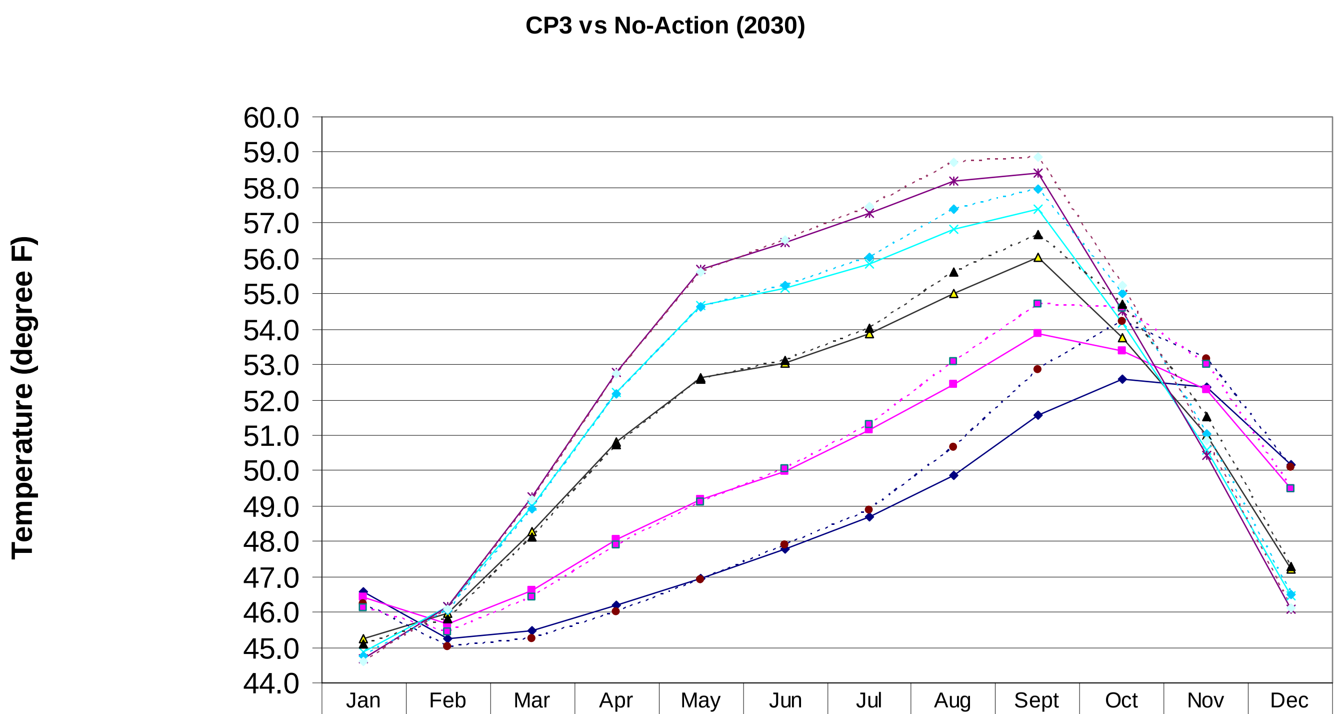
There would be very small water temperature–related effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River related to slightly cooler monthly mean water temperatures under CP3, relative to the Existing Condition and No-Action Alternative. Mean monthly water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River. Water temperature-related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP3_Below Shasta	46.6	45.3	45.5	46.2	46.9	47.8	48.7	49.9	51.6	52.6	52.3	50.2
CP3_Below Keswick	46.4	45.6	46.6	48.0	49.2	50.0	51.1	52.4	53.9	53.4	52.3	49.5
CP3_Balls Ferry	45.3	46.0	48.3	50.8	52.6	53.1	53.9	55.0	56.0	53.8	51.0	47.2
CP3_Bend Bridge	44.9	46.1	49.0	52.2	54.7	55.1	55.8	56.8	57.4	54.2	50.6	46.5
CP3_RBDD	44.7	46.2	49.3	52.8	55.7	56.4	57.3	58.2	58.4	54.5	50.4	46.1
EC_SHASTA DAM	46.3	45.1	45.3	46.0	46.9	47.9	48.9	50.4	52.5	54.0	53.1	50.2
EC_Keswick	46.2	45.5	46.5	47.9	49.2	50.0	51.3	52.9	54.6	54.4	53.0	49.6
EC_Balls Ferry	45.2	45.8	48.1	50.7	52.6	53.1	54.1	55.5	56.7	54.6	51.6	47.4
EC_Bend Bridge	44.8	46.0	48.9	52.1	54.7	55.2	56.0	57.3	58.0	54.9	51.1	46.6
EC_RBDD	44.6	46.1	49.2	52.7	55.7	56.5	57.5	58.7	59.0	55.1	50.9	46.2

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBDD = Red Bluff Diversion Dam

Figure 11-23. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (Existing Condition)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP3_Below Shasta	46.6	45.3	45.5	46.2	46.9	47.8	48.7	49.9	51.6	52.6	52.3	50.2
CP3_Below Keswick	46.4	45.6	46.6	48.0	49.2	50.0	51.1	52.4	53.9	53.4	52.3	49.5
CP3_Balls Ferry	45.3	46.0	48.3	50.8	52.6	53.1	53.9	55.0	56.0	53.8	51.0	47.2
CP3_Bend Bridge	44.9	46.1	49.0	52.2	54.7	55.1	55.8	56.8	57.4	54.2	50.6	46.5
CP3_RBDD	44.7	46.2	49.3	52.8	55.7	56.4	57.3	58.2	58.4	54.5	50.4	46.1
NA_SHASTA DAM	46.2	45.0	45.2	46.0	46.9	47.9	48.9	50.7	52.8	54.2	53.2	50.1
NA_Keswick	46.1	45.4	46.4	47.9	49.1	50.0	51.3	53.1	54.7	54.6	53.0	49.5
NA_Balls Ferry	45.1	45.8	48.1	50.7	52.6	53.1	54.0	55.6	56.7	54.7	51.5	47.3
NA_Bend Bridge	44.8	46.0	48.9	52.2	54.6	55.2	56.0	57.4	57.9	55.0	51.0	46.5
NA_RBDD	44.6	46.1	49.2	52.7	55.6	56.5	57.5	58.7	58.9	55.3	50.8	46.1

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBDD = Red Bluff Diversion Dam

Figure 11-24. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (No-Action Alternative)

Impact Aqua-14 (CP3): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows CP3 operations could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large flows providing the energy required to mobilize sediment from the river bed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

CP3 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

These effects would likely occur along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. These impacts would be potentially significant within the primary study area. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Delta

Impact Aqua-15 (CP3): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern CP3 operation would result in no discernable change in mean monthly flow or water temperature conditions in the lower Sacramento River; however, predicted changes in flow in the Feather River, American River, and Trinity River could result in an adverse effect on Chinook salmon, steelhead, coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass if they were to occur. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and increased cold-water pool) to be stored behind the raised dam.

Similar to CP1, monthly mean flows at model locations (i.e., Verona, Freeport) within the lower Sacramento River under CP3 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative conditions simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). All potential changes in flows diminished rapidly downstream from RBDD because of the increasing effect of inflows from tributaries, and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the lower Sacramento River from this alternative would be minimal. Differences in mean monthly flow are generally small (less than 2 percent) and within the existing range of variability. All potential changes in water temperatures in the lower Sacramento River due to small changes in releases would diminish rapidly downstream because of increasing effect of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts on fish species in the lower Sacramento River would be less than significant.

Also similar to CP1, monthly mean flows at all model locations within the lower Feather River, the American River, and Trinity River under CP2 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for most months; however, there are several months within the modeling record showed substantial changes (based on model simulations) to flows in tributaries (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). All potential changes in flows could be diminished in these areas per existing operational rules and because of operation of upstream reservoirs (i.e., Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects of inflows from tributaries and of diversions and flood bypasses. Nevertheless, based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts to species of management concern in the American, Feather, and Trinity rivers could occur and would be a potentially significant impact.

Monthly mean flows at all model locations within the lower Feather River (i.e., below Thermalito Afterbay) and the American River (i.e., near the H Street Bridge in Sacramento) under CP1 would also be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action

Alternative simulated for all months. All potential changes in flows were diminished in these areas because of operation of upstream CVP and SWP reservoirs (i.e., Lake Oroville and Folsom Lake) and increasing effect of inflows from tributaries, and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the Feather River and American River from this alternative would be minimal and within the range of existing variability.

All potential changes in water temperatures in the lower Sacramento River and primary tributaries (i.e., Feather River and American River) due to altered releases from reservoirs diminished downstream from RBDD because of increasing effect of inflows, and atmospheric and groundwater influences.

As under CP1, effects of altered flow regimes resulting from implementation of CP3 are unlikely to extend into the lower Sacramento River and Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the SWP and the CVP). The guidelines for this management, which are described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with OCAP to allow coverage by OCAP permits and BOs. Thus, under CP3, this project is not anticipated to cause an alteration in flow to the Delta nor cause an alteration to water temperatures in the lower Sacramento River and primary tributaries within the extended study area sufficient to cause discernable effects on Chinook salmon, steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass, relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and temperature-related effects on these fish species would be less than significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP3): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the lower Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which the reduces potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large floods providing the energy required to mobilize sediment from the river bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

CP3 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along upper reaches of the lower Sacramento River. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. These impacts would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP3): Effects to Delta Fishery Habitat Resulting from Changes to Delta Outflow Based on the results of hydrologic modeling comparing Delta outflow under CP3 relative to the Existing Condition and No-Action Alternative, CP3 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta.

Results of the comparison of Delta outflows under CP3 compared with the Existing Condition and No-Action Alternative are summarized by month and water-year type in Table 11-30. The comparison includes the estimated average monthly outflow, the average monthly flow under CP3, and the percentage change between base flows and CP3 operations. Results of the analysis (Table 11-30) showed that Delta outflows were observed to be slightly lower under many of the CP3 operations as well as slightly higher than basis-of-comparison conditions depending on month and water-year type. However, none of the changes were larger than 5 percent. Based on the results of this comparison, it was concluded that CP3 would have a less than significant impact on Delta fisheries and hydrologic transport processed within the Bay-Delta as a consequence of changes in Delta outflow under existing conditions. Mitigation for this impact is not needed, and thus not proposed.

Table 11-30. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	Water Year	Base Flow (cfs)	Flow (cfs)	Percent Change	Base Flow (cfs)	Flow (cfs)	Percent Change
January	Average	40,954	40,591	-0.9	40,167	39,890	0.7
	W	84,978	84,518	-0.5	83,595	83,313	0.3
	AN	47,101	46,194	-1.9	46,322	45,248	2.3
	BN	19,833	19,935	0.5	19,369	19,455	-0.4
	D	11,374	11,034	-3.0	10,881	10,620	2.4
	C	8,434	8,243	-2.3	8,111	8,195	-1.0
February	Average	52,699	51,986	-1.4	52,341	51,870	0.9
	W	98,900	97,867	-1.0	98,330	97,505	0.8
	AN	61,653	60,375	-2.1	60,800	59,710	1.8
	BN	35,173	35,171	0.0	35,441	35,087	1.0
	D	20,356	19,808	-2.7	19,894	20,141	-1.2
	C	12,605	12,074	-4.2	12,628	12,326	2.4
March	Average	42,610	42,422	-0.4	42,117	41,916	0.5
	W	79,254	79,240	0.0	78,370	78,405	0.0
	AN	53,361	52,713	-1.2	52,361	51,787	1.1
	BN	23,126	23,033	-0.4	23,136	23,093	0.2
	D	18,943	18,567	-2.0	18,596	18,062	2.9
	C	10,697	10,764	0.6	10,749	10,729	0.2
April	Average	27,104	27,095	0.0	27,096	27,047	0.2
	W	49,818	49,783	-0.1	49,806	49,743	0.1
	AN	27,420	27,336	-0.3	27,778	27,471	1.1
	BN	19,001	19,062	0.3	18,938	18,958	-0.1
	D	12,735	12,712	-0.2	12,516	12,552	-0.3
	C	8,586	8,645	0.7	8,600	8,628	-0.3
May	Average	20,470	20,427	-0.2	20,288	20,184	0.5
	W	37,736	37,694	-0.1	37,173	37,153	0.1
	AN	22,276	21,909	-1.6	22,205	21,662	2.4
	BN	14,200	14,217	0.1	14,080	13,940	1.0
	D	9,422	9,519	1.0	9,436	9,465	-0.3
	C	5,141	5,141	0.0	5,306	5,303	0.1
June	Average	13,104	13,058	-0.4	13,055	13,050	0.0
	W	23,675	23,682	0.0	23,303	23,342	-0.2
	AN	12,563	12,297	-2.1	12,587	12,395	1.5
	BN	8,735	8,589	-1.7	9,027	8,747	3.1
	D	6,611	6,662	0.8	6,656	6,869	-3.2
	C	5,580	5,608	0.5	5,615	5,697	-1.5
July	Average	7,927	7,969	0.5	8,291	8,312	-0.3
	W	11,228	11,241	0.1	11,501	11,469	0.3
	AN	9,085	9,169	0.9	10,040	10,098	-0.6
	BN	7,314	7,396	1.1	7,897	7,992	-1.2
	D	5,330	5,409	1.5	5,477	5,545	-1.3
	C	4,229	4,191	-0.9	4,271	4,213	1.4

Table 11-30. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	Water Year	Base Flow (cfs)	Flow (cfs)	Percent Change	Base Flow (cfs)	Flow (cfs)	Percent Change
August	Average	4,501	4,549	1.1	4,458	4,482	-0.6
	W	5,233	5,220	-0.3	4,961	4,952	0.2
	AN	4,000	4,000	0.0	4,039	4,037	0.0
	BN	4,000	4,000	0.0	4,144	4,140	0.1
	D	4,491	4,677	4.1	4,547	4,617	-1.5
	C	4,017	4,097	2.0	4,017	4,108	-2.3
September	Average	5,595	5,553	-0.7	5,262	5,261	0.0
	W	10,498	10,432	-0.6	9,510	9,419	1.0
	AN	3,781	3,761	-0.5	3,464	3,511	-1.4
	BN	3,516	3,428	-2.5	3,405	3,431	-0.8
	D	3,050	3,048	-0.1	3,277	3,344	-2.1
	C	3,025	3,009	-0.5	3,000	3,011	-0.4
October	Average	5,313	5,275	-0.7	5,023	5,022	0.0
	W	7,040	6,960	-1.1	6,464	6,447	0.3
	AN	4,540	4,534	-0.1	4,335	4,258	1.8
	BN	4,624	4,587	-0.8	4,427	4,457	-0.7
	D	4,388	4,364	-0.6	4,257	4,280	-0.6
	C	4,534	4,532	0.0	4,434	4,473	-0.9
November	Average	9,688	9,551	-1.4	9,238	9,154	0.9
	W	15,113	15,208	0.6	14,412	14,256	1.1
	AN	11,060	10,316	-6.7	10,265	10,071	1.9
	BN	6,529	6,236	-4.5	6,248	6,148	1.6
	D	6,755	6,667	-1.3	6,474	6,526	-0.8
	C	4,648	4,724	1.6	4,631	4,631	0.0
December	Average	22,933	22,581	-1.5	22,289	21,858	1.9
	W	47,953	46,947	-2.1	46,800	45,738	2.3
	AN	18,119	17,981	-0.8	17,859	17,392	2.6
	BN	13,712	13,312	-2.9	12,890	12,366	4.1
	D	8,645	8,793	1.7	8,366	8,534	-2.0
	C	5,728	5,882	2.7	5,460	5,645	-3.4

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
cfs = cubic feet per second
D = dry
W = wet

Impact Aqua-18 (CP3): Effects to Delta Fishery Habitat Resulting from Changes to Delta Inflow Changes in upstream reservoir storage have the potential to affect Delta inflow. Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. Based on the results of hydrologic modeling comparing Delta inflow under CP3 to Existing

Condition and No-Action Alternative, CP3 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta.

Results of the comparison of Delta inflows are summarized by month and water-year type in Table 11-31. The comparison includes the estimated average monthly inflow under the basis-of-comparison conditions, the average monthly flow under CP3, and the percentage change between base flows and CP3 operations. Delta inflows were observed to be slightly lower under many of the CP3 operations and slightly higher than basis-of-comparison conditions depending on month and water-year type. None of the comparisons exceeded 5 percent difference between the No-Action Alternative, Existing Condition and CP3. Based on the results of this comparison, it was concluded that CP3 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-31. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month		Base Flow (cfs)	Flow (cfs)	Percent Change	Base Flow (cfs)	Flow (cfs)	Percent Change
January	Average	50,193	49,878	-0.6	49,674	49,363	-0.6
	W	93,590	93,128	-0.5	92,710	92,441	-0.3
	AN	56,641	55,754	-1.6	55,935	54,823	-2.0
	BN	30,176	30,244	0.2	29,939	29,961	0.1
	D	21,201	20,955	-1.2	20,927	20,617	-1.5
	C	16,560	16,582	0.1	16,312	16,320	0.0
February	Average	61,147	60,567	-0.9	60,691	60,370	-0.5
	W	108,058	107,146	-0.8	107,699	106,984	-0.7
	AN	70,137	69,112	-1.5	69,901	68,791	-1.6
	BN	44,310	44,208	-0.2	43,831	43,604	-0.5
	D	28,791	28,237	-1.9	28,157	28,235	0.3
	C	18,694	18,678	-0.1	18,099	18,716	3.4
March	Average	50,938	50,790	-0.3	50,576	50,367	-0.4
	W	88,045	88,073	0.0	87,612	87,608	0.0
	AN	63,252	62,440	-1.3	62,667	61,943	-1.2
	BN	32,287	32,276	0.0	31,760	31,790	0.1
	D	26,931	26,735	-0.7	26,504	26,045	-1.7
	C	15,999	16,043	0.3	16,299	16,260	-0.2
April	Average	33,715	33,694	-0.1	33,832	33,817	0.0
	W	57,897	57,872	0.0	58,185	58,137	-0.1
	AN	35,063	34,892	-0.5	35,403	35,127	-0.8
	BN	26,022	26,028	0.0	25,955	25,965	0.0
	D	17,991	17,976	-0.1	17,853	18,012	0.9
	C	12,534	12,630	0.8	12,653	12,683	0.2

Table 11-31. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month		**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
May	Average	27,783	27,726	-0.2	27,762	27,661	-0.4
	W	47,155	47,092	-0.1	46,817	46,783	-0.1
	AN	30,016	29,594	-1.4	30,446	29,774	-2.2
	BN	21,135	21,171	0.2	21,177	21,089	-0.4
	D	15,555	15,666	0.7	15,529	15,605	0.5
	C	9,671	9,638	-0.3	9,827	9,866	0.4
June	Average	23,254	23,318	0.3	23,559	23,589	0.1
	W	35,726	35,775	0.1	35,503	35,570	0.2
	AN	23,868	23,637	-1.0	24,400	24,102	-1.2
	BN	18,814	18,636	-0.9	20,111	19,838	-1.4
	D	15,726	16,025	1.9	15,789	16,174	2.4
	C	12,089	12,409	2.6	12,516	12,619	0.8
July	Average	18,889	19,210	1.7	20,470	20,748	1.4
	W	23,568	23,745	0.8	24,661	24,797	0.5
	AN	19,796	20,029	1.2	22,429	22,697	1.2
	BN	18,549	18,979	2.3	21,709	21,822	0.5
	D	16,344	16,943	3.7	17,176	17,995	4.8
	C	12,058	12,235	1.5	12,928	12,904	-0.2
August	Average	18,889	19,210	1.7	16,281	16,378	0.6
	W	23,568	23,745	0.8	17,995	17,952	-0.2
	AN	19,796	20,029	1.2	17,543	17,689	0.8
	BN	18,549	18,979	2.3	17,273	17,239	-0.2
	D	16,344	16,943	3.7	15,167	15,651	3.2
	C	12,058	12,235	1.5	11,816	11,743	-0.6
September	Average	16,480	16,475	0.0	16,625	16,758	0.8
	W	23,176	23,134	-0.2	22,459	22,376	-0.4
	AN	15,742	15,737	0.0	15,814	15,951	0.9
	BN	14,961	14,778	-1.2	15,198	15,263	0.4
	D	12,749	12,882	1.0	14,118	14,610	3.5
	C	10,076	10,156	0.8	10,220	10,360	1.4
October	Average	15,542	15,545	0.0	14,833	14,888	0.4
	W	18,176	18,130	-0.3	17,270	17,297	0.2
	AN	14,399	14,446	0.3	13,708	13,717	0.1
	BN	15,010	15,022	0.1	14,436	14,479	0.3
	D	13,980	14,035	0.4	13,490	13,510	0.1
	C	13,942	13,917	-0.2	13,153	13,382	1.7
November	Average	19,409	19,400	0.0	19,043	19,041	0.0
	W	26,007	26,117	0.4	25,720	25,527	-0.8
	AN	20,432	19,805	-3.1	19,604	19,560	-0.2
	BN	16,833	16,513	-1.9	16,510	16,451	-0.4
	D	15,836	15,972	0.9	15,453	15,679	1.5
	C	12,458	12,955	4.0	12,354	12,535	1.5

Table 11-31. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month		Base Flow (cfs)	Flow (cfs)	Percent Change	Base Flow (cfs)	Flow (cfs)	Percent Change
December	Average	33,195	32,934	-0.8	32,657	32,310	-1.1
	W	58,863	57,858	-1.7	58,092	57,003	-1.9
	AN	28,400	28,495	0.3	28,098	27,769	-1.2
	BN	23,545	23,181	-1.5	22,831	22,296	-2.3
	D	19,116	19,386	1.4	19,010	19,285	1.4
	C	14,756	15,069	2.1	14,041	14,573	3.8

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-19 (CP3): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow Project operation would result in a variable response in Sacramento River flow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water-year type. This impact would be less than significant.

Results of hydrologic modeling, by month and year type, comparing basis-of-comparison Sacramento River flow, are presented in Table 11-32. Results of these analyses show a variable response in Sacramento River flow with CP3 operations resulting in both increases and decreases in river flow above basis-of-comparison conditions, depending on month and water year. All differences in Sacramento River flow between the No-Action Alternative, Existing Condition and CP3 operations were less than 5 percent. Based on these results, it was concluded that the effect of CP3 on fish habitat and transport mechanisms within the lower Sacramento River and Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 11-32. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	34,680	34,497	-0.5	34,363	34,196	-0.5
	W	56,231	56,100	-0.2	55,714	55,726	0.0
	AN	44,117	43,408	-1.6	44,049	43,308	-1.7
	BN	25,272	25,339	0.3	25,024	25,046	0.1
	D	18,166	17,924	-1.3	17,888	17,579	-1.7
	C	14,298	14,321	0.2	14,028	14,039	0.1
February	Average	40,650	40,306	-0.8	40,345	40,230	-0.3
	W	61,746	61,682	-0.1	61,676	61,609	-0.1
	AN	51,527	50,504	-2.0	51,346	50,234	-2.2
	BN	34,676	34,575	-0.3	34,309	34,083	-0.7
	D	24,116	23,408	-2.9	23,562	23,641	0.3
	C	15,834	15,826	-0.1	15,345	15,962	4.0
March	Average	35,093	34,978	-0.3	35,018	34,839	-0.5
	W	52,808	52,870	0.1	52,720	52,715	0.0
	AN	47,679	46,932	-1.6	47,821	47,194	-1.3
	BN	25,629	25,606	-0.1	25,210	25,240	0.1
	D	22,908	22,780	-0.6	22,615	22,226	-1.7
	C	13,443	13,487	0.3	13,907	13,869	-0.3
April	Average	24,190	24,157	-0.1	24,317	24,307	0.0
	W	39,645	39,580	-0.2	39,901	39,869	-0.1
	AN	26,322	26,152	-0.6	26,721	26,444	-1.0
	BN	18,746	18,752	0.0	18,673	18,682	0.1
	D	13,900	13,884	-0.1	13,782	13,940	1.1
	C	10,362	10,458	0.9	10,534	10,563	0.3
May	Average	20,098	20,042	-0.3	20,119	20,018	-0.5
	W	32,904	32,842	-0.2	32,639	32,607	-0.1
	AN	22,928	22,506	-1.8	23,355	22,684	-2.9
	BN	14,923	14,958	0.2	14,997	14,910	-0.6
	D	12,055	12,165	0.9	12,060	12,135	0.6
	C	7,622	7,590	-0.4	7,821	7,860	0.5
June	Average	17,718	17,782	0.4	18,092	18,122	0.2
	W	24,331	24,382	0.2	24,141	24,210	0.3
	AN	17,986	17,755	-1.3	18,678	18,379	-1.6
	BN	15,806	15,628	-1.1	17,160	16,887	-1.6
	D	14,015	14,312	2.1	14,146	14,528	2.7
	C	10,907	11,226	2.9	11,406	11,508	0.9

Table 11-32. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
July	Average	15,270	15,591	2.1	16,870	17,146	1.6
	W	16,088	16,264	1.1	17,160	17,295	0.8
	AN	16,682	16,914	1.4	19,335	19,602	1.4
	BN	16,500	16,931	2.6	19,698	19,811	0.6
	D	14,988	15,584	4.0	15,871	16,687	5.1
	C	11,077	11,253	1.6	11,974	11,950	-0.2
August	Average	12,649	12,940	2.3	13,790	13,886	0.7
	W	13,724	13,650	-0.5	13,840	13,797	-0.3
	AN	12,721	12,986	2.1	15,183	15,329	1.0
	BN	12,319	12,723	3.3	15,145	15,111	-0.2
	D	13,162	13,964	6.1	13,769	14,249	3.5
	C	9,865	10,070	2.1	10,738	10,664	-0.7
September	Average	13,697	13,692	0.0	13,863	13,996	1.0
	W	18,936	18,894	-0.2	18,242	18,159	-0.5
	AN	13,088	13,083	0.0	13,160	13,296	1.0
	BN	12,543	12,360	-1.5	12,817	12,882	0.5
	D	10,847	10,979	1.2	12,238	12,728	4.0
	C	8,577	8,652	0.9	8,737	8,877	1.6
October	Average	12,719	12,773	0.4	12,068	12,124	0.5
	W	14,766	14,884	0.8	14,040	14,071	0.2
	AN	12,049	12,096	0.4	11,379	11,389	0.1
	BN	12,322	12,334	0.1	11,758	11,801	0.4
	D	11,249	11,304	0.5	10,747	10,768	0.2
	C	11,619	11,593	-0.2	10,823	11,052	2.1
November	Average	15,858	15,847	-0.1	15,501	15,505	0.0
	W	21,159	21,229	0.3	20,878	20,687	-0.9
	AN	17,210	16,583	-3.6	16,355	16,340	-0.1
	BN	13,687	13,367	-2.3	13,377	13,322	-0.4
	D	12,805	12,992	1.5	12,475	12,701	1.8
	C	10,129	10,626	4.9	10,012	10,192	1.8
December	Average	26,148	26,014	-0.5	25,710	25,510	-0.8
	W	44,908	44,313	-1.3	44,459	43,709	-1.7
	AN	22,225	22,302	0.3	21,941	21,870	-0.3
	BN	19,129	18,762	-1.9	18,434	17,899	-2.9
	D	16,164	16,440	1.7	16,042	16,323	1.8
	C	12,587	12,900	2.5	11,848	12,380	4.5

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-20 (CP3): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP3 operations would result in no discernable change in San Joaquin River flows at Vernalis, and therefore no effects on fish habitat or transport mechanisms within the lower San Joaquin River and Delta compared with the Existing Condition and No-Action Alternative. This impact would be less than significant.

Results of the comparative analysis of model results, by month and water-year type, for basis-of-comparison conditions and CP3 for San Joaquin River flow are summarized in Table 11-33. Results of these analyses show that CP3 would have no effect on seasonal flows under existing conditions within the San Joaquin River. Similarly, modeling results showed that CP3 would have no effect on flows or fish habitat compared with the No-Action Alternative. Based on these results, it was concluded that CP3 would have no effect on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-33. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP3

		Existing Condition	Existing Condition With Project	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	4,772	4,772	0.0
	W	9,255	9,255	0.0
	AN	4,339	4,339	0.0
	BN	2,971	2,971	0.0
	D	2,084	2,084	0.0
	C	1,624	1,624	0.0
February	Average	6,434	6,433	0.0
	W	11,637	11,637	0.0
	AN	6,271	6,271	0.0
	BN	5,742	5,741	0.0
	D	2,506	2,506	0.0
	C	2,020	2,021	0.0
March	Average	6,339	6,338	0.0
	W	12,420	12,419	0.0
	AN	5,792	5,790	0.0
	BN	4,539	4,538	0.0
	D	2,372	2,372	0.0
	C	1,760	1,760	0.0
April	Average	6,006	6,006	0.0
	W	10,455	10,455	0.0
	AN	5,976	5,976	0.0
	BN	5,241	5,242	0.0
	D	3,050	3,050	0.0
	C	1,722	1,722	0.0
May	Average	6,022	6,022	0.0
	W	10,991	10,990	0.0
	AN	5,420	5,420	0.0
	BN	4,987	4,988	0.0
	D	2,895	2,896	0.0
	C	1,752	1,752	0.0

Table 11-33. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP3 (contd.)

		Existing Condition	Existing Condition With Project	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
June	Average	4,631	4,631	0.0
	W	9,577	9,575	0.0
	AN	4,946	4,946	0.0
	BN	2,320	2,321	0.0
	D	1,478	1,480	0.1
	C	1,022	1,022	0.1
July	Average	3,221	3,222	0.0
	W	6,646	6,646	0.0
	AN	2,779	2,779	0.0
	BN	1,755	1,755	0.0
	D	1,260	1,262	0.2
	C	895	896	0.0
August	Average	2,113	2,114	0.0
	W	3,350	3,350	0.0
	AN	2,010	2,010	0.0
	BN	1,827	1,827	0.0
	D	1,347	1,349	0.1
	C	1,021	1,022	0.1
September	Average	2,366	2,366	0.0
	W	3,433	3,434	0.0
	AN	2,293	2,293	0.0
	BN	2,077	2,077	0.0
	D	1,764	1,764	0.0
	C	1,368	1,368	0.0
October	Average	2,486	2,486	0.0
	W	2,915	2,915	0.0
	AN	2,099	2,099	0.0
	BN	2,428	2,428	0.0
	D	2,417	2,417	0.0
	C	2,113	2,113	0.0
November	Average	2,561	2,561	0.0
	W	3,311	3,311	0.0
	AN	2,104	2,104	0.0
	BN	2,334	2,334	0.0
	D	2,315	2,315	0.0
	C	2,026	2,026	0.0
December	Average	2,561	2,561	0.0
	W	3,311	3,311	0.0
	AN	2,104	2,104	0.0
	BN	2,334	2,334	0.0
	D	2,315	2,315	0.0
	C	2,026	2,026	0.0

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-21 (CP3): Reduction in Low Salinity Habitat Conditions Resulting from an Upstream Shift in X2 *Location* CP3 operation would result in less than 0.5 km movement upstream or downstream from the X2 location. This impact would be less than significant.

The 1 km X2 criterion was applied to a comparison of hydrologic model results for basis-of-comparison conditions and CP3, by month and water-year type, for the months from February through May. Results of the comparisons are summarized in Table 11-34. These results showed that changes in X2 location under CP3 were less than 1 km (all were less than 0.4 km) with both variable upstream and downstream movement of the X2 location depending on month and water-year type. These results are consistent with model results for Delta outflow that showed a less than significant change in flows.

Table 11-34. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
February	Average	65	66	20.0	66	66	10.0
	W	55	55	10.0	55	55	10.0
	AN	61	61	20.0	61	61	20.0
	BN	68	68	0.0	68	68	0.0
	D	73	74	40.0	73	73	0.0
	C	77	78	40.0	77	77	0.0
March	Average	65	65	10.0	65	65	10.0
	W	56	56	0.0	56	56	0.0
	AN	60	60	20.0	60	60	10.0
	BN	68	68	0.0	68	68	0.0
	D	72	72	30.0	72	72	20.0
	C	77	77	10.0	77	77	0.0
April	Average	68	68	0.0	68	68	0.0
	W	59	59	0.0	59	59	0.0
	AN	64	64	10.0	64	64	10.0
	BN	70	70	0.0	70	70	0.0
	D	74	74	10.0	74	74	0.0
	C	78	78	0.0	78	78	0.0

Table 11-34. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	Water Year	Base Flow (cfs)	Flow (cfs)	Percent Change	Base Flow (cfs)	Flow (cfs)	Percent Change
May	Average	71	71	0.0	71	71	0.0
	W	62	62	0.0	62	62	0.0
	AN	67	67	10.0	67	68	0.0
	BN	72	72	0.0	72	72	0.0
	D	76	76	-10.0	76	76	0.0
	C	83	83	0.0	82	82	0.0

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Results of a comparative analysis of changes in X2 location between the basis-of-comparison and CP3, assuming future operating conditions, are also summarized in Table 11-34. Results of these comparisons showed very little difference (less than 0.2 km) in the X2 location between CP3 and the No-Action Alternative. Based on these results, it was concluded that CP3 would have a less than significant effect on low salinity habitat conditions within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-22 (CP3): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers Project operation would result in an increase of reverse flows in Old and Middle rivers. The increase in reverse flows would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses. This impact would be potentially significant.

Results of the analysis showed several occurrences when reverse flows within Old and Middle rivers were greater than basis-of-comparison conditions by more than 5 percent. These events occurred typically in dry and critical water years, which would be expected as a result of greater export operations under CP3. During February (Table 11-35), operations under CP3 resulted in an increase in reverse flow of greater than 5 percent during critical years. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase from approximately 4,300 cfs under the basis-of-comparison in a critical water year to approximately 4,700 cfs would not be expected to result in a significant increase in adverse effects to delta smelt. Juvenile Chinook salmon and steelhead are migrating through the Delta during February, and an increase in average monthly reverse flows of 300 to 400 cfs would be expected to increase the potential risk of increased mortality.

However given the tidal volumes and hydrodynamics of the Old and Middle rivers region, it is not expected that the change in reverse flows in February in a critical year would result in a detectable change in fish survival. The majority of juvenile Chinook salmon emigrating from the San Joaquin River typically migrate downstream later in dry years and would not be expected to occur in high numbers within Old and Middle rivers in February.

Table 11-35. Reverse Flows Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	-6,592	-6,625	-0.5	-6,968	-6,942	0.4
	W	-5,026	-5,021	0.1	-5,624	-5,634	-0.2
	AN	-7,598	-7,610	-0.2	-7,828	-7,795	0.4
	BN	-7,717	-7,688	0.4	-8,042	-7,993	0.6
	D	-7,540	-7,606	-0.9	-7,880	-7,842	0.5
	C	-6,243	-6,405	-2.6	-6,402	-6,345	0.9
February	Average	-4,930	-5,029	-2.0	-4,996	-5,113	-2.3
	W	-3,582	-3,673	-2.5	-3,857	-3,942	-2.2
	AN	-5,663	-5,855	-3.4	-6,276	-6,263	0.2
	BN	-5,723	-5,644	1.4	-5,301	-5,399	-1.9
	D	-6,175	-6,164	0.2	-6,211	-6,081	2.1
	C	-4,326	-4,719	-9.1	-4,004	-4,713	-17.7
March	Average	-3,975	-4,004	-0.7	-4,148	-4,141	0.2
	W	-2,052	-2,081	-1.4	-2,394	-2,364	1.2
	AN	-5,528	-5,402	2.3	-5,933	-5,817	2.0
	BN	-5,264	-5,327	-1.2	-4,948	-5,003	-1.1
	D	-5,245	-5,380	-2.6	-5,313	-5,371	-1.1
	C	-3,181	-3,163	0.6	-3,479	-3,465	0.4
April	Average	-1,984	-1,975	0.5	-2,049	-2,074	-1.2
	W	-1,525	-1,531	-0.4	-1,709	-1,722	-0.7
	AN	-2,825	-2,758	2.4	-2,791	-2,814	-0.8
	BN	-2,488	-2,446	1.7	-2,460	-2,451	0.4
	D	-2,098	-2,102	-0.2	-2,128	-2,214	-4.1
	C	-1,382	-1,411	-2.1	-1,447	-1,445	0.2
May	Average	-1,649	-1,638	0.6	-1,729	-1,729	0.0
	W	-1,147	-1,130	1.4	-1,265	-1,255	0.8
	AN	-2,312	-2,270	1.8	-2,627	-2,528	3.8
	BN	-1,693	-1,706	-0.8	-1,755	-1,794	-2.2
	D	-2,088	-2,098	-0.5	-2,026	-2,057	-1.5
	C	-1,364	-1,340	1.8	-1,361	-1,391	-2.2

Table 11-35. Reverse Flows Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
June	Average	-2,858	-2,942	-2.9	-3,210	-3,236	-0.8
	W	-2,219	-2,252	-1.5	-2,387	-2,409	-0.9
	AN	-3,532	-3,558	-0.7	-4,011	-3,930	2.0
	BN	-3,752	-3,726	0.7	-4,578	-4,583	-0.1
	D	-3,341	-3,531	-5.7	-3,476	-3,606	-3.7
	C	-1,801	-2,024	-12.4	-2,194	-2,209	-0.7
July	Average	-3,942	-4,155	-5.4	-4,813	-5,010	-4.1
	W	-3,493	-3,619	-3.6	-4,027	-4,155	-3.2
	AN	-3,967	-4,080	-2.9	-5,167	-5,328	-3.1
	BN	-4,733	-4,999	-5.6	-6,665	-6,679	-0.2
	D	-4,859	-5,258	-8.2	-5,378	-5,954	-10.7
	C	-2,592	-2,754	-6.3	-3,154	-3,181	-0.8

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

The increase in reverse flows estimated to occur under CP3 in critical and dry years in June, and under critical, dry, and below-normal years in July, exceeded 5 percent compared with the Existing Condition. The increased reverse flows in June of critical and dry years occur at a time of year when water temperatures in the Delta are elevated and juvenile Chinook salmon or steelhead would not be expected to occur in the area. Juvenile delta smelt may occur in the area in June; however, a change in Old and Middle river flows of approximately 100 to 200 cfs may result in a small increase in their vulnerability to CVP and SWP salvage, but this increase is expected to be less than significant. As water temperatures increase in the Delta during June and July, the majority of delta smelt are located farther downstream in Suisun Bay where temperatures are more suitable. The increase in reverse flows estimated from the modeling in June of a critical year and in July of below-normal, dry, and critical years, would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses as a result of increased reverse flows. The increased reverse flows in low-flow years would be expected to result in a low, but potentially significant, increase in mortality for resident warm-water fish inhabiting the south Delta.

Results of the comparison of Old and Middle rivers reverse flows are summarized in Table 11-35. Results of the analysis show that in the majority of years and months, reverse flows under CP3 did not exceed basis-of-comparison conditions by more than 5 percent. CP3 exceeded basis-of-comparison conditions during February of a critical year by approximately 700 cfs. The increase in reverse flows would be expected, particularly in a critical year, to contribute to an increase in the potential for losses of adult delta smelt and other species, which is considered to be potentially significant. During June in a critical water year, under CP3 the magnitude of reverse flows was reduced more than 5 percent but would be expected to contribute to a less than significant biological benefit based on both the low reverse flow under the basis-of-comparison and under CP3. An increase in reverse flow above the basis-of-comparison of approximately 300 to 600 cfs during dry years in July would be expected to contribute to an increase in the risk of losses to resident warm-water fish species. Increased reverse flows in July would not be expected to adversely affect delta or longfin smelt, juvenile Chinook salmon, or steelhead based on their seasonal migration patterns and geographic distribution. The potential increase in losses during February and July under CP3 is considered to be potentially significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

Impact Aqua-23 (CP3): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP3 operations may result in an increase in CVP and SWP exports, which is assumed to result in a direct proportional increase in the risk of fish being entrained and salvaged at the facilities. This is a considered a less than significant impact to Chinook salmon, steelhead, and longfin smelt. This is considered a potentially significant impact to delta smelt, striped bass, and splittail. Future operations of the SWP and CVP export facilities would continue to be managed and regulated in accordance with incidental take limits established for each of the protected fish by USFWS, NMFS, and DFG.

Results of the entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-36 for CP3. The initial modeling was conducted using average fish densities developed from past fish salvage monitoring at the SWP and CVP export facilities. Average monthly water exports were used in the analysis based on hydrologic simulation modeling. The indices of the potential risk of entrainment for some species, such as Chinook salmon, were not estimated separately for each species (e.g., winter-run Chinook) in these initial analyses. If the proposed project is developed in the future a more detailed species-specific analysis of potential changes in fish salvage losses, in addition to an assessment of the population-level effects on each species, would be required for use as a basis for developing a biological assessment and Section 7 BOs and incidental take permits for project operations. These indices were calculated for wet, above-normal, below-normal, dry, and critical water-year types, and for an average across all years (no water-year type specified).

The total numbers of fish lost annually, by species, are presented in Attachment 13. The difference between the non-operations related and operations related fish mortality is represented as the entrainment index, shown in the tables, to represent the effect of project operations on each fish species at the CVP and SWP facilities.

Table 11-36. Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP3

Species	Water Year	CP3 minus Existing Condition	Percent Change	CP3 Minus Future Condition	Percent Change
Delta Smelt	Average	227	0.3	159	0.2
	W	-65	-0.1	-33	0.0
	AN	-422	-0.5	-1,582	-1.8
	BN	144	0.2	566	0.8
	D	903	1.6	970	1.7
	C	590	1.9	623	1.9
Chinook Salmon	Average	410	0.4	374	0.4
	W	139	0.1	112	0.1
	AN	-440	-0.4	-1,529	-1.2
	BN	-63	-0.1	643	0.6
	D	1,100	1.3	1,058	1.3
	C	1,363	2.8	1,506	3.0
Longfin Smelt	Average	-38	-0.2	15	0.1
	W	-53	-0.2	-32	-0.1
	AN	-187	-1.0	-343	-1.8
	BN	24	0.2	135	0.9
	D	51	0.4	167	1.4
	C	-59	-0.9	106	1.6
Steelhead	Average	40	0.8	36	0.7
	W	29	0.5	930	16.5
	AN	57	1.1	-18	-0.3
	BN	-31	-0.6	26	0.5
	D	17	0.4	-37	-0.8
	C	164	5.2	225	7.4
Striped Bass	Average	27,650	2.1	17,643	1.3
	W	10,968	0.7	9,537	0.6
	AN	14,544	1.0	436	0.0
	BN	16,514	1.3	2,955	0.2
	D	57,660	5.1	57,274	4.8
	C	44,881	6.8	10,098	1.4
Splittail	Average	5,759	2.1	3,377	1.1
	W	2,539	0.7	2,186	0.6
	AN	1,955	0.6	-2,349	-0.7
	BN	2,172	0.8	775	0.2
	D	12,446	5.4	12,268	5.1
	C	10,692	9.2	1,383	1.0

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent in wet, above-normal, and below-normal water years and an increase in risk ranging from approximately 1 to 4 percent during dry and critical water years under CP3 relative to the Existing Condition (Table 11-36). The risk of increased losses of delta smelt under CP3 compared to the No-Action Alternative (Table 11-36) was greatest in the dry years. Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations is small, delta smelt population abundance is currently at such critically low levels that even a small increase in the risk of losses is considered to be potentially significant. The increase in risk is also expected to contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for salmon follows a pattern similar to that described for delta smelt (Table 11-36). Overall, CP3 would result in a small increase in the risk of losses. The loss index for salmon also showed increased risk in wet, below-normal, dry, and critical years relative to the No-Action Alternative. Given the numbers of juvenile Chinook salmon produced each year in the Central Valley, the relatively small incremental increase in the risk of entrainment/salvage at the CVP and SWP export facilities is considered to be a less than significant direct effect but would contribute incrementally to the overall cumulative factors affecting juvenile Chinook salmon survival within the Delta, and population dynamics of the stocks.

The change in the risk of longfin smelt entrainment/salvage under CP3 compared to the No-Action Alternative and to the Existing Condition shows small positive and negative changes depending on water-year type and alternative (Table 11-36). These small changes in the risk of entrainment are considered to be less than significant.

The change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-36, respectively. The small positive and negative changes in risk under wet, above-normal, below-normal, and dry water years are considered to be less than significant. The increase in risk of steelhead losses in critical water years are considered to be less than significant based on the abundance of juvenile steelhead migrating through the Delta, but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The predicted increase in potential entrainment risk for steelhead under critically dry water years represents an initial estimate of the change (percentage) between the proposed project operations and the existing conditions and no-project alternatives and does not allow the predicted losses to be evaluated at the population-level. As noted above, more detailed modeling and analysis of potential steelhead losses would be required as part of preparing a project-specific analysis of entrainment losses for use in the Section 7 biological assessment and BOs for future project operations and incidental take of steelhead. As part of this more detailed analysis additional actions may be identified to further reduce and avoid potential adverse effects to steelhead.

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-36. The change in risk in wet, above-normal, and below-normal water years are considered to be less than significant based on the abundance of striped bass, but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The losses of juvenile striped bass increased substantially under dry and critical water years, which would be expected with an increase in exports during the summer months. The risk of increased losses ranged from 3.8 to 7.6 percent (approximately 30,000 to 60,000 fish) under CP3, compared to the Existing Condition, which is considered to be potentially significant. The increased losses under CP3, particularly in drier water years when juvenile striped bass production is lower, would be expected to contribute to the cumulative effects of factors affecting juvenile striped bass survival in the Delta.

Results of the risk estimates for juvenile splittail losses under CP3 compared with the No-Action Alternative and Existing Condition show a pattern similar to other species (Table 11-36). The increased risk index was 1.3 percent or less in wet, above-normal, and below-normal water years, and was considered to be a less than significant affect. The loss index increased during dry and critically dry water years, with the greatest increase for CP3. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect of abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower within the Delta in dry years. The increased risk of losses in drier years was considered to be potentially significant. The increased losses would also contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP1) is considered to be less than significant for Chinook salmon, steelhead, and longfin smelt, but potentially significant for delta smelt, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

CVP/SWP Service Areas

Impact Aqua-24 (CP3): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes. Project implementation would result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats that provide habitat for the fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP3 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and resulting flows downstream from those reservoirs, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

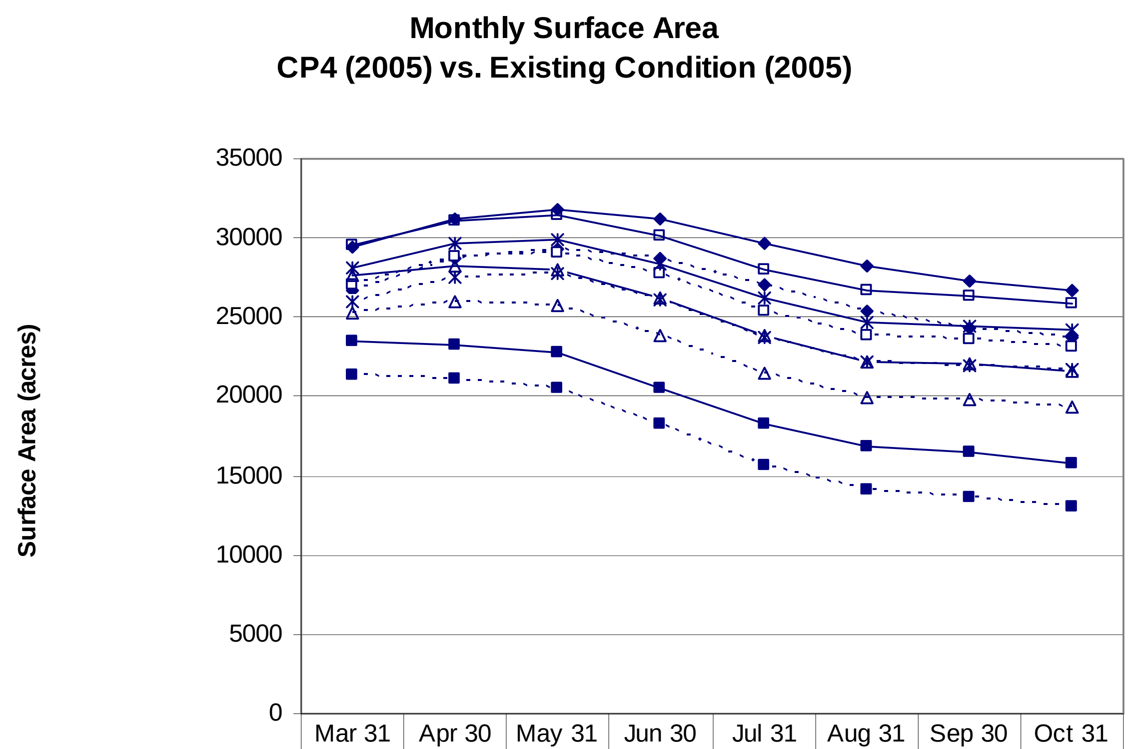
CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

The primary function of CP4 is to address survival of anadromous fish, while still improving water supply reliability. It focuses on increasing the volume of cold water available to the TCD through reservoir reoperations, and on raising Shasta Dam by 18.5 feet. CP4 also includes a 10-year spawning gravel augmentation program as an additional environmental commitment. As with CP3 and the common features above, this raise would increase the full pool by 20.5 feet and enlarge total reservoir storage space by 634,000 acre-feet. This additional storage space would expand Shasta Lake's cold-water supply available to the TCD by 378,000 acre-feet, a feature that would help reduce water temperatures in the upper Sacramento River.

Shasta Lake and Vicinity

Impact Aqua-1 (CP4): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP4, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. CP2 operations would also result in reduced monthly fluctuations in WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. Similar to CP-1 the value of existing structural habitat improvements would be diminished to varying degrees, large areas of the shoreline would not be cleared, and the vegetation along these sections will be inundated periodically. In the short term, this vegetation will provide warm-water lacustrine habitat, with decay expected to occur over several decades. This impact would be less than significant.

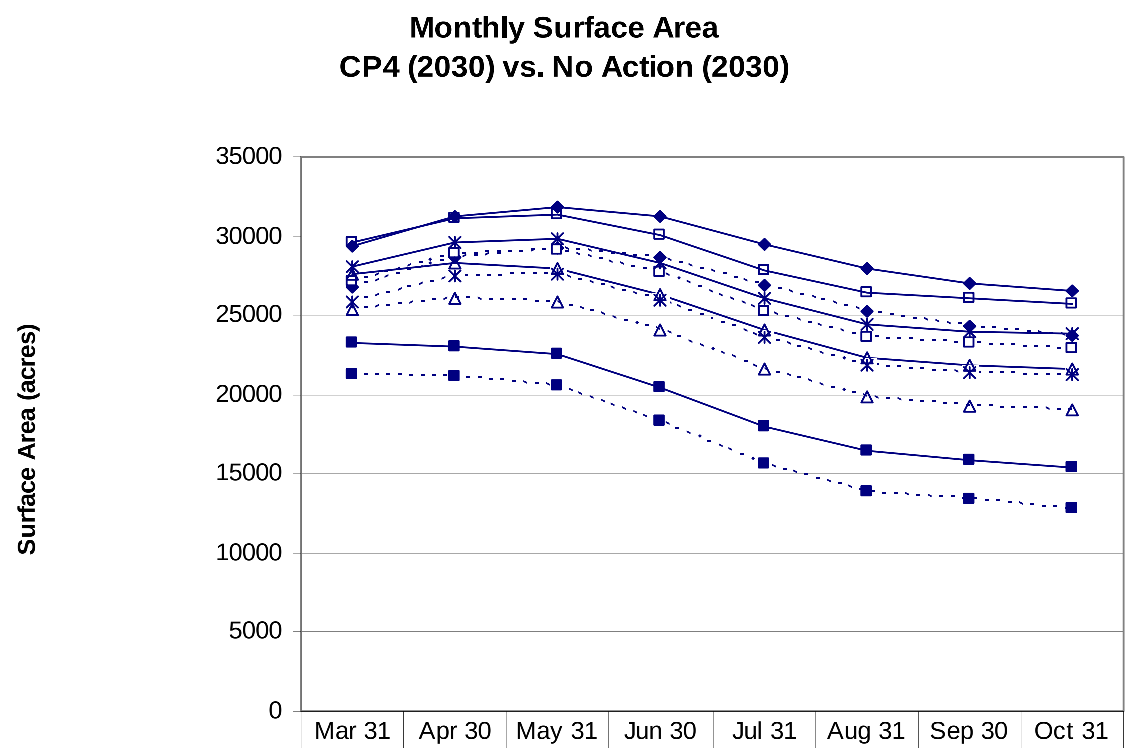
This impact would be similar to Impact Aqua-1 (CP1, CP2, and CP3), but the surface area would be larger under the 18.5-foot dam raise than under CP1 and CP2. CalSim-II modeling shows that the surface area of Shasta Lake would be larger under CP4 for both a 2005 and 2030 water supply demand than under the Existing Condition or the No-Action Alternative in all five water-year types (Figures 11-25 and 11-26).



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26726	28711	29305	28720	27042	25351	24380	23709
EC AN	27096	28851	29102	27792	25377	23881	23648	23105
EC BN	25942	27562	27715	26098	23740	22177	21932	21732
EC D	25311	26013	25724	23891	21531	19954	19778	19310
EC C	21336	21121	20583	18251	15644	14079	13655	12992
CP4 2005 W	29373	31194	31841	31249	29672	28201	27248	26661
CP4 2005 AN	29516	31136	31449	30168	27990	26638	26315	25818
CP4 2005 BN	28177	29712	29868	28370	26189	24694	24456	24243
CP4 2005 D	27605	28256	27958	26164	23871	22221	22070	21636
CP4 2005 C	23499	23277	22761	20582	18222	16813	16433	15832

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-25. Monthly Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 vs. Existing Condition (2005)



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26750	28695	29293	28690	26880	25222	24303	23671
NA AN	27167	28885	29069	27750	25285	23603	23283	22865
NA BN	25820	27477	27594	25947	23571	21815	21422	21291
NA D	25395	26108	25802	24026	21660	19855	19238	19017
NA C	21312	21115	20554	18343	15646	13859	13349	12834
CP4 2030 W	29388	31196	31838	31211	29423	27954	27050	26493
CP4 2030 AN	29562	31149	31393	30104	27889	26373	26055	25678
CP4 2030 BN	28048	29609	29777	28301	26108	24374	24002	23865
CP4 2030 D	27654	28311	27998	26274	24045	22340	21812	21596
CP4 2030 C	23242	23042	22505	20455	17986	16457	15829	15348

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-26. Monthly Surface Area for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 vs. No-Action Alternative

Monthly WSEL fluctuations were compared to projections for water supply demand. For CP4, with a 2005 water supply demand, 20 percent of monthly changes in projected WSELs (i.e., 5 of the 25 total projections made for the 5 months from March through July for all five water-year types) showed increased monthly WSEL fluctuations relative to the Existing Condition and 80 percent showed reduced monthly WSEL fluctuations (Figure 11-27). For CP3, with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSELs showed increased WSEL fluctuations relative to the No-Action Alternative and 64 percent showed reduced monthly WSEL fluctuations (Figure 11-28). Under CP4, none of the changes in monthly WSEL fluctuation are different enough from the Existing Condition to warrant the investigation of daily WSEL fluctuation.

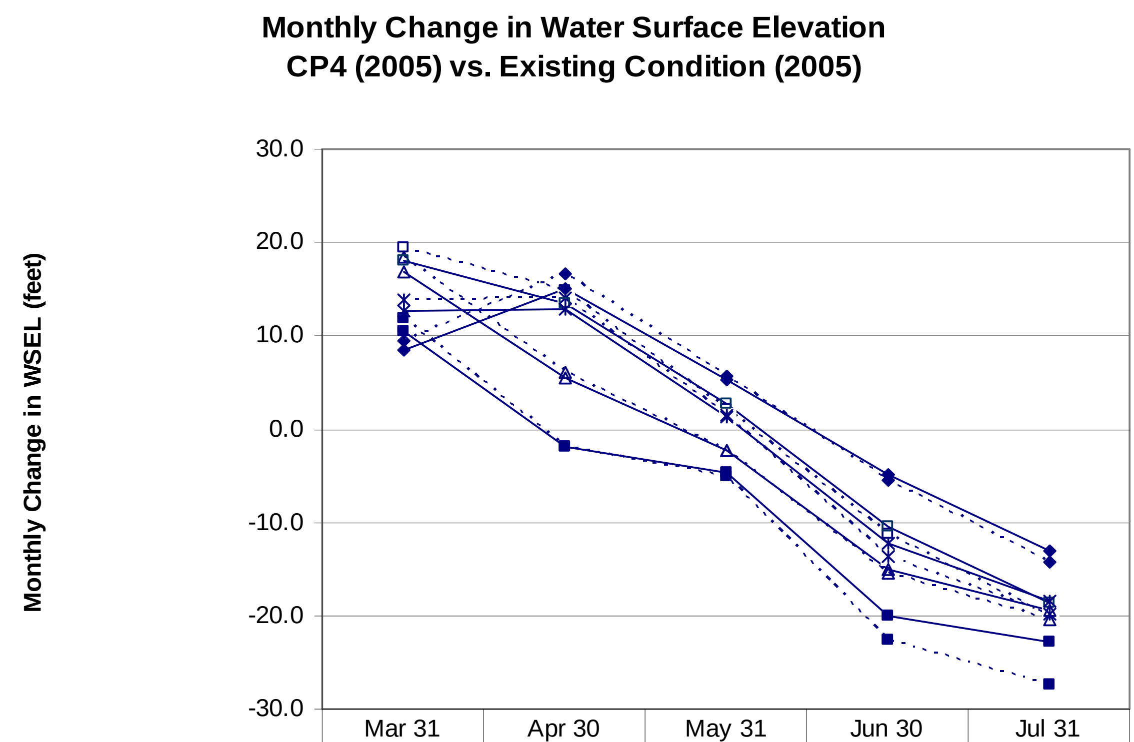
Increases in the overall surface area and WSEL under CP4 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations could contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water fish species. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-2 (CP4): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction This impact would be similar to CP3. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed

Impact Aqua-3 (CP4): Effects on Cold-Water Habitat in Shasta Lake Operations-related changes in the ratio of cold-water storage to surface area would affect the availability of suitable cold-water fisheries habitat in Shasta Lake, including rainbow trout. This impact would be beneficial.

This impact would be similar to Impact Aqua-3 (CP1, CP2, and CP3) but would be of lower magnitude than Aqua-1 (CP3) owing to its focus on increasing the volume of cold-water available to the TCD to benefit anadromous fish downstream from Shasta Dam.

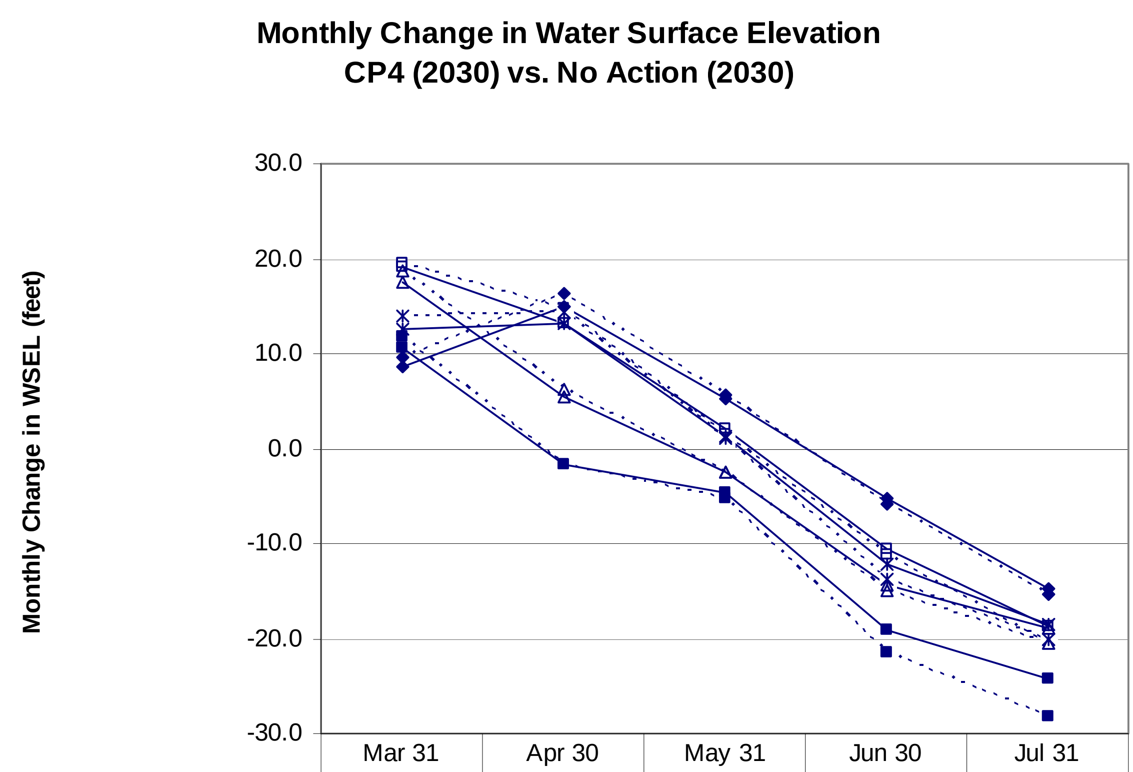
CalSim-II modeling shows that under CP4, with a 2030 water supply demand, the ratio of cold-water storage to surface area is higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occurred between June 30 and August 31, which is the critical holding and rearing period for cold-water fishes in reservoirs, and are greatest during critical water years (Figure 11-29). Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9.5	16.7	5.7	-5.6	-14.3
EC AN	19.5	14.9	2.1	-11.2	-20.1
EC BN	13.9	14.0	1.4	-13.6	-19.9
EC D	18.4	6.1	-2.3	-15.5	-20.5
EC C	11.8	-1.9	-5.0	-22.7	-27.5
CP4 (2005) W	8.5	15.1	5.3	-5.0	-13.1
CP4 (2005) AN	18.0	13.4	2.6	-10.5	-18.5
CP4 (2004) BN	12.6	12.9	1.3	-12.3	-18.5
CP4 (2005) D	16.8	5.4	-2.4	-15.0	-19.4
CP4 (2005) C	10.4	-1.9	-4.6	-20.0	-22.9

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

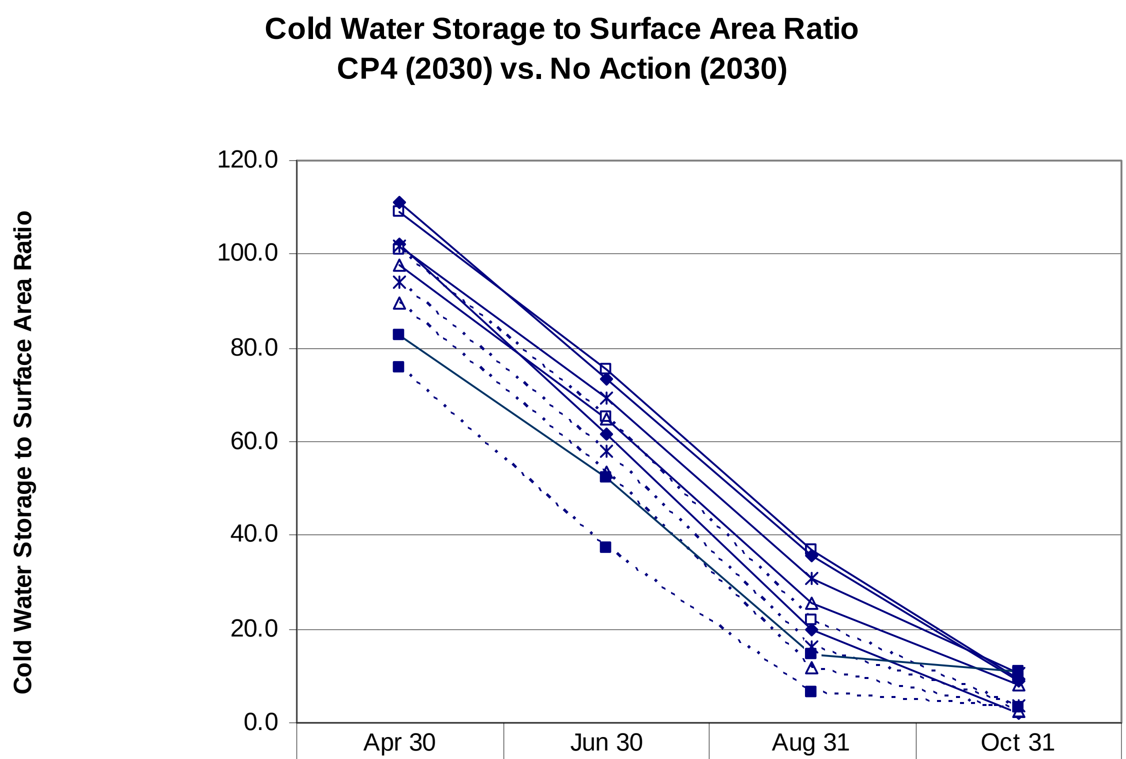
Figure 11-27. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 vs. Existing Condition (2005)



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	9.7	16.3	5.7	-5.8	-15.3
NA AN	19.4	14.7	1.5	-11.3	-20.5
NA BN	13.9	14.4	1.1	-13.8	-20.1
NA D	18.8	6.2	-2.4	-15.0	-20.5
NA C	11.9	-1.7	-5.3	-21.5	-28.3
CP4 (2030) W	8.7	14.9	5.3	-5.3	-14.8
CP4 (2030) AN	19.0	13.1	2.0	-10.6	-18.8
CP4 (2030) BN	12.7	13.2	1.3	-12.1	-18.5
CP4 (2030) D	17.5	5.4	-2.4	-14.3	-18.9
CP4 (2300) C	10.7	-1.7	-4.7	-19.1	-24.2

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-28. Monthly Change in WSEL for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 vs. No-Action Alternative



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	102.1	61.5	19.8	2.2
NA AN	100.9	65.2	21.8	3.1
NA BN	93.9	57.9	16.3	3.8
NA D	89.6	53.5	12.0	2.5
NA C	75.8	37.4	6.5	3.2
CP4 2030 W	111.1	73.4	35.6	9.0
CP4 2030 AN	109.1	75.3	36.8	9.5
CP4 2030 BN	101.7	69.5	30.7	10.4
CP4 2030 D	97.8	64.7	25.6	8.0
CP4 2030 C	82.9	52.2	14.7	10.8

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-29. Monthly Cold-water Storage to Surface Area Ratio for Each Water-Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 vs. Existing Condition

Impact Aqua-4 (CP4): Effects on Special-Status Aquatic Mollusks Under CP4, habitat for special-status mollusks could be inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP4): Effects on Special-Status Fish Species That Occupy Habitat Provided by Shasta Lake and Its Tributaries The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP4 could affect one species designated as sensitive by the USFS, the hardhead. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP4): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP4, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,090-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. However, based on digital topographic data and stream channel data generated from field inventories, there do not appear to be any substantial barriers between the 1,070-foot and 1,090-foot contours that would be inundated under this alternative. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP4): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP4 would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in the Sacramento River, McCloud River, Pit River, Big Backbone Creek, and Squaw Creek upstream from Shasta Lake. A total of 11 miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids would be affected by CP4, which is only about 2.8 percent of the low-gradient habitat upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-8 (CP4): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP4 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. About 24 miles of non-fish-bearing tributary habitat would be affected by CP4, which is only about 1 percent of the lengths of non-fish-bearing tributaries upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP4): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP4. There would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to RBDD)

Impact Aqua-10 (CP4): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Construction activities have the potential to increase sediments and turbidity, and release and exposure of contaminants. With environmental commitments in place, this would be a less than significant impact.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise. Additionally, CP4 also includes a 10-year gravel augmentation program as an additional environmental commitment. The placement of gravel along the Sacramento River channel and bank on an annual basis would result in an additional source of fine sediment being released and exposed to the river and aquatic communities. However, the gravel augmentation activities would only occur during pre-specified in-water work windows, which would minimize the potential for impacts associated with this activity.

Lastly, CP4 also includes riparian, floodplain, and side channel habitat restoration in the upper Sacramento River at Reading Island. The Reading Island riparian, floodplain, and side channel restoration could result in additional disturbed surfaces, but most of this construction is expected to occur away from the wetted channel, and all disturbed areas would be revegetated.

However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed. *Impact Aqua-11 (CP4): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities* Construction-related activities have the potential to result in the release and exposure of contaminants, resulting in adverse effects on aquatic habitats, the aquatic food web, and fish populations, including special-status species, within the primary study area downstream from project construction activities. This impact would be less than significant with all environmental commitments in place.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. Additionally, as discussed above, CP4 also includes a 10-year gravel augmentation program and restoration of riparian, floodplain, and side channel habitat as additional environmental commitments. Both of these construction activities could result in additional sources of equipment-related contaminants potentially being released and exposed to the river and aquatic communities. However, additional environmental commitments that call for in-water work windows and specific best management practices (BMP) would minimize and/or avoid the potential for impacts associated with this activity.

However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed *Impact Aqua-12 (CP4): Improved Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon* Project operation would result in improved flow and water temperature conditions in the upper Sacramento River for fish species of management concern. This impact would be beneficial.

Winter-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, overall average winter-run production for the 82-year period was greater under CP4 conditions relative to the No-Action Alternative and Existing Condition (Attachments 1A and 2A). The maximum increase in production relative to the No-Action Alternative was 233 percent, while the largest decrease in production under CP4 relative to the No-Action Alternative was less than 5 percent (Attachment 1A). The maximum increase in production relative to the Existing Condition was 233 percent in 1934 for CP4, while the largest decrease in production relative to the Existing Condition was 5 percent CP4 in 1976 (Attachment 2A).

All years with the lowest production over the simulation period show the largest increase in production under CP4 conditions.

Under CP4, critical water years 1924, 1931, 1933, 1934, 1977, 1988, and 1992, and dry water year 1932 had increases in production compared to the No-Action Alternative, ranging from 7 percent to 233 percent. No water years had a decrease in production compared with the No-Action Alternative greater than 5 percent.

Under CP4, critical water years 1924, 1931, 1933, 1934, 1977, 1988, 1992 and 1994 had substantial increases in production compared to the Existing Condition, ranging from 5 percent to 233 percent. Three dry (1932, 1944, and 1947) water years had increases over the Existing Condition ranging from 4 to 10 percent. No water years had a decrease in production greater than 5 percent relative to the Existing Condition.

When the spawning population equaled AFRP goal, the overall average winter-run Chinook salmon production was similar for CP4 relative to the No-Action Alternative (Attachment 3A). The maximum increase in production relative to the No-Action Alternative was 166 percent for CP4. The largest decrease in production relative to the No-Action Alternative was 15 percent for CP4. In all years, the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP4.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to winter-run Chinook salmon under CP4 occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-4 displays the overall mortalities for each Comprehensive Plan that were caused by nonoperational factors versus those caused by the operations (i.e., water temperature and flow) (Attachments 2B and 3B). Mortalities caused by the project decrease as the proposed dam height increases from 6.5 to 18.5 feet.

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, fry were the primary life stage affected, but operations-related activities had a greater effect on eggs than on presmolts and no effect on immature smolts. The same trends for each Comprehensive Plan were observed, with the bulk of the mortality affecting the fry and egg incubation life stages, and both water temperature and flow causing the mortality (Table 11-5).

In critical water years, mortality under CP4 conditions was dominated by forced movement of fry, then by superimposition and mortality to eggs due to unsuitable water temperatures. Attachments 1C and 2C contain tables of mortality to winter-run sorted by water-year type, and Table 11-6 outlines the ranks classified under each Comprehensive Plan for each water-year type.

In dry water years, mortality to fry when moving to new habitats was the primary cause of operations-related mortalities for CP4, followed by mortality to eggs due to redd superimposition. Third was the mortality to eggs due to redd scouring and/or dewatering, followed by mortality to presmolts while moving to new habitats.

Below-normal, above-normal, and wet water years also had the greatest number of winter-run Chinook salmon perish as fry caused by forced movement to habitat downstream, followed by mortality to eggs due to redd superimposition, then the loss of eggs from unsuitable water temperatures, and forced movement of presmolts to downstream habitats.

Under CP4, years with the highest mortality were 1924, 1932, 1934, 1963, 1970 and 1982, and included two critical water years, one dry water year, and three wet water years. These years were preceded by two critical, one dry, two below-normal, and one wet water year. Years with the lowest mortality varied between all water-year types. Years in which the project had the greatest impact on winter-run were also the years in which the lowest production occurred (Attachments 1C and 2C).

When the spawning population equaled the AFRP goal, winter-run Chinook salmon mortality caused by the operations-related activities decreased under CP4 compared to No-Action Alternative conditions. Under CP4, mortality caused by operations-related activities would decrease from non-operations related mortality by more than 12 percent. Under CP4, the greatest mortality to winter-run Chinook salmon occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives (Attachment 3B).

Because winter-run Chinook salmon have, overall, a reduced mortality, winter-run Chinook salmon would benefit from water temperature and flow conditions under in CP4. Additionally, winter-run Chinook salmon will likely benefit from the 10-year gravel augmentation program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, overall average spring-run Chinook salmon production increased for the 82-year period under CP4 compared to the No-Action Alternative and the Existing Condition (Attachments 4A and 5A). The maximum increase in production relative to the No-Action Alternative was 5,321 percent for CP4. The largest decrease in production relative to the No-Action Alternative was 9 percent for CP4 (Attachment 4A). The maximum increase in production relative to the Existing Condition was 5,586 percent for CP4. The largest decrease in production relative to the Existing Condition was 9 percent for CP4 (Attachment 5A).

Under CP4, critical water years 1924, 1931, 1933, 1934, 1977, 1988, 1991, 1992, and 1994, dry water years 1925, 1926 and 1932, below-normal water years 1935 and 1959, and above-normal water year 2000, had increases in production compared to the No-Action Alternative, ranging from 6 to 5,321 percent. In 1955 (dry water year, 1923 (below-normal water year) and 1969 and 1997 (wet water years), production decreased between 6 and 10 percent.

Under CP4, critical water years 1924, 1931, 1933, 1934, 1977, 1988, 1991, 1992, 1994, and 2001 had increases in production compared to the Existing Condition, ranging from 11 to 5,586 percent. Dry water years 1932 and 2002 resulted in substantial increases over the Existing Condition ranging between 8 and 3,081 percent. Two below-normal water years (1935 and 1959), and one above-normal water year (2000) had substantial increases relative to the Existing Condition, from 9 to 23 percent. One above-normal water years (1978), and two wet water years (1969, 1997) had decreases in production relative to the Existing Condition ranging from 5 to 9 percent.

The overall average spring-run Chinook salmon production was slightly higher for CP4 relative to the No-Action Alternative (Attachment 6A). The maximum increase in production relative to the No-Action Alternative was 10,446 percent for CP4. The largest decrease in production relative to the No-Action Alternative was 5 percent for CP4. Years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP4.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to spring-run Chinook salmon under CP4 occurred to the eggs, followed by presmolts, then fry. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-7 displays the overall mortalities for each Comprehensive Plan that were caused by nonoperational factors versus those caused by the operations (i.e., water temperature and flow) (Attachments 4B and 5B). Mortalities caused by the project decrease as the proposed dam height increases from 6.5 to 18.5 feet (Tables 11-7 and 11-8).

When removing nonoperations-related mortality, leaving mortality due to operations-related activities, only eggs and fry were affected (Table 11-8).

Critical water years under all Comprehensive Plans follow the same trends, with mortality to eggs due to unsuitable water temperatures as the primary cause of operations-related mortalities, followed by mortality to prespawned eggs and during incubation caused by dewatering the redds, then mortality to fry from forced movement to downstream habitats. Attachments 4C and 5C contains tables of mortality to spring-run Chinook salmon sorted by water-year type, and Table 11-9 outlines the rankings classified under each Comprehensive Plan for each water-year type.

In dry, below-normal and above-normal water years, all Comprehensive Plans were dominated by egg temperature mortality, followed by mortality resulting from redd dewatering. Mortality to prespawned eggs occurred in only two dry years but no below-normal water years. Mortality to fry from forced movement was relatively low in only several more years (Table 11-9).

In wet water years, the primary cause of mortality to spring-run Chinook salmon were to eggs due to redd dewatering and/or scouring, followed by mortality to eggs due to unsuitable water temperatures, then to fry resulting from forced movement and prespawn mortality (Table 11-9).

Years with the highest operations-related mortality were the same for all the Comprehensive Plans: 1924, 1931, 1932, 1933, 1934, 1977, and 1992. Except for 1932 (a dry water year), each of these years was a critical water-year type and was preceded by either a below, dry, or (predominantly) a critical water year. However, years with the lowest mortality varied between all water-year types. Years in which the project had the greatest impact on spring-run Chinook salmon were also the years in which the lowest production occurred, with nearly all of the mortality occurring in the egg incubation life stage (Attachments 4C and 5C).

When the spawning population equaled AFRP goals, spring-run Chinook salmon mortality caused by the operations-related activities decreased under CP4 compared to No-Action Alternative conditions. Under CP4, mortality caused by operations-related activities would decrease from non-operations related mortality by over 43 percent. Under CP4, the greatest mortality to spring-run occurs to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives (Attachment 6B).

Because spring-run Chinook salmon have, overall, a reduced mortality, spring-run Chinook salmon would benefit from actions taken in CP4. Additionally, spring-run Chinook salmon will benefit from the 10-year gravel augmentation program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

<u>Production</u>

Based on the 1999 through 2006 population average, overall average fall-run Chinook salmon production increased for the 82-year period compared with the No-Action Alternative and Existing Condition (Attachments 7A and 8A). The maximum increase in production relative to the No-Action Alternative was 350 percent. The largest decrease in production relative to the No-Action Alternative was 9 percent for CP4 (Attachment 7A). The maximum increase in production relative to the Existing Condition was 607 percent in 1934. The largest decrease in production relative to the Existing Condition was 11 percent for CP4 in 1969 (Attachment 8A).

In critical, dry, and below-normal water years, when production was lowest over the simulation period, the increase in production resulting from operations-related activities was greatest. In above-normal and wet water years, however, the lowest production years typically had a slight decrease in production under CP1 conditions relative to the No-Action Alternative.

Under CP4, critical water years 1924, 1931, 1933, 1934, 1977, 1992, and 1994, dry water year 1932, and below-normal water years 1937 and 1945 had increases in production relative to the No-Action Alternative, ranging from 6 to 351 percent. A wet water year (1999) had a production decrease of approximately 10 percent.

Under CP4, six critical water years (1924, 1931, 1933, 1934, 1977, 1992) had increases in production relative to the Existing Condition, ranging from 10 to 607 percent. Two dry water years, 1932 and 1955, had a 16 and 5 percent increase in production compared to the Existing Condition, respectively. Two below-normal water years, 1937 and 1945, had an increase in production relative to the Existing Condition of 9 and 7 percent, respectively. One dry water year (1985), one above-normal water year (1957) and two wet water years (1969 and 1999), resulted in a decrease in production relative to the Existing Condition, ranging from 5 to 11 percent.

When the spawning population equaled the AFRP goal, overall average fall-run Chinook salmon production was similar for CP4 relative to the No-Action Alternative (Attachment 9A). The maximum increase in production relative to the No-Action Alternative was 310 percent for CP4. The largest decrease in production relative to the No-Action Alternative was 9 percent for CP4. In critical, dry, and below-normal water years, years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP4. In above-normal and wet water years, however, the lowest production years typically remained similar or slightly decreased in production under CP4 conditions relative to the No-Action Alternative.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to fall-run Chinook salmon occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-10 displays the overall mortalities for each alternative that were caused by nonoperational factors versus those caused by operations (i.e., water temperature and flow) (Attachments 7B and 8B).

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, egg incubation was still the primary life stage affected, but operations-related activities had a greater effect on fry than on presmolts and an even lesser effect on immature smolts. The same trends for each Comprehensive Plan were observed, with the bulk of the mortality affecting the egg incubation life stage, with flow triggering more of the mortality (Table 11-11).

In all water-year types, under all Comprehensive Plans, the greatest portion of mortality occurred to fry caused by forced movement to downstream habitats. Prespawn, incubation, and superimposition mortality were greater than mortality to eggs caused by unsuitable water temperatures and presmolt habitat movement.

In critical water years, all Comprehensive Plans showed the same general trend in mortality factors. Mortality to fry due to forced movement downstream was the primary cause of operations-related mortalities for the No-Action Alternative and CP4, followed by mortality to eggs prior to spawning, and then to eggs from redd dewatering or scouring. Least affected were presmolts and then immature smolts by both water temperatures and forced movement.

Attachments 7C and 8C contain tables of mortality to fall-run Chinook salmon sorted by water-year type, and Table 11-12 outlines the rankings classified under each Comprehensive Plan for each water-year type.

As with critical water years, dry water years were dominated by mortality to fry due to forced movement downstream, followed by redd dewatering or scouring and redd superimposition. Additional mortality occurred to fall-run Chinook salmon presmolts and immature smolts from both forced movement and unsuitable water temperatures (Table 11-12).

Below-normal and above-normal water years were relatively similar for all Comprehensive Plans. The mortality factors were dominated by mortality to fry due to forced movement downstream, followed by redd superimposition, dewatering, or scouring. Mortality to presmolts caused by forced downstream movement was a greater factor affecting fall-run populations than was egg mortality caused by unsuitable water temperatures or to immature smolts and fry due to unsuitable water temperatures (Table 11-12).

As with the water-year types discussed above, under wet water year conditions, the majority of the mortality also occurred to fry due to forced downstream movement, followed by redd superimposition, and redd dewatering or scouring. Mortality to presmolts and immature smolts from downstream movement had the lowest mortality rates resulting from operations-related activities. Least affected were eggs due to unsuitable water temperatures, both pre- and post-spawn.

Under conditions created by CP4 compared with the No-Action Alternative, the years with the highest mortality tended to shift to all wet water years – 1956, 1958, 1970, 1978, and 1984 – which were preceded by wet, above-normal and dry water years (Attachment 7C).

Under conditions created by CP4 compared with the Existing Condition, the years with the highest mortality rates were 1955, 1957, 1969, 1973, 1981,1983, and 1996 (Attachment 8C).

When the spawning population equaled the AFRP goal, fall-run Chinook salmon mortality caused by operations-related activities decreased under CP4 compared to No-Action Alternative conditions (Attachment 9B). Under CP4, mortality caused by operations-related activities would decrease from non-operations related mortality by over 17 percent. Under CP4, the greatest mortality to fall-run occurred to the egg incubation life stage, followed by fry, then presmolts, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives.

Because fall-run Chinook salmon have, overall, a reduced mortality, fall-run Chinook salmon would benefit from actions taken in CP4. Additionally, fall-run Chinook salmon will benefit from the 10-year gravel augmentation program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

Production

Based on the 1999 through 2006 population average, overall average late fall-run Chinook salmon production for the 82-year period under CP4 conditions was slightly greater than the No-Action Alternative and the Existing Condition (Attachments 10A and 11A). The maximum increase in production relative to the No-Action Alternative was 27 percent, while the largest decrease in production relative to the No-Action Alternative was 6 percent for CP4 (Attachment 10A). The maximum increase in production relative to the Existing Condition was 28 percent, while the largest decrease in production relative to the Existing Condition was 7 percent for CP4 (Attachment 11A).

Under CP4, critical water years 1924, 1929, 1931, 1933, 1976, and 1991, dry water years 1930 and 1932, and below-normal water year 1923 had increases in production compared to the No-Action Alternative, ranging from 6 to 28 percent. No water years had a decrease greater than 5 percent.

Under CP4, five critical water years (1931, 1933, 1976, 1988, and 1991) had substantial increases in production compared to the Existing Condition, ranging from 5 to 28 percent. Five dry water years (1926, 1930, 1932, 1939, and 1985), and one below-normal water year (1923), had increases in production relative to the Existing Condition, ranging from 5 to 19 percent. One wet water year (1969) and one dry water year (1949) had a decrease in production over the Existing Condition by 5 percent to 7 percent.

When the spawning population equaled the AFRP goal, overall average late fall-run Chinook salmon production was similar for CP4 relative to the No-Action Alternative (Attachment 12A). The maximum increase in production relative to the No-Action Alternative was 28 percent for CP4. The largest decrease in production relative to the No-Action Alternative was 3 percent for CP4. In critical, dry, and below-normal water years, years with the lowest production under the No-Action Alternative typically had the greatest percent increase in production under CP4. In above-normal and wet water years, however, the lowest production years typically remained similar to, or had a slight decrease in production under CP4 conditions relative to the No-Action Alternative.

Mortality

Based on the 1999 through 2006 population average, the greatest mortality to late fall-run Chinook salmon under CP4 occurred to the egg incubation life stage, followed by fry, then presmolts, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-13 displays the overall mortalities for each Comprehensive Plan that was caused by nonoperational factors versus those caused by the operations (i.e., water temperature and flow) (Attachments 10B and 11B). Mortalities caused by the project decreased for all Comprehensive Plans relative to the No-Action Alternative.

When removing nonoperations-related mortality, allowing comparison of mortality for operations-related activities only, fry became the primary life stage affected, and operations-related activities had a greater effect on eggs than on presmolts and even less effect on immature smolts. Most of the mortality occurred as a result of flow conditions rather than water temperature (Table 11-14).

Under all Comprehensive Plans, mortality to fry resulting from unsuitable water temperatures only occurred at low levels to late fall-run Chinook salmon during critical, dry, and below-normal water years. In all water-year types, under all Comprehensive Plans, mortality to fry during forced movement to downstream habitats was the primary cause of operations-related mortality.

In critical, dry and below-normal water years, the causes of operations-related mortality followed similar trends for all Comprehensive Plans, with a few exceptions. In general, the effects of flow (and density) had the greatest effect on mortality. Forced movement of fry resulted in the greatest mortality, followed by flow effects on eggs via scouring, dewatering, or superimposition. Next affected were presmolts and immature smolts, by unsuitable water temperatures, and lastly temperature effects on eggs and flow effects on presmolts and immature smolts and fry (Table 11-15).

Wet and above-normal water years were overall similar to critical, dry, and below-normal water years except that mortality to fry due to unsuitable water temperatures disappeared and CP4 in wet years had no mortality due to redd scouring and/or dewatering.

Years with the highest mortality were the same for CP4 and the No-Action Alternative and the Existing Condition: 1937, 1957, 1982, 1985, 1994 and 1997. All water-year types were covered. Three of these with the highest mortality years were preceded by a wet water year, one preceded by an above-normal water year, and at least one below-normal water year (Attachments 10C and 11C).

When the spawning population equaled the AFRP goal, late fall-run Chinook salmon mortality caused by operations-related activities was slightly less under CP4 than under No-Action Alternative conditions. Under CP4, mortality caused by operations-related activities would decrease from non-operations related mortality by over 28 percent. Under CP4, the greatest mortality to late fall-run Chinook salmon occurred to the egg incubation life stage, followed by presmolts, then fry, and lastly to immature smolts. Nonoperational conditions were the primary causes of mortality for all life stages under all alternatives (Attachment 12B).

Because late fall-run Chinook salmon have, overall, a reduced mortality, late fall-run Chinook salmon would benefit from actions taken in CP4. Additionally, late fall-run Chinook salmon will benefit from the 10-year gravel augmentation program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP4): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass CP4 operations would result in slightly improved flow and, sometimes, improved water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass, particularly in critical water years. Overall, potential flow changes resulting from the implementation of CP4 would not be of sufficient frequency or magnitude to beneficially or adversely affect steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass, in the upper Sacramento River. However, potential water temperature changes (reductions) resulting from the implementation of CP4 would result in beneficial impacts on steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass in the upper Sacramento River especially during critical water years. Flow- and water temperature-related effects on these fish species would be less than significant (flow) and beneficial (water temperature), relative to the Existing Condition and No-Action Alternative. The benefits of the water temperature decrease outweigh the minimal effects of flow changes. Therefore, this impact would be beneficial.

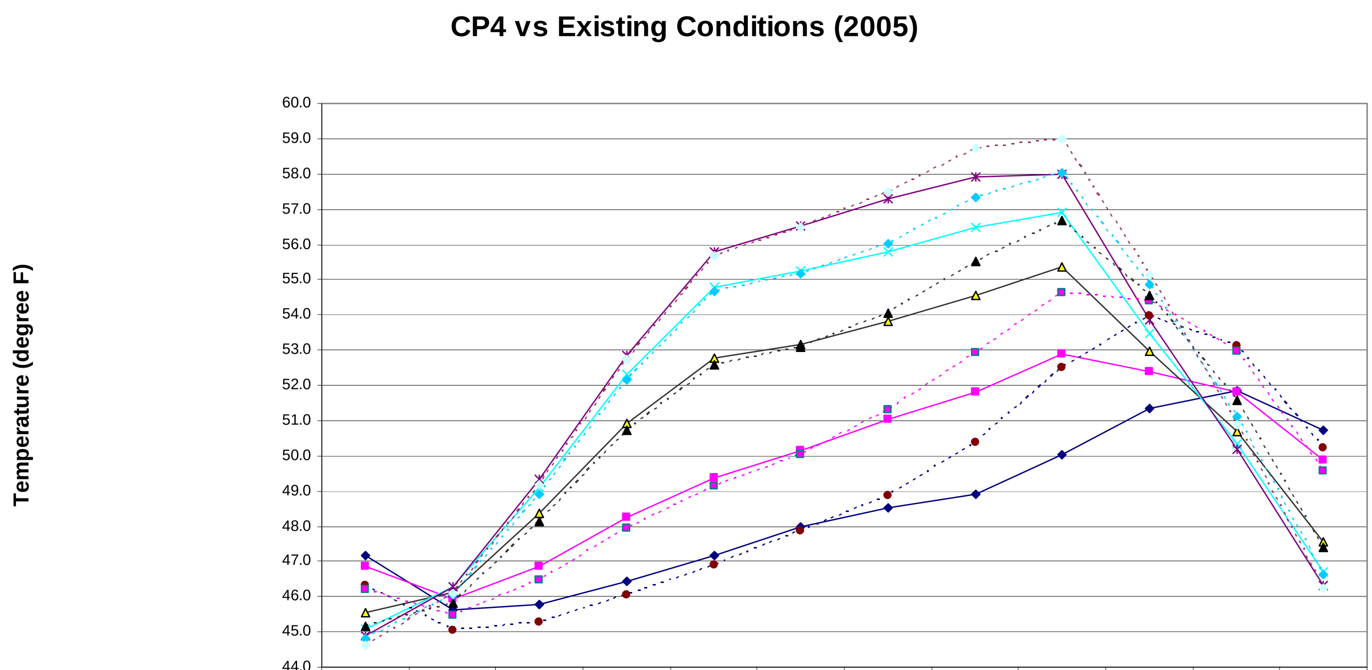
This impact would be similar to Impact Aqua-13 (CP1); however, the impact could be greater (beneficial) during certain years because of the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise and the additional volume of cold-water that would be available for anadromous fish.

Flow-Related Effects Similar to CP1, monthly mean flows at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP4 would be similar to flows (less than 4 percent) under the Existing Condition and No-Action Alternative simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). Potential flow-related effects on fish species of management concern in the upper Sacramento River from this alternative would be minimal. All potential changes in flows and stages would diminish rapidly downstream from RBDD because of the increasing effect of inflows from tributaries, and of diversions and flood bypasses.

There would be no discernable flow-related effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River related to changes in monthly mean flows under CP4, relative to the Existing Condition and No-Action Alternative. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Flow-related effects on these fish species would be less than significant.

Water Temperature-Related Effects Similar to CP1, monthly mean water temperatures at all model locations (i.e., below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBDD) within the upper Sacramento River under CP4 would be slightly less than those under the Existing Condition and No-Action Alternative conditions simulated for all months (Figures 11-30 and 11-31) (see also the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). As discussed above, modeling simulations may not fully account for real-time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some varying degree. During most years, flow releases from Shasta Dam would be unchanged. On average, the greatest cooling effect (more than a 4°F reduction) occurred during critical years and during the late summer (i.e., July through September) (Figures 11-32 and 11-33), because of the increased cold-water pool volume within Shasta Lake, even following an extended dry period. All potential changes in flows and stages would diminish rapidly downstream from RBDD because of the increasing effect of inflows from tributaries, and of diversions and flood bypasses.

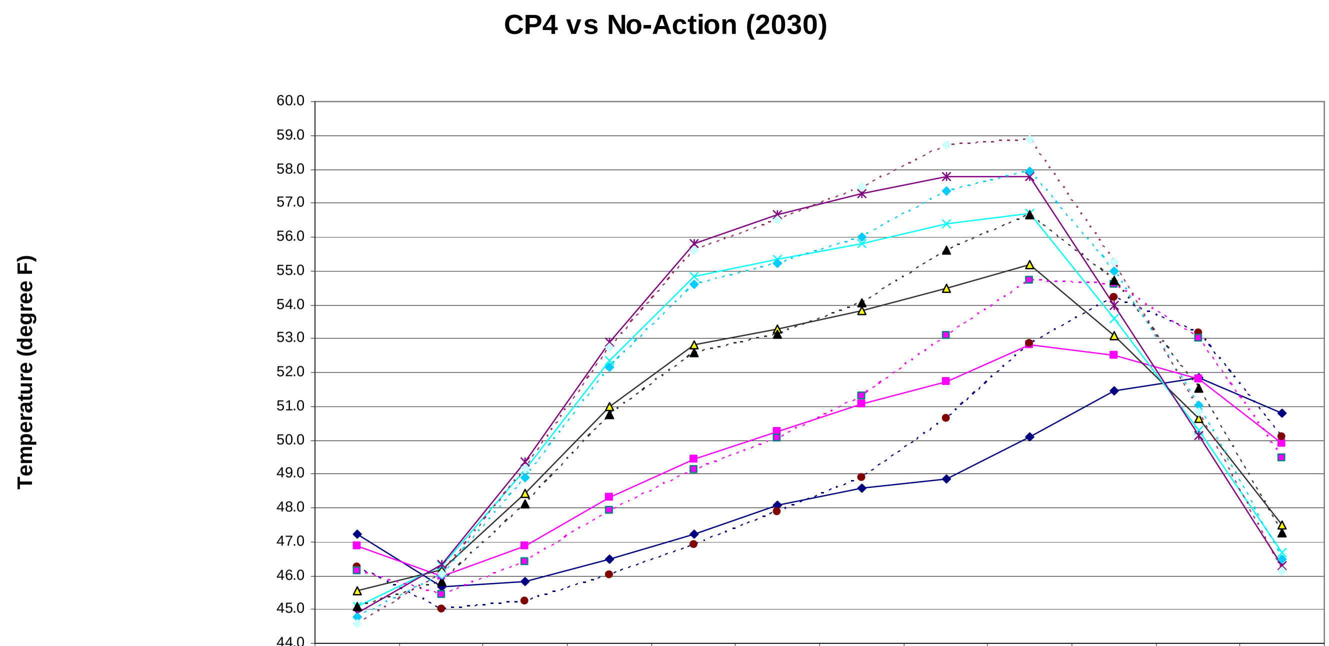
There would be water temperature-related effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River related to cooler monthly mean water temperatures under CP4, relative to the Existing Condition and No-Action Alternative. Mean monthly water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River, and would actually create more suitable conditions. Water temperature-related effects on these fish species would be beneficial. Mitigation for this impact is not needed, and thus not proposed.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP4_Below Shasta	47.2	45.6	45.8	46.4	47.2	48.0	48.5	48.9	50.0	51.3	51.8	50.7
CP4_Below Keswick	46.8	45.9	46.9	48.2	49.4	50.2	51.0	51.8	52.9	52.4	51.8	49.9
CP4_Balls Ferry	45.5	46.1	48.4	50.9	52.8	53.2	53.8	54.6	55.3	53.0	50.7	47.5
CP4_Bend Bridge	45.1	46.3	49.1	52.3	54.8	55.2	55.8	56.5	56.9	53.5	50.3	46.7
CP4_RBDD	44.9	46.3	49.3	52.9	55.8	56.5	57.3	57.9	58.0	53.9	50.2	46.3
EC_SHASTA DAM	46.3	45.1	45.3	46.0	46.9	47.9	48.9	50.4	52.5	54.0	53.1	50.2
EC_Keswick	46.2	45.5	46.5	47.9	49.2	50.0	51.3	52.9	54.6	54.4	53.0	49.6
EC_Balls Ferry	45.2	45.8	48.1	50.7	52.6	53.1	54.1	55.5	56.7	54.6	51.6	47.4
EC_Bend Bridge	44.8	46.0	48.9	52.1	54.7	55.2	56.0	57.3	58.0	54.9	51.1	46.6
EC_RBDD	44.6	46.1	49.2	52.7	55.7	56.5	57.5	58.7	59.0	55.1	50.9	46.2

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBDD = Red Bluff Diversion Dam

Figure 11-30. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (Existing Condition)

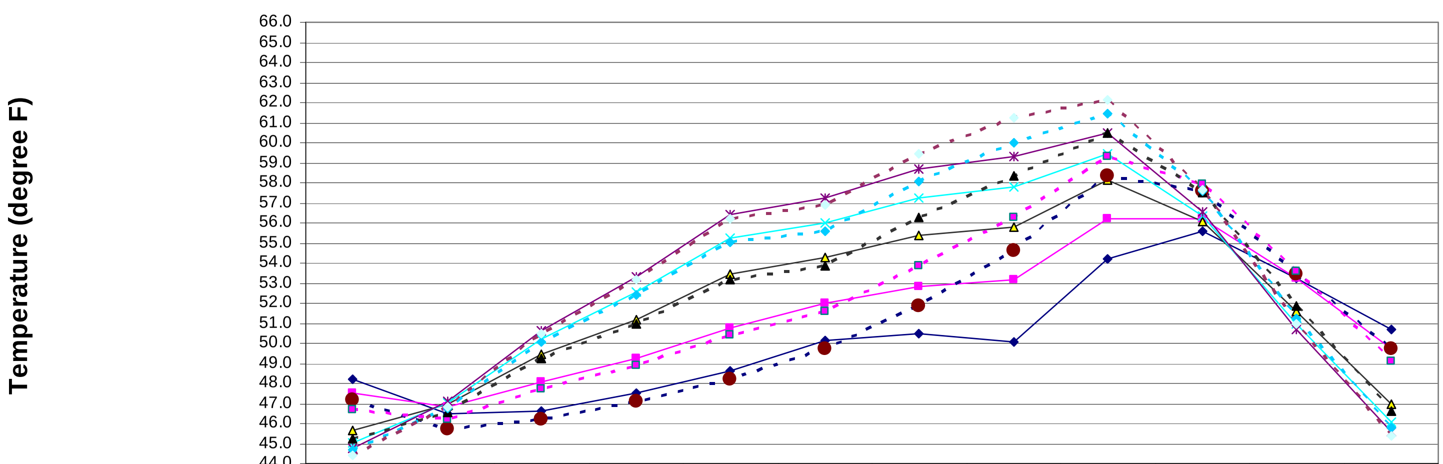


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP4_Below Shasta	47.2	45.7	45.8	46.5	47.2	48.1	48.6	48.9	50.1	51.5	51.9	50.8
CP4_Below Keswick	46.9	46.0	46.9	48.3	49.4	50.2	51.1	51.7	52.8	52.5	51.8	49.9
CP4_Balls Ferry	45.5	46.2	48.4	51.0	52.8	53.3	53.8	54.5	55.2	53.1	50.7	47.5
CP4_Bend Bridge	45.1	46.3	49.1	52.3	54.8	55.3	55.8	56.4	56.7	53.6	50.3	46.7
CP4_RBDD	44.9	46.3	49.4	52.9	55.8	56.6	57.3	57.8	57.8	54.0	50.1	46.3
EC_SHASTA DAM	46.2	45.0	45.2	46.0	46.9	47.9	48.9	50.7	52.8	54.2	53.2	50.1
EC_Keswick	46.1	45.4	46.4	47.9	49.1	50.0	51.3	53.1	54.7	54.6	53.0	49.5
EC_Balls Ferry	45.1	45.8	48.1	50.7	52.6	53.1	54.0	55.6	56.7	54.7	51.5	47.3
EC_Bend Bridge	44.8	46.0	48.9	52.2	54.6	55.2	56.0	57.4	57.9	55.0	51.0	46.5
EC_RBDD	44.6	46.1	49.2	52.7	55.6	56.5	57.5	58.7	58.9	55.3	50.8	46.1

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBDD = Red Bluff Diversion Dam

Figure 11-31. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (No-Action Alternative)

CRITICAL YEARS - CP4 vs. Existing Conditions (2005)

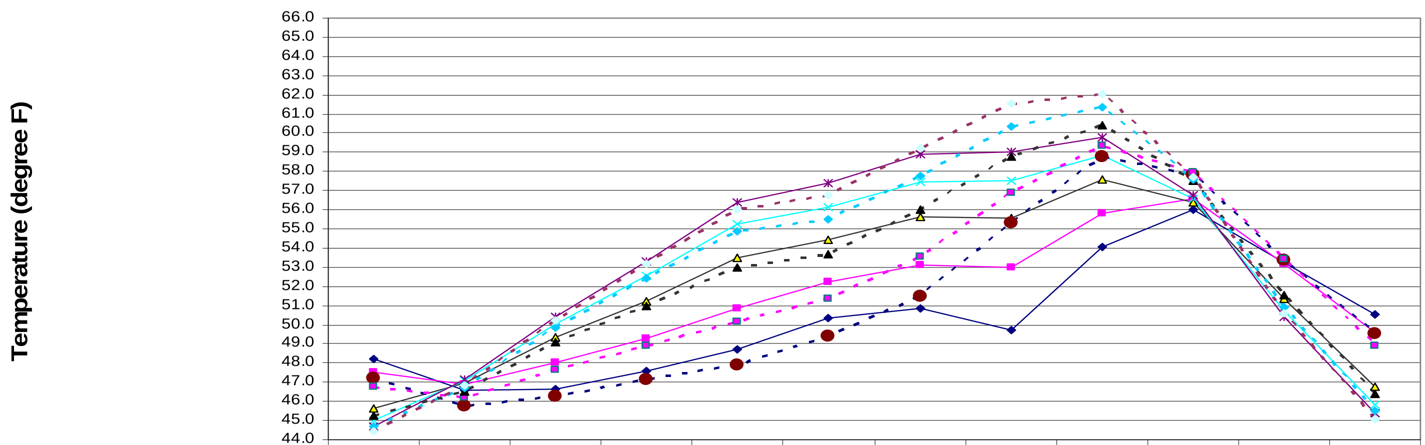


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP4_Below Shasta	48.2	46.5	46.6	47.5	48.6	50.1	50.5	50.1	54.2	55.6	53.2	50.7
CP4_Below Keswick	47.5	46.8	48.1	49.2	50.8	52.0	52.9	53.2	56.2	56.2	53.2	49.7
CP4_Balls Ferry	45.7	47.0	49.5	51.2	53.5	54.3	55.4	55.8	58.2	56.1	51.6	46.9
CP4_Bend Bridge	45.1	47.1	50.2	52.6	55.3	56.0	57.2	57.8	59.5	56.3	51.0	46.0
CP4_RBDD	44.7	47.1	50.6	53.3	56.4	57.2	58.7	59.3	60.5	56.6	50.7	45.6
EC_SHASTA DAM	47.2	45.8	46.2	47.1	48.2	49.7	51.9	54.6	58.4	57.6	53.4	49.7
EC_Keswick	46.7	46.2	47.7	48.9	50.4	51.6	53.9	56.2	59.3	57.9	53.6	49.1
EC_Balls Ferry	45.2	46.6	49.2	51.0	53.2	53.9	56.3	58.3	60.5	57.5	51.9	46.6
EC_Bend Bridge	44.7	46.7	50.1	52.4	55.1	55.6	58.0	60.0	61.4	57.6	51.3	45.8
EC_RBDD	44.4	46.8	50.5	53.2	56.2	56.9	59.4	61.3	62.2	57.7	51.0	45.4

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBDD = Red Bluff Diversion Dam

Figure 11-32. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area for Critical Years (Existing Condition)

CRITICAL YEARS - CP4 vs No-Action (2030)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
CP4_Below Shasta	48.2	46.6	46.7	47.6	48.7	50.3	50.9	49.7	54.1	56.0	53.2	50.5
CP4_Below Keswick	47.5	46.9	48.0	49.3	50.9	52.2	53.1	53.0	55.8	56.6	53.2	49.6
CP4_Balls Ferry	45.6	47.0	49.3	51.2	53.5	54.4	55.6	55.6	57.6	56.4	51.3	46.8
CP4_Bend Bridge	45.0	47.1	50.0	52.6	55.3	56.1	57.5	57.5	58.9	56.6	50.7	45.8
CP4_RBDD	44.7	47.1	50.4	53.3	56.4	57.4	58.9	59.0	59.8	56.8	50.4	45.4
NA_SHASTA DAM	47.2	45.7	46.2	47.1	47.9	49.4	51.5	55.3	58.8	57.8	53.3	49.5
NA_Keswick	46.8	46.2	47.6	48.9	50.2	51.4	53.6	56.9	59.3	58.0	53.4	48.9
NA_Balls Ferry	45.2	46.5	49.1	51.0	53.0	53.7	56.0	58.8	60.4	57.5	51.5	46.4
NA_Bend Bridge	44.7	46.7	49.9	52.4	54.8	55.5	57.8	60.3	61.3	57.6	50.9	45.5
NA_RBDD	44.4	46.8	50.2	53.2	56.0	56.8	59.2	61.5	62.0	57.7	50.6	45.1

Key:
EC = Existing Condition
CP = Comprehensive Plan
RBDD = Red Bluff Diversion Dam

Figure 11-33. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area for Critical Years (No-Action Alternative)

Impact Aqua-14 (CP4): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows CP4 operations could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large floods providing the energy required to mobilize sediment from the river bed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. CP4 operations could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

CP4 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

These effects would likely occur along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. As discussed above, CP4 also includes a 10-year gravel augmentation program and the restoration of riparian, floodplain, and side channel habitat at Reading Island as additional environmental commitments. The placement of gravel along the Sacramento River channel and bank on an annual basis and restoration of riparian, floodplain, and side channel habitat at Reading Island would result in ecological process (e.g., sediment transport and deposition, floodplain inundation) benefits that would partially offset the impacts described above. Nevertheless, reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. These impacts would be potentially significant within the primary study area. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Delta

Impact Aqua-15 (CP4): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernable change in mean monthly flow or water temperature conditions in the lower Sacramento River; however, predicted changes in flow in the Feather River, American River, and Trinity River could result in an adverse effect on Chinook salmon, steelhead, coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass if they were to occur. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and increased cold-water pool) to be stored behind the raised dam.

Similar to CP1, monthly mean flows at model locations (i.e., Verona, Freeport) within the lower Sacramento River under CP4 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). All potential changes in flows diminish rapidly downstream from RBDD because of the increasing effect of inflows from tributaries and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the lower Sacramento River from this alternative would be minimal. Differences in mean monthly flow are generally small (less than 2 percent) and within the existing range of variability. All potential changes in water temperatures in the lower Sacramento River due to small changes in releases would diminish rapidly downstream because of the increasing effects of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts on fish species in the lower Sacramento River would be less than significant.

Also similar to CP1, monthly mean flows at all model locations within the lower Feather River, the American River, and Trinity River under CP4 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for most months. However, there were several months within the modeling record that showed substantial changes (based on model simulations) to flows in tributaries (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). All potential changes in flows could be diminished in these areas per existing operational rules and because of operation of upstream reservoirs (i.e., Lake Oroville, Folsom Lake, and Trinity Lake), and increasing effects of inflows from tributaries, and of diversions and flood bypasses. Nevertheless, based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts on species of management concern in the American, Feather, and Trinity rivers could occur and would be a potentially significant impact.

Monthly mean flows at all model locations within the lower Feather River (i.e., below Thermalito Afterbay) and the American River (i.e., near the H Street Bridge in Sacramento) under CP4 would also be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for all months. All potential changes in flows were diminished in these areas because of operation of upstream CVP and SWP reservoirs (i.e., Lake Oroville and Folsom Lake), and the increasing effect of inflows from tributaries, and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the Feather River and American River from this alternative would be minimal and within the range of existing variability.

All potential changes in water temperatures in the lower Sacramento River and primary tributaries (i.e., Feather and American rivers) due to altered releases from reservoirs diminished downstream from RBDD because of increasing effect of inflows, and atmospheric and groundwater influences.

As under CP1, effects of altered flow regimes resulting from implementation of CP4 are unlikely to extend into the lower Sacramento River and Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the SWP and the CVP). The guidelines for this management, which are described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with the OCAP to allow coverage by the OCAP permits and BOs. Thus, under CP4, this project is not anticipated to cause an alteration in flow to the Delta nor cause an alteration to water temperatures in the lower Sacramento River and primary tributaries within the extended study area sufficient to cause discernable effects on Chinook salmon steelhead, green sturgeon, Sacramento splittail, American Shad, or striped bass relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and temperature-related effects on these fish species would be less than significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP4): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows   CP4 operations could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the lower Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large floods providing the energy required to mobilize sediment from the bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

CP4 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along the upper reaches of the lower Sacramento River. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. These impacts would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP4): Effects to Delta Fishery Habitat Resulting from Changes to Delta Outflow Delta outflow conditions under CP4 would be the same as those under CP1. Therefore, CP4 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-18 (CP4): Effects to Delta Fishery Habitat Resulting from Changes to Delta Inflow Changes in upstream reservoir storage have the potential to affect Delta inflow. Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. Delta inflow conditions under CP4 would be the same as those under CP1; therefore, CP4 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta compared with the Existing Condition and No-Action Alternative. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-19 (CP4): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow CP4 operations would be the same as those under CP1 and would result in a variable response in Sacramento River flow, in turn, resulting in both increases and decreases in river flow above the Existing Condition and No-Action Alternative depending on month and water-year type. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-20 (CP4): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP4 operation would be the same as under CP1 and would result in no discernable change in San Joaquin River flows at Vernalis. Therefore, CP4 would have no effect on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta relative to either the No-Action Alternative of Existing Condition. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-21 (CP4): Reduction in Low Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location CP4 operations, the same as CP1 operations, would result in a less than 0.5 km movement upstream or downstream from the X2 location. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-22 (CP4): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers CP4 operations, the same as CP1 operations, would result in an increase of reverse flows in Old and Middle rivers. The increase in reverse flows would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses. This impact would be potentially significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

Impact Aqua-23 (CP4): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP4 operations, which are the same as CP1 operations, may result in an increase of CVP and SWP exports, which is assumed to result in a direct proportional increase or decrease in the risk of fish being entrained and salvaged at the facilities. This is considered a less than significant impact to Chinook salmon, steelhead, and longfin smelt. This is considered a potentially significant impact to delta smelt, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

CVP/SWP Service Areas

Impact Aqua-24 (CP4): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes CP4 implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats that provide habitat for the fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-33 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP4 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and resulting downstream flows, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream flows. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP5 – 18.5-Foot Dam Raise, Combination Plan

CP5 focuses primarily on increased water supply reliability, Shasta Lake-area environmental resources, and increased recreation opportunities. Major components of this plan include the following:

- Raising Shasta Dam and appurtenant facilities by 18.5 feet.
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek.
- Constructing shoreline fish habitat around Shasta Lake.
- Improving operation and enhancing recreation facilities at various locations around Shasta Lake.
- Enlarging the Shasta Lake cold-water pool.
- Modifying the TCD.
- Increasing conservation storage.

- Reducing demand.
- Modifying flood operations.
- Increasing public safety at Shasta Dam.
- Modifying hydropower facilities.

The additional storage created by the 18.5-foot dam raise would be used primarily to increase water supply reliability, while also improving the ability to meet temperature objectives for winter-run Chinook salmon during drought years. The capacity of the reservoir would increase by 634,000 acre-feet to a total of 5.19 million acre-feet, and the existing TCD would be extended to achieve efficient use of the expanded reservoir.

CP5 includes restoring resident fish habitat in Shasta Lake and fisheries and riparian habitat at several locations along the lower reaches of the upper Sacramento River, McCloud River, and Squaw Creek. Specific locations and total area of restoration in the Shasta Lake area will be the subject of future studies.

Shasta Lake and Vicinity

Impact Aqua-1 (CP5): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP5, this impact would be similar to CP3. Its impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-2 (CP5): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction This impact would be similar to CP3. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-3 (CP5): Effects on Cold-Water Habitat in Shasta Lake Under CP5, operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

This impact would be similar to CP3 and would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-4 (CP5): Effects on Special-Status Aquatic Mollusks Under CP5, habitat for special-status mollusks could be inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be potentially significant.

This impact would be similar to CP3 and would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP5): Effects on Special-Status Fish Species That Occupy Habitat Provided by Shasta Lake and its Tributaries The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP5 could affect one species designated as sensitive by the USFS, the hardhead. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant.

This impact would be similar to Impact Aqua-5 (CP3) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP5): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP5, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,090-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. However, based on digital topographic data and stream channel data generated from field inventories, it appears no substantial barriers between the 1,070-foot and 1,090-foot contours would be inundated under this alternative. This impact would be less than significant.

This impact would be similar to Impact Aqua-6 (CP3) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP5): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP5 would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in low-gradient tributaries to Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. A total of 11 miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids would be affected by CP5, which is only about 2.8 percent of the low-gradient habitat upstream from Shasta Lake. This impact would be less than significant.

This impact would be similar to CP3 and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-8 (CP5): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP5 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. About 24 miles of non-fish-bearing tributary habitat would be affected by CP5, which is only about 1 percent of the total length of non-fish-bearing tributaries upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the FEIS. This impact would be less than significant.

This impact would be similar to Impact Aqua-8 (CP3) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP5): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP5. There would be no impact.

This impact would be similar to Impact Aqua-9 (CP1), and there would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to RBDD)

Impact Aqua-10 (CP5): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Construction activities have the potential to increase sediments and turbidity, and release and exposure of contaminants. With environmental commitments in place, this would be a less than significant impact

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise. Similar to CP4, CP5 also includes a 10-year gravel augmentation program as an additional environmental commitment. The placement of gravel along the Sacramento River channel and bank on an annual basis would result in an additional source of fine sediment being released and exposed to the river and aquatic communities. However, the gravel augmentation activities would only occur during pre-specified in-water work windows, which would minimize the potential for impacts associated with this activity.

Also similar to CP4, CP5 also includes a riparian, floodplain, and side channel habitat restoration in the upper Sacramento River at Reading Island. The Reading Island riparian, floodplain, and side channel restoration could result in additional disturbed surfaces, but most of this construction is expected to occur away from the wetted channel, and all disturbed areas would be revegetated.

However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed. *Impact Aqua-11 (CP5): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities* Construction-related activities have the potential to result in the release and exposure of contaminants, resulting in adverse effects on aquatic habitats, the aquatic food web, and fish populations, including special-status species, within the primary study area downstream from project construction activities. This impact would be less than significant with all environmental commitments in place.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. Similar to CP4, CP5 also includes the implementation of the gravel augmentation program and restoration of riparian, floodplain, and side channel habitat at Reading Island. However, the environmental commitments for all action would result in less than significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-12 (CP5): Improved Flow and Water Temperature in the Upper Sacramento River Resulting From Project Operation – Chinook Salmon Project operation would result in improved flow and water temperature conditions in the upper Sacramento River for fish species of management concern. This impact would be beneficial.

Winter-Run Chinook Salmon Impacts and benefits under CP5 to winter-run Chinook salmon are the same as those identified under CP3. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon Impacts and benefits under CP5 to spring-run Chinook salmon are the same as those identified under CP3. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon Impacts and benefits under CP5 to fall-run Chinook salmon are the same as those identified under CP3. Mitigation for this impact is not needed, and thus not proposed.

Late Fall–Run Chinook Salmon Impacts and benefits under CP5 to late fall-run Chinook salmon are the same as those identified under CP3. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP5): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass Project operation would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

This impact would be the same as Impact Aqua-13 (CP3). Flow- and water temperature-related effects on these fish species would be less than significant, relative to the Existing Condition and No-Action Alternative. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-14 (CP5): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large floods providing the energy required to mobilize sediment from the river bed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

CP5 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

These effects would likely occur along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. As discussed above, CP5 also includes a 10-year gravel augmentation program and the restoration of riparian, floodplain, and side channel habitat at Reading Island as additional environmental commitments. The placement of gravel along the Sacramento River channel and bank on an annual basis and restoration of riparian, floodplain, and side channel habitat at Reading Island would result in ecological process (e.g., sediment transport and deposition, floodplain inundation) benefits that would partially offset the impacts described above. Nevertheless, reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. These impacts would be potentially significant within the primary study area. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Tributaries, Delta, and Trinity River

Impact Aqua-15 (CP5): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernable change in mean monthly flow or water temperature conditions in the lower Sacramento River; however, predicted changes in flow in the Feather River, American River, and Trinity River could result in an adverse effect on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass if they were to occur. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and increased cold-water pool) to be stored behind the raised dam.

Similar to CP1, monthly mean flows at model locations (i.e., Verona, Freeport) within the lower Sacramento River under CP5 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative conditions simulated for all months (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete modeling results). All potential changes in flows diminish rapidly downstream from RBDD because of increasing effects of inflows from tributaries and of diversions and flood bypasses. Potential flow-related effects on fish species of management concern in the lower Sacramento River from this alternative would be minimal. Differences in mean monthly flow were generally small (less than 2 percent) and within the existing range of variability. All potential changes in water temperatures in the lower Sacramento River due to small changes in releases would diminish rapidly downstream because of increasing effects of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts on fish species in the lower Sacramento River would be less than significant.

Also similar to CP1, monthly mean flows at all model locations within the lower Feather River, the American River, and Trinity River under CP2 would be essentially equivalent (less than 2 percent difference) to flows under the Existing Condition and No-Action Alternative simulated for most months. However, several months within the modeling record showed substantial changes (based on model simulations) to flows in tributaries (see the *Hydrology, Hydraulics, and Water Management Technical Report* for complete CalSim-II modeling results). All potential changes in flows could be diminished in these areas per existing operational rules, and because of operation of upstream reservoirs (i.e., Lake Oroville, Folsom Lake, and Trinity Lake), and increasing effects of inflows from tributaries and of diversions and flood bypasses. Nevertheless, based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts on species of management concern in the American, Feather, and Trinity rivers could occur and would be a potentially significant impact. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP5): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains, all of which are processes necessary for the maintenance of important aquatic habitat functions and values for the fish and macroinvertebrate community. A reduction in these ecologically important geomorphic processes and related aquatic habitat functions and values in the lower Sacramento River and lowermost (confluence) areas of tributaries would be a potentially significant impact.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and associated stage elevation of water surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flow, with relatively large floods providing the energy required to mobilize sediment from the bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Project operation could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

CP5 would lead to a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along the upper reaches of the lower Sacramento River. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. These impacts would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP5): Effects to Delta Fishery Habitat Resulting from Changes to Delta Outflow Delta outflow conditions under CP5 would be identical to those under CP3. Therefore, CP5 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-18 (CP5): Effects to Delta Fishery Habitat Resulting from Changes to Delta Inflow Changes in upstream reservoir storage have the potential to affect Delta inflow. Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. Delta inflow conditions under CP5 would be the same as those under CP3; therefore, CP5 would have a less than significant effect on Delta fisheries and hydrologic transport processed within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-19(CP5): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow CP5 operations would be the same as those under CP3 and would result in a variable response in Sacramento River flow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-20 (CP5): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP5 operation would be the same as under CP3 and result in no discernable change in San Joaquin River flows at Vernalis; and therefore CP5 would have no effect on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta compared with both the No-Action Alternative and Existing Condition. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-21 (CP5): Reduction in Low Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location CP5 operation would be the same as under CP3 and result in a less than 0.5 km movement upstream or downstream from the X2 location. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-22 (CP5): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers CP5 operations would be the same as under CP3 and would result in an increase of reverse flows in Old and Middle rivers. The increase in reverse flows would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses. This impact would be potentially significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

Impact Aqua-23 (CP5): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP5 operations, which are the same as CP3 operations, may result in an increase of CVP and SWP exports, which is assumed to result in a direct proportional increase or decrease in the risk of fish being entrained and salvaged at the facilities. This is considered a less than significant impact to Chinook salmon, steelhead, and longfin smelt. This is considered a potentially significant impact to delta smelt, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs.

CVP/SWP Service Areas

Impact Aqua-24 (CP5): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes Project implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) from CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats that provide habitat for the fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP4 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and the resulting downstream flows, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream flows. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

11.3.4 Mitigation Measures

Table 11-7 presents a summary of mitigation measures for fisheries and aquatic ecosystems.

No-Action Alternative

Under the No-Action Alternative, no action would be taken, including implementation of mitigation measures; rather, existing conditions would continue to change into the future.

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-1: Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations	LOS before Mitigation	PS	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	PS	LTS	LTS	LTS	LTS	LTS
Impact Aqua-2: Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-3: Effects on Cold-Water Habitat in Shasta Lake	LOS before Mitigation	PS	B	B	B	B	B
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	PS	B	B	B	B	B

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-4: Effects on Special-Status Aquatic Mollusks	LOS before Mitigation	LTS	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-4: Implement Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact.				
	LOS after Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
Impact Aqua-5: Effects on Special-Status Fish Species	LOS before Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
Impact Aqua-6: Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-7: Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-8: Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-9: Effects on Water Quality at Livingston Stone Hatchery	LOS before Mitigation	NI	NI	NI	NI	NI	NI
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	NI	NI	NI	NI	NI
Impact Aqua-10: Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-11: Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-12: Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation—Chinook Salmon	LOS before Mitigation	PS	B	B	B	B	B
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	PS	B	B	B	B	B
Impact Aqua-13: Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass	LOS before Mitigation	PS	LTS	LTS	LTS	B	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	PS	LTS	LTS	LTS	B	LTS
Impact Aqua-14: Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-14: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-15: Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-15: Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-16: Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-16: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-17: Effects to Delta Fishery Habitat Resulting from Changes to Delta Outflow	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-18: Effects to Delta Fishery Habitat Resulting from Changes to Delta Inflow	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-19: Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-20: Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis	LOS before Mitigation	NI	NI	NI	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	NI	NI	LTS	LTS	LTS
Impact Aqua-21: Reduction in Low Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-22: Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	None proposed.				
	LOS after Mitigation	NI	PS	PS	PS	PS	PS
Impact Aqua-23: Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports	LOS before Mitigation	NI	LTS for Chinook salmon, steelhead, and longfin smelt: PS for delta smelt, striped bass, and splittail	LTS for Chinook salmon, steelhead, and longfin smelt: PS for delta smelt, striped bass, and splittail	LTS for Chinook salmon, steelhead, and longfin smelt: PS for delta smelt, striped bass, and splittail	LTS for Chinook salmon, steelhead, and longfin smelt: PS for delta smelt, striped bass, and splittail	LTS for Chinook salmon, steelhead, and longfin smelt: PS for delta smelt, striped bass, and splittail
	Mitigation Measure	None required.	None proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-37. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-24: Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Notes:
B = beneficial
LOS = level of significance
LTS = less than significant
NI = No Impact
PS = potentially significant
S = significant

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

No mitigation is needed for Impacts Aqua-1 (CP1), through Aqua-13 (CP1), or Aqua-17 through Aqua-21 (CP1). No mitigation is proposed for Impacts Aqua-22 (CP1) or Aqua-22 (CP1). Mitigation measures are provided below for other impacts of CP1 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP1): Implement Mitigation Measure Geo-2 (CP1) This mitigation measure is the same as Mitigation Measure Geo-2 (CP1) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel re-direction, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-2 (CP1) to a less than significant level.

Mitigation Measure Aqua-14 (CP1): Implement Mitigation Measure Bot-7 (CP1): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is the same as Mitigation Measure Bot-7 (CP1), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP1) to a less than significant level.

Mitigation Measure Aqua-15 (CP1): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP1) to a less than significant level.

Mitigation Measure Aqua-16 (CP1): Implement Mitigation Measure Bot-7 (CP1): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities Implementation of mitigation measure Bot-7 (CP1) would reduce Impact Aqua-16 (CP1) to a less than significant level.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

No mitigation is needed for Impacts Aqua-1 (CP2) through Aqua-13 (CP2), or Aqua-17 through Aqua-21 (CP2). No mitigation is proposed for Aqua-22 (CP2) or Aqua-23 (CP2). Mitigation measures are provided below for other impacts of CP2 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP2): Implement Mitigation Measure Geo-2 (CP2): Replace Lost Ecological Functions of aquatic Habitats by Restoring Existing Degraded aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP2) described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils.” The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel re-direction, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-2 (CP2) to a less than significant level.

Mitigation Measure Aqua-14 (CP2): Implement Mitigation Measure Bot-7 (CP2): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP2), described in Chapter 12, “Botanical Resources and Wetlands.” Implementation of this mitigation measure would reduce Impact Aqua-14 (CP2) to a less than significant level.

Mitigation Measure Aqua-15 (CP2): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP2) to a less than significant level.

Mitigation Measure Aqua-16 (CP2): Implement Mitigation Measure Bot-7 (CP2): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP2), described in Chapter

12, "Botanical Resources and Wetlands." Implementation of this measure would reduce Impact Aqua-16 (CP2) to a less than significant level.

CP3 – 18.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply
No mitigation is needed for Impacts Aqua-1 (CP3) through Aqua-13 (CP3), or Aqua-17 through Aqua-21 (CP3). No mitigation is proposed for Aqua-22 (CP3) or Aqua-23 (CP3). Mitigation measures are provided below for other impacts of CP3 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP3): Implement Mitigation Measure Geo-2 (CP3) : Replace Lost Ecological Functions of aquatic Habitats by Restoring Existing Degraded aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel re-direction, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-2 (CP3) to a less than significant level.

Mitigation Measure Aqua-14 (CP3): Implement Mitigation Measure Bot-7 (CP3): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP3) to a less than significant level.

Mitigation Measure Aqua-15 (CP3): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP3) to a less than significant level.

Mitigation Measure Aqua-16 (CP3): Implement Mitigation Measure Bot-7 (CP3): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, “Botanical Resources and Wetlands.” Implementation of this measure would reduce Impact Aqua-16 (CP3) to a less than significant level.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

No mitigation is needed for Impacts Aqua-1 (CP4) through Aqua-13 (CP4), or Aqua-17 through Aqua-21 (CP4). No mitigation is proposed for Aqua-22 (CP4) or Aqua-23 (CP4). Mitigation measures are provided below for other impacts of CP4 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP4): Implement Mitigation Measure Geo-2 (CP4) : Replace Lost Ecological Functions of aquatic Habitats by Restoring Existing Degraded aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils.” The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel re-direction, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-2 (CP4) to a less than significant level.

Mitigation Measure Aqua-14 (CP4): Implement Mitigation Measure Bot-7 (CP1): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP1), described in Chapter 12, “Botanical Resources and Wetlands.” Implementation of this mitigation measure would reduce Impact Aqua-14 (CP4) to a less than significant level.

Mitigation Measure Aqua-15 (CP4): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP4) to a less than significant level.

Mitigation Measure Aqua-16 (CP4): Implement Mitigation Measure Bot-7: Implement Mitigation Measure Bot-7 (CP1): Develop and Implement a

Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP1), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this measure would reduce Impact Aqua-16 (CP4) to a less than significant level.

CP5 – 18.5-Foot Dam Raise, Combination Plan

No mitigation is needed for Impacts Aqua-1 (CP5) through Aqua-13 (CP5), or Aqua-17 through Aqua-21 (CP5). No mitigation is proposed for Impacts Aqua-22 (CP5) or Aqua-23 (CP5). Mitigation measures are provided below for the other impacts of CP5 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP5): Implement Mitigation Measure Geo-2 (CP5) : Replace Lost Ecological Functions of aquatic Habitats by Restoring Existing Degraded aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel re-direction, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-2 (CP5) to a less than significant level.

Mitigation Measure Aqua-14 (CP5): Implement Mitigation Measure Bot-7 (CP3): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP5) to a less than significant level.

Mitigation Measure Aqua-15 (CP5): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP5) to a less than significant level.

Mitigation Measure Aqua-16 (CP5): Implement Mitigation Measure Bot-7 (CP3): Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this measure would reduce Impact Aqua-16 (CP5) to a less than significant level.

11.3.5 Cumulative Effects

Chapter 3, "Considerations for Describing the Affected Environment and Environmental Consequences," discusses overall cumulative impacts of the project alternatives and the No-Action Alternative, including the relationship to CALFED Programmatic Cumulative Impacts Analysis, qualitative and quantitative assessment, past and future actions in the study area, and significance criteria.

As described in Section 11.3, "Affected Environment," aquatic habitats within the primary and extended study areas historically contained large populations of anadromous and other native fish species. Water supply projects, urban development, and flood control modifications have resulted in altered and degraded habitat conditions and reduced this historical fishery throughout. The combined effects of past and present projects have resulted in a significant adverse cumulative impact on fisheries and aquatic ecosystems in the primary and extended study areas.

Many of the reasonably foreseeable future projects identified would involve changes to SWP and CVP water operations that would in turn be anticipated to affect fisheries and aquatic ecosystems. While some of these changes could result in beneficial effects compared to current conditions, aquatic habitat and fisheries resources would remain limited.

The effects of climate change on operations at Shasta Lake could potentially result in changes to water temperature, flow, and ultimately, fish populations. As described in the Climate Change Projection Appendix, climate change could result in increased inflows to Shasta Lake and higher reservoir releases in the future due to an increase in winter and early spring inflow into the lake from high-intensity storm events. The change in reservoir releases could be necessary to manage flood events resulting from these potentially larger storms. Climate change could also result in reduced-end-of September carryover storage volumes, resulting in lower lake levels for a portion of the year, and a smaller cold-water pool resulting in warmer water temperature and reduced water quality within Shasta Reservoir. Most importantly, it is expected that climate change will result in increased water temperatures downstream from Shasta Dam, particularly in summer months, and more frequent wet and drought (particularly extended drought) years. The increased water temperatures, and greater inter-annual precipitation variability will compound the threats to fish (especially anadromous fish) in the Sacramento River. Winter-run Chinook salmon are particularly vulnerable to climate warming, prolonged droughts, and other catastrophic environmental events because they have only one remaining population that spawns during the summer months, when water temperature increases are expected to be the largest (NMFS 2009). Additionally, ocean productivity is expected to decline from altered upwelling cycles. This could reduce the available food resources for ocean-rearing salmonids and sturgeon, impacting fish survival.

The following analysis evaluates the potential cumulative impacts on fisheries and aquatic ecosystems when considering the project alternatives in combination with other past, present, and reasonably foreseeable future projects.

CP1– 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

As described in Section 11.3, without mitigation, CP1 could cause potentially significant effects on vegetation and habitats and special-status species in the primary and extended study areas. These effects would be caused by the loss or degradation of aquatic habitats in the primary study area, or by alteration of the flow regime of the upper Sacramento River and associated geomorphic processes in the primary and extended study areas.

Given the scale and duration of the project construction activities associated with CP1, the contribution to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP1 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the RWQCB. The SWPPP would require implementation of extensive BMPs during project construction as well as post-construction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the proposed project's contribution to cumulative construction-related impacts to a less than significant level.

Given major past alterations to the Sacramento River aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP1 would be cumulatively considerable. With implementation of Mitigation Measures Aqua-14 (CP1) and Aqua-16 (CP1), adverse effects from CP1 would be reduced and would no longer result in a cumulatively considerable incremental contribution to cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP1 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for winter-run Chinook spawning. Under CP1, potential impacts to fish would be beneficial.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

The cumulative effects of CP2 are similar to those of CP1, but greater in magnitude because CP2 would require additional construction and would result in the potential for increased alteration of flows associated with increased storage volume.

Given the scale and duration of the project construction activities associated with CP2, the contribution to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP2 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the RWQCB. The SWPPP would require implementation of extensive BMPs during project construction as well as post-construction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the proposed project's contribution to cumulative construction-related impacts to a less than significant level.

Given major past alterations to the Sacramento River aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP2 would be cumulatively considerable. With implementation of Mitigation Measures Aqua-14 (CP2) and Aqua-16 (CP2), adverse effects from CP2 would be reduced and would no longer result in a cumulatively considerable incremental contribution to cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP2 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for winter-run Chinook spawning. Under CP2, potential impacts to fish would be beneficial.

CP3 – 18.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply

The cumulative effects of CP3 are similar to those of CP1 and CP2, but greater in magnitude because CP3 would require additional construction and would result in the potential for increased alteration of flows associated with increased storage volume.

Given the scale and duration of the project construction activities associated with CP3, the contribution to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP3 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the RWQCB. The SWPPP would require implementation of extensive BMPs during project construction as well as post-construction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the proposed project’s contribution to cumulative construction-related impacts to a less than significant level.

Given major past alterations to the Sacramento River aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP3 would be cumulatively considerable. With implementation of Mitigation Measures Aqua-14 (CP3) and Aqua-16 (CP3), adverse effects from CP3 would be reduced and would no longer result in a cumulatively considerable incremental contribution to cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP3 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for winter-run Chinook spawning. Under CP3, potential impacts to fish would be beneficial.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

The cumulative effects of CP4 are similar to those of CP1, CP2 and CP3, but greater in magnitude because CP3 would require additional construction and would result in the potential for increased alteration of flows associated with increased storage volume. Some of these impacts would be partially offset with the implementation of the gravel augmentation program, floodplain and riparian restoration at Reading Island, and cold-water supply for anadromous fish management.

Given the scale and duration of the project construction activities associated with CP4, the contribution to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP4 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the RWQCB. The SWPPP would require implementation of extensive BMPs during project construction as well as post-construction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways.

Implementation of these measures would reduce the proposed project's contribution to cumulative construction-related impacts to a less than significant level.

Given major past alterations to the Sacramento River aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP4 would be cumul--14 (CP4) and Aqua-16 (CP4), adverse effects from CP4 would be reduced and would no longer result in a cumulatively considerable incremental contribution to cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP4 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for winter-run Chinook spawning. Under CP4, potential impacts to fish would be beneficial.

CP5 – 18.5-Foot Dam Raise, Combination Plan

The cumulative effects of CP5 are similar to those of CP1, CP2 and CP3, but greater in magnitude because CP3 would require additional construction and would result in the potential for increased alteration of flows associated with increased storage volume. Some of these impacts would be partially offset with the implementation of the gravel augmentation program, floodplain and riparian restoration at Reading Island.

Given the scale and duration of the project construction activities associated with CP5, the contribution to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP5 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the RWQCB. The SWPPP would require implementation of extensive BMPs during project construction as well as post-construction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the proposed project's contribution to cumulative construction-related impacts to a less than significant level.

Given major past alterations to the Sacramento River aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP5 would be cumulatively considerable. With implementation of Mitigation Measures Aqua-14 (CP5) and Aqua-16 (CP5), adverse effects from CP5 would be reduced and would no longer result in a cumulatively considerable incremental contribution to cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP5 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for winter-run Chinook spawning. Under CP5, potential impacts to fish would be beneficial.